AMERICAN COLLEGE OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE

LOW BACK DISORDERS

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OVERVIEW

The Low Back Disorders treatment guideline is designed to provide health care providers who are the primary target users of this guideline with evidence-based guidance on the treatment of working-age adults with low back disorders whether acute, subacute, chronic, or post-operative. While the primary patient population target is working adults, it is recognized the principles may apply more comprehensively. This guideline does not address several broad categories including congenital disorders or malignancies. It also does not address specific intra-operative procedures.

Objectives of this guideline include evaluations of baseline evaluation, diagnostic tests and imaging, physical activity, return to work, medications, physical therapy, cryotherapy, heat therapies, electrical therapies, manipulation, acupuncture, injections, operative procedures, and rehabilitation. Comparative effectiveness is addressed where available. This guideline does not address comprehensive psychological and behavioral aspects of pain management as those are addressed in the ACOEM Chronic Pain guideline. It is recognized that there are differences in workers' compensation systems.(1) There also are regional differences in treatment approaches.(2-4) The Evidence-based Practice Spine Panel and the Research Team have complete editorial independence from the American College of Occupational and Environmental Medicine and Reed Group which have not influenced the guidelines. The literature is routinely monitored and searched at least annually for evidence that would overturn this guidance. The guideline is planned to be comprehensively updated at least every five years, or more frequently should evidence require it. The health questions for acute, subacute, chronic, and post-operative low back disorders addressed by this guideline include:

- What evidence supports the initial assessment and diagnostic approach?
- What red flags signify serious underlying condition(s)?
- What diagnostic approaches and special studies identify clinical pathology?
- What initial treatment approaches have evidence of efficacy?
- What is the evidence of work-relatedness for various diagnoses?
- What modified duty and activity prescriptions and limitations are effective and recommended?
- When is return to work status recommended?
- When initial treatment options fail, what evidence supports other interventions?
- When, and for what conditions are injections and other invasive procedures recommended?
- When, and for what conditions is surgery recommended?
- Which surgeries are recommended for which conditions?
- What management options are recommended for delayed recovery?

A detailed methodology document used for guideline development including evidence selection, scoring, incorporation of cost considerations,(5, 6) and formulation of recommendations is available online as a full-length document(7) and also summarized.(8, 9) All evidence in the prior low back disorders guidelines garnered from 7 databases was included in this guideline (Medline, EBM Online, Cochrane, TRIP, CINAHL, EMBASE, PEDro). Additionally, new comprehensive searches for evidence were performed with both Pubmed and Google Scholar up through 2018 to help assure complete capture. There was no limit on year of publication. Search terms are listed with each table of evidence. Guidance is developed with sufficient detail to facilitate assessment of compliance(5) and auditing/monitoring.(6) Alternative options to manage conditions are provided.

This guideline has undergone extensive external peer review. The only AGREE(6) and IOM criteria(5) not adhered to is incorporation of the views of the target population. Neither patients with low back pain nor other affected patient groups were involved. In accordance with the IOM's Trustworthy Guidelines, detailed records are kept, including responses to external peer reviewers.(5)

Impact.....

It is estimated that 60 to 80% of the general population will experience an episode of low back pain (LBP) during their lifetime.(10, 11) The annual prevalence rate is between 25 and 60%.(12) LBP recurrence rates reportedly range from 24 to 80%.(13, 14) Low back disorders are the most frequent problems presented to health care providers. Back injuries are among the most common causes of reported occupational disorders with an incidence rate of 20 per 10,000 full-time workers and an average of 7 days away from work per injury.(15) In addition, low back disorders are disproportionately expensive, accounting for 10 to 33% of workers' compensation costs.(16-18) Occupationally related back pain has a national direct annual cost of $10.8 billion (US). However, this estimate is overly conservative as it does not include the indirect cost to employers who must rehire and retrain replacement workers, the loss of productivity, reduced quality work, administrative costs, and losses to the patient and patient's family (including productivity at home). Finally, it does not take into account those workers who do not file for disability, but nonetheless experience the effects of LBP.(19)

Overview……

Recommendations on assessing and treating adults with low back problems are presented herein. Topics include the initial assessment and diagnosis of patients with acute, subacute, and chronic radicular and non-radicular low back disorders, identification of red flags that may suggest the presence of a serious underlying medical condition, initial clinical and mechanical evaluation, management, diagnostic considerations and special studies to identify clinical pathology, work-relatedness, modified duty and activity, and return to work, as well as further management considerations including delayed recovery. In accordance with the most common classification, LBP is categorized as acute (<1 month duration), subacute (1 to 3 months duration), and chronic (>3 months duration).[i]

Algorithms for patient management are included. This guideline's master algorithm schematizes how practitioners may manage acute, subacute, or chronic low back disorders. The text, tables, and numbered algorithms expand upon the master algorithm.

As there are few studies that primarily evaluated patients with work-related back disorders,[ii] studies that include broader populations of adults were necessarily used to develop the recommendations. In addition, most studies that focus on pharmaceuticals, appliances, and specific devices are industry-sponsored. In certain areas, this may have made little difference as the comparisons were between the medication and placebo and the results may be consistent and considerable. However, in other studies, the comparison groups may have been suboptimally treated (e.g., with low-dose of ibuprofen) and produced a bias in favor of the medication or device. In addition, industry-sponsored studies have been shown to frequently have better results and lower complication rates than studies conducted by independent investigators.(20-22) There are several widely used highly remunerative injections and invasive procedures with sparse studies without significant replication. These are also concerning for

[i]When a study used a different classification, those articles were grouped into one or more of these three categories for purposes of uniformity.

[ii]Many studies do not describe the work status of the patients included. Many other studies excluded those with workers' compensation claims.

potential biased reporting. High-quality studies of physical modalities and delayed recovery are methodologically challenging and thus scant. They commonly suffer from methodological weaknesses (e.g., unblinded, multiple co-interventions, non-standardized techniques) that necessarily limit the strength of conclusions.

Summary of Recommendations and Evidence……

The following is a summary of many of this guideline's recommendations:

- The initial assessment of patients with low back problems focuses on detecting indications of potentially serious disease, termed "red flags" (i.e., fever or major trauma).
- In the absence of red flags, the focus should begin and remain on functional recovery.
- At the first visit, the patient should be assured that LBP is normal, has an excellent prognosis and, in all but rare cases, is not debilitating on a long-term basis. Patients with elevated fear avoidance beliefs may require additional instructions and interventions to be reassured of this prognosis. Those reassurances are thought to reduce the probability of the patient developing chronic pain syndrome.
- To avoid undue back symptoms and debilitation from inactivity, some activity or job modification may be helpful in the acute period. However, bed rest is not recommended for essentially all LBP and radiculopathy patients other than those with unstable fractures or cauda equina syndrome with pending neurological catastrophe. Maintaining ordinary activity as much as possible leads to the most rapid recovery.
- Patients should be encouraged to return to work as soon as possible as evidence suggests this leads to the best outcomes. This process may be facilitated with temporary modified (or alternative) duty particularly if job demands exceed patient capabilities. Full-duty work is a reasonable option for patients with low physical job demands and/or the ability to control such demands (e.g., alternate their posture) as well as for those with less severe presentations.
- An early mechanical evaluation using repeated end-range test movements to determine the presence or absence of a directional preference and pain centralization has been shown to guide directional exercise treatments that are associated with better outcomes.
- Appropriate adjustment of physical activity if needed, an exercise prescription, non-prescription medication or an appropriately selected nonsteroidal anti-inflammatory drug (NSAID), and the use of thermal modalities such as heat and/or cryotherapies may be helpful in relieving discomfort.
- In the absence of red flags, imaging and other tests are not recommended in the first 4 to 6 weeks of low back symptoms as they are highly unlikely to result in a meaningful change in clinical management.
- "Abnormal" findings on x-rays, magnetic resonance images, and other diagnostic tests are so common they *are normal by age 40*. Studies, if repeated today, would likely reduce that age for normal findings as obesity is associated with degenerative findings on imaging studies.(23-25) Bulging discs also continue to increase after age 40, and by age 60 will be encountered in 70 to 80% of patients. This requires that a careful history and physical examination be conducted in order to correlate historical, clinical,(26) and imaging findings prior to assigning the finding on imaging to a patient's symptoms. It is recommended that those providers unable to make those correlations, and thus properly educate patients about these complex issues, should defer ordering imaging studies to a qualified consultant in musculoskeletal disorders. Without proper education on prevalence, treatment, and prognosis, patients may become focused on "fixing" their abnormality (which may be a completely normal finding) and thus iatrogenically increase their risk of developing chronic pain and needless debility.

- Among the modes of exercise, aerobic exercise has the best evidence of efficacy, whether for acute, subacute, or chronic LBP patients.
- Non-specific stretching is not recommended as it is not helpful for treatment of LBP. However, specific types of stretching exercises appear helpful (e.g., directional and slump stretching). Strengthening exercises, including lumbar stabilization exercises, are recommended, but not until the acute period of LBP has sufficiently subsided.
- Many invasive and noninvasive therapies are intended to cure or manage LBP, but no quality evidence exists that they accomplish this as successfully as therapies that focus on restoring functional ability without focusing on pain. In those cases, the traditional medical model of "curing" the patient does not work well. Instead, patients should be aware that returning to normal activities most often aids functional recovery.
- Patients should be encouraged to accept responsibility for managing their recovery rather than expecting the provider to provide an easy "cure." This process promotes the use of activity and function rather than pain as a guide, making the treatment goal of return to occupational and non-occupational activities more obvious.
- If symptoms persist without improvement, further evaluation is recommended.
- Patients with evidence of specific nerve root compromise confirmed by appropriate imaging studies may be expected to potentially benefit from surgery.
- Quality evidence indicates that patient outcomes are not adversely affected by delaying non-emergent surgery for weeks or a few months and continued conservative care is encouraged in patients with stable or improving deficits who desire to avoid surgery. However, patients with either moderate to severe neurological deficits that are not improving or trending to improvement at 4 to 6 weeks may benefit from earlier surgical intervention. Those with progressive neurological deficit(s) are believed to have indications for immediate surgery. Those with severe deficits that do not rapidly improve are also candidates for earlier testing and referrals.
- Nonphysical factors (such as psychiatric, psychosocial, environment including non-workplace and workplace, or socioeconomic problems) should be investigated and addressed, especially in cases of delayed recovery or delayed return to work.

Basic Principles and Definitions……

Active Therapy: The term "active therapy" generally involves the patient taking an active role in the treatment of their LBP using various modalities. Active therapeutic exercises include aerobic activity, muscle reconditioning (light-weight lifting or resistance training), directional exercises, and active physiotherapy.(27) Active therapy may also include psychological, social, and educational components in conjunction with therapeutic exercises.(28)

Acute, Subacute, and Chronic Low Back Pain: Acute, subacute, and chronic LBP are categorized as less than 1 month, 1 to 3 months, and greater than 3 months duration, respectively (29).[iii]

Adjacent Segment Disease: This theory postulates that if there is disease in one spinal segment, it increases the probability of disease in the neighboring segment. It is most commonly used to indicate the probability of a disc problem in the segment adjacent to a fused or otherwise operated segment, although surgery is not inevitably indicated.

Aggressive Exercise Therapy: This therapy typically concentrates on cardiovascular training and strengthening of muscles to improve back function.(30-32) Aggressive exercise therapy is a primary

[iii]This document uses these definitions regardless of whether other definitions were used at the onset of chronic LBP (e.g., a minority of studies use a 6-month duration for chronic pain).

treatment for chronic LBP and after various back surgeries, and is frequently initiated in the course of treating subacute LBP.

Ankylosing Spondylitis: Spondylitis is a chronic, inflammatory, rheumatic condition of the sacroiliac (SI) joints and the spine. As the condition advances, it may cause fusion of the vertebrae and SI joints (ankylosis). Spondylitis can affect other body tissues.

Bulging Intervertebral Disc: The intervertebral disc is a fibrocartilaginous material. Its primary function is to allow slight movement between each individual spinal segment and significant ranges of motion when all segments are considered together as one functional unit. A disc also acts as a shock absorber for the spine and is composed of an annulus fibrosis (a broad circumferential ligamentous structure) surrounding the nucleus pulposus (a gel-like substance). A bulging intervertebral disc involves an assessment that the degree of natural disc bulging is larger than is typical at a given level. "Protrusion" is a term sometimes used to describe a bulging disc, particularly in radiological literature. Such bulging may be described as focal, diffuse, central, and/or lateral. A key distinction is that there is no rupture of the nucleus pulposus through the annulus. Disc bulging increases as the day progresses (approximately 20% diurnal volume variation) and disc bulging is also magnified if an MRI is performed in a standing position. Other than relatively unusual situations (e.g., large lateral bulging into a narrowed neuroforaminal space or large central bulging into a narrowed spinal canal), bulging is thought to be asymptomatic.(33)

Centralization: Centralization is a pattern of pain response elicited and reported by patients during a form of lumbar assessment using repeated end-range movements in one direction of testing and various postures, most often end-range positioning. When pain referred or radiating away from the spine retreats back toward or to the midline in response to a single direction of sustained or repeated positional spinal testing, that pain is "centralizing" or has "centralized."

Chemonucleolysis: Chemonucleolysis is the process of injecting chymopapain (or other enzyme) into the intervertebral disc to dissolve the gelatinous intradiscal material. The disc then shrinks in size. This procedure is less invasive then back surgery, but is currently largely unavailable in the U.S. due in part to adverse effects.

Chronic Non-specific Low Back Pain: LBP lasting longer than 3 months (12 weeks) is defined in this document as "chronic." Chronic LBP is labeled as "non-specific" when it is deemed to be not attributable to a recognized, known specific pathology.(30) The majority of chronic LBP is non-specific.(13, 34) Included in this category are terms used to attempt to describe these patients with specificity that includes purportedly "specific" terms such as degenerative disc disease, "discogenic" back pain, "black disc disease," micro instability, lumbar spondylosis, facet syndrome, piriformis syndrome, sacroiliac joint syndrome, and myofascial pain. There is no scientific consensus that the pain-generating structure can be reliably identified in these pain syndromes. There are specific treatments used to target these patients, but most are not supported by evidence from high-quality randomized controlled trials (RCTs). As the placebo or control populations used in many studies included throughout this document routinely improve, one cannot infer that improvement in pain with such treatment is quality evidence in support of a mechanistic theory.

Degenerative Disc Disease: Degenerative disc disease (DDD) is the degeneration of the vertebral discs and may be a natural consequence of aging. It is sometimes used synonymously with the term "spondylosis." DDD may also lead to spinal stenosis (a narrowing of the spinal canal) that may place pressure on the spinal cord and other nerves.(35) DDD is generally considered to be a normal process of aging and is generally thought to be asymptomatic unless neurological impingement results.

Derangement: A non-specific term purportedly a painful displacement within the spine often used by those performing manipulation. A derangement is considered by some proponents to be "reducible" when a directional preference and pain centralization are elicited during a mechanical evaluation using repeated end-range test movements. May be used as an equivalent though less specific term to displaced intervertebral disc contents.

Delayed Recovery: Delayed recovery is an increase in the timeframe prior to returning to work or usual activities compared with the length of time expected based on average expectations, severity of the disorder, and treatments provided.

Directional Preference: The single direction of repeated end-range spinal bending or positioning tests that causes an individual's pain to centralize, abolish, or both. Midline-only pain cannot centralize (it is already central) but may have a directional preference where a single direction of end-range bending or positioning reduces or eliminates that midline pain.

Extrusion: See Herniated Intervertebral Disc below.

Facetectomy: Facet joints of the vertebrae (also called zygapophysial joints) are synovial fluid lubricated joints posterolaterally located on each side of the posterior (back) of the spine. The joint is formed where each side of the vertebrae overlap one another. A facetectomy is the removal of the bone that forms these joints.

Failed Back Surgery Syndrome: Failed back surgery syndrome (FBSS) is an ill-defined term sometimes used to label a heterogeneous set of conditions with suboptimal post-surgical results including chronic pain and persistent or recurrent disability. While indicating that surgery failed to achieve pre-operative goals, there are patients who do improve with either time or subsequent treatment. As negative terms may foster debility and impede recovery, this term is discouraged (LBP or chronic LBP are preferable diagnoses). However, because the term is used in the scientific literature, it is discussed in this document.

Foraminotomy: The intervertebral foramina are the normal gaps through the bone between the vertebrae through which a spinal nerve root exits the spinal canal. A foraminotomy is the removal of part of the bone around the intervertebral foramina to increase the size of this passage.

Functional Capacity Evaluation: A functional capacity evaluation (FCE) is a comprehensive battery of performance-based tests to determine an individual's ability to work and conduct activities of daily living.(36) An FCE may be done to identify an individual's ability to perform specific tasks associated with a job (job-specific FCE), or his or her ability to perform physical activities associated with any job (general FCE). The term "capacity" used in FCE may be misleading, as an FCE generally measures performance and effort rather than capacity.

Functional Improvement (especially Objective Evidence): Evaluation of the patient prior to the initiation of treatment should include documentation regarding objective physical findings and current functional abilities both at home and at work. This should include a clear statement regarding what objective or functional goals are to be achieved through the use of treatment if anything other than full functional recovery occurs. These measures should be tracked during treatment and evidence of progress towards meeting these functional goals should be sought. Examples of documentation supporting improved function would be increased physical capabilities including job specific activities, return to work, return from off-duty-status to modified duty, performance of exercise goals, participation in progressive physical therapy, and other activities of daily living. Validated tool(s), such

as the Modified Oswestry Questionnaire and Roland-Morris Disability Questionnaire may also help track progress, although they are subjective. Objectively measured improvements in strength or aerobic capacity may be physical examination correlates of improved function.

Functional Restoration: Functional restoration is a blend of various techniques and programs (both physical and psychosocial), rather than one specific set of active exercises, processes or therapies. The basic principle for all of these individually tailored programs is to help LBP patients cope with pain and return to the functional status required for their daily needs and work activities.(37) The term functional restoration program frequently refers to a full-day multidisciplinary, medically-directed program typically lasting from 3 to 6 weeks, employing an interdisciplinary team often consisting of therapists, psychologists, case managers, and nurses.(38)

Herniated Intervertebral Disc: A herniated intervertebral disc involves a defect in the annulus fibrosis with rupture of the nucleus pulposus out through that opening. A herniated disc may exert direct mechanical pressure and/or chemically irritate a nerve root, causing pain (see Table 2 for tests to help determine if a patient has a herniated intervertebral disc). Herniated discs are often asymptomatic.

Laminectomy: The lamina is the thin bony area of the vertebrae that covers each of the two posterolateral aspects of the spinal canal. Laminectomy is the complete removal of one lamina to expose or access the spinal canal.

Laminotomy: A laminotomy is the partial removal of the lamina to expose or access the spinal canal.

McGill Pain Questionnaire: The McGill Pain Questionnaire (MPQ) attempts to quantify pain, describing pain not solely in terms of intensity, but also in terms of sensory, affective, and evaluative qualities. It was intended to provide a way of identifying differences among different methods of relieving pain.(39-42)

Oswestry Disability Index: The Oswestry Disability Index (ODI) is a subjective tool intended to measure functional disability by evaluating a patient's perceived limitations in performing activities of daily living. There are 10 questions related to pain and disability. The "score" is presented as a percentage (0 to 100) – 0% represents no pain or disability while 100% represents total disability.(43, 44) However, the test is not standardized and is frequently modified, making interpretations difficult.(45, 46)

Passive Modality: Passive modalities refer to various types of treatment that usually involve administration of some form of applied stimulus rather than active therapy (see Active Therapy). Forms of passive modalities include massage, hydrotherapy (e.g., whirlpools, hot tubs, spas, etc.), ultrasound, and hot/cold compresses.

Percutaneous Discectomy: Percutaneous means "through the skin." In the case of surgery, it typically means a smaller incision than a traditional "open" procedure and consequently there is less access to the total disc or extruded portion(s). Discectomy is the surgical removal of an intervertebral disc. Thus, a percutaneous discectomy is the removal of a spinal disc via a small incision through the skin with the hope that the remaining aspects collapse like a balloon.

Physical or Occupational Therapy: The term "physical therapy" is used in ACOEM's *Guidelines* generically to mean physical medicine, therapeutic and rehabilitative evaluations and procedures. Much research uses this term generically. This rehabilitative therapy may be performed by or under the direction of trained and licensed individuals such as physical therapists, occupational therapists, exercise physiologists, chiropracters, athletic trainers, and physicians. Jurisdictions may differ on the

qualifications for licensure to perform these interventions. These *Guidelines* are not meant to restrict physical therapy to being performed only by physical therapists.

Protrusion: See Bulging Intervertebral Disc.

Radicular Pain Syndrome: Pain in the extremities (arms, hands, legs, and feet) that is caused by an associated nerve root being affected in or near the spine. Pain is usually substantially worse in the extremity than in the spine and some have only radiating pain in the extremity. An example of this syndrome is lumbar radiculopathy from a disc herniation, most typically resulting in sciatica (usually either an L5 or S1, less often L4, nerve root impingement with pain radiating down the lower extremity in those specific nerve root distributions). Radiculopathy may result in numbness or paresthesias in the corresponding dermatome, muscle weakness in the corresponding myotome, and/or loss of muscle stretch reflex corresponding to the affected root level (see Table 4).

Roland-Morris Disability Questionnaire: The Roland-Morris Disability Questionnaire is a self-administered disability measure consisting of 24 items abstracted from the Sickness Impact Profile. The items represent a variety of activities with which individuals with low back pain may have difficulty. However, the test is not standardized and is frequently modified, making interpretations difficult. (45, 46)

Sciatica: A clinical presentation of pain in the distribution of the sciatic nerve. While most commonly attributed to one, or rarely multiple, impinged L4, L5 or S1 nerve roots, there are many other potential causes (e.g., other musculoskeletal, tumors etc).(47-49)

Slump Stretching: Stretching by rounding the neck and back and flexing the hip to 90° with knee extension (ankle neutral or slightly dorsiflexed).

Spinal Motion Segment: The spinal motion segment is made up of two adjacent vertebrae, the intervertebral disc between them, connecting ligaments, and their two facet joints. The connections of these bones and discs constitute the functional unit of the spine. Spinal motion is the ability of the spine, as a whole, to flex in multiple directions. A spinal motion segment is the range of motion for one joint segment between two adjacent vertebrae. When two or more vertebrae are completely fused together, surgically or otherwise, the spinal motion of these two segments is eliminated and the overall range of motion for the entire spine decreases.

Spinal Stenosis: Spinal stenosis is anatomic narrowing of the spinal canal. It may or may not be accompanied by neurological impingement of the spinal cord and/or spinal nerves. When neurological impingement occurs in the lumbar segment of the spine, symptoms may include low back and lower extremity pain that is termed "neurogenic claudication," i.e., pain with walking. This condition is most often degenerative, although it may be congenital or acquired after significant trauma resulting in spondylolisthesis. Most commonly, spinal stenosis involves a combination of factors that may include facet joint osteoarthrosis with osteophytes, intervertebral disc space narrowing, hypertrophy of the ligamentum flavum and other ligamentous structures, and/or congenital narrowing of the spinal canal.

Spondylolisthesis: Spondylolisthesis is the abnormal alignment of one vertebra in relation to the adjacent vertebral body usually measured in millimeters of displacement between the posterior aspects of the two vertebral bodies. While most commonly degenerative, it may also be acquired from major trauma. Isthmic spondylolisthesis is a developmental defect. When congenital, it is a non-union of the pars. It also is believed to relatively rarely occur as a non-union of a stress fracture that occurs in childhood such as relatively rare circumstances such as football linemen and female gymnasts. It rarely progresses once skeletal maturity is attained. It is frequently asymptomatic, but it may be rendered

symptomatic by adult trauma. Degenerative spondylolisthesis has a different pathophysiology. It occurs as the facet joints and adjacent disc lose their stabilizing ability due to degenerative changes (e.g., facet joint osteoarthrosis and degenerative disc space narrowing), typically in those over age 60. The degree of spondylolisthesis tends to increase with age-related changes, especially as the degree of disc space narrowing advances. It is usually thought to be asymptomatic unless there is neurological impingement (e.g., accompanying spinal stenosis).

Spondylosis: Lumbar spondylosis is the degeneration of the lumbar vertebral discs. It is sometimes used synonymously with the term "degeneration of the disc." This affects the spinal facets as well as the disc. Lumbar spondylosis may also lead to spinal stenosis (see above) that may place pressure on the spinal cord and other nerves.(35) Spondylosis is generally considered to be a normal process of aging and is thought to be asymptomatic unless neurological impingement results.

Spondylolysis: A term sometimes used to refer to non-union of a pars defect and/or pars fracture (see also spondylolisthesis above).

Visual Analog Scale: The Visual Analog Scale (VAS) attempts to measure a patient's level of subjective pain with a 0 to 100 scale. In research and some clinical settings, this is commonly obtained with a horizontal line that is 10cm long with verbal scale anchors of "no pain" to "worst pain" that a patient marks and can then be measured in millimeters to give a VAS (e.g., 45mm = 4.5). Most commonly, a 0 to 0 verbal rating scale is used clinically as a surrogate without being a true VAS.

Initial Assessment. . . . . .

Most LBP has no definable pathophysiological abnormality. Accordingly, the initial assessment has a somewhat unusual emphasis on "ruling out" serious underlying conditions (e.g., kidney stone, infection, cancer, fracture). If there are no serious underlying conditions, the emphasis typically shifts to ruling out discrete anatomic causes (e.g., a pinched nerve) before allowing the generic diagnosis of "low back pain."

Thorough medical and work histories and a focused physical examination (see General Approach to Initial Assessment and Documentation Guideline) are sufficient for the initial assessment of a patient with potentially work-related low back symptoms. Findings of the medical history and physical examination may alert the examiner to other pathology (e.g., not of low back origin) that can present as low back disorders. In this assessment, certain findings, referred to as red flags, raise suspicion of serious underlying medical conditions (see Table 1). The absence of red flags and conditions rules out the need for special studies, referral, or inpatient care during the first 4 to 6 weeks. During this time, spontaneous recovery is expected, provided any associated workplace factors are mitigated.(30)

There also are psychological red flags that should be evaluated, such as PTSD, suicidality, hallucinations or intoxication, which have been called primary risk factors,(50) and have been reviewed elsewhere.(51) Suicidality though is a potentially fatal complication, which makes it a more severe complication than cauda equina.

Red Flags

Potentially serious disorders are referred to as "red flags." These include acute fractures, acute dislocations infection, tumor, progressive neurologic deficit, or cauda equina syndrome.

Table 1. Red Flags for Potentially Serious Low Back Conditions

Disorder	Medical History	Physical Examination/Diagnostic Testing
SPINAL DISORDERS		
Fracture	Major trauma, such as vehicular accident or fall from height Minor trauma or supra-maximal lifting in older or potentially osteoporotic patients	Percussion tenderness over specific spinous processes Careful neurological examination for signs of neurological compromise
Tumor and Neoplasia	Severe localized pain over specific spinal processes History of cancer Age >50 years Constitutional symptoms, such as recent unexplained weight loss or fatigue Pain that worsens when patient is supine Pain at night or at rest	Pallor, reduced blood pressure, diffuse weakness Tenderness over spinous process and percussion tenderness Decreased range of motion due to protective muscle spasm History of sciatica for detection of cancer† ▪ Sciatica sensitivity = 58 to 93% ▪ Sciatica specificity = 78% History of paresthesia for detection of cancer† ▪ Paresthesia sensitivity = 58% Plain radiography for detection of cancer‡ ▪ Radiography sensitivity = 60% ▪ Radiography specificity = 90 to 99.5% Magnetic resonance imaging (MRI) for detection of cancer‡ ▪ MRI sensitivity = 83 to 93% ▪ MRI specificity = 90 to 97% Radionuclide scanning for detection of cancer‡ ▪ Planer imaging sensitivity = 74 to 98% ▪ Planer imaging specificity = 64 to 81% ▪ SPECT sensitivity = 87 to 93% ▪ SPECT specificity = 91 to 93%
Infection	Risk factors for spinal infection: recent bacterial infection (e.g., urinary tract infection); IV drug abuse; diabetes mellitus; or immune suppression (due to corticosteroids, transplant, or HIV) Constitutional symptoms, such as recent fever, chills, or unexplained weight loss	Tenderness over spinous processes Decreased range of motion Vital signs consistent with systemic infection (late): ▪ Tachycardia ▪ Tachypnea ▪ Hypotension ▪ Elevated temperature ▪ Pelvic or abdominal mass or tenderness ▪ High white blood cell count ▪ Elevated erythrocyte sedimentation rate Plain radiography for detection of infection‡ ▪ Radiography sensitivity = 82% ▪ Radiography specificity = 57% Magnetic resonance imaging (MRI) for detection of infection‡ ▪ MRI sensitivity = 96% ▪ MRI specificity = 92% Radionuclide scanning for detection of infection‡ ▪ Radionuclide scanning sensitivity = 90% ▪ Radionuclide scanning specificity = 78%

Cauda Equina Syndrome/ Saddle Anesthesia	Direct blow or fall with axial loading Perianal/perineal sensory loss Recent onset of bladder dysfunction, such as urinary retention, increased frequency, or overflow incontinence Bowel dysfunction or incontinence Severe or progressive neurologic deficit in lower extremities, usually involving multiple myotomes and dermatomes	Unexpected laxity of bladder* or anal sphincter Major motor weakness in hamstrings (knee flexion weakness); ankle plantar flexors, evertors, and dorsiflexors (foot drop). May have more proximal myotomal weakness if higher cord level(s) affected. Spastic (thoracic) or flaccid (lumbar) paraparesis Increased (thoracic) or decreased (lumbar) reflexes
Progressive Neurologic Deficit	Severe low back pain Progressive numbness or weakness	Significant and progressive myotomal motor weakness Significant and increased sensory loss – in anatomical distribution Radicular signs
EXTRASPINAL DISORDERS		
Dissecting Abdominal Aortic Aneurysm	Excruciating low back pain History of atherosclerotic disease or multiple cardiovascular risk factors History of hypertension	Pulsatile midline abdominal mass Absent or variable pulses Asymmetric blood pressure Bruits
Renal Colic	Excruciating pain from costovertebral angle to groin, testis, or labia History of urolithiasis Hematuria	Possible tenderness at costovertebral angle
Retrocecal Appendicitis	Right lower quadrant abdominal pain and/or right low back pain Constipation Subacute onset without inciting event Nausea and vomiting variably present	Low-grade fever May have tender right lower quadrant Pain on rectal examination in right lower quadrant
Pelvic Inflammatory Disease	Vaginal discharge Pelvic pain Prior episode	Uterine tenderness Tender over right and/or left lower quadrants Cervical discharge
Urinary Tract Infection	Dysuria History of urinary tract infections	Fever Suprapubic tenderness Smelly or cloudy urine

Adapted from: †van den Hoogen HM, et al. 1995; ‡ Jarvik JG, Deyo RA 2002;*Bigos S, et al. 1994.
SPECT = single-photon emission computed tomography

Absence of Red Flags

Absent red flags, low back disorders can usually be classified into one of two working categories:

- **Non-specific disorders** including benign, self-limited disorders with unclear etiology, such as regional or non-specific LBP. This includes the majority of LBP patients' problems, generally more than 95% of those with acute LBP.
- **Specific disorders**, including potentially degenerative disorders such as herniated discs (see Table 2), spinal stenosis, other neurological impingements, and facet joint osteoarthrosis.

There may be overlap between these two categories.

Table 2. History and Physical Examination Findings with Reported Sensitivity and Specificity Estimates for Common Specific Spine Disorders

Disorder	Medical History	Physical Examination/Diagnostic Testing
Ankylosing spondylitis[‡†]	Onset usually <35 years of age Male gender at higher risk Reduced lateral mobility Pressure in the sacral or lumbar spine No relief from pain by lying down Three (3) months low back pain Stiffness in the morning Relief of pain with exercise Chronic onset	HLA B27 testing to detect ankylosing spondylitis ▪ Sensitivity = 95% ▪ Specificity = 85% Plain radiography for detection of ankylosing spondylitis[‡] ▪ Radiography sensitivity = 26 to 45% ▪ Radiography specificity = 100% Magnetic resonance imaging (MRI) for detection of ankylosing spondylitis[‡] ▪ MRI sensitivity = 56% Radionuclide scanning for detection of ankylosing spondylitis[‡] ▪ Radionuclide scanning sensitivity = 26% ▪ Radionuclide scanning specificity = 100%
Herniated Disc[‡£]	Sciatica/radicular pain Dermatomal distribution Myotomal distribution Low back pain	History of sciatica for detection of a herniated disc[‡£] ▪ Sensitivity = 85 to 99% ▪ Specificity = 6 to 88% Ipsilateral straight-leg raising for detection of a herniated disc[‡] ▪ Sensitivity = 80% ▪ Specificity = 40% Crossed straight-leg raising for detection of a herniated disc[‡£] ▪ Sensitivity = 23 to 25% ▪ Specificity = 90 to 100% Ankle dorsiflexion weakness for detection of a herniated disc[‡] ▪ Sensitivity = 35% ▪ Specificity = 70% Great toe extensor weakness for detection of a herniated disc[‡] ▪ Sensitivity = 50% ▪ Specificity = 70% Impaired ankle reflex for detection of a herniated disc[‡£] ▪ Sensitivity = 48 to 50% ▪ Specificity = 60 to 89% Ankle plantar flexion weakness for detection of a herniated disc[‡] ▪ Sensitivity = 6% ▪ Specificity = 95%

*Adapted from: [‡]Jarvik JG, Deyo RA 2002; [†]van den Hoogen HM, et al. 1995; [£]Vroomen PC, et al. 1999.

LOW BACK PAIN (LBP)

More than 95% of patients have no identifiable cause for acute LBP. Most with chronic LBP also have no clearly identifiable cause. Symptoms are pain, usually without radiation, although some patients have radiation into the buttocks or thigh. Pain that is solely or mostly in a thigh and calf generally, but not always, signifies radiculopathy, particularly when the radicular pain in the extremity substantially exceeds that in the back or is the sole symptom. LBP patients generally have no tingling, numbness, or

muscle weakness other than weakness associated with pain-producing activities. Some practitioners refer to these LBP patients as having incurred "sprains" and/or "strains"; however, these labels are not appropriate. A sprain is a disrupted ligament and a strain is a myotendinous junction disruption. Both imply knowledge of the anatomic cause of LBP and a forceful mechanism of injury when the former is untrue for LBP patients and the latter may or may not be true. Use of those terms also confuses the proper use of those diagnoses elsewhere in the body, becomes problematic in determination of work-relatedness, and misdirects patients on the value of activity for early functional recovery. Low back "strain" and "sprain" are included in non-specific low back pain.

RADICULAR PAIN SYNDROMES

Radicular pain denotes pain that is in a specific neurological distribution, nearly always involving only one nerve root. Symptoms typically include some combination of extremity pain, tingling and numbness, and muscle weakness (in the appropriate myotomal distribution). Corresponding signs, including sensory loss, muscle weakness, and a diminished reflex all in the distribution of that same nerve root may be present. Sciatica denotes pain in the sciatic nerve distribution and may be caused by many abnormalities, although it most commonly denotes impingement of either the L5 or S1 nerve roots as those are most frequently affected.(47-49) It less commonly may involve the L4 or other nerve roots as the sciatic nerve also has components from L4 to S3. The most common cause of sciatica is radiculopathy and the diagnosis of radiculopathy is generally not complex in moderate to severely affected individuals. It becomes more difficult with milder cases, as symptoms and examination findings may be less pronounced or some of the findings may be absent.

There are multiple possible causes of radicular pain. Most commonly, at least in the occupational setting, pain is due to a herniated intervertebral disc. This involves a rupture in the fibrous annulus fibrosis and protrusion or extrusion of nucleus pulposus material.(33, 52) A combination of a physical displacement of the nucleus pulposus along with a purported chemical reaction to this material with consequent swelling in the acute phase appears responsible for the development of the symptoms of neurological compromise. Other possible causes of radicular pain include a significant laterally bulging (but not herniated) disc into a narrowed canal that is sufficient to impinge the nerve root. It is also possible for a severe degenerative arthritic process to accumulate substantial osteophytic growths around the facet joint and/or intervertebral disc space and cause radicular symptoms.

ZYGAPOPHYSIAL (FACET) JOINT DEGENERATIVE JOINT DISEASE

Facet joints are small, synovial fluid filled, synovium lined, ligamentously encapsulated joints that are in alignment along the posterior aspect of the spinal column. They are in many ways similar to nearly all other joints (the main exceptions are the intervertebral discs). Facet joints are prone towards the same maladies that affect other joints, including osteoarthrosis (degenerative joint disease), gout,(53) psoriatic arthritis, and many other arthritides. There appears to be a propensity towards facet joint osteoarthrosis in those with other osteoarthrosis elsewhere in the body, sometimes referred to as "systemic osteoarthrosis."

The determination of facet joint osteoarthrosis is relatively straightforward. The disorder becomes nearly universal with increasing age.(54) Roentgenograms, particularly facet joint (or rotated) views for the lumbar spine and lateral views for the cervical spine, will show evidence of degenerative findings (i.e., sclerosis, joint space narrowing, and cyst formation). However, the diagnosis of pain arising from such degenerative facet joints is quite controversial compared with arthritis in peripheral joints. This is primarily due to a combination of the universal appearance of facet joint arthrosis with age, variable findings with facet joint blocks and injections, and especially the lack of an undisputed gold standard (see also facet joint injections and blocks).(54-56) Osteoarthrosis in the spine and disc

space narrowing are extremely common (so common that many radiologists do not record these abnormal findings, especially when more mild, on x-rays as they are "normal" for age). It appears to be largely asymptomatic.(57-59) In those with multiple levels affected, there often is not pain at all of those levels. As LBP is so common and the overwhelming anatomic cause of LBP is unknown,(13) it follows that attempting to diagnose the pain as related to a specific structure such as the facet joints is quite challenging.

Important diagnostic limitations also include that diagnostic blocks are often accomplished involving intra-articular injection(s) of anesthetic agents. This cannot be directly related to the value of neurotomies.(60) Other limitations include single diagnostic blocks versus multiple blocks and the use of corticosteroids. Problems with diagnostic blocks of the dorsal root rami include: 1) the ability to anesthetize the joint; 2) the specificity to not anesthetize adjacent neural structures; and 3) the likelihood ratio of a single diagnostic block.(60)

Although not necessarily related to facet joint disease, chronic LBP patients may develop segmental rigidity (SR) at one or more lower lumbar joints, generally thought to be due to a combination of tissue scarring, chronic immobility and muscle splinting. The location is commonly in the lower half of the lumbar spine, particularly above, below or bracketing a fusion or other prior lower lumbar surgical site. Segmental rigidity is initially noted on lateral bend motion, generally effects 1 to 2 levels, and may be asymmetric. Treatment involves a trial of *exercise only*, performed frequently to mobilize rigid facet joints after prolonged activity. If unsuccessful, the combination of facet injections and frequently-performed exercise may result in improvement of joint mobility, setting the stage for improved rehabilitative gains by decreasing pain and facilitating strengthening exercise.(61, 62)

SACROILIAC JOINTS

Sacroiliac joints (SIJs) are diarthrodial synovial joints at the lumbosacral junction. Nociceptors in the SIJ are reported to have a higher threshold than those within the lumbar facet joints, but lower than the anterior portions of lumbar discs, and may be a potential cause of pain. The joint is most prominently involved in ankylosing spondylitis, in which the joint may become obliterated, as well as Reiter's syndrome and psoriatic arthritis. Its role in other back pain is somewhat controversial, due in part to the lack of normal joint motion beyond a few degrees, the joint's close proximity to the L4-L5 and L5-S1 areas and consequent frequent tenderness in the surrounding structures. Physical examination maneuvers reportedly have poor ability to confirm a diagnosis of SI joint involvement.(63) These challenges make unequivocal definition of the SI joint as the problematic source of pain difficult, and in many cases, impossible.

A study evaluating pain diagrams in responders versus non-responders to double diagnostic fluoroscopically guided intra-articular sacroiliac joint block suggested subtle, but potentially significant differences in the pain diagrams to help guide diagnosis.(64) Those findings were a closer proximity to pain over the SI joint versus pain more distally in the lower buttocks in the non-responders. Another study compared the diagnostic accuracy of a multi-test regimen of 5 sacroiliac joint pain provocation tests with fluoroscopically controlled double SIJ blocks using a short- and long-acting local anesthetic in order to reduce the exposure of patients to unnecessary invasive SIJ procedures, for 60 patients with chronic LBP.(65) The study was designed to determine the relevance of a multi-test regimen of SIJ provocation tests. Application of this regimen was found to be useful in reducing unnecessary intra-articular SIJ block in the early stage of clinical decision making. "When three or more provocation tests are positive, the probability is between 65% and 93% that the pain is related to the SIJ, in which case confirming SIJ blocks are required." When fewer than three

provocation tests were positive, "the probability is between 72% and 99% that the SIJ is unlikely to be the source of pain."(65)

The International Association for the Study of Pain (IASP) has proposed diagnostic criteria for SIJ pain of: 1) pain in the SIJ region; 2) stressing the joint in clinical tests selective for the joint to reproduce the pain; and 3) selectively infiltrating the symptomatic joint with local anesthetic to completely relieve the pain.(66) However, while prevalence rates are estimated at 2 to 26.6%, false-positive rates are estimated at 20 to 22%. A systematic review of clinical tests of SIJ concluded that "there is no evidence to support the inclusion of mobility and pain provocation tests for the SIJ in clinical practice."(67) Estimates from local anesthetic blocks of the SIJ(s) are that these joints may be responsible for 10 to 26.6% of chronic LBP cases.(68) The joint can be anesthetized using a fluoroscopic guided or unguided injection of a local anesthetic or steroid.

Estimates vary regarding the rate that the SI joint may contribute to LBP. A small case series of patients with chronic pain after successful fusion surgery performed anesthetic blocks found a 35% rate of positive blocks in this population (at least 75% pain relief), inferring that the SIJ may be partially related to FBBS.(69) Another case series attributed the cause to the SI joint in 32% and another 29% were felt to be a possible cause.(70) Standard anteroposterior radiographs are thought to be sufficient for most purposes, rather that needing SIJ views in cases of reactive arthritides.(71) Therapies have been developed to attempt to address these joints including injections of glucocorticoids, radiofrequency neurotomy, physical therapy, manipulation, orthotics, mobilization, cryoneurolysis, neuroaugmentation, and surgery.(72)

CLINICAL SYNDROMES

The inability of conventional clinical testing and advanced imaging to reliably identify an anatomic pain source for most LBP has stimulated considerable research focused on reliably identifying and validating clinical syndromes or subgroups based on clusters of clinical examination findings. If homogeneous syndromes are validated, this may enable more effective individualized care than a less specific approach towards all non-specific LBP.

One syndrome with perhaps more support than others is "directional preference." A directional preference is often identifiable in a patient's history and examination. Directional preference patients typically describe a history of episodic and intermittent LBP with a directional theme as to what positions, movements and activities commence or worsen their pain and what improves or stops their pain. A presumptive pain generator's directional preference is that single direction of repeated end-range spinal bending tests or static positioning that causes the pain to "centralize," abolish, or both. Pain "centralization" is a pattern of pain response whereby pain referred or radiating away from the spine retreats back toward or to the midline in response to a single direction of sustained or repeated end-range spinal testing. Midline-only LBP cannot centralize because it is already central but it often has a directional preference where a single direction of testing will eliminate that midline pain. After pain centralization or elimination, the pain typically remains improved until or unless the patient moves excessively in the opposite direction of that preferred. Avoidance of moving in a direction that aggravates the pain should be minimized or avoided during the early phase of treatment to speed recovery.

The unique purpose of these end-range tests, performed in weight-bearing and recumbency, is to load the spine in different bending directions. The most common lumbar directional preference is extension, yet smaller numbers of pain-generators benefit from other directions of loading: lateral, rotational or

flexion movements. Those with an extension directional preference typically worsen with lumbar flexion and improve with extension or simply restoring their lordosis.

This syndrome has been referred to as a "reducible derangement" or a "directional preference syndrome." Its two characteristic clinical findings (directional preference and pain centralization) are identified with strong interexaminer reliability (Kappa = 0.9, 0.823, 0.7, % agreement: 88 to 100%),(73-75) with training.(76)

The prevalence of this directional preference syndrome is reportedly high: 70-89% of acute(77-80) and 40 to 50% in chronic LBP.(81-84) It is commonly elicited in axial LBP, referred, as well as radicular pain.(85-87) There is also suggestive evidence of a concomitant psychosocial benefit by teaching and empowerment with the knowledge and skills to effectively self-treat.(88)

Medical History and Physical Examination . . . . . .

A focused and detailed medical history and physical examination are necessary to assess the patient's medical condition and specific low back disorder. This section will review the medical history including the questions that should be asked. This diagnostic approach also needs tailoring to the specific patient, particularly as factors such as the patient's age, past medical history, underlying medical conditions, significant injury history and genetic predilections all probablistically adjust the diagnostic approach by altering the probabilities for and against specific diagnoses. For example, increasing age is associated with far higher probabilities for degenerative conditions such as spondylolisthesis and is simultaneously associated with reduced ranges of motion in normal individuals that must be incorporated in the diagnostic approach.

It is also important to understand the context of the appearance of the patient in the clinic. Patients with back disorders generally initiate treatment due to pain, which is often attributed to an ostensible injury. However, one should not assume that complaints of acute pain are directly attributable to pathophysiology.(66) Pain is known to be associated with sensory, affective, cognitive, social, and other processes.(89-92) The pain sensory system itself is organized into two parts, often called first and second pain. A-delta nerve fibers conduct first pain via the neospinalthalamic tract to the somatosensory cortex, and provide information about pain location and quality. In contrast, unmyelinated C fibers conduct second pain via the paleospinalthalamic tract, and provide information about pain intensity. Second pain is more closely associated with emotion and memory neural systems than it is with sensory systems.(66, 89-101)

As a patient's condition transitions through the acute, subacute and chronic phases, the central nervous system is reorganized. The temporal summation of second pain produces a sensitization or "windup" of the spinal cord,(101) and the connections between the brain regions involved in pain perception, emotion, arousal, and judgment are changed by persistent pain.(96) These changes cause the CNS's "pain neuromatrix" to become sensitized to pain.(89-92) This CNS reorganization is also associated with changes in the volume of brain areas,(95) decreased gray matter in the prefrontal cortex,(95) and the brain appearing to age more rapidly.(94) As pain continues over time, the CNS remodels itself so that pain becomes less closely associated with sensation, and more closely associated with arousal, emotion, memory and beliefs.(97, 98) Because of these CNS processes, one should be aware that as the patient enters the subacute phase, it becomes increasingly important to consider the psychosocial context of the disorder being treated, including the patient's social circumstances, arousal level, emotional state, and beliefs about the disorder. However, behavioral complications and physiological changes associated with chronicity and central sensitization may also be present in the acute phase, and within hours of the initial injury.(100)

Medical History

Asking the patient open-ended questions, such as those listed below, allows gauging the need for further discussion or specific inquiries to obtain more detailed information.

1. What are your symptoms?
   - Do you have pain or stiffness?
   - Do you have numbness or tingling?
   - For traumatic injuries: Was the area deformed? Did you lose any blood or have an open wound?
   - Is the discomfort located primarily in your low back? In your leg?
   - Do you have pain or other symptoms elsewhere? (Patients who present with a primarily with lower extremity pain may well have radiculopathy from a lumbar disc herniation or other lumbar pathology. Hip pain may present as back pain and vice versa. Hip pathology may affect the back.)
   - Have you lost control of your bowel or bladder? Are you soiling your undergarments?
   - Do you have fever, night sweats, or weight loss?
   - When did your symptoms begin? Have you ever had symptoms like this before?
   - Are your symptoms constant or intermittent? What makes the problem worse or better?
   - What is the day pattern to your pain? Are you better first getting out of bed in the morning, during the morning, mid-day, evening, or while asleep? Worse as the day progresses? Do you have a problem sleeping? What position is most comfortable? Is there any pain with cough, sneezing, deep breathing, or laughing?
   - How long can you sit, stand, walk, and bend?
   - Can you lift? How much weight (use items such as gallons of milk, groceries, etc., as examples)?
2. How did your condition develop?

   Past:

   - Have you had similar episodes previously?
   - Have you had previous testing or treatment? With whom?

   Cause:

   - What do you think caused the problem?
   - How do you think it is related to work?
   - Did your symptoms begin gradually or suddenly? Did you notice the pain the day after the event?
   - Did you slip, trip, or fall?
   - Were you doing anything at the time your symptoms began? (It is important to obtain all information necessary to document the biomechanical forces of injury.)

   Job:

   - What are your specific job duties?
   - How long do you spend performing each duty on a daily basis?
   - Do you have assistance of other people or lifting devices?

   Off-work Activities:

   - What other activities (hobbies, workouts, sports) do you engage in? At home or elsewhere?
   - Any heavy lifting? How? How often?

- Any physically demanding activities requiring awkward postures, prolonged sitting or standing?

3. How do these symptoms limit you?
   - What activities of daily living are limited? Are there specific challenges in your home environment (e.g., steep steps)?
   - How long have your activities been limited? More than 4 weeks?
   - Have your symptoms changed? How?
4. Do you have other medical problems?
5. What are your expectations regarding your return to work and disability from this health problem?
6. What are your concerns about the potential for further injury to your low back as you recover?
7. What is your job? What do you do on the job? How do you like your job? Your supervisor and coworkers? What is your relationship with your co-workers and supervisor and how do they treat you?
8. What do you hope to accomplish during this visit?

Determining whether or not there is lumbosacral nerve root compromise (and if so, the level of compromise) is important. Symptoms correlating with specific myotomal levels of compression and possible motor weakness are shown in Table 3.

Table 3. Symptoms of Lumbar Nerve Root Compromise

Root Level	Pain or Paresthesia	Motor Weakness
L1	Back, radiating to upper anterior thigh and groin	Hip flexion
L2	Back, radiating to anterior mid-thigh	Hip flexion and adduction, knee extension
L3	Back, radiating to anterior thigh and inner knee	Hip flexion and adduction, knee extension
L4	Back, radiating to lateral thigh, front and medial leg, and medial foot	Hip adduction, knee extension, foot inversion, foot dorsiflexion
L5	Back, radiating to lateral leg and dorsal foot (especially first web space)	Hip abduction, foot and great toe extension. Resisted extensor hallucis longus is considered the best of these as it is an L5 function.
S1	Back, radiating to back of thigh and lateral leg and foot	Knee flexion, plantar flexion. Plantar flexion is the best of these as it is purely an S1 function. It may be tested with repeated toe raises, particularly when there is a suspicion of radiculopathy, but weakness is not obvious on manual testing.

Physical Examination

The objective of the physical examination of the lumbosacral spine is to demonstrate those physical abnormalities that sort out the possible disease entities causing pain that were elicited during the medical history. Abnormalities of the lumbosacral spine may be discovered while the spine is static or during motion. Unless the tests are done in an orderly fashion, important observations may be missed. Therefore, it is helpful to evaluate the patient in a series of positions that test the function of musculoskeletal and neurologic structures of the lumbosacral spine.

The examination begins as soon as the provider introduces him or herself to the patient. The overall initial impression is a critical metric of functional status. Then, vital signs, such as an elevated temperature, may suggest the presence of an infection or neoplasm. Tachycardia may be a sympathetic nervous system response to the patient's pain or it may be anxiety related. For those undergoing more advanced testing for chronic pain, tachycardia may be relevant as indicating potential psychological disturbance, and illicit medication use. Physical examination tests show poor diagnostic performance when used to identify lumbar disc herniation.(102) It is estimated that 99% of patients

with serious spinal pathology can be examined with a history and physical examination focusing on the L4, L5 and S1 nerve root distributions.(103)

There are three primary distributions for back pain:

1. Those localized to the back musculoskeletal system (e.g., most commonly LBP of unknown anatomic cause or muscles, tendons, ligaments, or nerves).
2. Those referred to the back (e.g., from internal organs such as kidney, uterus, or abdominal aneurysm).
3. Those referred to the extremities in a dermatomal or myotomal distribution and likely include neurogenic involvement.

Guided by the medical history, the physical examination includes:

- General observation, including changes in positions, stance,
- Gait while walking an extended distance, typically in the hallway, and changes in gait with distance walked,
- Regional examination of the spine,
- Examination of organ systems related to appropriate differential diagnosis,
- Neurologic screening,
- Testing for lumbosacral nerve root tension, and
- Monitoring pain behavior during range of motion and while seated as a clue to the problem's origin.

The completely objective parts of the low back examination are circumferential measurements for atrophy or findings of fasciculations. All other findings require the patient's cooperation, although reflexes are generally much more objective than subjective.

A. OBSERVATION AND REGIONAL BACK EXAMINATION

The most important aspect of the examination is observation. This includes observing changes in position, stance, and gait. The examiner should ask the patient to walk down the hallway so there is sufficient distance over which to observe the gait as well as changes in the gait over some duration. In the process, the ease with which the patient stands should be carefully observed. The patient should be observed over at least 20 feet of ambulation. The examiner should observe whether the back is kept in a maintained flexed posture, erect, stiff, or if the lumbosacral spine is moved in the process. Gait fluidity should be carefully observed. How the patient turns around to return to the examination room is also of interest. Back pain usually decreases the mobility of the lumbar spine and produces restriction of normal spinal movement. The back is stiff, as if frozen in one position. Patients with LBP generally walk in a stiff, guarded fashion depending mainly on hip movement and lateral spine flexion rather than using a normal gait involving a more complete range of active spinal movements. This observation may provide some objectivity to the severity of the patient's problems and also provide a rapid assessment of subsequent progress. Thus, observation of gait is generally the most helpful aspect of the LBP physical examination.

The disrobed, but modestly covered, patient is examined standing. The spine is viewed from behind, laterally, and anteriorly for alignment. The levels of the shoulders and any lateral spinal curves (scoliosis), if present, should be noted. The patient should be positioned with his or her head centered over the feet and eyes level. It is wise to also have the shoulders and knees level so any discrepancy will not be due to a weight shift. Therefore, any deviation of the spine from the vertical is compensated by an opposite deviation elsewhere in the spine. The spine is compensated if the first thoracic vertebra is centered over the sacrum. Then, the posterior superior iliac spines, which should be of equal height,

should be viewed. The gluteal folds and knee joints should be at an equal height. In the absence of foot or ankle deformity, the feet should be in normal alignment. The patient with lumbar muscle spasm on forward flexion may demonstrate a list to one side – a compensatory scoliosis, with loss of normal spinal contours. Movement of the sacroiliac joint may be examined with the patient standing. The examiner places one thumb on the posterior superior iliac spine and the other on the sacral spine. The patient flexes the ipsilateral hip. Normally, the iliac spine moves downward. Upward motion is indicative of a fixed sacroiliac joint.

The patient should be positioned anteriorly – head straight with shoulders level. The highest points on the flanks or iliac wings should be of equal height. There should be no or very little tilt to the pelvis. Anatomic structures in the lower extremities (patellae, malleoli) should be of approximately equal height and aligned appropriately, although minor leg length discrepancy with typically slightly longer left legs has been reported.(104) The patient should squat in place. This maneuver tests general muscle strength and the integrity of function of the joints from the hips to the feet in the lower extremity. With the patient in the standing position, the range of motion of the lumbosacral spine in forward flexion, extension, lateral bending (side flexion), and rotation is observed. The normal range of motion (ROM) is 40 to 60° for forward flexion, 25° for extension, 15 to 25° for lateral bending, and 3 to 18° for rotation. Inquiries regarding which of these positions produced pain, if any, are also of interest and are used therapeutically.

Spinal motion is important in terms of symmetry and rhythm. The absolute range of motion is not of major diagnostic significance because of wide individual variance. The statement is frequently made that the patient bends forward and reaches to within 6 inches of the floor or 12 inches of the floor or places his or her palms to the floor. The important part of the observation of the patient as he or she bends toward the floor is the quality of spinal flexion in terms of the smooth reversal of the normal lumbar lordosis as the spine flexes forward. This is termed lumbosacral rhythm, and when abnormal (patient keeps his or her lumbar lordosis and bends from the hips) it is theorized to signify local back disease. Although limitation of spine flexion is of limited diagnostic value, the improvement of spine flexion is a means to monitor response to therapy of an individual patient.

Forward flexion of the spine is a segmental motion, with bending occurring at each functional unit (a functional unit comprising two adjacent vertebrae along with their interposed disc). These units also contain the ligaments, nerves, and facet joints of the two adjacent vertebrae. The most movement occurs at the lumbosacral L5 to S1 and L4 to L5 levels. As a result, most of the damage and most symptoms relate to these two functional units. In forward bending, each unit flexes about 8 to 10°. This means that the entire lumbar spine has only 45° of excursion, and as a patient reaches to touch the ground the rest of the motion comes from the pelvis rotating through the hip joints.

When a patient with an injury to one of the functional units attempts to bend forward, his or her flexion may be inhibited by protective muscle spasm. The lumbar spine may not have the normal curve in the erect position nor is there any reversal of the sway of the back on attempting to bend forward. As the patient attempts to touch the floor, almost all of the motion occurs at the hip joints.

Although this inability to flex the lumbar spine can be due to injury, it also may be voluntary if the patient is either afraid or does not wish to bend forward. Consequently, this restriction is not necessarily indicative of an injury. Flexion from an upright position should be compared with similar movement while the patient is distracted. If the patient lies on his or her abdomen with a pillow under the ankles and the head and shoulders resting on the bed, this removes the hamstring tension and the back is not being extended. Therefore, palpation of the back in the absence of spasm reveals a relaxed or flaccid muscle.

Flexion is relative and its limitation may be an indication of poor conditioning. The patient's perceived stiffness may actually represent little loss of flexibility in respect to a pre-injury state. If the protective spasm is unilateral owing to injury of the tissues on one side of the spine, a compensatory scoliosis develops. The spine is tilted to one side because of one-sided muscle spasm. It frequently will increase with forward flexion. Disc herniation can also cause a scoliosis by irritating nerves on one side of the spine.

Measurement of the distance from the floor to the patient's fingertips is an inexact measurement of lumbar flexion. However, the measurement is a useful way to follow the response of patients to therapy. Improvement in forward flexion will be manifested as a decrease in finger-to-floor distance whether the improvement is from decreased muscle spasm, increased hip motion, or decreased hamstring tightness.

After the patient has fully flexed, it is helpful to observe how an erect posture is regained. How this maneuver is performed reflects past habits as well as the constraints of any tissue injury. Patients with back pain tend to resume the erect position with a fixed lordosis and without any spine movement. The pelvis with the help of knee and hip flexion does it all. The ability to bend sideways in lateral flexion often has no major diagnostic significance. However, pain that increases with flexion to the ipsilateral side may be related to an articular disease or a disc protrusion lateral to the nerve root. If pain is increased with flexion to the contralateral side, the lesion may be articular, muscular (muscles are stretched), or a disc protrusion medial to the nerve root.

Hyperextension can cause pain by changing several anatomic relationships. Arching the back and increasing the lordosis forces the facet joints together, narrows the foramen through which the nerves exit the spine, and compresses the disc posteriorly. A combination of these three factors can create pressure on the nerves as they leave the spine and cause back pain, leg pain, or both. Rotation may be examined in the standing position, but care must be given to stabilize the pelvis to eliminate accessory motion of the hips. Rotation may be examined more accurately in the seated position. Hips and pelvis are stabilized with seating, limiting rotating motion of the spine.

The strength and stamina of the back and leg muscles can be tested by repeated active movement, especially flexion and extension of the lumbosacral spine. The patient should perform 10 toe raises on both feet and 10 more on each foot separately. Repeat testing causes fatigue which accentuates differences in strength in the lower extremities. The strength of the examiner's arms may be less than that of the patient's legs. By using the patient's own weight, instead of the examiner's strength, differences of strength between the legs are discovered. The patient may also be asked to walk on the heels to test for strength of the dorsiflexors of the foot. These muscles are also tested with the patient in the seated position.

The examiner should palpate the lumbosacral spine when the patient is both standing and sitting, and during testing of motions. It is helpful to palpate both groups of paraspinous muscles simultaneously to discern differences of firmness or tenderness in the muscle bodies. Muscles become more prominent as they contract with spasm. Observation may demonstrate this muscle prominence on one side of the midline of the spine. Localized areas of muscle tenderness, which may be a reflection of a trigger point for referred pain to other areas of the lumbosacral spine, should be identified. Unfortunately, even slight asymmetric stances will tend to produce relatively large differences in muscle texture and an appearance of asymmetric spasm even if such is not present, thus careful attention to position is important.

In addition to the soft tissue, bony structures should be palpated. The spinous processes are covered by ligamentous structures, not muscle, and are easily palpated. Localized tenderness suggests the presence of an isolated process, such as an infection, tumor, or fracture affecting that vertebral body. Localized tenderness over multiple spinous processes is also considered a sign of amplification.

Palpation of the lumbar spine should include the midline, paraspinous areas and out laterally. Palpation in the sciatic notch and along the sciatic nerve should also be performed. The levels of tenderness should be recorded and the presence or absence of widespread tenderness noted. The latter includes those who have tenderness that is present beyond the immediate paraspinous area of a few vertebral segments.

The patient should be examined in the seated position with feet on the floor. The strength of the dorsiflexors of the foot may be measured by the examiner maintaining steady downward pressure on the dorsum of the foot. The patient generates uniform resistance to pressure that is overcome in a smooth fashion. Patients may demonstrate give-way weakness, which is manifested by either resisted pressure for a few seconds and then suddenly release the muscle or demonstrate a stepwise release of the muscle resulting in a cogwheel effect. Causes of give-way weakness frequently include submaximal efforts, but can be due to other causes including pain, misunderstanding of directions, and attempting to help the examiner. The probability of feigning rises if the directions are repeated and give-way weakness remains. Testing ankle dorsiflexion bilaterally and simultaneously may help identify a mechanism for observed give-way weakness.

The patient should also be asked to bend forward over the examining table, allowing his or her weight to rest on the abdomen. This position flattens the lumbar lordosis and tilts the sacrum, allowing examination of the inferior portion of the sacroiliac joint, ischial tuberosities, and sciatic notch. Palpation over these anatomic structures may elicit pain. Patients with inflammatory processes of the sacroiliac joints (ankylosing spondylitis) are among those who experience increased pain with percussion over the sacroiliac joints.

Assessment of the neurologic status of the patient is important in the overall back evaluation. The history is the most critical feature and guides the degree to which the neurological testing must be performed. A positive neurologic finding will give objectivity to the patient's symptoms. Most of the neurological examination is performed with the patient seated with the legs dangling. Each nerve root must be examined. Abnormalities of motor, sensory, and reflex function are tested. It is worthwhile to review the anatomy of the nerve roots in order to better understand abnormalities discovered during the neurologic examination.

Each nerve root as it leaves the spinal canal through the neural foramen is enclosed within a sleeve that contains spinal fluid and small blood vessels about and within the nerve. This sac, referred to as the dural sleeve, provides nourishment to a particular nerve root. Any compression and/or traction on the dura will compress its contents and encroach upon the nerve and its blood supply. Secondary to compression, pain is produced along the course of the peripheral nerve and is accompanied by dysesthesias, motor weakness, and decreased reflex function associated with the affected nerve root. The goal of many of the maneuvers done during this phase of the examination is to increase nerve compression to uncover neurologic dysfunction. Of the possible neurologic abnormalities, true muscle weakness is the most reliable indicator of persistent nerve compression with loss of nerve conduction. Sensory changes are subjective, take significant time to document, and require the full cooperation and attention of the patient, but in certain circumstances may be helpful (e.g., lack of expected improvement with efficacious treatments, diagnostic uncertainty). Reflex changes may be lost in a previous episode of nerve root compression. Reflexes may not return even with recovery of sensory

and motor function. With age, reflexes diminish and are more difficult to elicit even without any prior history of nerve compression. However, the loss of reflexes is symmetric. Patients who lose reflexes in both lower extremities on the basis of compression may have spinal stenosis or a large central herniation of a disc.

In addition to nerve root lesions, upper motor neuron and peripheral nerve disease cause abnormalities that may be discovered during the neurologic examination. With upper motor neuron lesions, the fine control of muscles is lost while the trophic effects of the peripheral nerves remain intact. Muscle strength is diminished, but in a different pattern from lower motor neuron weakness. Patients develop spasticity of muscles (tonic contractions) and hyperreflexia. Patients also develop a positive Babinski reflex (extension of the large toe and spreading of the other toes with stroking of the sole of the foot). Ankle clonus, an involuntary rhythmic plantar flexion contraction/relaxation induced after rapid dorsiflexion of the ankle, may also suggest upper motor neuron compression. Peripheral nerve injuries may cause sensory and/or motor abnormalities, depending on the damaged nerve. Peripheral nerves receive nerve fibers from a number of nerve root levels.

Lying supine on the examining table is an excellent position for testing the status of the nerve roots and peripheral nerves. The classic test of sciatic nerve (L4, L5, S1) irritation is the straight leg raising test, the purpose of which is to stretch the dura. The more useful straight leg raising test is done by raising the leg with the knee extended. When the sciatic nerve is stretched and its nerve roots and corresponding dural attachments are inflamed, the patient will experience pain along its anatomic course to the lower leg, ankle, and foot. Symptoms should not be produced in the lower leg until the leg is raised to 30 to 35°. Until that elevation, there is no relevant movement of the nerve within the dura. Between 50 and 60 to 70° tension is applied to the dura and nerve roots. The rate of deformation of the roots diminishes as the angle increases. Symptoms produced at elevations above 70° are thought to more likely represent joint or muscle-related pain.

The patient with a positive straight leg raising test (Lasègue sign) will have pain that radiates from the posterior thigh to the lower leg (below the knee). To confirm the presence of nerve irritability, the raised leg should be lowered until the pain is relieved. At that position, the foot is dorsiflexed, which will cause a recurrence of pain as a result of stretching of the posterior tibial branch of the sciatic nerve. Pain with dorsiflexion of the foot with hip flexion is commonly referred to as Bragard's test. It is critical that the straight leg raising tests be noted as positive only with replication of true radicular symptoms. Mere LBP from these signs is not indicative of neurological compromise and is frequently incorrectly recorded in clinical practices. Due to the frequency of these errors, it is best to note that the positive test produced radicular pain to, for example, the calf.

A bilateral straight leg raising test may also detect sciatic nerve irritation. The test is performed in the supine position by raising both legs by the ankles with knees extended. Raising both legs simultaneously tilts the pelvis upward, diminishing some of the tethering of the sciatic nerve. Therefore, the legs may be raised to a greater angle before radicular pain appears. Pain that occurs before 70° of motion is caused by stress on the sacroiliac joints. Above 70° of motion, pain is related to a lesion in the lumbar spine. When the examination reveals a psychogenic cause of pain, a bilateral straight leg raising test is routinely painful at a lower elevation than a unilateral test.

Observing the patient's stance and gait is useful to guide the regional low back examination. Incoordination or abnormal use of the extremities may suggest the need for specific neurologic testing. Severe guarding of low-back motion in all planes may add credence to a suspected diagnosis of spinal or intrathecal infection, tumor, or fracture. However, because of the marked variation among patients with symptoms and those without, range-of-motion measurements of the low back are of limited value.

Vertebral point tenderness to palpation over spinous process(es), when associated with other signs or symptoms, is suggestive but not specific for spinal fracture or infection. Palpable soft-tissue tenderness by itself is an even less specific and less reliable finding. Waddell's signs are useful for assessing symptoms.(105)

B. NEUROLOGIC SCREENING

The neurologic examination focuses on a few tests that reveal evidence of nerve root impairment, peripheral neuropathy, or spinal cord dysfunction. Most symptomatic herniated discs in the lumbar spine involve the L5 nerve root (exiting between the L4 and L5 vertebral bodies) or the S1 nerve root (exiting between the L5 vertebral body and the sacrum (regarding S1)). The clinical features of lumbosacral nerve root compression are summarized in Table 4.

1. Testing for Muscle Strength

There are no specific muscle tests for the L1 to L3 nerve roots. The iliopsoas, the main flexor of the hip, is innervated by L1, L2, and L3, and is tested by asking the patient to flex the hip against resistance. The L4 nerve root can best be tested by evaluating the strength of ankle inversion and the strength of the quadriceps (knee extension against resistance). However, the quadriceps are also innervated by L2 and L3. The L5 nerve root when compromised may cause weakness of the great toe extensor on the affected side. In severe cases, the ankle dorsiflexors also may be weak and if so, the patient will have foot drop during gait. The S1 root generally supplies the plantar flexors of the foot and ankle, but motor weakness in the foot is harder to detect due to the bulk and normal strength of these muscles (gastrocnemius, soleus). The recommended test to detect S1 root compromise is repeated toe raises, generally a set of 10 on each side. Hamstring weakness may also be detected by this test.

Table 4. Physical Examination Correlates of Lumbosacral Nerve Root Dysfunction

Root Level	Sensory Deficit	Motor Weakness	Reflex
L1	Upper anterior thigh below inguinal ligament to groin	Hip flexion – Iliopsoas	**Cremaster**
L2	Anterior mid-thigh – Level of L2-3 posterior	Hip flexion and adduction; occasional knee extension	**Cremaster**
L3	Lower anterior thigh and inner knee	Hip flexion and adduction; knee extension	Knee jerk*
L4	Back, radiating to lateral thigh and front and medial leg	Hip adduction; knee extension; foot dorsiflexion	Knee jerk*
L5	Back, radiating to lateral leg and dorsal and lateral foot	Foot and great toe extension; hip abduction	Medial hamstring
S1	Back, radiating to back of thigh and lateral leg and foot	Knee flexion; plantar flexion	Ankle jerk

*****Note: patellar reflex diminishment is somewhat difficult to detect as the quadriceps are innervated by 3 nerve roots, thus detecting an asymmetric reflex is generally not present unless marked compromise of L4 or multiple nerve root involvement is present.

2. Circumferential Measurements

Muscle atrophy can be detected by bilateral circumferential measurements of the leg and thigh. This should be performed and recorded with specificity, e.g., with a tape measure and at identical levels of the leg and thigh such as 15cm below the inferior poles of the patellae in a seated position). Differences of less than 2 centimeters in measurement of the two limbs at the same level can be a normal variation, especially if the lesser measurement is on the non-dominant side. Symmetric muscle bulk and strength are expected unless the patient has a relatively long-standing neurologic impairment or disorder of the lower extremity muscle or joint.

3. Reflexes

Loss of or decrease in the ankle jerk reflex compared to the other side suggests interruption of the reflex arc, as may be found in S1 nerve root compromise such as L5-S1 disc herniation. For the other nerve root level commonly involved, L5 (L4-L5 disc), there is no reflex change except for the medial

hamstring reflex or the posterior tibial tendon reflex, which is difficult to elicit. Patellar reflexes are rarely abnormal in radiculopathy patients due to the multiple myotomal innervations of the quadriceps. When abnormal, consider the L4 nerve root (L3-L4 disc).

4. Sensory Examination

Sensory examination for nerve root compromise in the low back includes pinprick and light-touch testing. In general, the dorsal foot (especially the first web space), ankle, and leg areas are correlated with the L5 root, and the lateral foot is correlated with the S1 root. It is important to remember the subjective nature of sensory testing and the influence that past examinations may have on a patient with a history of back problems. Light pinprick should not elicit a painful response. If it does, ask the patient if this replicates his or her typical LBP and if the pain is superficial or deep. If the pain *is* typical, or if it is described as deep, this suggests a non-organic basis for the pain.

5. Physical Examination Tests

To be most successful, the treatment of LBP must be based upon a correct diagnosis. For a variety of reasons, a patient's response on any single test may not be reflective of the presence of identifiable underlying pathology. When ambiguity or inconsistency in test results prompts a concern regarding the correct diagnosis or the appropriate treatment approach, corroborative testing may be recommended. A number of tests are employed to distinguish between physiologic and nonphysiologic responses. These are commonly called "Waddell signs,"(105) and were originally described in the chronic LBP patient. These signs have subsequently been expanded as relevant to the evaluation of acute LBP patients.(106, 107)

Waddell recognized five categories of physical examination findings that suggest major psychosocial factors are present in addition to whatever residual physical injury or illness may still be present. These signs are not thought to usually represent malingering or other conscious manipulation to deceive.(108) Patients with signs in two of the categories may require consideration of the role of psychosocial factors in their presentations, and those with signs in three or four of the categories should receive increased scrutiny. However, there is literature suggesting that just one sign portends a worse prognosis in acute LBP patients.(106, 109) Waddell's categories are tenderness, simulation, distraction, regional, and pain behaviors:

- *Tenderness* is considered positive for non-organic signs when there is widespread, superficial, non-anatomic discomfort generally found more than 2cm lateral to the spine.
- *Simulation* is assessed by two tests – axial loading and rotation simulation. **Axial loading** can be performed while the patient stands by the examiner who pushes down with a few pounds of force on the patient's superior scalp. This places no significant stress on the lumbar spine and should not change the patient's pain. If the patient reports that this gentle pressure increases the back pain intensity, or causes the pain to radiate to additional places, this is a non-organic finding. A modification is to have the patient put his or her own hands on the superior scalp and apply the downward or axial force. This modification would prevent the patient from attempting the illogical claim that he or she was injured by the physical examination, although it would be predicted to be less sensitive. The other test is **rotation simulation**. While the patient is standing, the examiner holds the patient's wrists so that the wrists and forearms remain in contact with the patient's thighs. In this position, the examiner rotates the whole person (no significant spinal motion occurs) while asking if the pain changes. The non-organic pain response is when the patient perceives the twisting of the back as intensifying the existing pain or causing the pain to radiate to a new place.
- *Distraction* is assessed by the straight leg raising test performed in two different positions. The straight leg raising test is meant to detect irritation of the lumbar nerve roots by mechanically

pulling on the sciatic nerve, and thus the root, as it goes around the posterior hip. Straight-leg raising should be tested in both the seated position (when the patient is unaware of the relevance to the back) and the supine position (when the patient is aware of this testing). When the patient is sitting, he or she should extend and flex the knee while being asked if there is any knee pain. The knee should then be left fully extended and the patient asked if passive toe motion changes the back or leg pain. If a true radicular component is present, the patient should not easily tolerate full extension of the knee with dorsiflexion of the ankle in the sitting position – the typical response of a true positive straight leg raise test would be instead for the patient to lean back and complain of radiating pain. If there is no such response in the seated position, but there is a positive lying straight leg raise with at least a 40° difference between the seated and recumbent straight leg raising tests, a non-organic basis for the pain is suggested. This is one of the non-organic signs. These tests are subjective and can be confusing if the patient is simply having generalized pain that is increased by raising the leg. Results of the test may be influenced by repeated examinations in patients with a recurrent history of back problems (a learned fear that since leg raising has hurt in past exam, the current exam will also be painful). A negative test is generally a good prognostic sign. A positive test for lumbar nerve root irritation generally produces pain that radiates below the knee and that follows a precise radicular distribution consistent with the nerve root involved. Crossed straight-leg raises are the most highly specific test of sciatic nerve tension.

- *Regional* includes assessment of non-physiologic weakness and sensory deficits. Non-organic weakness is typically widespread involving more than one myotome and not fitting with imaging/electrodiagnostic findings. True neurologic weakness still permits constant sustained muscle contractions, while non-organic weakness is typically a sudden "give way" pattern or a "cog-wheel" pattern.
- *Pain behaviors* is a fifth category. There are concerns that this category is potentially affected by observer bias and patient culture. However, there is literature to support some pain behaviors as reliable signs that psychosocial issues are distorting the patient presentation(110, 111) and do not necessarily imply malingering.(112-114)

C. Early Disability Prevention and Management Issues

As an example of the biopsychosocial model, initial patient management should include alertness to the presence or development of physical and psychosocial factors that can be barriers to recovery and, if not addressed, are thought to increase the probability of the development of delayed recovery or chronic pain.(115-120) Initial "yellow" flags drawing attention to these potential issues include excessive verbal attention to symptoms or physical features, inquiries about permanent impairments during an initial presentation, prior history of disability or impairment, family members with acquired disabilities, a history of mental health disorders, histories of substance abuse, an apparent overreaction on examination, and presence of other non-organic physical examination signs. Besides the issues noted above, some additional yellow flags include early signs of medication dependence, disproportionate inactivity, fear avoidance, compliance/attendance problems, resistance to transitional work options, and provider shopping. See also the Cornerstones of Disability Prevention and Management guideline.

Management of the patient at this stage of treatment necessitates overcoming these identified barriers in order to facilitate functional recovery and patient autonomy. Avoidance of therapies that are not resulting in functional recovery or that foster treatment dependence should be terminated. In contrast to the "watch and wait" philosophy, it is increasingly recognized that better outcomes are associated with maintaining work status or early return to work and avoiding or resolving disability at the earliest possible time. These concepts recognize that chronicity of disability is the overriding barrier to ultimate benefit for the

injured worker. For example, the provider should consider early discontinuation of ineffective treatment and avoidance of interventional procedures of questionable significant functional benefit. For more difficult cases, referral for psychosocial evaluation and/or single-or-interdisciplinary treatment options with a proven record of success may be needed. For providers familiar with these management concepts, early referral (including after the first visit) to a provider well versed in the conservative management of LBP is recommended upon the discovery of these signs.

INDICATIONS FOR FURTHER WORKUP

Physical examination evidence of severe neurologic compromise that correlates with the medical history and test results may suggest a need for immediate evaluation and/or referral for definitive treatment. The examination may further reinforce or reduce suspicions of tumor, infection, fracture, or dislocation. A history of tumor, infection, abdominal aneurysm, or other related serious conditions, together with positive findings on examination, warrants further investigation or referral. A medical history that suggests pathology originating somewhere other than in the lumbosacral area may warrant examination of the knee, hip, abdomen, pelvis, or other areas.

ASSOCIATED FACTORS, RISK FACTORS AND WORK-RELATEDNESS

Most acute LBP is best modeled as a relatively sudden onset of pain in the context of a multifactorial disorder other than specific acute significant trauma (substantial slip, trip, or fall). The minority who sustained a significant traumatic event have workers' compensation claims that are largely non-controversial. As a method for determination of work-relatedness is already discussed detail in the Guideline on Work-Relatedness, this guideline will only briefly review back-specific issues.

Most patients either do not recall a specific event or recall an apparently trivial event even when job tasks are highly physical. Regardless of whether there was an obvious inciting event or not, the documentation of any initial event(s) along with the patient's job tasks is required and highly helpful for the patient's claim under most workers' compensation jurisdictional requirements. However, a prospective study addressing whether minor trauma causes significant permanent back pain showed that minor trauma is rarely the cause of serious low back illness, and when minor trauma and serious back pain are associated, it is when the back pain episode is potentially compensable.(121-123)

Recurrence of LBP is not uncommon and recurrences require adequate documentation of the inciting events if any. Physicians should distinguish between a temporary exacerbation of symptoms and a permanent aggravation of a back condition. Jurisdictions differ in defining permanent aggravations.(1) If an underlying, pre-existing condition is thought to be significantly aggravated or "flares up" in a worker at work, the purported aggravating event(s), prior medical course, prior extent of pain, and activity limitations should be recorded. At subsequent follow-up appointments, the extent of pain and activity limitation after the aggravation should be tracked. Restoration to the prior activity level is the goal. When that level has been reached, in many jurisdictions the effects of the aggravation or exacerbation are said to have ceased, and a permanent aggravation has not occurred. At that point, "cure" of the aggravation has been accomplished. This also requires that the treating physician have an understanding of both the true risk factors for back pain and as well as the work the patient performs to adequately capture and evaluate this information. Specific descriptions of work-duty activities, weights, sizes, and the frequencies of objects lifted are all helpful. Although frequently too generic for usability, it is recommended that a job description be nevertheless obtained from employer, if possible, to attempt to assist the practitioner with understanding the patient's job demands and duties.

Associated Factors and Risk Factors for Non-specific Low Back Pain

There are many non-occupational factors that have been associated with LBP. The most consistent and strongest is a prior history of LBP, which is one of the factors also confirmed in prospective studies.(124-136) Aging has been associated with LBP in some studies,(137-140) but many do not support a relationship with non-specific LBP in contrast with degenerative spine conditions. Instead, aging has been consistently associated with degenerative back disorders.(12, 24, 141, 142) Additional reported risk factors for LBP include: smoking,(133, 138, 143-145) obesity(127, 133, 134, 137, 138, 140, 143-162) height,(161) high triglycerides,(163) hypertension,(145) genetic factors,(54, 142, 164, 165) poor general health,(115, 166) poor sleep,(133, 143, 167) pain-related fear,(115, 135) prolonged driving,(133) deconditioning,(168) and physical inactivity or lack of exercise.(133, 143, 145, 169) A pattern of increased risk associated with cardiovascular risk factors and cardiovascular risk factor scores has been observed.(145) A U-shaped relationship between physical activity and risk of LBP has been reported in two epidemiological studies.(170, 171)

A number of physical factors are reported to be associated with LBP, although most of the evidence is from retrospective studies without measured job factors. Yet, recent data from a prospective cohort study with measured job physical factors have supported high lifting forces, as measured by the Cumulative Lifting Index, as associated with increased risk of LBP.(125, 126, 129) Cross sectional studies have reported mostly unconfirmed associations between LBP and heavy physical work (particularly heavy awkward of heavy lifting),(132, 133, 138, 143, 149, 166, 172-179) lifting weights above shoulder level,(177) carrying,(140, 178) trunk in a bent or twisted posture,(135, 140, 143) prolonged or highly repeated bending, inability to change posture regularly,(135, 180) standing and walking,(181) frequent reaching, or forceful pushing or pulling,(177, 182) kneeling(177) or squatting.(177) Housework was shown to be a risk factor in a prospective cohort study.(125, 129) Prolonged sitting and whole body vibration(141, 143, 183-185) are also suggested by some to be contributors. Work with scaffolding is a reported association.(166) These activities are not exclusive to job functions and should be reviewed as they pertain to non-occupational activities as well. Unaccustomed physically-demanding work (or sports or hobbies), another probable risk factor, is under recognized and may be fairly potent.

Until recently, prospective data supporting work-relatedness of LBP were limited. Recent data suggest increased risk of LBP as assessed by the Cumulative Lifting Index that was derived from the Revised National Institute for Occupational Safety and Health (NIOSH) Lifting Equation.(125, 126, 129, 186) Yet, support for degenerative disorders remains unsubstantiated.

Reduced lifting programs have been found to be successful at reducing risk of LBP in settings of manual patient transfers,(187-192) but not in most other settings. Programs have been ineffective for stress management, shoe inserts, insoles, back supports.(193) Lifting advice and training also do not appear effective.(194)

It has also been theorized that these "stressors" do not cause back disorders. Rather, when a back disorder arises in an individual who does heavy physical work, the work is then more difficult to accomplish and the individual is more likely to file a workers' compensation claim. This is compared to the sedentary worker who develops back pain and may continue to perform work though more carefully (reporting bias).(195, 196)

Psychosocial factors, both occupational and non-occupational, also have been reportedly associated with back disorders.(197) These include task enjoyment, monotony,(177) mental stress,(143, 177) work stress,(138) job dissatisfaction,(125, 198) life dissatisfaction,(143) high demand/low control,(166, 167) low supervisor support,(167) low co-worker support,(167) and social isolation.(133) Psychiatric

symptoms such as anxiety, depression,(125, 129, 132, 199) low energy,(133) emotional problems,(133) and somatization all are apparent risk factors. Providers with high fear avoidant beliefs also may contribute by prescribing more sick leave, bed rest, and less return to normal function.(200, 201) Many cases of LBP in the general population are idiopathic and the mechanism of LBP has not yet been elucidated.

Associations with Degenerative Spine Conditions including Sciatica

There are no quality studies of degenerative spine conditions including radiculopathy, and thus no true job physical risk factors are known. There is a poor correlation between LBP and degenerative findings on imaging studies,(12) as well as between LBP and MRI findings of disc protrusion, nerve root displacement or compression, disc degeneration, and high intensity zone.(59) The prevalence of nerve root contact is 11 to 23% and for displacement and/or compression 2 to 5%. Overall prevalence of disc degeneration in asymptomatic people is 54%, with a strong relationship with age.(59) Prevalence of HIZ or anular tear overall is 28 to 56%.(202)

Risk factors for degenerative back conditions that include spinal stenosis are not well defined compared with those for non-specific LBP. Nutrient vessels disappear to the disc, requiring diffusion.(203) This may provide a mechanistic explanation for cardiovascular disease risk factor impacts, particularly on degenerative spine disorders.(145) Degenerative disc changes have been well linked with inheritance,(54, 142, 164, 165, 204-207) and genetic influences on the outcomes of spine surgery have also been reported.(208, 209) Available epidemiological studies suggest the risk factors for degenerative conditions include aging,(12, 24, 141) male gender,(24, 210-212) obesity,(24) heredity,(12) and systemic arthrosis.(213) Reported risks for spondylolysis include increasing age and male gender.(24) Risks for degenerative spondylolisthesis include age and female gender.(24) Risks for facet joint arthritis are increasing age and obesity.(24) A trend towards greater spinal stenosis in those with a BMI >30 has been reported,(24) but that study is likely underpowered. There are no quality ergonomic-epidemiological studies reported for degenerative spine conditions and job physical factors.

There are no proven risk factors for radiculopathy as it is a relatively rare event and quality epidemiological studies have not been reported. However, heavy lifting and activities that substantially increase the intradiscal pressures are theorized factors. Prolonged whole-body vibration such as prolonged driving is a reported, but disputed factor.(183) Aside from age, smoking appears to be a factor. Spondylolisthesis is most often degenerative in nature. There are acute trauma-related cases in which causal analysis is straight forward and centers on whether the inciting trauma was in the context of work and that the magnitude of the event was sufficient to truly be an acute traumatic event.

There are no quality epidemiological studies that support the theory that degenerative spondylolisthesis, spinal stenosis, degenerative facet disease, or sciatica/radiculopathy are occupational conditions. However, there is a biomechanical theory that physical factors may contribute through degenerative disease in the discs with resulting theoretically altered biomechanical forces in the facets resulting in or accelerating degenerative facet osteoarthrosis. Yet, there also is evidence that these conditions may have a genetic basis.(214, 215)

Follow-up Visits

It is recommended that patients with potentially work-related low back disorders should follow-up every 3 to 5 days with a health care provider who can offer subsequent assessments and counseling regarding advancing activity levels, avoiding static positions or inactivity, medication use, anticipated favorable prognosis, and other concerns [**Recommended Insufficient Evidence (I)**]. Interactive sessions may assist involving the patient fully in his or her recovery. If the patient has returned to

work, these interactions may be conducted on site or by telephone to avoid interfering with work activities. Subsequent follow-up can occur when there is need for: 1) altered treatment; 2) release to modified, increased, or full duty; or 3) after appreciable healing or recovery can be expected. Typically, this will be no later than 1 week into the acute pain period. At the other extreme, in the stable chronic LBP setting, follow-up may be infrequent, such as every 6 months.

Special Studies and Diagnostic and Treatment Considerations……..

Detailed discussion of various imaging studies follows this section. Lumbar spine x-rays are not recommended in patients with LBP in the absence of red flags for serious spinal pathology within the first 4 to 6 weeks. Among patients with evidence of radiculopathy, imaging in the acute pain setting is also not recommended as the natural history is for such problems to resolve with conservative care. Table 5 provides a general comparison of the abilities of different techniques to identify physiologic insult and define anatomic defects. An imaging study may be appropriate for a patient whose limitations due to consistent symptoms have persisted for 1 month or more to further evaluate the possibility of potentially serious pathology such as a tumor.

Table 5. Ability of Various Techniques to Identify and Define Low Back Pathology and Sequela

Technique	Low Back Pain	Disc Herniation/ Protrusion	Cauda Equina Syndrome	Spinal Stenosis	Post-laminectomy Syndrome
History	++++	+ + +	+ + +	+ + +	+ + +
Physical examination	+ +	+ + +	+ + + +	+ +	+ +
Laboratory studies	0	0	0	0	0
Imaging studies					
Radiography[1]	0	+	+	+	+
Computerized tomography (CT)[1,2]	0	+ + +	+ + +	+ + +	+ +
Magnetic resonance imaging (MRI)[1,2]	0	+ + + +	+ + + +	+ + +	+ + + +
Electromyography (EMG), sensory evoked potentials (SEPs)[3]	0	+ + +	0 / +	+ +	+

[1]Risk of complications (e.g., infection, radiation) highest for myeloCT, second highest for myelography, and relatively less for bone scan, radiography, and CT.
[2]False-positive results in up to 30% of people over age 30 who do not have symptoms and may be over 50% in those over age 40.
[3]EMG is generally unhelpful in the first month of symptoms other than to document prior disease or injury status.

Note: Number of plus signs indicates relative ability of technique to identify or define pathology.

Diagnostic Testing and Other Testing

Diagnostic tests can be categorized into three broad categories: 1) anatomical; 2) functional; and 3) physiological. Anatomical tests help to define anatomy and include roentgenograms, magnetic resonance imaging (MRI), bone scans, computerized tomography (CT), and myelograms. Functional tests include those that assess voluntary lifting or pushing or pulling capacities. Physiological tests include electromyography and thermography. Tests such as discography attempt to bridge the gap between two of these testing domains and are organizationally included in this document in one domain. In considering which test to order, it is important to be able to address two key questions:

1. What is the specific question to be addressed?
2. What will be done with the results?

The first question must be clearly addressed and the second must result in an unequivocal answer used for a decision point with the results having a significant probability of altering the clinical management. Otherwise, the test is almost never indicated.

The operant characteristics of the test being ordered are critical to the proper interpretation of the results. For example, lumbosacral spine MRIs are more likely to be "abnormal" by age 40 in normal

individuals (show normal aging changes), and herniated discs are not infrequently found in screening studies of asymptomatic teenagers. The pre-test probability of disease, determined by a careful clinical evaluation is critical to address the probability that the abnormality identified on the image is actually causing the individual's symptoms. At present, there is not one type of imaging method that shows a clear advantage over others. Generally, MRI is superior for imaging soft tissue including intervertebral disc herniations.

There are many additional diagnostic tests possible for the evaluation of LBP and spinal conditions. In the absence of moderate- to high-quality studies, other tests are **Not Recommended, Insufficient Evidence (I)**.(9)

FUNCTIONAL CAPACITY EVALUATIONS

Functional capacity evaluations (FCEs) consist of a comprehensive battery of performance-based tests to attempt to determine an individual's ability for work and activities of daily living.(36, 119, 216-237) The goals of FCEs include:

- determine individual's readiness to work after injury or illness at Maximum Medical Improvement (MMI),
- assist with goal-setting and treatment planning for rehabilitation or to monitor the progress of a patient in a rehabilitation program,
- estimate potential vocational status and provide a foundation for effective vocational rehabilitation,
- provide information to assist in disability determinations,
- provide information for hiring decisions (post-offer or fit-for-duty testing),
- assess the extent of disability in litigation cases, and
- provide information regarding a patient's level of effort and consistency of performance.

1. *Recommendation: Functional Capacity Evaluations for Chronic Disabling Low Back Pain*
   Functional capacity evaluations (FCEs) are a recommended option for evaluation of disabling chronic LBP where the information may be helpful to attempt to objectify worker capability, function, motivation, and effort vis-à-vis either a specific job or general job requirements. There are circumstances where a patient is not progressing as anticipated at 6 to 8 weeks and an FCE can evaluate functional status and patient performance in order to match performance to specific job demands, particularly in instances where those demands are medium to heavy. If a provider is comfortable describing work ability without an FCE, there is no requirement to do this testing. Recordings of observation for signs of mismatch between effort and self-reported abilities may be particularly helpful.

   Harms – Medicalization, worsening of LBP with testing; may have misleading results that understate capabilities.
   Benefits – Assess functional abilities and may facilitate greater confidence in return to work.
   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

3. *Recommendation: Functional Capacity Evaluations for Chronic Stable Low Back Pain or Post-Operative Recovery*
   There is no recommendation for or against the use of functional capacity evaluations for chronic stable low back pain or after completion of post-operative recovery among those able to return to work.

   Strength of Evidence **– No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

3. *Recommendation: Functional Capacity Evaluations for Acute Low Back Pain, Acute or Subacute Radicular Syndromes, or Post-Operative Back Pain*

Functional capacity evaluations are not recommended for evaluation of acute low back pain, acute or subacute radicular syndromes, or post-surgical back pain problems within the first 12 weeks of the post-operative period.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendations
FCEs are one of the few means to attempt to objectify limitations and are frequently used in workers' compensation systems, particularly as the correlation between pain ratings and functional abilities appears weak.(238-244) Yet, obtaining objective data regarding spine problems is somewhat more challenging than for extremity-related impairments due to the degree of reliance on the patient's subjective willingness to exert or sustain major activities (e.g., standing, walking, sitting) that are critical for job performance. Because their reliability and validity have not been proven, FCEs should be utilized to evaluate work ability about what a patient was willing to do on a given day. They should not be used to override the judgment about the work ability of a patient with a back problem.

Many commercial FCE models are available. There is research regarding inter-and intra-rater reliability for some of the models (complete discussion is beyond the scope of this guideline). The validity of FCEs, particularly predictive validity, is more difficult to determine, since factors other than physical performance may affect return to work.(218, 245) An FCE may be done for one or more reasons, including identifying an individual's ability to perform specific job tasks associated with a job (job-specific FCE) and physical activities associated with any job (general FCE), or to assist in the objectification of the degree(s) of impairment(s). The type of FCE needed, and any other issues the FCE evaluator needs to address, should be specified when requesting a FCE.

The term "capacity" used in FCE may be misleading, since an FCE generally measures an individual's voluntary performance rather than his or her capacity. Physical performance is affected by psychosocial as well as physical factors. The extent of an individual's performance should be evaluated as part of the FCE process through analysis of his or her level of physical effort (based on physiological and biomechanical changes during activity) and consistency of performance. Perhaps more importantly, the objective findings identified in the musculoskeletal evaluation should correlate with any identified functional deficits. The individual's performance level, especially as it relates to stated levels of performance, should be discussed in the FCE report. A properly performed and well-reported FCE will highlight such discrepancies. This is particularly important in low back evaluations where there may be greater degrees of impairments at stake and where there are somewhat fewer metrics available than for the distal upper extremity.

FCE test components may vary depending on the model used, but most contain the following:

- Patient interview including:
  - Informed consent
  - Injury/illness and medical history
  - Current symptoms, activities and stated limitations
  - Pain ratings/disability questionnaires
- Musculoskeletal examination (e.g., including Waddell's non-organic signs)
- Observations throughout the session (e.g., demonstrated sitting tolerance, pain modifying behaviors)
- Material handling tests (lifting, carrying, pushing, pulling)
- Movement tests (walking, crouching, kneeling, reaching, etc.)

- Positional tolerance tests
- Dexterity/hand function
- Static strength (varies among models)
- Aerobic fitness (usually submaximal test-also variable among models)
- Job specific activities as relevant
- Reliability of client reporting (e.g., non-organic signs, pain questionnaires, placebo tests, etc.)
- Physical effort testing (e.g., Jamar Dynamometer maximum voluntary effort, bell curve analysis, rapid exchange grip, competitive test performance, heart rate, observation of clinical inconsistencies, etc.)

FCE test length may vary between FCE models, although most 1-day FCEs are completed in 3 to 4 hours. Two-day tests, where the patient is seen on 2 consecutive days, may be recommended when there are problems with fatigue (e.g., chronic fatigue syndrome), delayed onset of symptoms, unusually complex job demands to simulate, and questions about symptom validity. Test length for 2-day tests is generally 3 to 4 hours on the first day, and 2 to 3 hours on the second day.

Interpretation of FCE results is complicated in that it is a measure of voluntary performance. Before beginning testing, the patient is counseled to avoid doing anything to knowingly reinjure him or herself. Thus "fear avoidance" may cause testing to seriously underestimate actual ability and result in a report that the patient had "self-limited performance due to pain," suggesting a low pain tolerance, when in reality the patient was doing what he or she was instructed.

The best studies on the ability of FCEs to predict safe re-entry to the workplace following rehabilitation of work-related back pain/injury suggest that FCEs are not able to predict safe return to work (concurrent validity).(219, 246, 247) In a prospective cohort study of 1,438 consecutive work-related back patients, all underwent a FCE prior to return to work. In the control group, the FCE was used to write return-to-work guidelines, while in the study group it was ignored and the worker was returned usually to full duty. Ignoring the FCE improved outcome.(248)

Evidence for Use of Functional Capacity Evaluations (FCEs)
We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: functional capacity evaluations, FCE, chronic low back pain, postoperative recovery, acute low back pain, acute radicular pain, subacute radicular pain, postoperative back pain, diagnostic, sensitivity, specificity, predictive value, efficiency, and efficacy to find 781 articles. Of the 781 articles, we reviewed 10 and included five articles.

Author/ Year	Score (0-11)	Study Design	Population/Case Definition	Investigative Test	Gold Standard / Comparative Test	Results	Conclusion	Comments
Lemstra 2004	7.5	Diagnostic	N = 90 (n = 44 60% effort vs. n = 46 100% effort) with level 1 or 2 low back strain or sprain without neuro signs, active time loss WC claim for 6+ weeks, lifting a central job requirement.	Assigned participants (38.98±10.39 years) instructed to perform FCE tasks at 100%.	Assigned participants (36.23±12.66) instructed to perform FCE tasks at 60%.	Blinded FCE assessors determined 30/46 (65.2%) true 100% participants correctly (sensitivity). 37/44 (84.1%) true 60% participants correctly (specificity). PPV = 81.1%. NPV = 69.8%. (p = 0.040).	"The determination of maximal effort in a functional capacity evaluation is complex."	Data suggest that patients with 6 months injury duration of low back pain, rater/therapist determination of submaximal effort on FCE has acceptable specificity but low sensitivity.
Oesch 2006	6.0	Diagnostic	N = 174 – function-centered treatment (FCT, n = 87) vs. pain-centered treatment (PCT, n =87) age 20-55 with non-acute non-specific chronic LBP and 6+-weeks sick leave during 6 months prior to enrollment.	In FCT group, treating physician received blinded therapist's preliminary FCE information.	In PCT group, treating physician determined work capacity based only on medical findings. Preliminary FCE not provided.	Fitness for Work Certificates (FWC) quality better in FCT group vs. PCT: 26 FWCs rated as medium quality vs. 44 (p = 0.03). DOT information missing in 5 FCT and 11 PCT; all DOT categories used in FCT while PCT used 3. DOT differences significant (p = 0.038). 31 FCT vs. 20 PCT considered fit for previous work while 34 FCT vs. 27 PCT judged fit for alternative work. Work capacity differences signficant (p = 0.008).	"Functional Capacity Evaluation positively influences quality and information regarding working capacity of medical Fitness for Work Certificates in patients with chronic low back pain."	Data suggest FCEs add information that helps with return to work decision.
Gross 2014	5.5	Diagnostic	N = 225 mean age 43.2±13.1 years. N = 120 for Interview group/n = 105 for functional capacity evaluation group	Proprietary WorkWell (Duluth, MN) FCE.	Self-report functional assessment interview developed based on items in WorkWell FCE.	FCE vs. Interview: claimants rated sedentary: 12% vs. 31% (p <0.001); capable of performing heavier	"Performance-based FCE integrated into occupational rehabilitation appears to lead to higher baseline functional levels	Data suggest FCE vs. interview did not significantly improve work activity outcomes after a rehabilitation program. However at baseline FCEs

			(FCE). Smple of claimants undergoing work assessment at Alberta Workers' Compensation Board's rehab facility Nov. 28, 2011 to Jan. 10, 2012.			work – 2.7/4 vs. 2.1/4 ($p < 0.001$); Discharge VAS score: 2.5 (2.2) vs. 3.6 (2.2) ($p < 0.05$); anticipated duration of rehab (weeks) - 4.3 (1.5) vs. 3.8 (0.9) ($p < 0.05$); SF36 physical health composite score - 32.1 (7.5) vs. 35.3 (7.9) ($p < 0.05$); discharge percent pain disability index ($n = 76$) – 25.3 (23.0) vs. 36.1 (23.5) ($p < 0.05$); mean improvement – 0.3/4 vs. 0.9/4 ($p < 0.001$).	compared to semi-structured functional interview, but not improved RTW rates or functional work levels at follow-up"	reported higher level of activity compared to interview.

ROENTGENOGRAMS (X-RAYS)

X-rays are commonly utilized for evaluation of LBP, particularly that which is chronic, persistent and accompanied by red flags or trauma.(254, 255) Similar to most diagnostic studies, MRI is usually considered the gold standard comparison.

1. *Recommendation: X-ray for Acute Non-specific Low Back Pain*
   Routine x-ray is moderately not recommended for acute non-specific low back pain.

   Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
   Level of Confidence – High

2. *Recommendation: X-ray for Acute Low Back Pain with Red Flags or Subacute or Chronic Low Back Pain*

   X-ray is recommended for acute low back pain with red flags for fracture or serious systemic illness, subacute low back pain that is not improving or chronic low back pain as an option to rule out other possible conditions.

   Indications – Option to rule out other possible conditions.

   Frequency/Duration – Obtaining x-rays once is generally sufficient. For patients with chronic LBP, it may be reasonable to obtain a second set of x-rays years later to re-evaluate the patient's condition, particularly if symptoms change.
   Harms – Medicalization or worsening of otherwise benign back condition; radiation exposure.
   Benefits – Diagnosis of a fracture or otherwise latent medical condition(s).

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

3. *Recommendation: X-ray for Spondylolisthesis*
   Flexion and extension views are recommended for evaluating symptomatic spondylolisthesis in which there is consideration for surgery or other invasive treatment or occasionally in the setting of trauma.

   Indications – Chronic severe mechanical pain suspected to be due to instability.

   Frequency/Duration – Flexion and extension views are generally needed no more than every few years. However, after surgical intervention, flexion/extension views may be used to attempt to assess extent of successful fusion.
   Harms – Medicalization or worsening of otherwise benign back condition. Radiation exposure.
   Benefits – Diagnosis of significant spondylolisthesis that is able to be surgically improved.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations

Standard film views are generally an anterior-posterior (AP) film, a lateral film, and on occasion, a coned or focused view of the L5-S1 joint. Routine inclusion of oblique views has been discouraged except in specific circumstances, such as an evaluation of trauma where the AP and lateral views fail to show a fracture but there remains significant concern that a fracture did occur.(256) Oblique views are also needed if there is reason to evaluate a pars defect. If an MRI is used as imaging, plain x-ray may not be needed.

Flexion and extension films are occasionally used to evaluate spinal instability, particularly in the setting of degenerative spondylolisthesis and fractures. The criteria generally accepted for this purpose are to measure whether there is 5mm or more of movement of one vertebral body in relation to an

adjacent vertebral body, or whether the angular motion measured on radiographs at a disc given level exceeds 20° for the L1-L2 level through the L4-L5 level, or exceeds 25° for the L5-S1 level.(257) Depending on the translation forward or backwards, referred to as anterolisthesis or retrolisthesis.

X-ray is unnecessary for the routine management of LBP outside of the setting of red flags.(258-261) When red flag(s) are present, x-rays at the first visit are usually recommended to assist in ruling out these possible conditions (e.g., fracture, neoplasias, infection, etc.). Without red flags, there also is concern for medicalization and catastrophization of the case by obtaining x-rays.(262) Even when red flags are suspected, judgment is recommended and it should not be mandatory to order an x-ray in all cases (e.g., significant typical LBP in the course of a manual patient transfer in a patient with a remote history of cancer). In the event that there is LBP without any improvement over 4 to 6 weeks, x-rays may be recommended to rule out other possible problems. Those with subacute LBP that is not improving or chronic LBP should generally have x-rays at least once for purposes of ruling out other conditions. X-rays are non-invasive, moderately costly, and have a low risk of adverse effects, other than their considerable exposure to ionizing radiation. Thus, x-rays are recommended for select situations. The radiation dosage from common medical tests is available from the Australian Radiation Protection and Nuclear Safety Agency at www.arpansa.gov.au/radiationprotection/basics/xrays.cfm, and further reviewed in scientific literature.(263, 264)

Evidence for the Use of Roentgenograms (X-ray)
There are 5 moderate-quality studies incorporated into this analysis.(259-261, 265) There is 1 low-quality studies in Appendix 1.(266)

We searched PubMed, Ebsco, Cochrane Review and Google Scholar with limits between 2008 and 2013. We used the following search terms: X-rays, roentgenograms, radiography, acute low back pain, subacute low back pain, chronic low back pain, spondylolisthesis, low back pain, diagnostic, sensitivity, specificity, negative predictive value, positive predictive value, efficiency, and efficacy to find 258 articles in PubMed, 548 in EBSCO, 11 on Cochrane Review, and 173,720 on google scholar, for a total of 174, 537. From the 174, 537 articles, we reviewed 11 articles, and included 9 in the draft (5 RCTs, 3 reviews, 1 cross sectional study).

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of X-rays	CT used	MRI used	More than One Rater	Blinding of rater	Myelography	Surgery performed	Clinical Outcomes Assessed	Long term follow-up	Results	Conclusion	Comments
Jarvik 2003 Diagnostic	6.5	380	Lumbar	LBP with or with-out radiating leg pain; no lumbar surgery 1 year prior to enrollment; no history of acute external trauma; no metallic implants in lumbar spine; no contra-indications for MRI	Radiograph anteroposterior and lateral viewssome oblique views	-	+	-	-	-	-	+	12 months	Patients rated reassurance from MRI (74%) results higher vs. radiographic (58%) results at 12 months, p = 0.002. MRI scans most predictive of future surgery: those that detected either disk herniation or central stenosis. Lumbar spine surgery within 1 year: MRI, 10 patients (6%) vs. x-ray, 4 patients (2%), risk difference 0.34, p = 0.09.	"In this setting, a cautious approach is probably most prudent, and we recommend that rapid MRI not become the first imaging test for primary care patients with back pain until its consequences for surgical rates and costs are better defined."	Data suggest low utility of either x-ray or MRI for non-specific LBP.
Kendrick 2001 Diagnostic	6.0	421	Lumbar	LBP with median duration 11 weeks	Lumbar x-rays	-	-	-	-	-	-	+	3-9 months follow-up	Participants randomised to x-rays more likely to report LBP at 3 months (OR = 2.72; 95%CI, 1.80 to 4.10). Satisfaction with care greater in group receiving radiography.	"Lumbar spine radiography in primary care patients with low back pain of at least 6 weeks duration is not associated with improved functioning,	Study did not compare x-rays to any other diagnostic tool. Data suggest worse outcomes with x-ray.

															severity of pain or overall health status, and is associated with an increase in GP workload."	This is more a guideline.
Djais 2005 Diagnostic	6.0	101	Lumbar	Acute LBP <3 months	Lumbar spine radiograph	-	-	-	-	-	-	+	3 weeks or 3 months follow-up	Median Roland Disability Quesionnaire at baseline, 3 weeks after treatment, intervention vs. control group: 9 and 6.5 vs. 9.5 and 4.5 (p = 0.18). Median VAS pain score at baseline and 3 weeks after treatment 6 and 4 vs. 6 and 3 (p = 0.70).	"We also have shown that lumbar spine radiography is not associated with improvements in patient functioning or severity of pain."	X-rays did not improve outcomes. Study suggests that in otherwise healthy (no red flags) adults with acute LBP, lumbar radiographs do no improve outcomes.
van Wilgen 2013 Cross-sectional	5.0	115	Lumbar	Back pain >6 months	Lumbar	+	-	-	-	-	-	+	No follow up.	Participants with chronic LBP believed everyone should have x-rays or CT to determine LBP cause, vs. participants without chronic pain who believed same.	"Based on the results of this study, clinicians should ask patients with low back pain if they are of the opinion that specific movements can lead to more serious complaints, patient's thoughts about additional X-rays or Ct scans, and the role of psychological factors."	Questions given to population to assess results. Data suggest perceptions of pain and causes of pain differ in persons with chronic LBP compared to those without LBP or only acute LBP.

Kerry 2002 Diagnostic	4.0	153	Lumbar	LPB	Lumbar radiology	-	-	-	-	-	-	+	6 weeks and 1 year follow-up	SF-36 Physical functioning mean (SD) at baseline and mean (SE) at 6 weeks of not referred vs. referred: 57 (28)/65 (3) vs. 66 (24)/67 (3), NS. SF-36 mental health mean (SD) at baseline and mean (SE) at 6 weeks of not referred vs. referred: 66 (17) and 65 (3) vs. 68 (18) and 74 (3), NS. Roland Morris Disability score mean (SD) at baseline and mean (SE) at 6 weeks not referred vs. referred: 10.9 (5.3) and 6.9 (0.8) and 10.2 (5.5) and 5.9 (0.7), NS.	"[R]eferral for lumbar spine radiography for first presentation of low back pain in primary care is not associated with improved physical functioning, pain or disability."	Data suggest x-rays did not improve outcomes. Study suggests lumbar radiographs done in primary care setting with acute LBP patients does not affect clinical outcome in terms of function and pain.

MAGNETIC RESONANCE IMAGING (MRI)

Magnetic resonance imaging (MRI) has been widely used to evaluate the lumbar spine, particularly soft-tissues such as the intervertebral discs.(254, 267-277) This discussion will cover the three types of MRI – open, closed, and standing or weight-bearing.

Several terms are used to describe disc abnormalities and five different terms are used to describe a change in disc shape that can potentially cause radicular symptoms (bulge, protrusion, extrusion, sequestration, and herniation). There are multiple "definitions" of these terms, which creates confusion, but a consensus conference has provided definitions that may facilitate communication.(33)

Table 6. Terms Used to Describe Disc Abnormalities/Change in Disc Shape

Term	Definition
Normal	Does not reach beyond the borders of adjacent vertebral bodies.
Bulging	A circumferential symmetric extension of the disc beyond the vertebral border.
Herniation	Localized displacement of disc material beyond the limits of the intervertebral disc space. Disc material may be nucleus, cartilage, fragmented apophyseal bone, anular tissue, or any combination thereof. The term "localized" contrasts to "generalized," the latter arbitrarily defined as >50% (180°) of the periphery of the disc. Localized displacement in the axial (horizontal) plane can be "focal," signifying <25% of the disc circumference, or "broad-based," meaning between 25 and 50% of the disc circumference. Presence of disc tissue "circumferentially" (50-100%) beyond the edges of the ring apophyses may be called "bulging" and is not considered a form of herniation. Herniated discs may take the form of protrusion or extrusion, based on the shape of the displaced material.
Protrusion	Present if the greatest distance, in any plane, between the edges of the disc material beyond the disc space is less than the distance between the edges of the base in the same plane. In the cranio-caudal direction, the length of the base by definition cannot exceed the height of the intervertebral space.
Extrusion	Present when, in at least one plane, any one distance between the edges of the disc material beyond the disc space is greater than the distance between the edges of the base or when no continuity exists between the disc material beyond the disc space and that within the disc space. Extrusion may be further specified as sequestration if the displaced disc material has completely lost any continuity with the parent disc.
Sequestration	A herniated disc fragment that is detached and separated from the disc. It may or may not appear to have migrated cephalad or caudally.
Migration	Signifies displacement of disc material away from the site of extrusion, regardless of whether sequestrated or not. Because posteriorly displaced disc material is often constrained by the posterior longitudinal ligament, images may portray a disc displacement as a protrusion on axial sections and an extrusion on sagittal sections, in which cases the displacement should be considered an extrusion.
Intravertebral Herniations	Herniated discs in the cranio-caudal (vertical) direction through a break in the vertebral body endplate.

Adapted from Fardon DF, Milette PC. Nomenclature and classification of lumbar disc pathology: recommendations of the Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology. *Spine*. 2001;26(5):E93-113.

1. *Recommendation: MRI for Diagnosing Red Flag Conditions*
   MRI is recommended for patients with acute low back pain during the first 6 weeks if they have demonstrated progressive neurologic deficit, cauda equina syndrome, significant trauma with no improvement in atypical symptoms, a history of neoplasia (cancer), persistent fever plus elevated erythrocyte sedimentation rate without other infectious source, or atypical presentation (e.g., clinical picture suggests multiple nerve root involvement).
   Harms – Medicalization or worsening of otherwise benign back condition.
   Benefits – Diagnosis of a surgically treatable condition or otherwise latent medical condition(s).
   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

2. *Recommendation: Early MRI for Diagnosing Radicular Syndrome*
   MRI is moderately not recommended for acute radicular pain syndromes in the first 6 weeks unless the problems are severe and not trending towards improvement and both the patient

and the clinician are willing to consider prompt surgical treatment, assuming the MRI confirms ongoing nerve root compression. Repeat MRI imaging without significant clinical deterioration in symptoms and/or signs is also not recommended.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

3. *Recommendation: MRI for Diagnosing Subacute and Chronic Radicular Syndromes*
MRI is moderately recommended for patients with subacute or chronic radicular pain syndromes lasting at least 4 to 6 weeks in whom the symptoms are not trending towards improvement if both the patient and clinician are considering prompt surgical treatment, assuming the MRI confirms a nerve root compression consistent with clinical examination. In cases where an epidural glucocorticosteroid injection is being considered for temporary relief of acute or subacute radiculopathy, MRI at 3 to 4 weeks (before the epidural steroid injection) may be reasonable. It is recommended to administer with and without contrast in post-operative settings when there are concerns about recurrent disc problems (see Epidural Glucocorticosteroid Injections).

Harms – Medicalization or worsening of otherwise benign back condition.
Benefits – Diagnosis of a surgically treatable condition or otherwise latent medical condition(s).
Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – High

4. *Recommendation: MRI for Diagnosing Select Chronic LBP*
MRI is recommended as an option for the evaluation of select chronic LBP patients in order to rule out concurrent pathology unrelated to injury. This option is not recommended before 3 months and only after other treatment modalities (including NSAIDs, aerobic exercise, and directional preference exercises) have failed.

Harms – Medicalization or worsening of otherwise benign back condition.
Benefits – Diagnosis of a surgically treatable condition or otherwise latent medical condition(s).
Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

5. *Recommendation: Standing or Weight-bearing MRI for Back or Radicular Pain Syndrome Conditions*
Standing or weight-bearing MRI is not recommended for back or radicular pain syndrome conditions as, in the absence of studies demonstrating improved patient outcomes, this technology is experimental.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation: Closed MRIs
MRI has been evaluated in quality studies. The sensitivity and specificity of MRI or CT are difficult to define as they require a "gold standard" that is difficult to define in back pain since the final diagnosis often is based on the same imaging modality being tested; therefore, these clinical studies may be prone to incorporation bias, artificially inflating the sensitivity and specificity with some assuming MRI has 100% sensitivity and specificity. Most cases of LBP and radicular pain syndromes spontaneously resolve and require no imaging. Disc degeneration, disc bulging and herniation, and endplate changes are widely prevalent in asymptomatic people on MRI(122, 202, 278-295) have been

shown to either not correlate, or correlate poorly with symptoms,(122, 202, 284-286, 288, 290, 295-297) suggesting that MRI is not useful for the vast majority of patients.(298) In a 17-year follow-up study, patients with LBP at age 20 who had degenerative changes on MRI have greater risk for more severe degenerative changes. However, there was almost no correlation with clinical outcomes and no increased risk of surgery.(299) Early imaging likely results in higher overall costs and increased morbidity through the performance of some unnecessary procedures and/or surgeries.

Despite disc degeneration, bulging, herniations, and endplate changes that are widely prevalent on MRI in asymptomatic people, MRI is still considered the gold standard in diagnostic imaging for defining anatomy because it typically has the greater ability to distinguish soft tissues of any test currently available.(267-271, 273-275, 277) While computerized tomography (CT) remains an important analytical tool especially for evaluating bony or calcified spinal structures, there is less need for CT at the current time as MRI has greater soft tissue resolution. In patients of reproductive age, MRI may be preferable for the diagnosis of disc herniation, as CT involves considerable ionizing radiation. An evaluation of the association between the rates of advanced spinal imaging and spine surgery across geographic areas concluded that a significant proportion of the variation in rates of spine surgery can be explained by differences in the rates of advanced spinal imaging. "Improved consensus on the use and interpretation of advanced spinal imaging studies could have an important effect on variation in spine surgery rates."

In the absence of red flags suggesting fracture or serious systemic illness, imaging before 6 weeks produces no clear benefits. MRI is either non- or minimally-invasive and has few adverse effects, but is costly. In the absence of red flag symptoms and/or signs, MRI is not recommended to reassure patients that no serious injury or disease is present.(300) MRI is not recommended for evaluation of acute, subacute, or nearly all chronic LBP cases. MRI is indicated for discrete, potentially surgically treatable disorders such as radiculopathy, spondylolisthesis, and spinal stenosis.

Radicular pain syndrome patients should not have MRI within the first 6 weeks, except in rare cases for which early emergent/urgent surgery is proposed. Patients presenting with single nerve root neurological deficit, including an absent deep tendon reflex, should not have early MRI, as their condition usually resolves spontaneously, thus the test does not alter the course of treatment. Those who have a documented presentation that then objectively deteriorates (particularly a significant increase in weakness, an increased loss of sensation, compared with the prior examination, cauda equina syndrome, history of cancer with symptoms suggesting atypical radicular presentation) do have an indication for early imaging with MRI. It is strongly recommended that those ordering MRIs should be well aware of the tremendously high prevalence of abnormalities, which are essentially "false positives" in otherwise normal people (285).

Patients should be *a priori* informed that their MRI is highly unlikely to be "normal" as few have a normal MRI. A patient handout describing the prevalence of "abnormal findings" on lumbar MRI of asymptomatic individuals is helpful. Providers lacking the time or knowledge to explain these facts to patients should avoid ordering MRIs. The discovery of degenerative changes or clinically irrelevant disc herniations in many may cause them to focus on the need to "fix" MRI changes that are actually normal for their age or are asymptomatic findings. This may also become a rationale for avoiding participation in the therapeutic activities that promote functional recovery. In addition, lack of understanding of the strengths, indications, and limitations of a technology preclude adequate clinical interpretation of the results. In those cases, consultation with a provider experienced in treating musculoskeletal disorders may be recommended.

Rationale for Recommendation:Open MRIs
Open MRIs have gained in popularity. However, they have lower resolution without lower costs and are not recommended other than when the patient's weight exceeds the closed MRI unit's specifications, or suffers from claustrophobia that is not sufficiently alleviated with a pre-procedure low-dose anxiolytic.

Rationale for Recommendation: Standing ("Upright" or "Positional") MRIs
Standing MRI units are designed to evaluate the discs and spine under usual conditions of axial loading and can be used in other positions. Magnets are typically weaker than conventional MRI, resulting in lower resolution ("fuzzier images"). These units have unsurprisingly revealed a modestly greater prevalence of disc bulging with the spine loaded.(301, 302) There are studies demonstrating higher prevalence rates of disc herniations with upright-sitting examinations and an overall estimation of superiority for detections of spine abnormalities. These findings have not been shown to improve patient outcomes.(303) Another study of asymptomatic volunteers demonstrated a 41% prevalence rate for disc bulges.(304) There is a case report of positive findings where a closed MRI did not show neurological impingement.(305) One study noted that the information gained in addition to that from standard MRIs is limited.(306) Another comparative study in multiple positions concluded that positional MRIs more frequently demonstrate minor neural compromise than conventional MRI and that positional pain differences are related to position-dependent changes in foraminal size.(307) There are currently no quality studies to recommend standing MRI for uses outside of research settings, and interpretation of normal findings of increased disc bulging with standing are unclear.

Table 7. Change in MR Findings at 6-week Follow-up

Change in MR Findings at 6-week Follow-up		
Finding	**No. of Patients with LBP**	**No. of Patients with Radiculopathy**
Degenerative disc disease		
Normal at Baseline		
Unchanged	41 (91.1)	22 (84.6)
New herniation	4 (8.9)	4 (15.4)
Herniation at baseline		
Unchanged	46 (69.6)	25 (54.3)
New and/or enlarged	10 (15.2)	5 (10.9)
Reduced or gone	10 (15.2)	16 (34.8)
Nerve root compression		
Normal at baseline		
Unchanged	74 (91.4)	37 (97.4)
New compression	7 (8.6)	1 (2.6)
Compression at baseline		
Unchanged	21 (70.0)	18 (52.9)
New and/or worse	4 (13.3)	6 (17.7)
Reduced or gone	5 (16.7)	10 (29.4)
No 6-week MR imaging	39	24

Note: Data in parentheses are percentages.

Modic MT, Obuchoski NA, Ross JS, et al. Acute low back pain and radiculopathy: MR imaging findings and their prognostic role and effect on outcome. *Radiology*. 2005;237:597-604. Reprinted with permission from the Radiological Society of North America.

Evidence for the Use of Magnetic Resonance Imaging (MRI)
There are 8 high-quality(122, 269, 274, 296, 308-311) and 30 moderate-quality(267, 268, 271, 273, 277, 284, 290, 293, 298, 300, 312-331) studies incorporated into this analysis (see also Cervical and Thoracic Spine Disorders Guideline for additional studies). There is 1 low-quality study(265) and 2 other studies(332, 333) in Appendix 1. It is important to note that the sensitivity and specificity of CT or MRI are difficult to define as they require a "gold standard" that is difficult to define in back pain

since the final diagnosis often is based on the same imaging modality being tested; therefore, these clinical studies may be prone to incorporation bias, artificially inflating the sensitivity and specificity with some assuming MRI has 100% sensitivity and specificity.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with limits on publication dates from 2008-present. We used the following terms: magnetic resonance imaging, MRI, acute low back pain, subacute low back pain, chronic low back pain, diagnostic testing, sensitivity, specificity, positive predictive value, negative predictive value, efficacy, efficiency, and low back pain to find 58,060 articles. Of the 58,060 articles, we reviewed 20 articles (11 original articles, 4 review articles, and 5 new RCTs) and an addition 18 articles from references and 20 articles were included.

Author/Year Study Type	Score	Number	Area of Spine	Diagnoses	Type of MRI used	Type of CT used	T1 weighted images	T2 weighted images	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Suri 2010 Diagnostic	9.0	160	L	Nerve root impingement	Not specified	-	+	+	-	-	-	-	-	None	ODI: less impairment: independent group vs. non independent group: 45 vs. 54; p = 0.014. Sensitivity of deep tendon reflex: prior knowledge of MRI vs. without: 36% vs. 20%; p = 0.05.	"Prior knowledge of lumbar MRI results may introduce bias into the pinprick sensory testing component of the physical examination for lumbar radiculopathy. No statistically significant effect of bias was seen for other components of the physical examination. The effect of bias due to prior knowledge of lumbar MRI results should be considered when an isolated sensory deficit on examination is used in medical decision-making. Further studies of bias should include surgical clinic populations and other common diagnoses including shoulder, knee and hip pathology."	Data suggest knowledge of MRI results in patients with possible radiculopathy in lumbar spine can bias how certain physical exam maneuvers are interpreted or reported.

Carragee 2006 Diagnostic	8.0	200	L	Asympto-matic individuals	Not specified	-	+	-	+	-	+	-	+	60 months	Odds ratio (95% CI): LBP events perceived to be associated with minor trauma: 3.97 (95% 2.19-7.22).	"Findings on MR imaging within 12 weeks of serious LBP inception are highly unlikely to represent any new structural change. Most new changes (loss of disc signal, facet arthrosis, and end plate signal changes) represent progressive age changes not associated with acute events. Primary radicular syndromes may have new root compression findings associated with root irritation."	Data suggest smoking, abnormal psychological profile and nonlumbar chronic pain are more correlated to future LBP than are MRI findings prior to LBP or within 12 weeks of the development of LBP.
Lei 2008 Diagnostic	8.0	55/131 discs		Painful disc, end plate changes, and HIZ	0.2 T	-	-	+	-	-	2	+	+	None	Inter-observer agreement (κ = 0.70: 95% CI 0.56-0.84) and intra-observer agreement (κ = 0. 74: 95% CI 0.64-0.84). Correlation between MRI and discography significant (p <0.001). MRI predictors of concordant pain; sensitivity 94%, specificity 77%, positive predictive value 78%, negative predictive value 94%.	"Although MRI is an excellent investigation for assessing disc morphology it should be interpreted along with discography findings before planning fusion surgery. The proposed MRI classification is a useful aid in predicting painful degenerative disc. The utility of HIZs and end plate changes is limited due to low sensitivity."	Patients considering spinal surgery. Used minimal sedation for discography. As comparative is with discography, utility of the study is unclear.

O'Neill 2008 Diagnostic	7.5	143	L	Chronic LBP	Not specified	None	+	+	Dis co-graphy	-	-	-	-	None	For correlation between MRI procedures, strongest correlations between nuclear signal, disc height, and disc contour. Correlations between bone marrow intensity change, and other parameters relatively weak. Correlations between MRI parameters and discography classification significant correlation between discography classification and MRI ordinal parameters (p <0.0005). Correlations with disc classification with nuclear signal (correlation coefficient = 0.598), disc height (cc = 0.565), disc contour (cc = 0.531), high intensity zone (cc = 0.345), bone marrow intensity change (cc = 0.206). No correlation between tear	"MRI parameters are correlated with each other and with discography findings, influencing the diagnostic performance of MRI. Combining MRI parameters improves the diagnostic performance of MRI, but only in the presence of moderate loss of nuclear signal. When there is either normal nuclear signal or severe loss of nuclear signal the other MRI parameters have no influence on test performance. The practical implication for physicians that use discography is that the most important single MRI parameter to consider is nuclear signal. If nuclear signal is normal the disc is very likely to be negative on discography, while if there is severe loss of nuclear signal it is very likely to be positive. Discography will be most useful in	Data suggest normal nuclear signal on MRI or severe loss of nuclear signal alone correlate well with normal or abnormal discs on discography. As comparative is with discography, utility of study unclear. Moderate loss of disc signal on MRI can be combined with other MRI findings to help identify presumptive problematic lumbar discs.

															type and discography classification (p = 0.54). Nuclear signal, disc height, disc contour combined individually with discography classification highly significant (p <0.0005, cc = 0.662).	discs with moderate loss of nuclear signal, particularly if there are no other MRI abnormalities present."	
Karppinen 2001 Diagnostic	7.0	160	L	Sciatica with unilateral symptoms below knee for 3 weeks to 6 months	1.5 T imaging system	-	+	+	-	-	+	-	+	-	MRI associated with straight leg raising restriction (p < 0.01), radicular pain (p <0.01) and nerve root enhancement (p < 0.001)	"The results suggest that a discogenic pain mechanism other than the nerve root entrapment generates the subjective symptoms among sciatic patients. The findings of this study thus indicate that magnetic resonance imaging is unable to distinguish sciatic patients in terms of the severity of their symptoms."	Pain 3 weeks to 6 months, sciatica. Data suggest that extent of disc herniation on MRI does not correlate well with symptoms of sciatica. Clinical physical exam findings correlate better.
Modic 2005 Diagnostic	7.0	246	L	Acute LBP	1.5T scanner	-	+	+	-	-	+	+	+	24 months	Nerve root compression mild or moderate in 23% with radiculopathy and 24% with just LBP. Severe nerve root compression 23%	"In typical patients with LBP or radiculopathy, MR imaging does not appear to have measurable value in terms of planning conservative care. Patient knowledge of imaging	Three assessors used. Data suggest no prognostic behavioral or morphologic changes identified on MR images that significantly alter patient

															radiculopathy, 3% with LBP (p <0.001). At 6 weeks, herniations reduced in size or completely resolved in 15% LBP, 35% radiculopathy. At 6 weeks: 72% with herniation improved as did 48% without; 66% with nerve root compression improved as did 60% without. In herniations, no relationship to findings and outcomes. Mean general health improved more blinded group vs. unblinded (p = 0.008).	findings does not alter outcome and is associated with a lesser sense of well-being."	care. Patient knowledge of MR findings associated with lesser sense of well-being. Data suggest early MRI in acute LBP with or without radiculopathy did not improve clinical outcomes. If surgery is not being considered, immediate MRI does not appear to be indicated.
Hanly 1994 Diagnostic	6.5	36 – 24 inflammatory LBP, 12 controls	L	Sacroiliitis	1.5 T	Single Photon Emission Computed Tomography	+	+	+	-	2	-	+	None	More abnormalities found by MRI than plain film radiography in patients with inflammatory LBP (p < 0.01). MRI had enhanced ability to identify bony sclerosis (p <0.05). Plain film radiography found changes of sacroiliitis in single SI joint that was normal	"MRI and SPECT bone scanning provide objective and complementary evidence of sacroiliitis in patients with clinical features of inflammatory spinal disease in the absence of conventional radiographic changes."	Data suggest MRI and SPECT scanning may help in identifying sacroiliitis in patients with strong clinical suspicion using the calin's criteria model. Small sample size and few controls limits conclusions.

															on MRI and SPECT. Sensitivity and specificity of MRI scanning for detection of sacroiliitis was 54 and 67% respectively and SPECT 38 and 100%. When abnormalities detected by MRI and SPECT scanning were combined evidence of sacroiliitis in 15/24 (63%) with ILBP compared to 2/12 (17%) controls (p = 0.025).		
Elfering 2002 Diagnostic	6.5	41		asymptomatic individuals	1.5 T	-	+	+	-	-	+	-	+	62 months	Odds ratio (95% CI) at follow-up for risk of deterioration increased when showing herniation at baseline: 12.63 (1.24-128.49); evening or night work increased risk of deterioration: 23.01 (1.26-421.31); lack of sports activities increased risk of deterioration: 2.71 (1.04-7.07).	"The results indicate that the extent of disc herniation, the lack of sports activities, and night shift work are significant risk factors for the development of lumbar disc degeneration and its progression."	41 asymptomatic aged 20-50. Longitudinal study. Data suggest lack of physical activity (sports activity), night shift work and previous herniation increases the chance of developing more degenerative changes over 3 years in asymptomatic individuals.
Hu 2011 Diagnostic	6.0	29	L	Chronic LBP	1.5 T	CT scanner	-	+	-	-	3	-	-	Twice within	Mean±SD reliability of measurement for	"The reliabilities of the CT scan and MRI for measuring	Mean BMI 23.8 (21.5-28.7). Data suggest

														3 weeks	FCSA, cm^2 for L3-L4, L4-L5, and L5-S1 spinal levels was 4.75±1.22, 6.30±1.41, and 6.94± 1.33 respectively and interclass coefficient (ICC) was 0.587, 0.690, and 0.794 respectively. Comparison of Reliabilities of measurements between CT scan and MRI for ICC and FCSA 0.823± 0.055 for CT and 0.851± 0.043 for MRI (p = 0.152).	the FCSA and fatty infiltration of the atrophied lumbar paraspinal muscles were acceptable. It was reliable for using uniform one image method for a single paraspinal muscle evaluation study. And the authors preferred to advise the MRI other than CT scan for paraspinal muscles measurements of FCSA and fatty infiltration."	MRI and CT scanning can be used to measure paraspinal muscles atrophy in patients with chronic LBP. However normal controls were not used in this study for comparison and no obese patients included in study.
Carragee 2005 Diagnostic	5.5	100	L	Mild persistent LBP and those with history of chronic nonlumbar pain	Not specified	-	-	-	-	-	-	-	+	60 months	No statistical association was observed of any structural measure with adverse outcomes for MRI. Mean episodes per 5-year follow up for chronic pain: back pain VAS: yes vs. no: 2.04 vs. 0.70, p = 0.0002; mean 6-month remissions per subject per 5-year follow-up: yes vs. no: 0.22 vs. 0.95, p = 0.0002; Mean	"The development of serious LBP disability in a cohort of subjects with both structural and psychosocial risk factors was strongly predicted by baseline psychosocial variables. Structural variables on both MRI and discography testing at baseline had only weak association with back pain episodes and no association with disability or	Data suggest baseline MRI findings in patients with LBP do not correlate well with future episodes of more serious LBP. Chronic pain was strongest effect observed for future episodes of more serious LBP.

															episodes per 5 year work loss in weeks for Longer Term Disability: distressed vs. normal: 9.909 vs. 0.00; additional short term work loss incidence: distressed vs. normal: 0.42 vs. 0.02, p <0.0001.	future medical care."	
Boos 2000 Diagnostic	5.5	46	L	Asymptomatic individuals	1.5-T MR imager	-	+	+	-	-	+	-	+	60 months	Prevalence percentages: disc herniation (73.9%); neural compromise (26.1%) and disc degeneration (50%). P-values: vitality: p <0.05; general job satisfaction: p <0.05; influence of work on private life: p <0.05; physical job characteristics: p <0.01; shift work: p <0.01.	"Physical job characteristics and psychological aspects of work were more powerful than magnetic resonance imaging–identified disc abnormalities in predicting the need for low back pain–related medical consultation and the resultant work incapacity."	Patients not told their baseline MRI results unless they had a tumor. Data suggest MRI findings in asymptomatic workers are not predictive of future back pain. Listlessness, job satisfaction, and shift work predictive of needing medical care for LBP.
Boos 1995 Diagnostic	9.5	46	L	Asymptomatic individuals vs. sciatica		-			-	-	+	-	-	none	76% of age, sex, risk factor matched controls had disc herniations vs. 96% for symptomatic group. Greater severity in symptomatic (extrusions 35% vs. 13%.	"[I]n…matched group of asymptomatic individuals, disc herniation had a substantially higher prevalence (76%) than previously reported…Individuals with minor disc herniations….are	Data suggest most matched subjects have disc herniations, requiring very careful clinical correlations. Data suggest psychological factors including work perception, depression, and

															Neurological compromise 83% vs. 22%, p <0.0001.	at a very high risk that their (MRIs) are not a causal explanation of pain…"	anxiety can increase sensitivity and specificity of MRIs in identifying symptomatic patients. Neural compromise most significantly different MRI finding.
Borenstein 2001 Diagnostic	5.0	67	L	Asymptomatic individuals	1.5-T imaging system	-	+	+	-	-	+	-	+	84 months	Correlation between duration of LBP and presence of herniated nucleus pulposus (p = 0.01) or moderate degenerative disc changes (p = 0.04). Relative risk: LBP would develop in individuals with worsening abnormalities on MRI scans: 3.5.	"The findings on magnetic resonance scans were not predictive of the development or duration of low-back pain. Individuals with the longest duration of low-back pain did not have the greatest degree of anatomical abnormality on the original, 1989 scans. Clinical correlation is essential to determine the importance of abnormalities on magnetic resonance images."	1989, 32 had normal MRI, 18 had abnormal MRI with an average age <43.6 years. Minimal baseline characteristics given (possibly in appendix). Data suggest that MRI findings in asymptomatic people do not predict future low back pain with or without radiculopathy.

Beattie 2000 Diagnostic	5.0	408	L	LBP or lower extremity radiculopathy	1.5 T clinical MRI system	-	-	-	-	-	+	-	+	-	Extrusion in predicting severe nerve compression: sensitivity, 0.36, specificity, 0.84; positive predictive value, 0.68, negative predictive value, 0.58; p = 0.005. disc extrusion and presence of lower extremity pain: sensitivity, 0.15, specificity: 0.95, positive predictive value, 0.82, negative predictive value, 0.43; p = 0.04. Self-report weakness and presence of nerve compression: sensitivity, 0.42, specificity, 0.67, positive predictive value, 0.50, and negative predictive value, 0.60.	"The presence of disc extrusion and/or ipsilateral, severe nerve compression at one or multiple sites is strongly associated with distal leg pain. Mild to moderate nerve compression, disc degeneration or bulging, and central spinal stenosis are not significantly associated with specific pain patterns. Although segmental distributions of pain can be determined reliably from pain drawings, this finding alone is of little use in predicting lumbar impairment. The self-report of lower extremity weakness or dysesthesia is not significantly related to any specific lumbar impairments."	13.5 % (55/408) had acute pain <2 month first episode of pain. 12.3 % (50/408) recurrence of previous symptoms. 303 were chronic. No controls done. Data suggest that disc extrusion seen on MRI has high specificity for distal lower extremity pain and low sensitivity, but they used those with reported symptoms as comparison groups.
Jarvik 1997 Diagnostic	4.5	62	L	LBP	Rapid MRI	-	-	-	+	-	-	+	+	3 months	Dropouts younger more likely to be smokers with worse baseline scores. No significant differences in pain or disability between groups.	"Rapid MRIs and radiographs resulted in nearly identical outcome for primary care patients with low back pain. "Randomly selecting patients to undergo	Lack of details on imaging used. No control to monitor natural progression without imaging. Data suggest use of rapid MRI does

																imaging examinations and measuring outcome is feasible; however, a larger, multicenter study is necessary to determine whether rapid MR imaging is a cost-effective replacement for plan radiography in patients with low back pain."	not result in superior outcomes over conventional x-ray for LBP; 3 month follow-up. Data suggest doing MRI early in treatment does not make clinical significance in outcome at 3 months over x-ray imaging.
Suri 2014 Follow-up of LAIDBACK study	4.5	62	L	LBP	Rapid MRI	-	-	-	+	-	-	+	+	3-years	3-year cumulative incidence of MRI findings 2-8%. OR for reporting chronic LBP from incidence annular fissures (OR = 6.6), radicular symptoms after incident disc extrusions OR = 5.4), and nerve root impingement OR = 4.1.	"Even when applying more specific definitions for spine-related symptom outcomes, few MRI findings showed large magnitude associations with symptom outcomes… MRI findings (were) extremely low and did not explain the vast majority of incident symptom cases."	Data suggest new MRI findings incidence of 2-8% and mostly not associated with symptoms.
Carrino 2009 Diagnostic	4.5	111	L	Spondylolisthesis, intervertebral disk posterior anular HIZ, disk degeneration, marrow endplate abnormality, and facet osteoarthritis	1.5 T	none	+	+	-	-	4	-	+	122 days	Interobserver agreement for disk degeneration κ = 0.66; for spondylolisthesis κ = 0.55; modic changes κ = 0.59; facet arthropathy κ = 0.54; posterior HIZ κ = 0.44; intra-observer	"The interpretation of general lumbar spine MR characteristics has sufficient reliability to warrant the further evaluation of these features as potential prognostic indication."	Data suggest trained practitioners overall had good interobserver reliability in detecting abnormalities. Not clinically correlated in this study.

															agreement spondylolisthesis κ = 0.66; disk degeneration κ = 0.74; modic changes κ = 0.64; facet arthropathy κ = 0.69; posterior HIZ κ = 0.67.		
Visuri 2005 Diagnostic	4.5	108	L	Chronic LBP	0.1 T imager, Coil QD-spine	-	+	+	-	-	-	-	-	-	Patients with abnormalities: CLBP vs. control: 67 (62.0%) vs. 31 (34.4%), p <0.001. Corresponding values (percent of patients): disc degeneration 46 (42.6%) vs. 19 (21.1%), p > 0.00; protrusion 33 (30.6%) vs. 11 (12.2%), p = 0.002; disc herniation 31 (28.7%) vs. 13 (14.4%), p = 0.008.	"Narrowing of the vertebral canal in the anteroposterior direction was more likely to produce CLBP and radiating pain than intervertebral disc degeneration or narrowing of the intervertebral nerve root canals."	Young conscripts 18-26 years of age. Data suggest that abnormalities on lumbar MRI in people under age 26 are more likely associated with LBP. However, 34.4% of the controls had degeneration at L4/5, protrusions and herniations at L5/S1.
Schenk 2006 Diagnostic	4.5	109	L	females with chronic LBP	1.0 T Siemens Expert or 1.5 T Siemens Symography magnet	-	+	+	-	-	-	-	-	-	MRI findings: significant risk factor for nurses: nerve root compromise at L4-L5 and end plate changes at L5- S1. Administrative workers: nerve root compromise at L5-S1 and endplate	"These findings give evidence that in subjects performing nonheavy work, patterns of lumbar disc degeneration are not associated with the job type and characteristic physical loadings."	Females age 45-62 with persistent LBP with age matched controls. Data suggest endplate changes at L5-S1 and nerve root compromise at L4-5 on lumber MRI may be more prevalent in women with chronic non-

															changes at L5-S1.		specific LBP. BMI higher in LBP group so changes may be more prevalent in higher BMI patients regardless of LBP.
Savage 1997 Diagnostic	4.5	149	L	Male workers with no LBP or chronic LBP	1.5 T	-	+	+	-	-	+	-	-	12-months	No difference in MRI appearances of lumbar spine observed between 5 occupational groups. Independent assessor agreement: 53.6%, kappa coefficient 0.87.	"This study suggests that MRI does not provide a suitable pre-employment screening technique capable of identifying those who are at risk of developing LBP."	Working men 20-58 years. Data suggest lumbar MRIs can be useful, but there are often findings on MRI that do not appear to correlate with LBP presence or absence.
Kleinstück 2006 Diagnostic	4.0	53	L	Chronic non-specific LBP	1.5T scanner	-	-	+	-	-	-	-	+	12 months	Clinical outcomes after physical exercise program 2x a week 3 months not associated with MRI findings. No MRI variable measured contributed significantly to baseline pain or disability (R2 <8%; p >0.05). No MRI variables had significant association with pain intensity or disability directly after therapy or 12	"In the patient group examined, the presence of common "structural abnormalities" on MRI had no significant negative influence on the outcome after therapy."	Assessor blinded and all images scored twice at least 1 week apart. Assessor a spine surgeon, not radiologist. Data suggest degenerative findings on MRI not significantly associated with pain or disability in patients with chronic non-specific LBP. Data also suggest structural abnormalities on MRI did not predict level of pain or disability

															months after therapy or could predict pain or disability. Presence of high intensity zone associated with less pain at 12 months (p = 0.006).		after 12 months of conservative therapy in chronic LBP patients.
Li 2011 Diagnostic	4.0	160	T, L	Spinal stenosis, disc herniation, degenerative disc disease, facet joint degeneration, spondylolisthesis, and annular tear	Not specified	+	-	-	+	+	4	+	-	7 weeks	Most common radiologic diagnosis was degenerative disc disease (n = 78, 63%), but it was diagnosed clinically as arthritic back pain in 41 patients (27%, p <0.001). Disc herniation more common radiologic diagnosis (n = 69, 56%) than clinical diagnosis of radiculopathy (n = 25, 16%, p <0.001). Spinal stenosis radiologically diagnosed in 31 patients (25%) and neurogenic claudication clinically diagnosed in 27 (18%, p = 0.16)	"The clinical diagnosis had a poor association with radiologic abnormalities. Despite an increase in the number of MRI and CT scans, the number of patients deemed surgical candidates has not changed."	Did not compare images, but what impact MRI scans have on surgical rates. Data suggest there are a large number of MRI scans ordered in 2007 compared to 1996. No increase in surgical rates noted.

Ash 2008 Diagnostic	4.0	246	L	Acute onset (< 3weeks) of LBP and/or radiculopathy	1.5T scanner	-	+	+	-	-	+	-	+	24-months	No significant differences for primary or secondary outcomes of two groups.	"Patient knowledge of imaging findings do not alter outcome and are associated with a lesser sense of well-being."	Acute onset <3 weeks LBP with or without radiculopathy. MRI done at presentation and 6 weeks. Data suggest MRI for sake of patient preference or reassurance does not have positive outcome after conservative care. Outcome trend worse vs. blinded patients.
Videman 2003 Diagnostic	4.0	230 (155 monozygotic male twin pairs)	L	Chronic LBP	1.5-Tesla scanner	-	+	+	-	-	+	-	+	12 months	OR (95% CI) (0-3 pain scale): anular tears: LBP over the past 12 months vs. LBP today: 1.8 (95% 1.1-2.9) vs. 2.1 (95% 1.0-4.4), p <0.05. Pain previous 12 months vs. number lifetime episodes vs. intensity of worst episode: 1.8 (95% 1.2-3.0) vs. 1.9 (95% 1.1-3.2) vs. 1.5 (95% 1.1-2.1), p <0.05. Disc Height Narrowing: back pain lasting > 1 day: 2.4 (95% 1.2-4.7), p <0.05.	"These findings raise new questions about the underlying mechanisms of LBP. The sensitivities of the only significant MRI parameters, disc height narrowing and anular tears, are poor, and these findings alone are of limited clinical importance."	Monozygotic twin study with males only. Data suggest annular tears and loss of disc height on MRI associated with prior LBP. Disc herniations not associated with LBP.

Siddiqui 2005 Diagnostic	4.0	120	L	LBP, spondylosis or lower extremity radiculo-pathy	1.5 T scanner	-	+	+	-	-	+	-	-	-	Frequency (percentage) of MRI findings according to pain distribution: Spondylolisthesis: distal lower extremity pain vs. weakness and numbness vs. primary low back and thigh pain: 6 (54%) vs. 4 (37%) vs. 1 (9%), p = 0.04. Spinal nerve compression: 37 (77%) vs. 9 (18%) vs. 2 (5%), p = 0.002. Disc extrusion: 16 (73%) vs. 6 (27% vs. 0 (0%), p = 0.01.	"The presence of disc extrusion or ipsilateral severe nerve compression at one or multiple side is strongly associated with distal leg pain. There should be a correlation between patient symptoms and signs of sciatica and imaging demonstration of nerve root compression before invasive therapy is undertaken."	23 had pain <2 months; 40 had recurrence of previous LBP. 57 had chronic pain. Data suggest MRI findings of disc extrusion are associated with distal leg pain.
Jarvik 2001 Diagnostic	4.0	148	L	without LBP in past 4 months	1.5 Tesla MR system	-	-	+	-	-	+	-	+	-	Number of patients for MRI findings: disc degeneration: 134 (91%) at baseline; moderate to severe desiccation at 1 or more disc levels: 123 (83%); 1 or more bulging discs: 95 (64%); loss of disc height: 83 (56%); at least 1 disc protrusion: 48 (32%); 1 or more disc extrusions: 9 (6%).	"Many MR imaging findings have a high prevalence in subjects without low back pain. These findings are therefore of limited diagnostic use. The less common findings of moderate or severe central stenosis, root compression, and extrusions are likely to be diagnostically and clinically relevant."	VA patients without pain for 4 months. 49% (69/148) never experienced LBP. Data suggest degenerative findings on MRI are common in asymptomatic patients. Age is correlated with more findings on MRI than in previous episodes of low back pain, other than disc extrusion and stenosis.

Jarvik 2005 Diagnostic	4.0	148	L	without LBP in the past 4 months	1.5 Tesla MR system	-	+	+	-	-	+	-	+	36 months	Number of patients (percentage of group): Incident MRI findings: after 3 years: disc signal loss: 11 (9%). 5 had disc change from normal to bulging, 8 had disc change from normal to protrusion, 1 disc change from bulging to protrusion. Depression high predictor of subsequent LBP: (HR = 2.3, 95% CI 1.2-4.4); Proportion of subjects with or without depression at baseline developed back pain: 1 year: 0.71 vs. 0.34, p <0.01, then decreased at 3 years, but not significant.	"Depression is an important predictor of new LBP, with MRI findings likely less important. New imaging findings have a low incidence; disc extrusions and nerve root contact may be the most important of these findings."	Follow-up for Jarvik 2005. 123/148 followed up for repeat MRI after 3 years. Data suggest MRI findings at baseline not predicitive of LBP in 3 years as was self-identified depression.

MRI for Detection of Herniated Disc or Spinal Stenosis

Author/Year Study Type	Score	Number	Area of Spine	Diagnoses	Type of MRI used	Type of CT used	T1 weighted images	T2 weighted images	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes assessed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Aota 2007 Diagnostic	9.0	117	L	Lumbar spinal stenosis	0.5 T imager with a surface coil receiver	-	+	+	-	+	+	-	-	-	Foraminal narrowing on MRI sensitivity (kappa = 0.671) 96%, Specificity 67%, PPV 4%, NPV 100%. Abnormal course of nerve roots on MRM (kappa = 0.843) corresponding values 96%, 83%, 7%, 100%. Spinal nerve swelling on MRM (kappa = 0.928), same corresponding values 60%, 99%, 35%, 99%.	"MRM adds additional and more specific information for evaluation of symptomatic foraminal stenosis. MRM is particularly useful in cases of multiple sites or levels of involvement, or in situations of confounding clinical features, especially when equivocal findings from MRI in the foramen or equivocal results of selective nerve injections exist."	Data suggest some potential utility for MR myelography but data not tied to outcomes.
Bischoff 1993 Diagnostic	9.0	57	L	Herniated Nucleus Pulposus (HNP) and Spinal Stenosis	1.5 T General Electric sigma unit	+	+	+	-	+	-	-	-	-	CT scan most sensitive for HNP (77%) and accurate (76%), vs. Myelography most specific (89%) test. MRI and CT equally accurate (85%) and sensitive (87%) for spinal stenosis vs. Myelography more specific (81%)	"It was found in our series of patients that in the diagnosis of HNP and/or spinal stenosis, the trend was that myelo-CT was the most accurate and sensitive test and myelography the most specific in patients who had not undergone	Data suggest CT-myelography more sensitive for HNP.

																previous lumbar surgery."	
Pui 2000 Diagnostic	8.5	72	L	Suspected cervical, thoracic, and lumbar (n = 60) disc herniation	1.5 T magnet with surface coil	-	+	+	-	+	+	+	-	-	Sensitivity (MRI/magnetic resonance myelography (MRM)/MRI and MRM) compared to operative findings: observer A (95.6%/ 89.0%/97.8%); observer B (89.0%/ 82.4%/91.2%). Accuracy (MRI/magnetic resonance myelography/MRI and MRM) vs. operative findings: observer A (95.7%/ 89.1%/97.8%); observer B (89.1%/ 82.6%/91.3%). No significant differences.	"Although it did not significantly improve the diagnostic accuracy of MRI in the present study, MRM allowed a better overall view of the dural sac and the root sleeves."	Data suggest MRM doesn't add information over just MRI in diagnosing herniation or stenosis.
Chawalparit 2006 Diagnostic	8.0	123	L	LBP with lumbar intervertebral disc herniation (LDH)	1.5 Tesla machine	-	+	+	-	-	+	+	+	-	Diagnostic performance for LDH limited MRI vs. full MRI (95% CI) sensitivity (%)/ specificity (%)/ accuracy (%)/ PPV (%)/ NPV (%)/ likelihood ratio positive: limited – 82.6 (62.9, 93.0)/ 80.0 (49.0, 94.3)/81.82/90.5 (71.1, 97.3)/66.7 (39.1, 86.2)/4.13 vs. full MRI – 82.61 (62.9, 93.0)/70.0	"The limited protocol MRI (sagittal T2wi) may be enough for evaluative lumbar disc herniation before surgery in cases of clinically suspected LDH but not enough for evaluative nerve root compression."	Data suggest a limited MRI protocol as described can help diagnose LDH but may miss any nerve root compression.

															(39.7, 89.2)/78.79/ 86.4 (66.7, 95.3)/ 63.6 (35.4, 84.8/ 2.75.		
Yan 2010 Diagnostic	7.5	29, 26 had MRI	L	Central canal or nerve root canal stenosis confirmed by CT and MRI with clinical symptoms; lateral herniated nucleus pulposus confirmed by CT or MRI with irritation sign of nerve root; clinical symptoms of lumbar spinal stenosis; post-op recurrence of lumbar decompression procedure	Not mentioned	+	NA	NA	-	-	-	+	-	1-10 months for surgery patients	MRI vs. surgery: 15 true positive for stenosis for both MRI and surgery; 2 positive on MRI but true negatives on surgery; 2 negative on MRI but false negative on surgery; 3 true negatives for both MRI and surgery. Sensitivity (CT/MRI/multi-spiral computed tomography epidurography on diagnosis of lumbar nerve root canal stenosis: 76.5%/ 88.2%/94.1%. Specificity (CT/MRI/multi-spiral computed tomography epidurography on diagnosis of lumbar nerve root canal stenosis: 60.0%/ 60.0%/80.0%. Total consistent rate (CT/MRI/multi-spiral computed tomography epidurography on diagnosis of lumbar nerve root canal stenosis: 72.7%/ 81.0%/90.9%.	"[M]ultispiral computed tomography epidurography could obtain the image findings giving consideration to both bone and soft tissue by contrast medium and three-dimensional reconstruction."	Small numbers. Data suggest epidurography may help in diagnosis of lumbar nerve root canal stenosis but cost-benefit ratio not evaluated.

Lee 2012 Diagnostic	7.5	753 (437 HIVD, 316 SS)	L	LBP or radiating pain at least 2 months with diagnosed herniation of intervertebral disc (HIVD) or spinal stenosis (SS)	Intera 1.5T unit	-	+	+	-	-	-	-	+	-	EDX to MRI sensitivity (total group/ HIVD subgroup/SS subgroup): 0.532/0.591/0.472. EDX to MRI specificity (total group/HIVD subgroup/SS subgroup): 0.837/0.795/0.919. MRI to EDX sensitivity (total group/HIVD subgroup/SS subgroup): 0.779/0.705/0.901. MRI to EDX specificity (total group/HIVD subgroup/SS subgroup): 0.623/0.701/0.526. Odds ratio, 95% CI, p-value: total – 5.84, 4.14-8.22, p = 0.007; HIVD – 5.6, 3.67-8.55, p <0.002; SS – 10.08, 4.98-20.41, p <0.001.	"[I]n symptomatic patients with lumbosacral HIVD or SS, EDX was significantly more correlate with clinical data than was MRI…EDX may be a useful diagnostic tool to establish management protocols."	Data suggest EDX studies correlate well with physical findings suggestive of radiculopathy.
Barz 2010 Diagnostic	7.0	200 (100 LB, 100 LSS)	L	Low back pain and symptomatic lumbar spinal stenosis (LSS)	1.5 Tesla	-	-	+	-	-	+	-	+	-	LSS group: positive sedimentation sign identified in 94%, other 6 patients false negatives. LBP group: 0% positive sedimentation. Rater agreement of subsample: 19 of 20 interobserver kappa 0.93. Severity of functional limitation (ODI): 66% in LBP group vs. 64% in LSS group, p <0.01. Correlation between	"A positive sedimentation sign exclusively and reliably occurs in patients with LSS, suggesting its usefulness in clinical practice."	Data suggest nerve root sedimentation sign ("sedimentation of lumbar nerve roots to the dorsal part of the dural sac on supine" MRIs) can be used to help diagnose LSS in patients with clinical

															ODI and smallest CSA of dural sac: rho = 0.14.		signs consistent with LSS.
Jia 1991 Diagnostic	6.5	78	L	Lumbar canal stenosis and/or disc herniation	Super-conducting MI/Simager with surface coil and spinecho sequence	-	+	+	+	+	-	+	-	-	Accuracy herniation (N): surgery 65 vs. MRI 63 (97%) vs. myelography 64 (98.5%). Accuracy stenosis (N): surgery 27 vs. MRI 23 (85.2%) vs. myelography 30 (90%).	"[M]RI could clearly reveal the pathological changes and anatomical relations of lumbar structures without invasive and radioactive damages, and that with the improvement of operative technique, better understanding of image, and reduction of cost, MRI is likely to replace myelography in the future."	Data suggest MRI and myelography comparable in diagnosing lumbar disc herniations and/or spinal stenosis confirmed by surgery.
Modic 1986 Diagnostic	5.5	60	L	Herniated disk or lumbar canal stenosis with likelihood of require surgery	0.6 T superconductive unit using prototype surface coil.	+	-	-	-	+	+	+	-	-	Percent agreement: between surgical findings and MR: 82%; between surgery and CT: 83%; between surgery and myelography: 71%; between surgery and MR+CT: 92%; between surgery and CT +myelography: 89%. Total disagreement (N) vs. surgery: MR 11; CT 9; myelography 16.	"[S]urface coil MR was as accurate as CT and slightly more accurate than myelography in evaluating lumbar disk disease and canal stenosis."	Data suggest good correlation in MRI and CT findings with findings on surgery for disc herniation and stenosis in lumbar spine.

Mayerhoefer 2012 Diagnostic	4.0	31, 155 discs	L	Single or recurrent episode of low back pain within the last 6 months	3.0 Tesla MR scanner	-	+	+	-	-	+	-	-	-	*Post hoc* t-tests (normal vs. bulging/ normal vs. herniation/bulging vs. herniation): mean T_2 (0.32/ 0.001/ 0.001); T_2 texture entropy (0.001/ <0.001/ 0.003); T_2 difference (0.001/ <0.001/ 0.018); T_2 sum average (0.15/0.061/ 0.73); geometry: GeoM2xy (<0.001/<0.001/ 0.001); geometry: GeoFv (0.016/ <0.001/0.001); geometry: GeoRf (0.049/<0.001/0.005).	"[T]he results of our study show that quantitative T_2 texture features and geometric parameters are sensitive to the presence of abnormalities at the posterior aspect of lumbar intervertebral discs (i.e. bulging or herniation), probably more so than simple mean T_2 relaxation time measurements."	Data suggest T_2 texture images can assist in looking for disc abnormalities on MRI's of lumbar spine.
Lurie 2008 Diagnostic	4.5	50	L	Radicular pain with positive nerve root tension sign or neurologic deficit at least 6 months and inter-vertebral disc herniation confirmed by imaging	No mention	-	+	+	-	-	+	-	-	-	Overall intra-reader reliability measured by weighted kappa statistics (95% CI): disc morphology - 0.9 (0.85, 0.94); thecal sa compression – 0.84 (0.71, 0.93); root impingement – 0.63 (0.49, 0.76).	"Classification of disc morphology showed substantial intra- and inter-reader agreement, whereas thecal sac and nerve root compression showed more moderate reader reliability."	Data suggest readers with specific training in how to grade MRI films in low back pain patients can have good reliability in patients with herniated discs and slightly less well at identifying nerve root pathology.

MRI for Evaluation of Non-specific Chronic Low Back Pain
See Cervical and Thoracic Spine Disorders Guideline.

Table 8. Findings of Lumbar MRI

Finding	Percentage
Normal disc signal	42%
Normal disc height	45%
Annular tears	7%
Bulging disc	14%
Disc contact with nerve root	8%
Displacement of nerve root	2%
End plate changes	0.5%
Anterolisthesis	3%

Adapted from Kjaer P, Leboeuf-Yde C, Sorensen JS, Bendix T. 2005.

A review of LBP found the following prevalence of "abnormalities" on MRI in asymptomatic individuals:

Table 9. Abnormalities on MRI in Asymptomatic Individuals

Finding	Number of Studies	Prevalence of Finding
Herniated disc	5	22-40%
Bulging disc	5	24-81%
Degenerative disc	4	46-93%
Stenosis	3	1-21%
Annular tear	3	14-56%

Adapted from Deyo RA, Weinstein JN. 2001.

COMPUTERIZED TOMOGRAPHY (CT)
Computerized tomography (CT) is primarily used today to define fractures not visible on plain x-rays or to image when MRI is unavailable or contraindicated.(334) CT was the main imaging study for defining spinal anatomy prior to the advent of MRI. Due to the greater soft tissue contrast of MRIs, there is less current need for CT.(254, 335)

1. *Recommendation: Routine CT for Acute, Subacute, or Chronic Non-specific Low Back Pain or Radicular Pain Syndromes*
   Routine CT is not recommended for acute, subacute, or chronic non-specific low back pain, or for radicular pain syndromes.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – High

2. *Recommendation: CT for Patients with Acute or Subacute Radicular Pain Syndrome*
   CT is recommended for patients with acute or subacute radicular pain syndrome who failed to improve within 4 to 6 weeks and if there is consideration for an epidural glucocorticoid injection or surgical discectomy (see Epidural Steroid Injection). If there is strong consideration for surgery, then CT myelography should be considered instead of CT alone (see below).

   Indications – Patients with an indication for MRI who cannot complete the MRI due to contraindications such as implanted metallic-ferrous device or significant claustrophobia.

   Frequency/Duration – Obtaining serial CT exams is not recommended, although if there has been a significant worsening in the patient's history of examination, repeat imaging may be recommended.

Harms – Medicalization or worsening of otherwise benign back condition. Radiation exposure.
Benefits – Diagnosis of a fracture or otherwise latent medical condition(s).
Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendations
CT is equivalent to MRI for many typical spine imaging purposes. The sensitivity and specificity of CT or MRI are difficult to define as they require a "gold standard" that is difficult to define in back pain since the final diagnosis often is based on the same imaging modality being tested; therefore, these clinical studies may be prone to incorporation bias, artificially inflating the sensitivity and specificity with some assuming MRI has 100% sensitivity and specificity. CT is also widely thought to be sufficient to evaluate most patients with suspected disc herniations even though it is not as successful for soft tissue imaging.(336-338) CT is most useful to evaluate the spine in patients with contraindications for MRI (most typically an implanted metallic-ferrous device). CT is somewhat less costly than MRI. There also may be situations in which MRI is so distant geographically that CT is the most practical option. Contraindications for MRI that may necessitate CT include any implantable ferrous or metallic device and claustrophobia to an extent that even open MRI is infeasible or unavailable. CT myelography has limited uses, however, if there is a contraindication to MRI and surgery is considered moderate to high probability, then CT myelography is a consideration instead of CT followed by another CT with myelography. CT and MRI are both options for consideration before invasive procedures (e.g., acute severe radiculopathy with consideration of epidural glucocorticoid injection or surgery). CT is not invasive (minimally invasive when contrast is needed), has low potential adverse effects, but is costly.

Evidence for the Use of Computerized Tomography (CT)
There are 4 high-(339-342) and 4 moderate-quality(343-346) incorporated into this analysis. Please note that older generation machines were used in older studies rendering the results difficult to interpret in today's world.

We searched PubMed, EBSCO, Cochrane Review and Google Scholar with limits between 2008 and 2013. We used the following search terms: Computerized Tomography, CT scan, acute low back pain, subacute low back pain, chronic low back pain, acute radicular pain, subacute radicular pain, low back pain, radicular pain, diagnostic, sensitivity, specificity, negative predictive value, positive predictive value, efficiency, and efficacy to find 103 articles in PubMed, 413 in EBSCO, 1 on Cochrane Review, and 13,004 on Google Scholar, for a total of 13,521. From the 13,521 articles, we reviewed 12 articles, and included 6 in the draft (1 RCTs, 1 cross-sectional study, 1 case study, and 3 reviews).

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of CT	X-ray used	MRI used	More than One Rater	Blinding of rater	Myelography	Surgery performed	Clinical Outcomes Assessed	Long term follow-up	Results	Conclusion	Comments
Iversen 2013 RCT/ Diagnostic	9.0	116	L	Unilateral chronic lumbar radiculopathy lasting >12 weeks	Lumbar CT scan	-	+	+	+	-	-	+	-	Prevalence of disc herniation 77.8 %. No individual tests highly accurate, sensitivities and specificities low with wide CIs. All positive likelihood ratios (LR) were ≤4.0, and all negative LR ≥0.4. Overall clinical evaluation slightly more accurate, with a positive LR of 6.28 (95% CI 1.06–37.21) for L4, 1.74 (95% CI 1.04–2.93) for L5, and 1.29 (95% CI 0.97–1.72) for S1 nerve root impingement.	"The accuracy of individual clinical index tests used to predict imaging findings of nerve root impingement in patients with chronic lumbar radiculopathy is low when applied in specialised care, but clinicians' overall evaluation improves diagnostic accuracy slightly. The tests are not very helpful in clarifying the cause of radicular pain, and are therefore inaccurate for guidance in the diagnostic workup of the patients. The study population was highly selected and therefore the results from this study should not be generalised to unselected patient populations in primary care nor to even more selected surgical populations."	CT used for comparison. Data suggest physical exam has overall low accuracy to predict nerve root impingement.
Nakao 2010 Diagnostic	9.0	75	L	L5 radiculopathy	New 3-dimensional computed tomography	-	+	-	+	-	+	+	-	After surgery, all reported relief from L5 radiculopathy. Lumbosacral bony tunnel (LSBT) on 9 patients in group A, 13 in group B, 53 in group C on ipsilateral side.	"All patients with extraforaminal stenosis had an LSBT. The minimum cross-sectional area of the bony tunnel was significantly smaller in patients with an extraforaminal lesion	Applies only to patients with L5 radiculopathy after microendoscopic spinal surgery for L5 radiculopathy. Data suggest 3D-CT can be useful

					(3D CT)									Minimum cross-sectional area of LSBT: significantly smaller in group A vs. group B, p <0.005. Cutoff value between groups A and B 0.8 cm^2. Values <0.8 cm^2 are positive results, thus 7 of 75 were false positive; none false negative. Specificity of diagnosis method 89.6%, sensitivity 100%.	than in those without an extraforaminal lesion. 3D CT is a useful tool for diagnosing extraforaminal stenosis at the lumbosacral junction."	in diagnosing "far-out" syndrome in patients with L5 radiculopathy who were referred for surgery.
Slebus 1988 Diagnostic	8.5	109	L	Radicular leg pain	Lateral scout views of CT scans. Philips Tomoscan 350.	-	-	+	+	+	+	-	18 months	CT superior for cause of potential nerve root involvement and myelography better at assessing effects. CT does not provide direct image of intrathecal nerve root.	"[O]ur experience shows that a second radiological procedure is particularly indicated in cases of spinal stenosis, especially in combination with a bulging disc, and in cases of scar formation due to previous operation."	Study did not use any specific measurement for outcomes, besides re-evaluations. Data suggest CT superior to myelography for potential nerve root involvement. Suggests both CT and myelography can detect lumbar disc herniation seen on surgery. Study done with no discussion or comparison of MRI.
Willen 2001 Diagnostic	8.0	172	L	LBP, sciatica, or neurgenic claudication	Compression device, Dynawell for axial loading of lumbar spine in computed tomography	-	+	-	-	+	-	+	-	During exam in axial loading, additional information found in 50 (29%) of 170 patients. Percentage of additional valuable information increased to 50% in patients with sciatica if recommended inclusion criteria for exam in axial loading used.	"According to the study results, axially loaded imaging adds frequent additional valuable information, as compared with conventional imaging methods, especially in patients with neurogenic claudication, but also in patients with sciatica if defined inclusion criteria are used."	Data suggest axial loading can provide additional information in degenerative lumbar spine patients, but overall low percentage. No mention of cost-benefit analysis to see if additional cost is appropriate.

Beauvais 2003 Diagnostic	6.0	78	L	Sciatica or femoral neuralgia <1 month duration, presumably due to a disk herniation	Lumbar CT scan	-	-	-	+	-	-	+	3 months	All herniations in location consistent with pain. After 3 months treatment, 45 (75%) recovered partially (n = 18, 30%) or completely (n = 27, 45%); 15 (25%) had not recovered, thus needed surgery or chemonucleolysis. No statistically significant differences in symptoms duration, sex ratio or age found between groups. Patients admitted for pain: higher in failure group (p = 0.01).	"[E]arly CT scan did not predict the clinical outcome of patients with nerve root pain from lumbar disk herniation. None of the CT criteria was associated with a poor clinical outcome. Early CT scan has no prognostic value in this setting."	Data suggest that despite care based on bedrest, medications, and back braces, early CT of lumbar spine did not help differentiate between acute LBP patients with a disc herniation on who recovered and who did not.

Carrera 1980 Diagnostic	6.0	243	L	LBP and/or sciatica.	GE CT/T 8800	-	-	+	-	+	-	+	-	Lumbar facet abnormalities in 139 (57 %), herniated disk in 48 (20 %); 28/48 with herniated disk had myelograms before or after CT. 3 myelograms negative, 2 equivocal for herniated disk. Defects shown by myelography correlated with CT scans of herniated nucleus pulposus. CT findings correlated with surgical observations in cases of herniated disk and results of intra-articular facet block in small series of patients.	"CT can effectively diagnose and differentiate between lumbar facet arthropathy and a herniated disk."	Data suggest CT scans can help delineate between herniated vs. non-herniated disc low back pain.
Gilbert 2004 RCT/Diagnostic	5.0	782	L	LBP, nerve root entrap-ment, neuro-genic claudica-tion, patho-logical fractures, osteo-porosis	Lumbar CT scan	-	+	+	+	-	-	+	24 months	Differences in mean ALBP scores -3.05 (95% CI:-5.16, 0.95; p = 0.005) at 8 months and -3.62 (95% CI: -5.92, -1.32; p = 0.002) at 24 months. FSF-36 differences in bodily pain subscale score 4.54 (95% CI 1.23, 7.86; p = 0.007) at 8 months, and 5.14 (95%CI: 1.61, 8.67; p = 0.004) at 24 months.	"[E]arly use of imaging does not appear to affect the treatment overall. Decisions about the use of imaging depend on judgments concerning whether the small observed improvement in outcome justifies additional cost."	Early imaging appeared largely ineffective for improved outcomes. Did randomization into CT/MRI early or late. Early gap had shorter duration of LBP and better scores. Data suggest early imaging in LBP without red flags does not change clinical outcomes. Did questionnaires, but did not look at depression diagnosis. Looked at impact on treatment. Data suggest early spinal imaging with MRI or CT does not

																significantly impact clinical outcomes at 24 months. Patients with imaging appeared to feel more re-assured at higher cost of care.
Kalichman 2010 Diagnostic	5.0	187	L	LBP with pain in buttocks or thighs, pain in one lower leg, numbness or tingling in leg or foot, weakness of leg or foot, degeneration, intervertebral disc narrowing, facet joint osteoarthritis, spondilolisthesis, spondylolysis and spinal stenosis.	8-slice multidetector CT scan, with saggital and coronal reconstructions	-	-	-	+	-	-	+	-	Spinal stenosis associated with self-reported LBP after adjustment with CT-degenerative features (95% CI: 3.45[1.12-10.68]; p = 0.27).	"This ancillary project to the Framingham Heart Study is the first community-based study of the prevalence of CT-evaluated lumbar spinal degeneration features in an unselected population."	No reported follow-up. Data suggest CT findings of spinal stenosis can be related to LBP and is a correlation between facet OA and decreased muscle density. Difference between "relative stenosis (10-12mm" and "absolute" (<10mm). Differentiates between congenital and acquired stenosis.

MYELOGRAPHY (INCLUDING CT MYELOGRAPHY AND MRI MYELOGRAPHY)

Myelography is the injection of a radiocontrast media into the thecal sac with subsequent imaging. Historically, myelography with standard roentgenograms was the most common method to diagnose herniated discs, spinal stenosis, or other forms of neurological compromise.(347-350) It was subsequently paired with CT (CT myelography) or rarely MRI (MRI myelography). However, it has been almost completely replaced by MRI that produces superior resolution of images. Consequently, there may be little use for myelography,(351) though many spine surgeons use CT myelography to help with surgical decision-making in cases in which MRI is equivocal or not possible.

Recommendation: Myelography in Uncommon Situations

Myelography, including CT myelography, is recommended only in uncommon specific situations (e.g., contraindications for MRI such as implanted metal that preclude MRI, equivocal findings of disc herniation on MRI suspected of being false positives, spinal stenosis, and/or a post-surgical situation that requires myelography). MRI is preferred in most post-operative settings to distinguish, e.g., residual or recurrent disc problems.

Harms – Headache; rare infections or cord compromise; medicalization or worsening of otherwise benign back condition; radiation exposure.

Benefits – Diagnosis of significant neurological impingement that is able to be surgically improved.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**

Level of Confidence – High

Rationale for Recommendation

The primary use of CT myelography today is for those with contraindications for MRI, such as implanted ferrous metal. Quality literature correlating surgical discectomy outcomes with CT myelogram results in cases with equivocal MRIs is sparse. However, MRI may well have false-positives for disc herniation, and CT myelograms may then confirm the "disc" seen on MRI is actually an osteophyte without nerve root compression. CT myelography is still considered by many spine surgeons to be the gold standard test for spinal stenosis. However, there are no recent quality studies to document this belief, rather there are small case series reporting continuing uses in evaluating neurological compromise based on positional changes.(352, 353)

Myelography is substantially invasive compared with other imaging procedures because it involves a lumbar puncture.(354, 355) As such, a post-procedure headache is not uncommon and procedures (e.g., blood patching) are required when headaches are severe. Myelography is costly. It has been almost entirely replaced by MRI and other imaging procedures.(351) Myelography (as well as CT myelography and MRI myelography) is recommended only on a limited basis (see above) and is otherwise not recommended as the first diagnostic study for the diagnosis of lumbar nerve root compromise. Plain CT is not an adequate substitute for most patients meeting the above indications.

Evidence for the Use of Myelography

There are 2 high-(308, 309) and 2 moderate-quality(356, 357) incorporated into this analysis. There is 1 low-quality study in Appendix 1.(358)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: myelography, acute low back pain, subacute low back pain, chronic low back pain, and low back pain to find 1443 articles. Of the 1443 articles, we reviewed 5 articles and included 5 articles (5 epidemiological).

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of Myelography used	CT used	MRI used	X-rays used	More than one Rater	Blinding of rater	Surgery Performed	Clinical Outcomes Assessed	Long-term Follow-up	Results	Conclusion	Comments
Aota 2007 Diagnostic	9.0	117	L	Lumbar spinal stenosis	Magnetic Resonance Myelography (MRM)	-	+	-	+	+	-	-	-	Foraminal narrowing on MRI sensitivity (kappa = 0.671) 96%, Specificity 67%, PPV 4% and NPV 100%. For abnormal course of nerve roots on MRM (kappa = 0.843) corresponding values 96%, 83%, 7%, and 100% respectively. For spinal nerve swelling on MRM (kappa = 0.928), same corresponding values 60%, 99%, 35%, 99%.	"MRM adds additional and more specific information for evaluation of symptomatic foraminal stenosis. MRM is particularly useful in cases of multiple sites or levels of involvement, or in situations of confounding clinical features, especially when equivocal findings from MRI in the foramen or equivocal results of selective nerve injections exist."	Data suggest some potential utility for MR myelography but data not tied to outcomes. Data suggest MRM can be useful in detecting foraminal stenosis. The findings on the 27 volunteers suggest foraminal stenosis is not always the pain generator.
Bischoff 1993 Diagnostic	9.0	57	L	Herniated nucleus puposus (HNP) and spinal atenosis	Myelography and CT-Myelography	+	+	-	-	-	-	-	-	CT scan most sensitive for HNP (77%) and accurate (76%), vs. Myelography most specific (89%) test. MRI and CT equally accurate (85%) and sensitive (87%) for spinal stenosis vs. Myelography more specific (81%).	"It was found in our series of patients that in the diagnosis of HNP and/or spinal stenosis, the trend was that myelo-CT was the most accurate and sensitive test and myelography the most specific in patients who had not undergone previous lumbar surgery."	Data suggest CT more sensitive for HNP than myelography. CT-myelography, myelography, MRI had no statistical difference in SN and SP or accuracy in HNP or spinal stenosis. MRI less potential for adverse events.

Engelhorn 2007 Diagnostic	5.5	20	L	Lumbar spinal stenosis	Flat panel volumetric computed tomography (FPVCT) with conventional lumbar myelography and compared to multislice computed tomography (MSCT).	+	-	-	-	-	-	-	-	Mean dural cross-sectional diameter (D-CSD) for all levels referred to MSCT and FPVCT 9.26±3.06mm and 9.48±2.9mm. Mean dural cross-sectional area (D-CSA) all levels referred to MSCT and FPVCT 63.2+ 10.8mm^2 and 64.7±11.2mm^2. FPVCT vs. MSCT, no difference between D-CSD and D-CSA all disc levels (p >0.89).	"This study shows that FPVCT is equal to MSCT in analysis of lumbar spinal stenosis and degenerative disc disease. Compared with MSCT, FPVCT decreases radiation dose and examination time."	Data suggest some measures of cord compromise not better with myelography vs. CT. Data suggest similar findings with FPUCT and MSCT in analysis of lumbar spinal stenosis and DDD.
Bakhsh 2012 Diagnostic	4.0	80	L	Lumbar spinal stenosis and sciatica	Lumbar Myelography	-	-	+	-	-	-	-	-	Right sciatica in 40 patients (50%) and left sciatica in 29 (36.25%). Myelograms positive in 77% and negative in 22.5% of cases. Each myelogram suggested either lumbar disc herniation or spinal stenosis.	"Myelography is an informative technique in areas where CT and MRI are not available… should be reserved only for those patients who have a strong clinical diagnosis of lumbar disc lesion or spinal stenosis."	Data suggest some potential utility for myelography but data not tied to outcomes. Data suggest x-ray myelogram can show evidence of disk herniation or spinal stenosis, but there were no comparisons made.

BONE SCANS

Bone scans involve intravenous administration of a radioactive tracer medication that is preferentially concentrated in areas of metabolic activity in bone. The radioactivity is then converted into skeletal images. Bone scans show increased radioactive uptake and are most commonly used for evaluating many types of metastases,(359, 360) infection, inflammatory arthropathies, occult fractures,(361-363) or other significant bone trauma.(364)

Recommendation: Bone Scanning for Low Back Pain

Bone scanning is not recommended for routine use in diagnosing low back pain. However, it has select use including for suspected metastases, occult fractures, and infectious complications. May help to distinguish acute versus old fractures.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

Bone scanning is not used for evaluation of most LBP. However, it is a good diagnostic test for specific situations, including evaluations of suspected metastases, infected bone (osteomyelitis), inflammatory arthropathies, and trauma (fractures). Perhaps the most common use of bone scans for evaluating LBP is imaging of sacroiliac joints (one study reported that a combination of a quantitative bone scan and an HLA-B27 measurement were superior to MRI and CT scans for assessing sacroiliitis).(365) Bone scanning is minimally invasive, has no adverse effects aside from radiation exposure, but is costly. The combination of a bone scan and HLA-B27 is occasionally required when attempting to differentiate LBP that is occupational from ankylosing spondylitis, particularly in young males. Aside from specific indications which involve a minority of LBP patients, the routine use of bone scanning is not recommended in LBP patients.

Evidence for the Use of Bone Scanning

There are no quality studies evaluating bone scans for diagnosis of typical occupational LBP patients. Reported sensitivity and specificity were not satisfactory for evaluating chronic LBP patients and the population studied was felt to be too small to develop normative values.(366)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with limits on publication dates from 2008-2013. We used the following terms: bone scans, acute low back pain, subacute low back pain chronic low back pain, diagnostic testing, sensitivity, specificity, positive predictive value, negative predictive value, efficacy, efficiency, and low back pain to find 69,215 articles. Of the 69,125 articles we reviewed zero articles and included zero articles.

SINGLE PROTON EMISSION COMPUTED TOMOGRAPHY (SPECT)

Single proton emission computed tomography (SPECT) is a 3-dimensional imaging technique. For evaluation of LBP issues it has been primarily used for the diagnosis of inflammatory arthropathies, particularly spondyloarthropathies such as ankylosing spondylitic affecting the SI joints and other structures which are difficult to image.(367-374)

Recommendation: SPECT for Low Back Pain and Related Disorders

SPECT is not recommended for the evaluation of patients with low back pain and related disorders.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
There is no quality evidence with patient-related outcomes that SPECT is helpful in improving care of acute, subacute, or chronic LBP, or radicular pain syndromes or other LBP-related conditions. However, one study found SPECT helpful in evaluating patients with inflammatory arthropathies, particularly if there are concerns about the SI joints.(375) Some data suggest SPECT may outperform bone scanning. Additional studies are needed to determine if SPECT adds something to the diagnosis, treatment and outcomes beyond that obtained by a careful history, physical examination, plain x-rays, and clinical impression before it can be recommended for evaluating facet arthropathies.

Evidence for the Use of Single Proton Emission Computed Tomography (SPECT)
There is 1 high-(376) and 4 moderate-quality(377-380) studies incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: Back, SPECT, work, low, pain, diagnostic, acute, subacute, sensitivity, specificity, positive, negative predictive, value, efficiency, efficacy, and chronic to find 263,834 articles. Of the 263,834 articles, we reviewed six articles and included six articles.

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of SPECT	CT used	MRI Used	More than One Rater	Blinding of rater	Myelography	Surgery Performed	Clinical Outcomes Assessed	Long-term Follow-up	Results	Conclusion	Comments
Ryan 1992 Diagnostic	8.0	80	Lumbar and pelvis	LBP between lower ribs and gluteal folds	Bone scintigraphy	+	-	-		-	-	-	-	60% of with abnormalities using SPECT vs. 35% abnormalities using planar imaging. SPECT also found 51% of lesions in vertebral body or in individual parts of posterior neutral arch.	"[I]n a group of patients with chronic back pain who often difficult to manage because of an imprecise or unknown diagnosis many have abnormalities on radionuclide bone scan, reflecting altered metabolic activity, and these mostly do not correspond to a detectable lesion on plain X-ray."	Data suggest SPECT more sensitive, however, data not shown related to outcomes. Study suggest SPECT is superior to planar bone imaging especially in identifying specific facet pathology.
Harisankar 2012 Diagnostic	6.5	30	L4/L5	Chronic LBP	Hybrid with bone scintigraphy	+	+	-	-	-	-	-	-	Significant difference (p = 0.002) between the SPECT (+) and SPECT (-) patients for reduction in functional capacity. No prevalent difference for abnormalities at p = 0.07 for those +SLRT SPECT and 25% having -SLRT.	"[A]ll patients with LBP are likely to have some MRI abnormality. Most of the patients are likely to have MRI abnormalities at multiple sites. Addition of SPECT/CT is invaluable in differentiating significant from incidental non-significant findings on MRI. Increased tracer uptake in the anterior part of the vertebral body with associated osteophytes and or sclerotic changes in CT is the SPECT/CT equivalent of	Data suggest SPECT may have utility, however data not shown to improve outcomes. Study suggests SPECT/CT may find more endplate changes but was less sensitive to facet abnormalities. SPECT/CT may be a useful adjunct to MRI in CLBP patients.

															intervertebral disc degeneration. This pattern has statistically significant agreement with MRI evidence of intervertebral disc degeneration."	
Gunzburg 1994 Diagnostic	6.0	18	L2 to L5-S1	No prior back history and present first episode of acute LBP undergoing MRI, radiography or tomoscintigraphy.	Low-energy parallel collimator with bone scintigraphy	-	+	-	+	-	-	-	-	Not enough data to show a significant correlations between scintigraphic intervertebral disc activity from the control group vs. MRI patients of L2-3, L3-4, L4-5 , and L5-S1.	"[W]e propose using SPECT for the study of the lumbar intervertebral disc and suggest that further investigations will help determine its clinical value."	Small sample size limited conclusions. No past medical history, mechanism of injury provided. Study suggests that SPECT done on young patients in first 72 hours after injury may show abnormalities not seen on lumbar radiographs. Clinical significance unclear as no follow-up or a treatment given.
Bodner 1988 Diagnostic	5.5	15	L3, L4, L5	Mechanical LBP	High resolution collimator with bone scintigraphy	+	+	-	-	-	-	-	-	SPECT confirmed 11 vs. Bone scan had 6, and x-ray had only 3. Four were omitted for normal examinations. SPECT test more sensitive.	"Single photon emission computed tomography images holds great promise for orthopedic application, especially in areas of difficult anatomy such as the spine, pelvis, and small bones of the hands and feet."	Data suggest SPECT superior to bone scanning, however data not shown to improve outcomes.

Pneumaticos 2006 Diagnostic	4.5	47	L	Back pain scheduled for facet joint injections	Bone scintigraphy/ bone scanning	-	-	-	+	-	-	+	-	A1 only group with difference at 1 month ($p < 0.008$). Change in pain scores at 3 months higher in Group A1 ($p < 0.001$) than other two. Group B higher ($p = 0.015$) than A2. No differences at 6 months.	"[B]one scanning with SPECT helps in the identification of patients who would benefit from a facet joint injection."	No placebo. Trial included facet joint abnormalities in 100%, making limited utility for diagnostic purposes or specificity or positive predictive value. Data suggest better short-term response to injection if SPECT positive and used to target injection. No difference at 6 months; suggests no intermediate- or long-term benefits. Had previous imaging done. Data suggest using SPECT scans to identify which facet joint injections can decrease number of facets injected and improve pain reports up to 3 months after injections. No clinical difference reported at 6 months.

ELECTROMYOGRAPHY

Electromyography (EMG) is a physiological test that assesses the function of the motor unit (including the neuron's anterior horn cell, its axon, the neuromuscular junctions, and muscle fibers it supplies).(381, 382) It differs from surface EMG which is discussed below. EMG technically refers to the needle electromyogram and the term "EMG" is usually misused as a euphemism for an electrodiagnostic exam that includes both needle EMG and peripheral nerve conduction testing. Among spine patients, EMG has been used primarily to evaluate radiculopathy.(383)

1. *Recommendation: EMG with Leg Symptoms*
   Electrodiagnostic studies, which must include needle EMG, are recommended where a CT or MRI is equivocal and there is ongoing pain that raise questions about whether there may be a neurological compromise that may be identifiable (i.e., leg symptoms consistent with radiculopathy, spinal stenosis, peripheral neuropathy, etc.). Also, may be helpful for evaluation of chronicity and/or aggravation of a pre-existing problem.

   Indications – Failure to resolve or plateau of suspected radicular pain without resolution after waiting 4 to 6 weeks (to provide for sufficient time to develop EMG abnormalities as well as time for conservative treatment to resolve the problems), equivocal imaging findings such as CT or MRI, and suspicion by history and physical examination that a neurologic condition other than radiculopathy may be present instead of, or in addition to radiculopathy.
   Harms – Medicalization or worsening of otherwise benign back condition; pain; hematoma, or misinterpretation if not done by an appropriately trained person.
   Benefits – Diagnosis of neurological compromise.
   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – High

2. *Recommendation: EMG without Leg Symptoms*
   Electrodiagnostic studies are not recommended for patients with acute, subacute, or chronic back pain who do not have significant leg pain or numbness.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

Rationale for Recommendations

Needle EMG may help determine if radiculopathy and/or spinal stenosis is present and can help address acuity.(384, 2450-2456) EMG requires full knowledge of the anatomy and precise innervation of each muscle to properly perform and interpret the test results. Needle EMG also requires the skills of an experienced physician who can reliably spot abnormal motor potentials and recruitment patterns. Nerve conduction studies are usually normal in radiculopathy (except for motor nerve amplitude loss in muscles innervated by the involved nerve root in more severe radiculopathy and H-wave studies for unilateral S1 radiculopathy). Nerve conduction studies rule out other causes for lower limb symptoms (generalized peripheral neuropathy, peroneal compression neuropathy at the proximal fibular, etc.) that can mimic sciatica.

An abnormal EMG that persists after anatomic resorption of the herniation and that correlates with the patient's symptoms is generally considered proof the symptoms are due to radiculopathy. Thus, the EMG study documents that management for chronic neuropathic pain appears appropriate.

As imaging studies (especially CT and MRI) have progressed, the need for EMG has declined. However, EMG remains helpful in certain situations. These include ongoing pain suspected to be of neurological origin, but without clear neurological compromise on imaging study. EMG can then be

used to attempt to rule in/out a physiologically important neurological compromise. An abnormal study confirming radiculopathy permits a diagnosis of neuropathic pain (helping with pain management decisions). This test should not be performed in the first month unless there is a desire to document pre-existing neurological compromise, as it requires time (generally at least 3 weeks) to develop the needle EMG abnormalities. EMG is minimally invasive, and has no long-term adverse effects (although it is somewhat painful), and it is costly. To result in reliable measures, it must be performed by a practitioner well skilled in the appropriate anatomy and testing procedures. Post-operative changes may persist in normal individuals without clinical significance, thus also requiring careful interpretation.

Evidence for the Use of Electromyography

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with limits on publication dates from 2011-2012 and then an updated search was conducted using PubMed for publications between 1/1/2013 and 11/15/2017. We used the following search terms: electromyography, EMG, surface EMG, intramuscular EMG, acute low back pain, subacute low back pain, chronic low back pain, diagnostic testing, sensitivity, specificity, positive predictive value, negative predictive value, efficacy, efficiency, and low back pain to find 10,054 articles. Of the 10,054 articles, we reviewed and included 7 articles (7 randomized controlled trials and 0 systematic reviews).

Evidence for the Use of Electromyography

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Diagnoses:	Comparison:	Results:	Conclusion:	Comments:
Chiodo 2007 (score=7.5)	Needle EMG	Diagnostic	Sponsored by the Unites States of Health and Human services, national institutes of health under Grant No. 5 R01 NS41855-02. No mention of COI.	N=32 patients with spinal stenosis.	Mean age: 65 years; no mention sex.	Lumbar Spinal stenosis	Non-contrast lumbosacral spinal MR imaging (Performed by neuroradiologist, masked from patients clinical status.) vs. Electrodiagnostic testing (performed by a electro diagnostic specialist which tested five limbs muscles using a Nicolet Viking II (50-75-mm monopolar needle))	Disk Herniation: VAS pain (0.00 cm, 0.0SD), Pain Disability Index (0.80, 1.79SD), Quebec Back Pain Disability Scale (1.40, 3.13SD), and McGill Pain Scale (0.0, 0.0SD), were not statistically different than the other asymptomatic subjects ($p > .3$ all cases) Vs. Spinal stenosis: VAS pain (0.22 cm, 0.58SD), Pain Disability Index (0.69, 2.09SD), Quebec Back Pain Disability Scale (3.00, 9.00SD), and McGill Pain Scale (3.94, 10.26SD), all not statistically different than radiologist normal subjects ($p > .15$, all cases)	" MRI changes, motor unit changes on EMG needle examination, and low paraspinal mapping scores are not uncommon in asymptomatic older adults with spinal stenosis or disk herniation and may lead to false positive tests."	Data suggest EMG has greater specificity than MRI (less false positives) in older asymptomatic patients.
Haig 2005 (score=7.0)	Needle EMG & Back	Diagnostic	Sponsored by United States	N= 150 patients with	Age range from 55-80	Lumbar spinal stenosis	All patients received history and physical	Compared back pain vs asymptomatic groups	"This first masked study in the 60-year	Data suggest EMG is highly

			Department of Health and Human Services, National Institutes of Health under Grant No. 5 R01 NS41855-02. No mention of COI.	spinal stenosis.	years. No mean age, or sex mention.		examination, MRI, and paraspinal mapping EMG. Stenosis vs. Back pain (n=36), Stenosis vs. Asymptomatic (n=36), Stenosis vs. Back pain and Asymptomatic (n=48).	(each, $P <$ 0.04), Paraspinal mapping EMG score of >4 had 100% specificity and 30% sensitivity for stenosis. Electrodiagnostic testing results of any abnormality: stenosis abnormal n=24) vs back pai abnormal (n=12) sensitivity and specificity score: 19 (79.2%), 6 (50.0%) (in that order).	history of needle electromyography also introduces anatomically validated needle placement, quantified and reproducible examination of the paraspinal muscles."	specific and marginally sensitive in diagnosing spinal stenosis in comparison with low back pain or asymptomatic parsons.
Yagci 2009 (score=6.5)	Needle EMG and Back	Diagnostic	No mention of sponsorship or COI.	N= 60 patients with spinal stenosis.	Mean age= 55.5 years; No mention of patients sex.	Lumbar spinal stenosis	Clinical and radiologic lumbar spinal stenosis (CR-LSS)(n=28): patients had typical spinal stenosis symptomatology and also radiologic findings. Vs. Radiologic lumbar spinal stenosis (R-LSS) (n=16): patients who had radiologic spinal stenosis without any symptoms. Vs. Control group (n=16): patients who had mechanical low-back pain as a result of various etiologies but	Right PSM score CR-LSS: 18.71 ± 11.06 (range, 0–38) , R-LSS: 0.00 ± 0.00, Control:2.31 ± 3.28 (range, 0–9) P= 0.00, Post HOC : CR-LSS- RLSS: P = 0.00; CR-LSS-C: P=0.00 Left PSM score CR-LSS:15.11 ± 12.06 (range, 0–45) , R-LSS 0.19 ± 0.75 (range, 0–3) , Control: 0.63 ± 1.75 (range, 0–6) 23.13 0.00 CR-LSS-RLSS: P = 0.00; Post Hoc	"Paraspinal mapping technique is a sensitive method in the diagnosis of lumbar spinal stenosis and reflects physiology of nerve roots better than the limb electromyography."	Data suggest paraspinal mapping is sensitive for detecting spinal stenosis.

							Without any radiologic finding of spinal stenosis.	CR-LSS-C: *P* = 0.00 Total PSM score CR-LSS:33.64 ± 21.17 (range, 0–81), R-LSS: 0.44 ± 1.21 (range, 0–3), Control: 2.94 ± 3.28 (range, 0–9), P=0.00 Post HOC: CR-LSS-RLSS: *P* = 0.00; CR-LSS-C: *P* = 0.00		
Hasankhani 2013 (score=6.0)	Needle EMG & Back	Diagnostic	No mention of sponsorship. No COI.	N=152 patients with sciatica with back pain	Mean age= 43±5.8; 96 males, 56 females.	Radicular Low back pain	All the patients' went through a comprehensive history and physical examination, received a lumbosacral X-ray, MRI scanning, and Electro diagnostic study (including EMG and NCV). Comparing diagnostic sensitivity of MRI and electrodiagnosis.	There was 67 cases (44.1%) with radicular pain in left lower limb, 46 (30.3%) in right, and 36 (25.6%) in both lower limbs. Abnormal finding results: 104 cases (68.4%) abnormalities in both MRI and electro diagnostic, 30 (19.7%) shown abnormality only in MRI, 21 (13.8%) only in electrodiagnosis, while 10 cases (6.5%) had both normal MRI and electrodiagnostic studies.	"In MRI negative but symptomatic subjects, electrodiagnosis has an important diagnostic value."	Data suggest EMG superior to MRI for diagnosing lower extremity radicular pain.
Coster 2010 (score=5.5)	Needle EMG & Back	Diagnostic	No mention of sponsorship or COI.	N= 202 patients with lumbosacral radicular syndrome (LSRS)	Mean age= 46 years; 92 males, 110 females.	Lumbosacral Radiculopathy	Needle EMG performed by a neurophysiologist. Vs. MRI performed with a standardized	MRI results: 95 patients (47%) had radiological nerve root compression, 85 (42%) were	"[F]or clinicians in daily practice, dermatomal radiation, more pain on coughing, sneezing or straining	Data suggest EMG may be useful in determining nerve root compressi

							lumbar spin protocol (sagittal and transverse T1 and T2 weighted sequences with 4 mm slice thickness)	monoradicular injuries. EMG results: 57 patients (28%) had ongoing denervation, 31 patients (15%) had only reinnervation suggestive of chronic root dysfunction or past root involvement. 42 patients (21%) had both radiological nerve root compression and ongoing denervation on EMG and 92 patients (46%) had no radiological nerve root compression or ongoing denervation.	and positive straight leg raising are of diagnostic value in the clinical evaluation of LSRS."	on especially in patients with suspicious of LSRS and a negative MRI.
Tong 2012 (score=5.5)	Needle EMG & Back	Diagnostic	No mention of sponsorship or COI.	N=78 patients with radiating low back pain.	Mean age=66.9 years; 28 males, 50 females.	Low back pain	3 diagnostic criteria was used to identified whether the electromyography came out positive or negative: MiniPm vs. PorFib changes vs. PorFib or, 30% MUAP changes PorFib, _30% MUAP changes, or MiniPM.	Positive for radiculopathy scores vs specificity in Asmptomatic: MiniPM (n=16/48) (33.3), (n=24/30) (80) *t*=.21 PorFib changes (n=13/48) (27.1), (n=30/30) (100) *t*=.001 PorFib or ≥ 30% MUAP changes (n=22/48) (45.8), (n=26/30) (87) *t*=.008 PorFib, ≥ 30% MUAP changes, or MiniPM (n=24/48) (50), (n=24/30) (80) .t=003	"In addition to the presence of positive sharp waves or fibrillations, considering greater than or equal to 30% motor unit action unit potential changes as well as the MiniPM score maintains good specificity and improves the ability of the needle electromyography study to detect lumbar radiculopathy in subjects with radiating low back pain."	Data suggest mini PM score maintains fair specificity and improves EMG study to detect lumbar radiculopathy in patients with radiating low back pain.

Kuittinen 2014 (score=5.5)	Needle EMG & Back	Diagnostic	Sponsored by Finnish Cultural Foundation. No mention of COI.	N=14 patients with lateral lumbar spinal canal stenosis.	Mean age=58 years; 6 males, 8 females.	Lateral lumbar spinal canal stenosis	Mr imaging of lumbar spine performed by a 1.5 T imager and a dedicated receive-only spine coil. Vs. Lumbar paraspinal and lower limb needle EMG (pre-operatively recorded by a neurophysiologist who was blinded to the radiological data and clinical assessment) using a monopolar needle electro (Medtronic, 50x0.04 mm)	Abnormal EMG findings had higher scores in the VAS (41.9 ± 25.7 vs 31.5 ± 18.1; p = 0.018), VAS leg pain (7.5 ± 1.5 vs 6.3 ± 2.1; p = 0.000) and BDI (9.8 ± 3.8 vs 8.0 ± 3.9; p = 0.014) EMG results were normal in 92 (66%) roots and abnormal in 48 (34%) roots.	"Among persons previously selected for surgery, lateral stenosis seen on MRI correlates with EMG, and thus may be a clinically significant finding."	Data suggest lateral stenosis seen on MRI correlates with EMG.

SURFACE ELECTROMYOGRAPHY

Surface electromyography (sEMG) has been used to diagnose LBP(385-401) and involves the recording of summated muscle electrical activity by skin electrodes (such as those used in an electrocardiogram or EKG). Unlike traditional needle EMG (see above), no needle is used to explore specific portions of specific muscles for motor unit potentials.

Surface EMG has also been used for many neuropathies, myopathies, myotonic dystrophy, Duchenne muscular dystrophy, Becker muscular dystrophy, spinal muscular atrophy, hereditary motor and sensory neuropathy, amyotrophic lateral sclerosis, McArdle's disease, postpoliomyelitis, familial hypokalemic periodic paralysis, limb girdle dystrophy, Steinert disease, and Charcot-Marie-Tooth.(402-418) These disorders are beyond the scope of this guideline.

Recommendation: Surface EMG for Diagnosing Low Back Pain

Surface EMG is not recommended to diagnose low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**

Level of Confidence – High

Rationale for Recommendation

There are no quality studies demonstrating that the use of surface EMG results in improved diagnosis or evaluation of patients with LBP. Available studies have methodological weaknesses, including poor descriptions of patients, small sample sizes, types of machine, electrode placement, and analysis of the output making outcomes difficult to compare across studies.(385, 392, 396, 400, 419)

Surface EMG primarily measures the muscle activity of the nearest muscle group and over a wide geographic area rather than measuring deep and/or individual muscles,(409, 420) although some

research suggests it may be possible to obtain measurements from deeper muscles.(421) Surface EMG is highly sensitive to the placement of the electrode, as well as quite sensitive to changes in posture. Thus it is technically demanding to obtain valid and reliable data. Common uses of sEMG are in research laboratory studies (e.g., physiology, kinesiology, gait analysis, ergonomics) and small scale-ergonomics studies in employment settings. Research studies of sEMG have suggested some differences between normal and chronic LBP patients and in pre- and post-intervention populations.(385, 386, 389, 393-396, 400, 401) A meaningful application to the clinical setting resulting in improved outcomes is not as clear.

The American Association of Neuromuscular and Electrodiagnostic Medicine's position is that there are no clinical indications for the use of sEMG in the diagnosis and treatment of disorders of nerve and muscle, although potential future uses are possible.(405, 422) Surface EMG is not invasive, has few adverse events, is moderately costly, but has a lack of quality evidence of benefits for the clinical evaluation or treatment of back disorders and thus is not recommended.

Evidence for the Use of Surface Electromyography
There are 4 moderate-quality studies incorporated into this analysis.(400, 423-425) There are 2 low-quality studies(385, 426) and 19 other studies in Appendix 1.(398, 402-404, 406, 408, 410, 412-416, 419, 427-432)
We searched PubMed, EBSCO, and Cochrane Review without limits on publication dates. We used the following search terms: Surface Electromyography, low back pain, Diagnostic, Sensitivity, Post-operative to find 170 articles. Of the 170 articles we reviewed 28 articles and included 24 articles.

Author/Year Study Type	Score	N	Area of Body	Surface EMG (Type)	Needle EMG used for comparison	MRI	CT	X-ray	More than one rater	More than one muscle group tested	Surgery Performed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Sihvonen 1991 Diagnostic	6.0	112	L	Averaged electric activity (RMS, EMG)	+	-	-	+	-	-	+	No	There was only a partial decrease of EMG activity after flexion in back pain patients with current pain…The ratio of mean reached at maximal activity level during extension and flexion was less in patients (1.8, SD = 0.5, p <0.001) than able-bodied controls (3.2, SD = 0.8).	"We believe that it (EMG) is an invaluable aid in detecting and objectifying disturbed function in paraspinal muscles in back pain patients and in general disability."	Surface EMG readings from right side of lumbar spine only. Data suggest ratio of EMG activity during extension and flexion to be more sensitive in detecting abnormalities than flexion relaxation phenomenon. Data suggest that absence of flexion relaxation in the lumbar paraspinal muscles correlate well with current LBP.
Ramprasad 2010 Cross sectional Study	4.5	50	Rectus Abdominis, Lumbar Erector Spinae	Neurocare TM-advanced 2000 Surface EMG	-	-	-	-	+	+	-	No	Results showed significantly different mean PPR (preprogrammed reactions) and voluntary response RMS amplitudes in LBP group vs. controls for rectus abdominus and erector spinae muscles (p <0.05). Kappa agreement ranged from 0.7 to 1.	"LBP group exhibited poor modulation of highly flexible preprogrammed reactions during perturbation tasks compared to asymptomatic population. A disproportional increase in EMG amplitudes of voluntary responses of global trunk muscles to perturbation was associated with poor PPR modulation in the CLBP group compared to asymptomatic participants."	Data suggest potential deconditioning in LBP group. Low back patients were older than controls. Data suggest a difference in muscle activation in patients with low back pain compared to controls.
McNeill 1977 Diagnostic	4.0	110	Lumbar spine	None	*	-	-	+	-	+	+	Yes	Percent agreement at L-3 level was 94.3% with a correlation coefficient of +0.7. At L-4 it was 71% and +0.43. At L-5 it was 63% and +0.34. The EMG	"This study shows that an electromyographic study three months postchemonucleolysis is of value for corroboration of clinical	No surface EMG used. Lack of baseline data. Data suggest needle EMG may help determine recovery after chemonucleolysis if

													improved from grade 3 or 4 to grade 1 in 20 cases. Of these, 85% improved clinically (p = 0.005 by chi square test comparing clinical end result in those with improved EMG results with those still rated in grade 3 or 4).	improvement only if the EMG becomes completely normal."	completely normal after procedure. Data suggest if EMG was abnormal before chemonucleolysis and completely normal after. It can be useful in corroboration of clinical improvement.
Butler 2013 Prospective comparative study	4.0	87	L and Abdomen	Surface EMG	-	-	-	-	-	+	-	No	Performance similar between the two groups, but significant difference in neuromuscular recruitment patterns in the LBI group compared to the control group (p <0.05)	"Despite outcomes indicating recovery, the LBI group had altered neuromuscular patterns compared to asymptomatic controls supporting that residual alterations remain following recovery."	Primarily women participants. Low back patients had 12 weeks of post injury time to recover. Patients with LB pain were older and heavier. The low back injury patients were recruited from PT offices, while asymptomatics were not. The differences in muscle use could be due to therapy. Data suggest there are differences in muscle activation in patients with low back pain when lifting.

* = only needle EMG used in this study
‡ = needle EMG only done on a portion of the participants

ULTRASOUND (DIAGNOSTIC)

There are two uses for ultrasound technology – one is therapeutic and is discussed in the heat therapies section, and the other is for diagnostic purposes. Ultrasound projects high-frequency sound waves through tissue and records the echoes through a 2-dimensional imaging system. Ultrasound is seldom used for diagnostic purposes in the spine other than for unusual specific purposes such as detection and guided drainage of superficial abscesses.(433-439)

Recommendation: Ultrasound for Diagnosing Low Back Pain

Diagnostic ultrasound is not recommended for diagnosing low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

Ultrasound has not been shown to result in improved patient outcomes or diagnoses other than minor applications. Ultrasound has been used to train patients to preferentially activate their transverse abdominis muscle.(440) However, altered long-term outcomes in a sizable patient population have not been shown. Ultrasound is not invasive, does not have adverse effects, and is moderately costly. There are other imaging techniques which are currently shown to be useful for diagnosis in patients with LBP. For most imaging purposes, CT and MRI are superior.

Evidence for the Use of Ultrasound

There is 1 high-(435) and 1 moderate-quality(441) study incorporated into this analysis. There is 1 low-quality study in Appendix 1.(442)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: Back, ultrasound, work, low, pain, diagnostic, acute, subacute, sensitivity, specificity, positive, negative predictive, value, efficiency, efficacy, and chronic to find 1,383,441 articles. Of the 1,383,441 articles, we reviewed one article, found an additional four articles from the reference list and included three articles.

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of Ultrasound	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical Outcomes Assessed	Long-term Follow-up	Results	Conclusion	Comments
Klauser 2005 Diagnostic	10.5	103	L	Patients with inflammatory LBP	Color Doppler ultrasound (CDUS)	-	+	-	+	-	-	-	-	Unenhanced CDUS MRI: sensitivity of 17%, specificity of 96%, PPV 65%, NPV of 72%. Contrast-enhanced CDUS: sensitivity of 94%, specificity of 86%, PPV of 78%, and a NPV of 97%.	"Microbubble contrast-enhanced CDUS is a sensitive technique with a high NPV for detection of active sacroiliitis compared with MRI."	Baseline characteristics not well described. Chronic LBP patients. Study suggests contrast-enhanced ultrasound is a highly sensitive and specific test for sacroiliitis in chronic back pain consistent with SI joint pain.
Pulkovski 2012 Diagnostic	4.0	100	L	No LBP history and patients with persistent LBP at least 3 month	Linear array transducer	-	-	+	+	-	-	+	-	Patients with chronic LBP had significantly lower TrA ratio when compared to control group of healthy patients at p = 0.005. ROC analysis showed non-significant results when comparing TrA-CR to chronic LBP patients and control patients individually at 0.60 [95% CI 0.495; 0.695], p = 0.08.	"[T]he TrA-CR during abdominal hollowing does not distinguish well between patients with chronic low back pain and healthy controls."	Study suggests no significant difference was found by U.S. of TA muscles between patients with chronic low back pain and controls.

THERMOGRAPHY

Thermography is a diagnostic test that has been used to assess LBP and radicular pain syndromes and other conditions.(443) This involves measuring skin surface temperature through infrared scanning. For the purposes of spinal assessments, these measurements involve particular attention to the lower extremities and over the lower spine.

Recommendation: Thermography for Diagnosing Acute, Subacute, or Chronic Low Back Pain or Radicular Pain

Thermography is not recommended for diagnosing acute, subacute, or chronic low back pain, or radicular pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation

There are no studies documenting meaningful impacts of thermography on improving outcomes of LBP patients. Studies have inferred that there are differences in thermal imaging, and thus blood supply, among patients with LBP, lumbar radicular syndromes, and sacroiliitis. There are both positive(444) and negative studies(445, 446) for asymmetry for LBP. Studies have been positive for lumbar radicular syndromes,(447, 448) while others have been negative(447, 449, 450) including one moderate-quality study that evaluated 55 lumbosacral radiculopathy patients and 37 controls with 5 blinded readers interpreting thermograms and calculated a positive predictive value of thermography for the diagnosis of radiculopathy at less than 50%, concluding that "thermography has little or no utility in the diagnosis of lumbosacral radiculopathy."(451) Studies have also failed to find associations with tender points.(452) Other diagnostic tests have been shown to be effective in the evaluation of acute, subacute, and chronic LBP. The added expense of thermography has not been shown to positively influence patient management. As it is not specific for musculoskeletal disorders, it has been shown to have poor specificity for LBP and back-related conditions. It is not invasive, has little potential for adverse effects, but is costly. Thus, there is no convincing evidence that thermography is an effective test for assessing LBP.

Evidence for the Use of Thermography

There are no quality studies regarding the use of thermography. There are 2 low-quality studies in Appendix 1.(444, 453)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: Back, thermography, work, low, pain, diagnostic, acute, subacute, sensitivity, specificity, positive, negative predictive, value, efficiency, efficacy, and chronic to find 74,025 articles. Of the 74,025 articles, we reviewed two articles and included two articles.

FLUOROSCOPY

Fluoroscopy is live (real-time) x-ray imaging which can define abnormalities that may be visualized on movement, but that are not apparent on static films. It has been used for evaluation of LBP.

Recommendation: Fluoroscopy for Evaluating Acute, Subacute, or Chronic Low Back Pain

Fluoroscopy is not recommended for evaluating acute, subacute, or chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
The main use for fluoroscopy is to guide procedures (e.g., facet injections, radiofrequency procedures, etc.) that are discussed individually elsewhere. While this test was previously used to image the spine, it has been largely supplanted by other studies. Because continual x-ray exposure is needed to obtain the images, exposure to radiation is far higher with this procedure than with static x-rays. Fluoroscopy is not invasive, has low risk of adverse effects, but is costly and involves considerable radiation exposure. There are no evidence-based indications for fluoroscopy outside of its use in the performance of specific diagnostic tests or procedures and other infrequent indications.

Evidence for the Use of Fluoroscopy
There are no recent quality studies of the value of fluoroscopy in the evaluation of LBP or radicular pain syndromes or other back-related conditions.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: fluoroscopy, sensitivity, specificity, acute low back pain, subacute low back pain, chronic low back pain, and low back pain to find 3,299 articles. Of the 3,299 articles, we reviewed 1 article and included zero articles.

VIDEOFLUOROSCOPY
Videofluoroscopy involves recording a videotape of fluoroscopic images of the spine that has been used for diagnostic purposes. Videofluoroscopy has been used for evaluation of LBP, particularly searching for possible spinal instability. After evidence interpreted as consistent with instability is found, surgery is typically proposed. A dynamic spinal motional analysis system for videofluoroscopy has been developed to reduce the tedious and time-consuming aspects of videofluoroscopy.(454)

Recommendation: Videofluoroscopy for the Assessment of Acute, Subacute, or Chronic Low Back Pain
Videofluoroscopy is not recommended for the assessment of acute, subacute, or chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no studies demonstrating improved clinical outcomes attributable to videofluoroscopy. There are no validated criteria for the utilization of videofluoroscopy to evaluate lumbar spine conditions. Other diagnostic tests have been shown to be effective in the evaluation of acute, subacute, and chronic LBP. One pilot study of videofluoroscopy suggested some differences between young healthy individuals and older individuals with spondylolisthesis.(455) However, there was no difference between young individuals and those with chronic LBP. Thus, as this study contains uncontrolled confounders, there are no quality studies evaluating videofluoroscopy for the evaluation of acute, subacute, or chronic LBP or radicular pain syndromes. The added expense of videofluoroscopy has not been shown to positively influence patient management. It is not invasive, has little potential for adverse effects, but is costly. It involves considerable radiation exposure. The clinical relevance of instability demonstrated via videofluoroscopy has not been established.

Evidence for Use of Videofluoroscopy
There are no quality studies regarding the use of videofluoroscopy. There are 2 low-quality studies in Appendix 1.(454, 456)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: videofluoroscopy, diagnostic, sensitivity, specificity, predictive value, efficiency, efficacy, acute low back pain, subacute low back pain, chronic low back pain, and low back pain to find 128 articles. Of the 128 articles, we reviewed 3 articles and included two articles (1 prospective case-series, 1 prospective case-control).

LUMBAR DISCOGRAPHY

Discography attempts to determine if chronic spinal pain is caused by disc pathology. Discography is usually used in patients with chronic spinal pain without significant leg pain, as MRI and/or CT provide adequate anatomic information for surgical decisions on decompressive surgery for patients with significant radiculopathy. Discography involves a needle that is inserted into the middle (nucleus) of a disc and x-ray dye is injected. Images are then made, usually both by plain x-ray and by computed tomography (CT).(457-462) Images are able to classify a disc as normal or as having varying degrees of degeneration.(463) Positive test results involve reproduction and/or augmentation of the patient's pain with the injection. This procedure is fairly painful and sedation is required.(459, 461, 464-466) The procedure has been variously modified to include injection of anesthetics sometimes followed by provocative physical activity such as lifting(467-469) and pressure measurements to attempt to improve its operant characteristics. Few quality studies have evaluated these modified procedures.

Recommendation: Discography for Assessing Acute, Subacute, or Chronic Low Back Pain or Radicular Pain Syndromes

Discography, either performed as a solitary test or when paired with imaging (e.g., MRI), is strongly not recommended for acute, subacute, or chronic low back pain or radicular pain syndromes.

Strength of Evidence – **Strongly Not Recommended, Evidence (A)**
Level of Confidence – High

Rationale for Recommendation

This test relies on a theory that discs with more severe degrees of degeneration are more likely to be painful on discography.(458, 461, 470) The test analyzes the pain responses of the sedated patient. If a patient does not experience pain on injection, that disc is considered as unlikely to be the source of chronic spinal pain.(459, 461) If a patient experiences pain that is mild or that is clearly different in location or character to his or her chronic pain, that disc is considered as unlikely to be the source of chronic spinal pain. However, if the patient experiences significant pain that is identical in location and character to the patient's chronic pain ("concordant pain"), proponents believe that discography has identified the pain-generating structure responsible for chronic spinal pain.(458, 461, 462, 470-473) It also follows that changes on MRI (e.g., Modic changes) should be more severe in those with positive discography, however, that has not been shown.(474)

Due in part to recognition that discography is not a highly accurate test in the lumbar, thoracic, or cervical spine,(464, 475-478) attempts have been made to modify the test to attempt to increase its accuracy, including measurement of pressures where pain occurs,(460, 470, 472) as well as injection of anesthetics.(461, 479, 480) Some studies have added measurement of the injection pressure (pressure in the disc at the time of pain production) as a test criterion. Those discs with pain provoked at less than 15 psi have been categorized as chemically sensitive, 15 to 50 psi are mechanically sensitive, and those over 50 psi are classified as not clinically significant.(481) Chemical sensitivity supposedly suggests the disc is degenerate, but not necessarily the pain-generating structure. High injection pressures may produce pain even in radiographically normal discs. Thus, concordant pain response at

injection pressures of 15 to 25 psi has been sought as a criterion for determining the disc to be the pain-generating structure.

The technique of discography is not standardized. There is no validated definition of what constitutes a concordant painful response. There are no published intra-rater or inter-rater reliability studies on discography. The discussion of discography is important to the subsequent discussion of IDET, spinal fusion for "degenerative disc disease," and artificial disc replacement, as many North American (but not European) surgeons continue to use discography results in surgical planning.(477) If discography can accurately identify a disc as the pain-generating structure, then surgical procedures on that disc should lead to patient improvement.(472, 482) If discography can produce pain, but cannot accurately identify that disc as the pain generating structure, then surgery on that disc is presumably unlikely to be helpful.(464, 475, 477)

Discography has been evaluated in quality studies (see also Cervical and Thoracic Spine Disorders Guideline). The highest quality study with at least 50 subjects suggests the test is unhelpful for evaluation of spine patients.(483) Currently, the estimated positive predictive value appears to be at or below 50%, which means the test is not helpful.(484) These studies have failed to find that discography reliably indicates what particular disc is the source of the patient's pain. Validity of those findings through improved operative successes is not present.(485) There are a number of studies comparing lumbar discography to other imaging studies such as MRI and CT myelography. These studies can describe how likely a given finding on imaging is to be associated with pain on injection, but cannot determine whether the pain response is a true-positive or a false-positive response. Thus, these studies are not capable of guiding surgical therapy. Studies on imaging have shown that most imaging findings do not correlate with an individual's pain status.(486) There are a number of studies that have assessed the rate of positive or painful responses in individuals without back pain. If the asymptomatic population has a high rate of painful responses to disc injection, a similar pain response (and the inevitable age-related degeneration on imaging studies) can easily be interpreted as a positive discogram (false-positive). Since these were experimental subjects who did not have back pain, the pain could not be concordant with pain they did not have; however, the intensity of the pain response is such that it could easily be misinterpreted as a painful response (false-positive).

Discography is invasive and has adverse effects. The 0.1 to 0.2% rate of discitis (disc space infection) is low.(487, 488) Temporary complications include headache, nausea, and worsened back pain. Uncommon, but serious reported complications include meningitis, epidural abscess, arachnoiditis, intrathecal hematoma, intradural injection of contrast, retroperitoneal hematoma, cauda equina syndrome, and acute disc herniation.(459, 475, 480, 489-491) Some literature reporting longitudinal evaluations after discography of normal (or "control") discs suggests discography results in more rapid disc degeneration and an increased incidence of disc herniation.(492, 493) Discography requires that one or two normal discs be injected and be painless on injection, so that the disc that is painful during injection can be identified. If discography iatrogenically damages the normal control discs, and does not lead to improved treatment outcomes, then there is evidence that discography should not be performed. Discography results in a patient exposure to radiation of 1.5 to 4.0 rads.(256, 494) Discography is also costly and has not been found to provide information that has sufficient positive or negative predictive value to warrant its addition to the clinical examination or other testing currently under use. It is not currently recommended, although there are potential modifications to the procedure being further studied.

Evidence for the Use of Lumbar Discography
There are 2 high-(494-496) and 22 moderate-quality(83, 297, 467, 483, 484, 486, 497-512) studies incorporated into this analysis. A recent systematic review did not find high-quality evidence to support cervical discography and did not find studies that show discography could improve clinical outcomes in patients considering cervical surgery.(513)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar for articles published from 2008-present. We used the following search terms: lumbar discography, low back pain and diagnostic sensitivity to find 3,110 articles. Of the 3,110 articles, we reviewed 24 articles and included 21 article.

Author/Year/Study Type	Score	N	Area of Spine	Diagnoses	Injected Medications	Intradiscal Local Anesthetic	Sedation Used	Fluoroscopy/imaging	Pressure Readings	MRI	CT	CT Myelography	X-ray	More than one rater	More than one level	Surgery Performed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Jackson 1989 Diagnostic	9.0	124	L	Chronic pain patients who underwent surgical exploration	Contrast	-	-	+	-	-	+	+	-	+	+	+	No	Discography Sn- 81%, Sp- 31%. CT-discography: Sn- 92%, Sp- 81%. Disc Injection: Sn- 43%, Sp- 89%.	"Disco-CT is the most accurate, sensitive, and specific of these radiographic test. It has the lowest false positive and false negative rates. More importantly, it provides a higher level of confidence and fewer equivocal results than myelography and CT."	Study of herniated discs. Discography less accurate than CT, CT myelography, and myelography. CT-discography suggested to be accurate, especially in patients with possible foraminal or recurrent herniated discs. No functional outcomes data. Data suggest a combination of discography and lumbar CT had lowest false positive rates. They continued to report side effects of myelography and discography.
Jackson 1989 Diagnostic	9.0	59	L	Chronic LBP who underwent testing and then surgical exploration						+	+	+		+	+	+	-	MRI: Sn- 64%, Sp- 87% CT Sn- 60%, Sp- 86% CT-Myelography: Sn- 73%, Sp- 79% Myelography: Sn- 56%, Sp- 86%	"MRI compares very favorably with each of these established neuroradio-graphic imaging technique and has several attractive features. It is noninvasive, exposes the	Study of herniated discs. MRI compared well to other diagnostic modalities in study. Suggested to be a good choice for imaging when considering more invasive treatment for herniated lumbar discs. Data suggest MRI of lumbar spine to be sensitive and

																			patient to no ionizing radiation, and produces images that are of high quality. For these reasons, we feel it to be the procedure of choice in the diagnosis of most lumbar disc herniations."	specific in detection of disc herniations.
Walsh 1990 Diagnostic	7.5	17	L	7 with LBP, 10 asymptomatic	Contrast	-	+	+	+	-	-	-	+	-	+	-	No	False positive rate: 0%. Sp-100%.	"The single most important finding of this study was the 0% false-positive rate for discography when both an abnormal image and substantial pain were considered criteria for a positive test."	Very small sample sizes precludes strong conclusions. Discography revealed abnormal in 65% of discs in symptomatic group in all 7 patients. IV valium given during discography.
Carragee 2004 Diagnostic	7.5	50	L	Asymptomatic cases and controls	Contrast	-	+	+	+	+	-	-	+	-	+	-	4 years	Psychometric scores at start of study predicted future LBP (p <.01) Chronic non-lumbar pain weakly associated with future LBP (p = 0.06). Painful disc injection did not predict future LBP.	"Discography, using modern techniques, does not appear to represent a significant risk of precipitating clinical back pain problems in subjects without serious psychological issues."	Data suggest patients with history of somatization distress and non-lumbar chronic pain be carefully screened when considering invasive procedures. Data suggest painful discography does not correlate well with future LBP. Psychological distress and chronic pain are predictive of future low back pain.
Birney 1992	7.0	90	L	Incapacitating LBP or radicular pain; 20	Contrast	-	-	+	?	+	-	-	-	+	+	+^	No	MRI degeneration: Sn- 93%, Sp-100%. MRI	"This study confirms the essential equivalence of	No clinical outcome data presented to evaluate if either test selected patients with

Diagnostic				had prior surgery at one or more investigated levels.														herniation: Sn- 100% Sp- 93%. Discography degeneration: Sn- 100% Sp- 100%. Discography herniation: Sn- 88% Sp- 100%.	discography and MRI in the detection of both herniation and degeneration in lumbar degenerative disc disease."	better outcomes after surgery. MRI appears helpful for assessing disc degeneration and herniation. LBP and radicular pain. 57 had surgery. Data suggest MRI more sensitive in diagnosing disc herniations confirmed by surgery.
Ito 1998 Diagnostic	7.0	39	L	Chronic LBP failed conservative measures	Contrast	-	-	+	-	+	+	-	-	+	+	-	No	23% concordant pain with discography, 33% non-concordant pain, 45% no pain with discography. Detecting concordant pain reproduction on MRI: Radial tears, Sn- 87% Sp-66%. Degeneration: Sn- 9%, Sp- 100%. Concentric and transverse tears: Sn- 52%, Sp- 80%. Disruption of outermost annulus: Sn- 35%, Sp- 90%.	"The findings of the current study show that radial tears commonly are found on MRI and have a low correlation with concordant pain reproduction."	Results included many degenerated discs seen on T2 MRI without pain reproduction on discography. Data suggest high-intensity zones seen on MRI correlated with discs with concordant pain, especially discs with outermost annulus disruption. However, used discography as "gold standard" for specificity/sensitivity analyses.
Derby 2005a	6.5	86 (279 discs)	L	Rate of annular disruption measured by CT diskography.	+	+	?	+	+	-	+	-	-	+	+	-	-	Number of discs at each annular disruption grade: 19 at grade 0, 29 at grade 1, 35 at grade 2, 42 at grade 3, 69 at grade 4, 85 at grade 5. 93 of 279 discs met	"Annular disruption directly correlates with diskography findings for a symptomatic disk when pressure-controlled manometric techniques with	Data suggest discs with annular disruption on CT scan are more likely to be positive on discography.

																		criteria for symptomatic discs. Significant correlation between annular disruption and rate of symptomatic disc, Grade 4 showed highest rate (p <0.001).	strict criteria are used."	
Linson 1990 Diagnostic	6.5	50	L	Chronic LBP that failed conservative therapy	Contrast	-	-	+	-	+	-	-	-	-	-	-	No	6% negative correlation. 5 discs read by MRI as normal were read on discography as abnormal. 1 disc read as abnormal on MRI was read as normal on discography.	"The MRI will, however, allow the clinician to identify degenerative disc levels prior to further evaluation with discography, thereby reducing the risk and morbidity to the patient. The discogram remains the exam of choice for differentiating between degenerative discs that are symptomatic and those that are not."	30/57 (53%) discs read as degenerative by discography had reproduction of back pain with injection. MRI helpful for identifying degenerative discs.
Laslett 2005 Diagnostic	6.0	69	L	Chronic LBP patients seeking out discography	Contrast	Local anesthetic	-	+	+	-	+	-	-	+	+	-	No	Sensitivity, specificity, and positive likelihood ratios for centralization: 40%, 94%, 6.4. In presence of severe disability: 46%, 80%, 3.2. In	"The report of centralization in nondistressed and not severely disabled chronic LBP patients suggests that discography may be delayed if a McKenzie treatment	Report of centralization in non-distressed and not severely disabled chronic LBP patients suggest discography not necessarily indicated if McKenzie centralization exam is positive; as expected

																		presence of distress: 45%, 89%, 4.1. With moderate, minimal or no disability: 37%, 100%. With no or minimal distress: 35%, 100%.	program is available, because the expected result of discography is already known (ie, positive pain provocation), and there is a good prognosis with conservative care."	results of discography already known (positive pain provocation.) Study assumes discography only credible method of "directly testing discs." Data suggest centralization may be as useful in diagnosing disc pathology in CLBP patients without significant psychosocial pathology.
Schneiderman 1987 Diagnostic	6.0	36	L	Chronic LBP	Contrast	-	-	+	-	+	+	-	+	-	+	-	No	MRI 99% accurate in predicting whether disc would be normal or abnormal on discography.	"Although discography may still be helpful in assessing degenerative levels, discography is not considered to be indicated when MRI demonstrates a normal disc signal intensity."	Suggests no reason to do discography if MRI does not show any abnormalities. No clinical correlation or outcomes discussed. Data suggest MRI can help diagnose degenerative discs seen on discography.
Osti 1992 Diagnostic	6.0	33	L	LBP	Contrast	-	-	+	+#	+	-	-	-	+	+	-	No	All discs identified as abnormal on MRI abnormal on discography. 6/60 (10%) of normal discs on MRI showed degeneration on discography. 27/39 (69%) of discs with typical pain with discography had abnormal signals on MRI.	"We conclude that discography is, at present, the more accurate investigation for annular tears which are likely to produce low back pain."	MRI is a diagnostic tool for degenerative disc disease, since no clinical correlations or outcomes reported it is difficult to assess clinical relevance of findings. Data suggest MRI helpful, but in 1988 discography appeared to identify more disc pathology. No correlation to clinical outcomes reported.

Gibson 1986 Diagnostic	5.5	22	L	Mechanical back pain	Contrast	-	+	+	-	+	-	-	-	-	-	-	No	44/50 (88%) of discs evaluated as degenerative by both MRI and discography.	"We believe that MRI will become the most useful single investigation to determine the stage of disc degeneration. Discography may still have a role as a "pain reproduction test" in selected cases."	MRI is a valid diagnostic tool for diagnosing degenerative disc disease. No outcome measures. Data suggest MRI is as accurate or more so than discography in diagnosing irregular intervertebral disc disease.
Derby 2005c	5.0	13 (9 physician volunteers and 4 lay volunteers)	L	Rate of annular disruption measured and NRS pain by discography.	+	+	?	+	+	+	+	-	-	+	+	-	-	In patients with no history of back pain, 12 of 23 (52%) discs painful. No relationship between MRI appearance of disc and pain, nor was there a relationship between discogram rating and pain. In Grade 3 annular tears, equal number of discs painful and not painful.	"Lumbar discs in asymptomatic volunteers can be made painful, but as a rule, the pain is mild and requires high pressures of injection."	Asymptomatic volunteers, 9 of which were physicians. All were pre-medicated with midazolam. Data suggest asymptomatic discs may be painful on discography, even with sedation.
Collins 1990 Diagnostic	5.0	29	L	Chronic pain, failed conservative therapy	Contrast	-	-	+	-	+	+	-	-	-	+	+^	No	Discography correlated with MRI in 90% of discs.	"No specific features have been found on the MRI images to differentiate symptomatic from asymptomatic damaged discs. A significant annular bulge was, however present in the majority of patients with	All symptomatic level at discography had evidence of degeneration on MRI. Results suggest disc levels that appear normal on MRI should not undergo discography. MRI can lead to reduction of disc levels requiring injection. 3/12 (25%) had no benefit from surgery. Data suggest MRI can find lumbar

																			symptom reproduction and in whom surgery was performed."	spine degeneration, but cannot differentiate well symptomatic from asymptomatic discs on discography. Annular bulge on MRI present more in symptomatic patients.
Carragee 2006 Diagnostic	5.0	121	L	69 with no clinically significant LBP; 52 with chronic LBP considering additional treatment	Contrast	-	-	+	+	-	-	-	-	-	+	-	-	Positive injections correlated with annular disruption, abnormal psychometric findings, and chronic pain states. 17/69 (25%) in experiment group had positive low-pressure discography. 14/52 (27%) of chronic LBP patients had positive low-pressure discography.	"As in previous studies in this center, the findings continue to offer support for the conclusion that subjects with neither LBP, a chronic pain state, nor previous surgery have a low risk of painful injections."	Using low-pressure guideline 15-25 psi unlikely to eliminate all/most false-positive injections in those with pain sensitivity risk factors. In those without psychological distress, chronic pain or previous surgery low-pressure discography likely more accurate, but these are not typically patients referred for procedure. Data suggest low-pressure discography can still cause significant (25%) false positive rate. Data suggest psychometric distress and other chronic pain still has significant effect on discography outcomes even with using low-pressure.
Carragee 2000 Diagnostic	5.0	26	L	10 asymptomatic, 10 chronic neck and arm pain but no back pain, 6 primary	Contrast	-	+	+	+	+	-	-	+	-	+	-	1 year	Positive pain response to discography reported in 10% of asymptomatic group, 40% in cervical pain group, and 83%	"Discography in a subject group without low back pain but with significant emotional and chronic pain problems may result in	Subjects with other chronic pain issues and somatization disorders more likely to have a positive pain response to lumbar discography regardless of clinical history of LBP.

				somatization disorder														in somatization group.	significant back pain symptoms for at least 1 year after injection. Subjects with normal psychometric test results had no significant long-term back symptoms after discography."	Suggests caution in interpreting results. Patients had no LBP. Data suggest discography can cause persistent low back pain in previously asymptomatic patient with significant emotional and other chronic pain problems. Psychometric testing should be done and considered when evaluation patient with discography.
Manchikanti 2001 Diagnostic	5.0	50	L	25 chronic LBP patients with somatization disorder and 25 without	Contrast	-	-	+	-	-	-	-	-	-	+	-	No	14/25 (56%) in non-somatization group and 12/25 (48%) in somatization group judged positive.	"Provocative discography yielded similar results irrespective of the patient's psychological condition, with or without somatization disorder, with or without depression."	No differences in positive outcomes with discography based on a diagnosis of somatization disorder. Did MBBs L1 through L4/L5. Data suggest a diagnosis of somatization does not affect the outcome of diagnostic medial branch blocks.
Carragee 2002 Diagnostic	5.0	25	L	3 groups: 1) 13 patients with good results from cervical spine surgery; 2) 12 patients continued pain after cervical surgery; 3) 52 chronic LBP patients seeking discography	Contrast	-	-	+	+	+	-	-	+	+	+	-	No	23% Group 1 positive discograms; 50% Group 2 had positive discograms; 73% of Group 3 positive discograms. Disc degeneration with annular disruption 43% in Groups 1 and 2, 50% in Group 3. Discography:	"The presence of positive concordant pain responses and negative control discs in 33% of subjects without CLBP illness seriously challenges the specificity of provocative discography in identifying a clinically relevant spinal pathology."	Failure to find a definitive spinal lesion that consistently causes chronic LBP illness without associated co-morbidities suggests social, emotional, neurophysiological variables exert a strong permissive effect. They had mild persistent LBP with normal psychometric scores. Data suggest discography can cause pain in a large

				for possible surgery														Sp- 74%, PPV-31%.		portion of patients without clinical symptoms consistent with discogenic pain. Implies that the specificity of discography may be lower than previously reported.
Alamin 2011 Diagnostic	4.5	52	L	Standard pressure-controlled provocative discography (PD) vs. Functional anesthetic discogram (FAD)	Contrast	-	-	-	-	+	-	-	-	+	+	-	No	For PD, 58% had single level findings that were positive. 30% had 2 positive levels and 12% had negative. FAD was concordant with PD for 50% of patients. 24% of FAD was completely negative. FAD positive at a single level in 16%.	"We have reported on the results of a new diagnostic technique in 52 patients with chronic low back pain presumed discogenic in origin that was designed to help differentiate between symptomatic and asymptomatic disc degeneration. The findings of the test differed from those of standard pressure–controlled PD in 46% of the cases reported on here. Further studies will be needed to demonstrate the clinical utility of the test."	Study suggests that anesthetic placement into the suspected disc and assessing pain is a more specific test compared to provocative discogram. Will want to see long term follow-up data. All patient were referred to single practitioner's office. Data suggest local anesthetic injection into a vertebral disc can help in differentiating spinal pain. However psychosocial aspect of the patient can also influence test results and interpretations.

Derby 1999	4.5	102	L	Discogram used to assess sensitivity in back	-	?	-	+	+	+	-	-	-	?	?	+	16 and 32 months	No significant differences between interbody/combined fusion and intertransverse fusion groups (p >0.05). In subgroup analysis with patients with chemically sensitive discs (n = 36), 89% the interbody group showed favorable outcome compared to 20% in intertransverse function group (p <0.01).	"Patients with highly sensitive discs appear to achieve significantly better long-term outcomes with interbody/combined fusion than with intertransverse fusion."	Data suggest that chemically sensitive doses on discography may benefit from interbody fusion. But given retrospective nature and uncertain decision making process conclusions are limited.
Derby 2005b Diagnostic	4.0	106	L	16 asymptomatic patients; 90 chronic LBP who failed conservative therapy	Contrast	Local anesthetic	+	+	+	-	+	-	-	+	+*	-	-	In asymptomatic patients: Grade 3 annular tears exhibited in 32/55 (58%). 141/199 (71%) of discs in symptomatic patients had Grade 3 annular tears. All discs in asymptomatic group classified as negative.	"Advanced discography technique and strict criteria may distinguish negative asymptomatic discs among morphologically abnormal discs in patients with suspected chronic discogenic LBP."	Pain tolerance regardless of clinical status influenced pain provocation with discography. Mental and physical distress influences outcomes with discography need to be considered when choosing patients to send to discography. Higher grade annular tears more likely painful on discography than lower grade tears. About 50% Grade 4 tears painful with discography both high and low pressure. Leaves 50% of Grade 4 tears not painful. Annular tears can be a pain generator, but only up to 50% of time; 16

																				healthy volunteers, 90 LBP patients. Data suggest discography that does not cause regular pain in patients with LBP similar to discograms in asymptomatic patients. Also notes grade 3 discs can be asymptomatic on discography.
Madan 2002 Diagnostic	4.0	73	L	Patients underwent LBP surgery. A = 41 surgery without discography. B = 32 discography screening before surgery	Contrast	-	-	+	+	+	-	-	+	-	+	+	2.8 years	Group A and Group B had satisfactory outcomes; 75.6% and 81.2% respectively.	"Our study shows that provocative discography has limited efficacy in improving clinical outcome scores after low back surgery for discogenic back pain. Because of its invasive nature, we do not recommend using provocative discography for this purpose."	According to study provocative discography has limited efficacy in improving clinical outcome scores after low back surgery for discogenic back pain. Data suggest discography did not affect clinical outcomes when used prior to lumbar fusion surgery.
Carragee 2000 Diagnostic	6.5	47	L	Single level discectomy for sciatica previously.	Contrast	-	+	+	+	-	-	+	-	+	+	+	1 mo	Asymptomatic subjects with normal psychometric testing had painful disc injections at levels that had previous surgery in 40% studied. Symptomatic patients with normal psychometric testing with painful discs on discography	"Patients with abnormal psychological profiles have significantly higher rates of positive disc injections that either asymptomatic volunteers or symptomatic subjects with normal psychological screening."	Results suggest positive discography in patients with emotional stress or abnormal psychometric testing be interpreted with caution. Data suggest psychological factors and litigation or open workers' compensation claims increased pain response with discography.

																		43%. 70% of symptomatic patients with abnormal psychometric scores had painful disc injections.		
Carragee 2006	5.0	62	L	30 with positive single-level discogram, 32 with spondylolisthesis.	Contrast	-	-	+	+	+	-	-	+	-	+	+	2 years	Highly effective success criteria: 72% spondylolisthesis group and 27% presumed discogenic group. Minimal effective success: 91% spondylolisthesis , 43% discogenic	"The retrospective analysis shows that the rate of low pressure painful injections in subjects without chronic LBP illness is approximately 25%, and correlates with both anatomic and psychosocial factors."	Despite removal of pain generator as diagnosed by discography, approximately half continued with significant pain and impairment. Complete removal of supposed pain source in spondylolisthesis group frequently completely removed pain. Data suggest low-pressure discography can still cause significant (25%) false positive rate. Also suggests psychometric distress and other chronic pain has significant effect on discography outcomes even with using low-pressure.

MRI DISCOGRAPHY

MRI is sometimes paired with discography for evaluation of the intervertebral discs.(499-501, 503, 506)

Recommendation: MRI Discography for Evaluating Herniated Discs

MRI discography is not recommended for evaluating herniated discs.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendation

There is no quality evidence supporting the use of discography combined with MRI to improve outcomes for herniated discs. MRI discography is invasive, has adverse effects, and is costly.

Evidence for the Use of MRI Discography

There are 5 moderate-quality studies incorporated into this analysis. (499-501, 503, 506) There is 1 other study in Appendix 1.(514)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: MRI discography, herniated disc, diagnostic, sensitivity, specificity, predictive value, efficiency, and efficacy to find 222 articles. Of the 222 articles, we reviewed 7 articles and included six articles (5 comparative studies, 1 prospective case-series).

Author/Year/Study Type	Score	N	Area of Spine	Diagnoses	Injected Medications	Intradiscal Local Anesthetic	Sedation Used	Fluoroscopy/imaging	Pressure Readings	MRI	CT	CT Myelography	X-ray	More than one rater	More than one level	Surgery Performed	Long term follow-up	Results	Conclusion	Comments
Birney 1992 Diagnostic	6.0	90	L	Chronic LBP or radicular pain	None	-	-	-	-	+	-	-	-	+	-	+	-	Herniated discs better identified with MRI than discography (100% vs. 87.5%).	"An analysis of the relative sensitivity and specificity of each test in the diagnosis of degeneration and herniation revealed that the greater sensitivity of MRI in the detection of herniation was the only statistically significant difference ($p<0.05$)."	Older generation MRI. Details to properly calculate operant characteristics not provided.
Collins 1990 Diagnostic	5.0	29	L	Chronic pain, failed conservative therapy	Contrast	-	-	+	-	+	+	-	-	-	+	+^	No	Discography correlated with MRI in 90% of discs.	"No specific features have been found on the MRI images to differentiate symptomatic from asymptomatic damaged discs. A significant annular bulge was, however present in the majority of patients with symptom reproduction and in whom surgery was performed."	All with symptomatic level at discography had evidence of degeneration on MRI. Results suggest disc levels that appear normal on MRI should not undergo discography. MRI can lead to a reduction of disc levels requiring injection. 3/12 (25%) did not have any benefit from surgery. Data suggest MRI can find lumbar spine degeneration, but cannot differentiate well symptomatic from asymptomatic discs on discography. Annular bulge on MRI present more in symptomatic patients.

Schneiderman 1987 Diagnostic	5.5	36	L	Chronic LBP and associated leg pain for minimum of 2 months	Metrizamide contrast	-	-	+	-	+	+	-	+	+	-	-	-	Sensitivity, specificity, PPV, and NPV all 98%.	"Clinically, MRI is a useful technique for detecting early disc degeneration and for assessing the affected disc level and adjacent levels in patients with low-back pain and spondylolisthesis."	Older generation MRI
Gibson 1986 Diagnostic	4.5	22	L	LBP	Contrast of either Niopam 200 or Niopam 300	-	+	-	-	+	-	-	-	-	+	-	-	Older generation MRI vs. discography had sensitivity 96%, specificity 84%, positive predictive value 86%, and negative predictive value 95%.	"MRI was shown to be more accurate than discography in the diagnosis of disc degeneration. It has several major advantages, which should make it the investigation of choice."	Small sample size. Older generation MRI.
Linson 1990 Diagnostic	4.0	50	L	Chronic LBP	Renografin 60, half strength	-	-	+	-	+	-	-	-	-	+	-	-	Sensitivity of older generation MRI 91%, specificity 97%, positive predictive value 98%, negative predictive value 88%.	"A high correlation in the identification of the degenerative disc between these two modalities."	Patients not well described. Assumed non-radicular. Older generation MRI.

DIAGNOSTIC FACET BLOCKS (INTRA-ARTICULAR AND NERVE BLOCKS)

See Injection Therapies.

MYELOSCOPY

Endoscopic examination of the epidural space is termed "myeloscopy." This procedure is minimally invasive and theoretically can be used solely for diagnostic purposes. It is most often performed in conjunction with adhesiolysis (see Adhesiolysis). The other method for performing adhesiolysis does not involve myeloscopy.(515-517)

Recommendation: Myeloscopy for Diagnosing Acute, Subacute, or Chronic Low Back Pain, Spinal Stenosis, Radicular Pain Syndromes, or Post-surgical Back Pain

Myeloscopy is not recommended for diagnosing acute, subacute, or chronic low back pain, spinal stenosis, radicular pain syndromes, or post-surgical back pain problems.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

Currently, while there are studies suggesting different levels of neurological impingement are identified with myeloscopy, there are no quality controlled studies identifying the utility of this diagnostic procedure for improving long-term outcomes. A few reported studies have used this procedure in conjunction with adhesiolysis (see surgical treatments section of this Guideline). Myeloscopy has not been shown to be beneficial in large scale, medium- to long-term studies sufficient. (516, 517) It is invasive, has likely complications, and is costly. Well-designed multi-center studies are needed prior to recommending this procedure.

Evidence for the Use of Myeloscopy

There are 3 moderate-quality studies incorporated into this analysis.(518-520)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with limits on publication dates from 2008 to 2014. We used the following search terms: myeloscopy, epiduroscopy, spinal endoscopy, acute low back pain, subacute low back pain, chronic low back pain, radicular pain, spinal stenosis, postsurgical back pain, diagnostic, sensitivity, specificity, efficiency, efficacy and predictive value to find 672 articles. Of the 672 articles, we reviewed 10 articles and included four articles (1 RCT, 2 prospective cohort, 1 review).

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of Myeloscopy used	Injected Medication	Sedation used	Fluoroscopy/Imaging	Pressure readings	MRI	CT	CT Myelography	X-Ray	More than one rater	More than one Level	Surgery performed	Long-term follow-up	Results	Conclusion	Comments
Manchikanti 2003 RCT/Diagnostic	7.5	39	L	Chronic LBP ≥6-months, no facet joint pain based on controlled comparative local anesthetic blocks, failed other treatment (e.g. epidural injections), and respond to percutaneous adhesiolysis with hypertonic saline.	Endoscopy vs. endoscopy with adhesiolysis	10mL 1% lidocaine, 6-12mg Celestone or40-80mg methyl-prednisolone	+	+	-	-	-	-	-	-	+	-	3 months	MRI impressions: epidural fibrosis (10.3% mild, 20.5% moderate, 35.9% severe), disc herniation (10.3%), bulging (5.1%), severe degeneration (5.1%) and severe spinal stenosis (5.1%). Oswestry Disability Index (ODI) scores: 3.5±0.7 vs. 3.6±0.5 at baseline, 2.9±0.8 vs. 2.5±1.0 at	"[S]pinal endoscopic adhesiolysis with targeted injection of local anesthetic and steroid is an effective treatment in a significant number of patients without major adverse effects at 6-month follow-up."	Patients unblinded if they requested (data suggest 64.1% unblinded at 3 mos), thus limiting blinding to 3 months and resulting in questions about conduct of study. Medication doses apparently not standardized. How ODI scores were that low, yet 74.4% disabled from work, not clear. Data suggest relatively modest differences in pain scores at 3 months.

																	1 month, 3.1±0.7 vs. 2.6±1.1 at 3 months.		
Bosscher 2012 Diagnostic	7.0	143	L	Patients included if they had back pain and/or radiating pain >6-months. Those with lumbar or sacral spinal surgery included.	Epiduroscopy	Saline	-	+	-	+	-	-	-	-	+	-	-	Clinical evaluation diagnosed a different spinal region than epiduroscopy in 103 of 143 (72%) patients (p<0.01). MRI diagnosed a different vertebral level in 115 of 143 (80%) patients (p <0.01). Only in 5 (3.5%) patients did all three tests agree.	"Results of this study indicate that epiduroscopy is more reliable than is either clinical evaluation or MRI for determining the vertebral level where clinically significant spinal pathology occurs in patients with LBP/RP."	Data suggest epiduroscopy can help determine level of pathology in patient with low back pain but that is often very different than MRI. Further evaluation is needed into this discrepancy.

Richardson 2001 Diagnostic	4.0	38	L	Chronic LBP with radiculopathic element.	Epiduroscopy	Local anesthetic (lidocaine 1%)	+	-	-	-	-	-	-	-	-	-	12 months	VAS pain scores for pre-op, 2-month, 6-month, and 12-month follow-up: 8.2 (6.8-9.1); 5.6 (0-8.7); 6.8 (4-8.7), 6.7 (1.8-9) respectively (p <0.0004). Post-op, total function scores improved to median of 4, 3 and 3 at 2, 6, and 12 months respectively (p = 0.0004).	"Spinal endoscopy with modern equipment appears to be the diagnostic method of choice for epidural fibrosis."	Data suggest using epiduroscopy to give medications may be beneficial However, no comparison group was conducted.

Initial Care. . . . . .

Comfort is normally a patient's first concern. Activity levels, aerobic exercise and directional preference exercises (stretching in the direction that centralizes or abolishes the pain, see below) should be addressed. Nonprescription analgesics may provide sufficient pain relief for most patients with acute and subacute LBP. If treatment response is inadequate (i.e., if symptoms and activity limitations continue) or the provider judges the condition limitations to be more significant, prescribed pharmaceuticals or physical methods can be added. Comorbid conditions, invasiveness, adverse effects, cost, and provider and patient preferences help guide the provider's choice of recommendations. Initial care and comfort items may include non-steroidal anti-inflammatory drugs (NSAIDs), acetaminophen, heat, cryotherapy, exercises, advice on activities, and manipulation. Education about LBP should begin at the first visit, including principles of fear avoidance belief training (FABT) for patients who appear to have elevated fear avoidance beliefs.

There is increasing belief that chronically impaired LBP patients begin a course towards disability at their first clinical encounter. As such, those who do not respond to appropriate treatment should have their treatment, compliance, and psychosocial factors assessed early. Additionally, those patients whose course ventures beyond the abilities of that healthcare provider should be referred to others with greater experience in evaluation and functional recovery of complex LBP patients.

The remainder of this document discusses evidence of efficacy for dozens of LBP interventions used for spinal conditions. This evidence and consequent guidance is further subdivided into acute, subacute, and chronic LBP, radicular pain syndromes, post-operative, and when evidence is available, other spinal conditions including spondylolisthesis, spinal stenosis, facet joint osteoarthrosis, and failed back surgery syndrome. A rigorous attempt has been made to ascertain evidence for radicular versus non-radicular pain in the development of this guideline. Unfortunately, the literature largely lacks specification of clear exclusionary criteria. Most trials did not report lower extremity symptoms and those that did nearly always reported percentages of subjects with "leg pain" without clarifying whether this was general lower extremity pain or anatomically consistent nerve root pain. A minority of such studies reported stratified analyses to detect if such patients responded differently. However, where identifiable radicular pain patients were included, these have been noted.

This guideline recommends interventions with quality evidence of proven efficacy. Known complication rates and safety profiles, if available, should always be utilized in decision making and were considered in developing this guideline. Besides those treatments reviewed herein, there are many additional theoretically potential treatments possible for the management of LBP and spinal conditions. In the absence of moderate- to high-quality studies,(9) other interventions are not recommended and are indicated as **Not Recommended, Insufficient Evidence (I).**

Activities and Activity Modification

There has been a major revision in the management of activity limitations in patients with LBP over the past 10 to 20 years. Previously, bed rest was prescribed. It is now widely recognized that prescription bed rest was ineffective (see following discussion), reinforced a belief that the injury was severe and contributed to delayed recovery in some cases. Patient management recommendations pertaining to occupational and non-occupational physical capabilities have advanced and there is now information available on posture, lumbar supports, and mattresses. There also has been much revision in the approaches for patient management regarding work restrictions, other activity limitations, and some information available on posture, mattresses, lumbar supports, and other appliances. The approach to exercise, or physical activity, has similarly advanced and has been significantly revised. Revisions have also been the result of the greater understanding that natural history shows that LBP is

commonly a persistent or recurrent problem and "most workers do continue working or return to work while symptoms are still present: if nobody returned to work till they were 100% symptom free, only a minority would ever return to work."(521)

In general, activities causing a *significant* increase in low back symptoms should be reviewed with the patient and modifications advised when appropriate. Driving posture or duration, workstation design, lifting modifications, and other activities may require at least temporary modification. Usually these activities are obvious to the patient, yet, this is not always true. For example, patients may not realize the importance of monitoring symptoms and adjusting their positions or activities. It is now believed to be quite important to emphasize that a modest increase in pain does not represent or document damage. Instead, such symptoms may actually be beneficial to the patient to experience some short-term pain. For example, getting out of bed in the morning is frequently painful for acute LBP patient. Yet, it is beneficial to the patient's overall recovery to get out of bed and to maintain as nearly normal a functional status as possible (see Bed Rest, Exercise, and Fear Avoidance Belief Training). While the patient is recovering, activities that do not aggravate symptoms should be maintained and exercises to prevent debilitation due to inactivity should be advised. Aerobic exercise is highly beneficial as a cornerstone therapeutic management technique for acute, subacute, and chronic LBP (see Aerobic Exercise). The patient should be informed that such activities might temporarily increase symptoms.

WORK ACTIVITIES

Work activity modification is an important part of many treatment regimens. A patient's expectations regarding return-to-work status are often set prior to the first appointment,(522) thus education may be necessary to set realistic expectations and goals. Advice on how to avoid aggravating activities that at least temporarily increase pain includes a review of work duties to decide whether or not modifications can be accomplished without employer notification and to determine whether modified duty is appropriate and available. Making every attempt to maintain the patient at the maximal levels of activity, including work activities, is strongly recommended as there is evidence that not returning to work has detrimental effects on a patient's pain ratings and functionality.(523) No specific profession is recognized as singularly qualified to opine on job requirements and changes in job physical factors. Some occupational physicians by training and experience and by having visited the workplace in question will be qualified to recommend potential workplace modifications. Others who may also have the training and experience to assist with workplace assessments may include certified professional ergonomists, occupational therapists, physical therapists, certified safety professionals, or certified industrial hygienists. There are large differences in practice patterns and capabilities among these professionals (e.g., some measure job physical demands, some measure worker capabilities, some match these demands and capabilities, etc.), thus inquiries to ascertain the professional's experiences and capabilities are often necessary.

The analysis of work ability requires an assessment of "risk," "capacity," and "tolerance." Risk refers to what a patient can do but should not do, due to the substantial risk of significant harm, considering probability and severity of potential adverse events. Providers impose work restrictions based on estimates of risk. Capacity refers to what a patient is physically capable of doing as measured by concepts such as range of motion, exercise ability in metabolic equivalents (METs), etc. Providers describe work limitations (for example "can only exert to 6 METs due to prior myocardial infarction"). Tolerance for chronic symptoms such as back pain is the basis for a patient (not a provider) to decide whether the rewards of work are worth the cost of the symptoms. However, it is incumbent to inform the patient that in the chronic pain setting, the development of routine symptoms in the course of normal occupational activities (or exercise) is not believed to signify tissue damage. Details of this assessment methodology have been described.(524)

The first step in determining whether work activity modifications are required usually involves a discussion with the patient regarding whether he or she has control over his or her job tasks. In cases where the worker can obtain assistance from someone else to lift, and can alternate sitting and standing as needed, there may be no requirement to write any restrictions even if the pain is severe. In some situations, it may be advisable to confirm this report with the patient's supervisor or to write "activities as tolerated by pain" to signal to the supervisor that the person is under treatment, although again judgment is required as writing that phrase for a patient with perceptions of LBP equating serious injury may reinforce a detrimental injury mindset that contributes to further disability beyond that needed (see Fear Avoidance Belief Training). In such cases, specified limitations may be a better treatment strategy.

Work modifications should be tailored taking into account the three main factors: 1) job physical requirements; 2) severity of the problem; and 3) patient's understanding of his or her condition. A fourth factor, employer expectations, does not influence the writing of limtations, but does influence whether the limitations will be accepted and/or enacted. Sometimes it is necessary to write limitations or prescribe activity levels that are above what the patient feels he or she can do, particularly when the patient feels that bed rest or similar non-activity is advisable. In such cases, the provider should be careful to not overly restrict the patient as it is clearly not in his or her best interest. Education about LBP and the need to remain active should be provided.

Common limitations involve modifying the weight of objects lifted, frequency of lifts, and posture all while taking into account the patient's capabilities. For severe cases of acute LBP with or without radicular symptoms, frequent initial limitations for occupational and non-occupational activities include:

- no lifting over 10 pounds,
- no prolonged or repeated bending (flexion), and
- alternate sitting and standing as needed.

These work and home activity guidelines are generally reassessed every week in the acute phase with gradual increases in activity recommended so that patients with severe non-specific back pain evolve off modified duty, typically within a couple weeks, but nearly always within 6 to 12 weeks. The amount of weight handled can be progressively increased. An alternative is to return the patient at first to 1 to 2 hours a day on his or her prior full-duty job, with the remainder of the day spent at modified duty. The numbers of hours of full-duty work can be increased every 1 to 2 weeks.

However, individualization is often necessary and if the prior job physical tasks involved frequent lifting of more than 100 pounds, then restrictions at work guidance may reasonably be substantially greater, e.g., initial limitations of 25 pounds of lifting and carrying. The size of the object lifted is a major consideration as it requires a long horizontal distance between the hands and the spine, which necessitate high back forces to lift the object even if it weighs under 20 pounds. Twisting while lifting is thought to put significantly greater stress on the back. However, epidemiological evidence to support this theory is weak. Regardless, this is usually readily controlled by patient education as few jobs are structured to require simultaneous lifting and twisting. In some cases, preclusion of a specific lift may be necessary. The need to alternate positions frequently is clinically highly helpful. LBP patients tend to experience significant increases in pain when in one position for an extended period of time, and perhaps this is one reason why bed rest is counterproductive. Patients should be encouraged to change positions frequently, ideally prior to experiencing major increases in symptoms. Thus, restrictions that state "sedentary work" are *not* appropriate for most LBP patients as they convey misinformation while also potentially increasing symptoms.

Some workplaces provide health care or physical therapy on-site, thus brief periods of recumbent time during the day may be possible. Physical therapy may also be provided on-site and this may further facilitate the rehabilitation process. While there is one report that modified duty policies were not effective in Norway,(525) there have been large savings realized in the U.S. from accommodation of modified ("light") duty.

It is best to communicate early in the treatment that limitations will be progressively reduced as the patient progresses. This should be communicated at each successive visit so that the patient is well advised in advance of the treatment plan. Tailoring of limitations in the context of radicular pain may also be necessary as some workers have specific intolerances (e.g., intolerance of sitting or prolonged driving).

The provider can make it clear to patients and employers that:

- even moderately heavy lifting, carrying, or working in awkward positions may aggravate symptoms of LBP or lumbosacral nerve root irritation, and
- any restrictions are intended to allow for spontaneous recovery or for time to build activity tolerance through exercise.

Every attempt to maintain the patient at maximal levels of activity, including work activities, should be made as it is in the patient's best short- and long-term interest. *Work activity limitations should be written whether the employer is perceived to have modified duty available or not. Written activity limitations guidance communicates the status of the patient and also gives the patient information on what he or she should or should not do at home.*

Activity Modification and Exercise . . . . . .

BED REST

Bed rest has long been used for the treatment of LBP,(526-541) particularly acute LBP. Use of bed rest is believed to have evolved from consideration of the pain experienced by those with acute LBP when engaged in activities such as getting out of bed, without consideration of whether there might be any adverse short- or long-term implications. Description of bed rest as a treatment implied that compliant patients were those that spent a greater proportion of time in bed, thus increasing the likelihood that they would get better sooner. Traditional teaching held that patients who did not get better with bed rest were either non-compliant or needed longer periods of bed rest.

1. *Recommendation: Bed Rest for Acute, Subacute, Chronic, Radicular Low Back Pain, or Stable Spinal Fractures*
   Bed rest is not recommended for the management of acute, subacute, chronic, radicular low back pain, or stable spinal fractures.
   Strength of Evidence – **Strongly Not Recommended, Evidence (A)** [Acute]
   Moderately Not Recommended, Evidence (B) [Subacute, Chronic]
   Not Recommended, Evidence (C) [Radicular]
   Not Recommended, Insufficient Evidence (I) [Stable Spinal Fractures]
   Level of Confidence – High

2. *Recommendation: Bed Rest for Unstable Spinal Fractures*
   Bed rest is recommended for unstable spinal fractures.
   Harms – Deconditioning, DVT risk.
   Benefits – Avoidance of catastrophic injury.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

3. *Recommendation: Bed Rest for Other Low Back Problems*
   Bed rest is not recommended for other low back problems.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

4. *Recommendation: Specific Beds or Other Commercial Products for Prevention or Treatment of Acute, Subacute, or Chronic Low Back Pain*
   Specific beds or other commercial sleep products are not recommended for prevention or treatment of acute, subacute, or chronic low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
In 1986, bed rest was usually recommended for acute LBP.(528) Today, multiple quality studies demonstrate that bed rest of any duration is ineffective for LBP (see Evidence Table). Several trials have either included significant numbers of patients with radicular pain symptoms,(528, 530, 534, 535, 541) or specifically focused on patients with sciatica(532, 538) and failed to find evidence that bed rest had a favorable impact on outcomes among patients with either LBP or radicular pain syndromes.

Bed rest, while non-invasive, is costly (due to lost time), and can have documented adverse effects beyond those associated with deconditioning such as pulmonary emboli.(532) Studies document compliance to be poor, which likely results in underestimation of the magnitude of the adverse effects of bed rest. Bed rest is strongly not recommended as a treatment strategy for management of acute LBP. Evidence is modestly less strong but also suggests bed rest is ineffective for subacute and chronic LBP.

There are no quality studies evaluating the role of bed rest in the management of unstable spinal fractures or cauda equina syndrome, yet it is required for those conditions. There is consensus that these require bed rest or other marked activity limitations to prevent adverse events. Although bed rest is costly and has no documented benefits, the hazard of mobilization in this setting is theoretically catastrophic, thus this treatment strategy is recommended for unstable fractures. There is also no quality evidence regarding the use of bed rest or other activity limitations for the treatment of stable spinal fractures, such as transverse process fractures or compression fractures. In those settings, bed rest is costly, has no documented benefits, and is expected to be associated with higher morbidity, although it is non-invasive. Instead, gentle activity within tolerance is recommended.

There is no quality evidence that other back pain-related problems are successfully treated with bed rest, including spondylolisthesis, spondylolysis, spinal stenosis, facet related pain, or pain thought to be related to the sacroiliac joint. There also are likely adverse effects. Bed rest is costly, has no documented benefits, and is expected to be associated with higher morbidity, although it is non-invasive.

There is no quality evidence that specific commercial products (e.g., pillows, mattresses, etc.) have a role in the primary prevention or treatment of acute, subacute, or chronic LBP.

Evidence for the Use of Bed Rest
There are 11 moderate-quality RCTs incorporated into this analysis.(526, 528-530, 532-537, 541)
There is 1 low-quality RCT in Appendix 1.(540)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: bed rest, subacute low back pain, chronic low back pain, radicular pain syndromes (including 'sciatica'), Spinal stenosis, spinal fractures' sacroiliitis, and spondylolisthesis to find 9,972 articles. Of the 9,972 articles we reviewed 15 articles (11 original RCT, and 4 reviews) and all were included.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Sciatica						
Hofstee 2002 RCT Industry sponsored (Hoelen Foundation). No mention of COIs.	6.5	N = 250 age <60 with sciatica <1 month	Bed rest (7 days home, n = 43, or hospital, n = 41) vs. physiotherapy (n = 83, education, segmental mobilization, disc unloading/loading exercises, hydrotherapy) vs. control group (n = 83, maintain activities of daily living). Follow-up 0, 1, 2, 6 months.	Mean improvement in VAPS slightly higher in bed rest group than physiotherapy group and QDS score slightly lower in bed rest group than physiotherapy group. No differences in improvement in VAPS and QDS at 1, 2, and 6 months.	"[B]ed rest and physiotherapy are not more effective in acute sciatica than continuation of ADLs."	Age higher in controls (p = 0.02). One PE in bed rest group. Data suggest bed rest ineffective and one pulmonary embolus is concerning for potentially unrecognized serious adverse effects of bed rest.
Coomes 1961 RCT No mention of COIs or industry sponsorship.	4.5	N = 40 with sciatica	Bed rest with epidural anesthesia (n = 20) vs. procaine for acute and subacute sciatica patients (n = 20).	Mean time to recover 31 days with bed rest vs. 11 days with epidural injections (p <0.001).	"From this investigation it appears that epidural injection is a better form of conservative treatment for this group of patients than bed rest."	Small numbers. Bed rest used as treatment comparison; lack of baseline characteristics; co-interventions not well explained. Epidural injections associated with more pain relief than bed rest for several weeks.
Low Back Pain						
Wilkinson 1995 RCT Industry sponsored (Royal College of General Practitioners scientific foundation research grant). No mention of COIs.	6.5	N = 42 with acute LBP <7days	Two days of bed rest (n = 21) vs. mobile activity (n = 22). Follow-up Days 1, 7, and 28.	Bed rest had non-significant worse ROM and higher disability scores at Days 7 and 28. Bed rest group had worse Roland-Morris scores at Day 7 (9.7 ±19.9 vs. 5.3 ±5.7, p <0.05), but not Day 28 (5.9 ±5.9 vs. 3.2±4.0, p = NS).	"Subjects in the control group possibly fared better as they appeared to have better lumbar flexion at day seven. It appears that 48 hours' bed rest cannot be recommended for the treatment of acute low back pain on the basis of this small study. Large-scale definitive trials are required to detect clinically significant differences."	Some baseline differences. Inclusion of those with <24 hours of LBP may limit some results. Data suggest bed rest of 2 days ineffective compared to no bed rest.
Malmivaara 1995 RCT	6.5	N = 134 with acute LBP <3 weeks in Finland	Two days bed rest (n = 67) vs. back-mobilizing exercises (n = 52) vs. ordinary activities (n = 67). Controls attended 3 exercise sessions vs. 61 for	Sick days used favored ordinary activities group (4.7 days vs. 7.2 vs. 9.2), as did pain scale at follow-up (1.3 vs. 1.8 vs. 2.1). Flexion scores: 6.6 vs. 6.0 vs. 6.3 (NS). Patient satisfaction favored	"Among patients with acute low back pain, continuing ordinary activities within the limits permitted by the pain leads to more rapid recovery than either	Baseline variable may theoretically favor against the control group with 22/67 in controls with heavy physical work ≥5 hours/day versus 10/67 bed rest and

No mention of COIs or industry sponsorship.			exercise group and 8 for bed rest.	exercise (7.7 vs. 8.1 vs. 7.3, NS). Cost analyses (Finland) per person: $123 vs. $165 vs. $144, favored ordinary activities over bed rest and then exercises.	bed rest or back-mobilizing exercises."	13/52 exercise. Data suggest bed rest ineffective and ordinary activities superior.
Gilbert 1985 RCT Industry sponsored (Ontario Ministry of Health). No mention of COIs.	6.0	N = 252 with LBP	Physiotherapy plus education plus bed rest vs. physiotherapy plus education vs. bed rest vs. control.	Bed rest group at 10 days had small increase in "restrictions in daily activities" (p = 0.034). Bed rest group took 42% longer to report having achieved "normal level of activities" (p = 0.004). Physiotherapy and education group stopped taking drugs 46% sooner (p = 0.048). No differences at 6 and 12 months.	"[F]amily doctors have little reason to prescribe either bed rest or isometric exercises to patients who suffer from low back pain."	Chronic LBP population subset data also failed to find benefits from bed rest.
Deyo 1986 RCT Industry sponsored (Robert Wood Johnson Foundation). No mention of COIs.	5.5	N = 203 walk-ins with mechanical LBP; 78% acute pain (≤30 days), no marked neurologic deficits	Two days of bed rest vs. 7 days of bed rest.	There were 45% fewer lost workdays among those treated with 2 days of bed rest (3.1 vs. 5.6 days). Subgroup of possible sciatic irritation also had fewer days of limitation or lost time.	"For many patients without neuromotor deficits, clinicians may be able to recommend two days of bed rest rather than longer periods, without any perceptible difference in clinical outcome. If widely applied, this policy might substantially reduce absenteeism from work and the resulting indirect costs of low back pain for both patients and employers."	Compliance with activity recommendations lower in 7 days bed rest vs. 2 days. Data suggest 7 days rest not more effective than 2 days rest.
Rozenberg 2002 RCT No COIs or industry sponsorship.	5.0	N = 278 with acute LBP <72 hours	Continuing normal activities within pain limitations (n = 140) vs. 4 days bed rest (n = 138). Outcome assessments at 1 week, 1 and 3 months.	No benefit from bed rest with any metric. Fewer patients in bed rest group adhered to treatment than regular activity (72% vs. 90%).	"For patients with acute low back pain, normal activity is at least equivalent to bed rest. The findings of this study indicate that prescriptions for bed rest, and thus for sick leaves, should be limited when the physical demands of the job are similar to those for daily life activities."	Fewer patients compliant in bed rest than regular activity (72% vs. 90%). Data suggest bed rest ineffective.
Molde Hagen 2003 RCT Industry sponsored (Norwegian Ministry of Health and Social	4.5	N = 510 with LBP placed on sick list 8-12 weeks	Early intervention with light mobilization with radiation (n = 254) vs. without radiation (n = 256). Outcome assessment at 3, 6, 12 and 24 months; 3-year follow-up.	Intervention group not more likely to report less pain and improvement, used less bed rest and more likely to stretch or walk. Economic benefits for early intervention present at 3 years and benefits at $2,822 per person.	"For patients with subacute low back pain, a brief and simple early intervention with examination, information, reassurance, and encouragement to engage in physical activity as normal as possible had economic gains for the society. The effect occurred during the first year after intervention. There were no	Data from Norway and practice and financial issues may be different.

Affairs). No COIs.					significant long-term effects of the intervention. The initial gain obtained during the first year does not lead to any increased costs or increased risks for reoccurrence of illness over the next 2 years."	
Evans 1987 RCT Industry Sponsored (Ontario Ministry of Health). No mention of COIs.	4.5	N = 260 with LBP	Four treatment groups stratified by major (prescription NSAID or analgesic with at least 8 aspirin a day) or minor medication (up to 8 aspirin a day or muscle relaxants). At entry exercise and education group (n = 62, Kendall's flexion exercises) vs. bed rest (n = 60, minimum 4 days) vs. bed rest, exercise, education (n = 65) vs. control (n = 65, analgesic medications).	Flexion exercise group discontinued medications earlier. No differences in degree of pain, activities of daily living, straight leg raise, or lumber flexion.	"This study demonstrates that subjects who received back flexion exercises and a back education program were able to stop their medication sooner than subjects who received bed rest or no treatment."	Medication stratification at entry may confound data. Data suggest bed rest ineffective compared with exercise.
Low Back Pain and Sciatica						
Szpalski 1992 RCT No mention of COIs or industry sponsorship.	5.0	N = 51 with acute LBP and sciatica	3 days bed rest (n = 26) vs. 7 days of bed rest (n = 25).	VAS score improvement in both groups ($p<0.001$) (7.9 ± 1.71 to 1.3 ± 0.69 for 3 day bed rest and 8.1 ± 1.89 to 1.1 ± 0.53 for 7 day bed rest). Functional testing and VAS pain scale not different between groups.	"In these relatively young and motivated patients, a duration of bed rest of 3 days resulted in the same objective functional improvement of trunk function and pain rating as a period of 7 days. This shorter duration should be considered as preferable, given the same objective results but important physiological and economical advantages."	Study hypothesis included that some bed rest necessary for acute LBP. Excluded workers except self-employed to remove motivation to desire bed rest. Data suggest no differences in pain or function between 3-days vs. 7 days of bed rest.
Back Pain with/ without Radiculopathy						
Jensen 2012 RCT Industry sponsored (Velux Foundation). No COIs.	6.5	N = 100 with persistent LBP (duration 2-12 months) with or without radiculopathy.	Rest (lying prone) 2x/day for 1 hour plus back belt up to 4 hours/day (n = 49) vs. exercise 1x/week for 1 hour with physiotherapist (n = 51).	No differences between groups for pain, disability, general health, depression, global assessment outcomes. 22/100 (22%) dropout rate. Mean±SD pain NRS at baseline vs 1-year: Rest 5.6±1.5 vs. 4.8±2.3. Exercise 5.1±2.2 vs. 4.3±2.4; p = 0.9.	"There was no statistically significant difference on any outcome measure between the treatment approach of rest and reduced load and the conventional approach of exercise and staying active."	No placebo. Trial not of "bedrest," rather intermittent rest. Other group appears to have had so little exercise as to potentially be equivalent to placebo. Thus, trial may have been a comparison of 2 placebo-equivalents. High dropout rate.

SITTING POSTURE

There are strong beliefs and little supportive quality evidence that lordotic postures are superior for LBP treatment and prevention.(542, 543)

Recommendation: Sitting Posture for Acute, Subacute or Chronic Low Back Pain, Radicular Pain or Post-operative Pain

Lordotic sitting posture is recommended for treatment of acute, subacute, or chronic LBP, radicular pain and post-operative pain.

Indications – Acute, subacute, or chronic LBP.
Indications for Discontinuation – Non-tolerance.
Harms – Negligible.
Benefits – Better sleep and potentially reduced pain.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are no quality trials that address sitting posture as a treatment for LBP. Yet, low-quality trials suggest efficacy, the intervention would help to maintain a typical lordotic posture, and the intervention is simple.(542, 543) A pillow or an existing feature of a motor vehicle seat is not invasive, has few adverse effects, is low cost and is recommended.

Evidence for the Use of Sitting Posture

There are 2 low-quality RCTs which reported on sitting postures to prevent or treat LBP in Appendix 1.(542, 543)

SLEEP POSTURE

Certain sleep postures have been sometimes thought of as superior. The controversy appears largely driven by a theory that a straight spine while sleeping is beneficial. This theory holds that specific sleep postures that maintain the nocturnal alignment of the spine will reduce LBP incidence, persistence, and/or severity. Recommendations include sleeping on the side, sleeping with a pillow between the legs, and use of brand-name pillows and mattresses (see Mattresses, Water Beds, and other Sleeping Surfaces section).

Recommendation: Sleep Posture Adjustment for Acute, Subacute or Chronic Low Back Pain

Sleep postures are recommended that are most comfortable for the patient. If a patient habitually chooses a particular sleep posture, it is reasonable to recommend altering posture to determine if there is reduction in pain or other symptoms.

Indications – Acute, subacute, or chronic LBP that results in nocturnal awakening, particularly if not amenable to other treatments.
Indications for Discontinuation – Non-tolerance.
Harms – Negligible.
Benefits – Better sleep and potentially reduced pain.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

Changing sleep posture is low cost and not invasive, although there is the potential for increased symptoms. Alteration of sleep posture may initially affect quality of sleep, which has been suggested

to be a contributor to daytime pain. Thus, recommendations to change sleep posture should be given with appropriate counseling, because the theory may not be correct.

Evidence for the Use of Sleep Posture
There are no quality studies reported on sleep posture to prevent or treat LBP.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: sleep posture, subacute low back pain, chronic low back pain, post-operative, and post surgery, to find 0 articles in PubMed, 0 on EBSCO, 0 on Cochrane Review, and 10,737 in Google Scholar, for a total of 10,737 articles. No RCT's were found.

MATTRESSES, WATER BEDS, AND OTHER SLEEPING SURFACES

Sleep disturbance is common with LBP.(544) Dogma holds that a firm mattress is superior for LBP treatment and/or prevention.(545) Commercial advertisements also advocate brand-name mattresses allegedly to treat LBP.(546) The purpose for including a discussion about mattresses and sleeping surfaces in this section is not to involve providers in prescriptions of mattresses, but to make health care providers aware of the available evidence so that patients can make informed decisions.

1. *Recommendation: Mattresses for Treatment of Acute, Subacute, or Chronic Low Back Pain*
   There is no recommendation for or against the use of mattresses for treatment of acute, subacute, or chronic low back pain other than to raise provider awareness that the dogma to order patients to sleep on firm mattresses appears wrong. By analogy, sleeping on the floor may be incorrect as well.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

2. *Recommendation: Other Sleeping Surfaces for Treatment of Acute, Subacute, or Chronic Low Back Pain*

   There is no recommendation for or against the use of optimal sleeping surfaces (e.g., bedding, water beds, hammocks) for treatment of acute, subacute, or chronic low back pain. It is recommended that patients select mattresses, pillows, bedding, or other sleeping options that are most comfortable for them. Individuals with LBP may report better or worse pain and associated sleep quality with different sleeping surfaces. In cases where there is pain sufficient to interfere with sleep, recommendations by the provider for the patient to explore the effect of different surfaces in the home is appropriate. This could include switching to a different mattress, sleeping on the floor with adequate padding, or using a recliner. Any recommendation in this regard should be preceded by adequate exploration of varied sleep positions/posture that could improve sleep quality. For instance, a recommendation to place a pillow between the knees in the side-lying position or a pillow under the knees in the supine position to alter lumbopelvic posture could be useful.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendations
One quality study of chronic LBP patients reported a medium firm mattress was superior to a firm mattress,(547) but it neither discussed sleep position nor prior mattress firmness which may be important issues. Another trial suggested a waterbed or foam mattress is superior to a hard mattress.(548) Mattress selection is subjective and depends on many factors including personal habits and the weight/size of an individual. For these reasons, individuals must evaluate which mattress is best suited to provide some relief to their particular problem and it is not appropriate for providers to order mattresses or bedding for patients. However, providers should be aware that the dogma that a more firm mattress is superior to a less firm mattress currently appears wrong.

Evidence for the Use of Mattresses, Water Beds, and Other Sleeping Surfaces
There is 1 high-(547) and 1 moderate-quality(548) RCT incorporated into this analysis. There are no quality studies on water beds or sleeping on the floor. There are 2 low-quality RCTs in Appendix 1.(549, 550)

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates. The following search terms were used :"(beds OR other commercial sleep products OR Mattresses made of optimal sleeping surfaces OR bedding OR water beds OR hammocks) AND (sub-acute low back pain OR chronic low back pain)" to find 148 articles. Of those 148 articles, we reviewed 2 articles and included 2 articles (2 RCT, 0 reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Kovacs 2003 RCT Study supported by Kovacs Foundation. FLEX provided and installed mattresses. No COI declared.	10.0	N = 313 with at least 3 months of LBP	Firm mattress (n = 158) vs. medium-firm mattress (n = 155) for 90 days.	At 90 days, medium-firm mattress use with less daytime and nighttime LBP and less disability. Median (range) disability of RMQ: firm 3.0 vs. medium 4.0, p = 0.008. LBP on rising: firm 122 patients vs. 95 medium, p = 0.008. Pain-related disability improved both groups, but higher in medium firm mattress (81.9%) vs. firm mattress (68.3%), p = 0.005.	"A mattress of medium firmness improved pain and disability among patients with chronic non-specific low back pain."	Soft mattress not used in trial. Firmness of prior mattress not measured, thus whether results may be produced among those who previously had a soft mattress to a firmer mattress cannot be determined. However, overall data suggest medium mattress preferable to firm.
Bergholdt 2008 RCT, single-blinded clinical trial Industry sponsored (name not stated). No COI declared.	4.0	N = 160 with chronic LBP or daily LBP (Th12-S1) with dominant morning pain; leg pain, at least 6 months	Waterbed-4 fiber layers stabilizing water movement after 1 second (n = 54) vs. foam mattress-temperature sensitive pressure relieving material that molds to person's shape after few seconds (n = 52) vs. firm mattress-3 layers of cotton, firm mattress (n = 54).	Including "no-influence," where drop-outs were given baseline scores; LBP, sleeping and leg pain, p = 0.07, but not ADL. Using worst-case data/no influence data; waterbed and foam mattress vs. hard mattress, p = 0.015/p = 0.1. Total sample correlation, p = 0.02.	"The waterbed and a body-contour foam mattress generally influenced back symptoms, function, and sleep more positively than a hard mattress, but the differences were small."	Data suggest firm mattress was inferior.

EXERCISES

For decades, exercises have been considered among the most important therapeutic options for the treatment and rehabilitation of LBP.(61, 62, 86, 551-594) While there are many ways to categorize and analyze exercise, this guideline evaluates exercise in three broad groupings: 1) aerobic exercise, 2) stretching and 3) strengthening. Additional subsequent sections include reviews of aquatic therapy, yoga, tai chi, and pilates.

ALL EXERCISE PRESCRIPTIONS

Recommendation: Exercise Prescriptions for Acute, Subacute, Chronic, Post-operative or Radicular Low Back Pain

An exercise prescription is moderately recommended for treatment of acute, subacute, chronic, post-operative and radicular low back pain.

Indications – All patients with LBP appear to benefit from an exercise prescription.

Frequency/Duration – If a supervised program is felt to be needed, recommended frequency is 1 to 3 sessions a week for up to 4 weeks as long as objective functional improvement and symptom reduction is occurring. If self-directed, daily exercise is recommended. An exercise prescription should address specific treatment goals and be time limited with transition to an independent exercise program as part of a healthy lifestyle (no longer considered treatment). The purpose of supervised exercise therapy is symptom reduction, functional improvement, and educating the patient so that he or she can independently manage the program. Evaluation for an exercise prescription involves consideration of five critical components:

1. stage of (theoretical) tissue healing (acute, subacute, chronic),
2. severity of symptoms (mild, moderate, severe),
3. identification of the presence or absence of a directional preference
4. degree and type of deconditioning (flexibility, strength, aerobic, muscular endurance), and
5. psychosocial factors (e.g., medication dependence, fear-avoidance, secondary gain, mood disorders).

Harms – None reported in quality studies. Theoretical risk of myocardial infarction, angina and musculoskeletal injury in a severely deconditioned patient.

Benefits – Improvement in low back pain, improved cardiovascular fitness.

Strength of Evidence – **Moderately Recommended, Evidence (B)**

Level of Confidence – High

AEROBIC EXERCISES

1. *Recommendation: Aerobic Exercise for Treatment of Acute or Subacute Low Back Pain*
   Aerobic exercise is moderately recommended for treatment of acute and subacute low back pain.

   Indications – All patients with acute or subacute LBP appear to benefit from aerobic exercises.[iv]
   Frequency/Duration **–**For acute or subacute LBP patients, a graded walking program is generally desired, often using distance or time as minimum benchmarks – e.g., start with 10 to 15 minutes twice a day for 1 week, increase in 10 to 15 minute increments per week until ≥30 minutes walking a day is achieved. A reasonable eventual target for patients based on treatment of chronic LBP is

[iv]Those with significant cardiac disease, or significant potential for cardiovascular disease should be evaluated prior to institution of vigorous exercises. It is recommended that the American College of Sports Medicine's *Guidelines for Exercise Testing and Prescription*, 9th ed., be followed for health screening and risk stratification. This is rarely required in the acute LBP setting as the initial exertion levels are so low relative to prior activity levels.

walking at least 4 times a week at 60% of predicted maximum heart rate (220-age = predicted maximum heart rate).(595)

Indications for Discontinuation – Development of angina pectoris, myocardial infarction or other intolerance. After LBP resolves, nearly all patients should be encouraged to maintain aerobic exercises on a long-term basis for prevention of LBP,(193, 596) and to maintain cardiovascular fitness and optimal health.

Harms – None reported in quality studies. Increased pain with onset of exercise. Theoretical risk of myocardial infarction and angina in a severely deconditioned patient.

Benefits – Improvement in low back pain, improved cardiovascular fitness.

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – High

2. *Recommendation: Aerobic Exercise for Radicular Low Back Pain*

Aerobic exercise is recommended for patients with radicular low back pain symptoms.

Indications – All radicular LBP patients.

Frequency/Duration – A graded walking program is generally desired, often using distance or time as minimum benchmarks – e.g., start with 10 to 50 feet depending largely on severity of the condition. Gradually increasing distance and duration of walking. A reasonable eventual target for the post-recovery period is based on treatment of chronic LBP and is walking at least 4 times a week at 60% of predicted maximum heart rate.(595)

Indications for Discontinuation – Development of angina pectoris, myocardial infarction or other intolerance. Nearly all patients should be encouraged to maintain aerobic exercises on a long-term basis for prevention of LBP and to maintain cardiovascular fitness and optimal health.

Harms – None reported in quality studies. Increased back pain may occur. Possible fall risk if moderate to severe weakness. Theoretical risk of myocardial infarction and angina in a severely deconditioned patient.

Benefits – Improvement in low back radicular pain, improved cardiovascular fitness.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

3. *Recommendation: Aerobic Exercise for Chronic Low Back Pain*

Aerobic exercise is strongly recommended for treatment of chronic low back pain.

Indications – All patients with chronic LBP. However, those with significant cardiac disease or significant potential for cardiovascular disease should be evaluated prior to instituting vigorous exercises, following the American College of Sports Medicine's *Guidelines for Exercise Testing and Prescription*, 9th ed.,(597) in regards to health screening and risk stratification.

Frequency/Duration – For patients with chronic LBP, walking at least 4 times a week at 60% of predicted maximum heart rate (220-age = maximum heart rate) is recommended.(595) Benchmarks were 20 minutes during Week 1, 30 minutes during Week 2, and 45 minutes after that point. Nearly all patients should be encouraged to maintain aerobic exercises on a long-term basis additionally to maintain optimal health.

Indications for Discontinuation – Intolerance (rarely occurs), development of other disorders.
Harms – None reported in quality studies. Increased back pain with exercise initiation common. Theoretical risk of myocardial infarction and angina in a severely deconditioned patient. Intolerance of weight bearing is severe lower extremity osteoarthrosis. Other musculoskeletal disorders possible (e.g., plantar heel pain).
Benefits – Improvement in LBP, improved cardiovascular fitness, improved health status.

Strength of Evidence – **Strongly Recommended, Evidence (A)**
Level of Confidence – High

4. *Recommendation: Aerobic Exercise for Post-operative Low Back Pain*

Aerobic exercise is recommended for patients with post-operative low back pain.

Indications – All post-operative LBP patients.

Frequency/Duration **–**A graded walking program is generally desired, often using distance or time as minimum benchmarks – e.g., start with 10 to 50 feet depending largely on severity of the operative procedure. Gradually increasing distance and duration of walking. A reasonable eventual target after the operative recovery period is based on treatment of chronic LBP and is walking at least 4 times a week at 60% of predicted maximum heart rate.(595)

Indications for Discontinuation – Development of angina pectoris, myocardial infarction or other intolerance. Nearly all patients should be encouraged to maintain aerobic exercises on a long-term basis for prevention of LBP and to maintain cardiovascular fitness and optimal health.

Harms – None reported in quality studies. Brief increased pain with onset of exercise. Theoretical risk of myocardial infarction and angina in a severely deconditioned patient.
Benefits – Improvement in LBP, improved cardiovascular fitness.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

General Exercise Approach: Acute Low Back Pain
Directional exercises and aerobic exercise are recommended. Strengthening is delayed to late in the acute recovery stage or for subacute or chronic LBP as there is a potential for aggravation of LBP. Pain control modalities may be needed as a complement to exercise. The recommended frequency is 1 to 3 sessions a week for up to 4 weeks as long as objective functional improvement and symptom reduction are occurring.

General Exercise Approach: Acute Radicular Low Back Pain
The treatment strategy is the same as for acute LBP. However, movements that centralize LBP are recommended to guide exercise selection. Concentration on radicular symptoms is emphasized over axial pain. Rapid progression of radicular symptoms and objective signs may necessitate discontinuation of exercise, changing the exercise approach and consideration of further diagnostic testing.

General Exercise Approach: Subacute Low Back Pain
For patients with no prior treatment, the treatment plan is similar to non-specific LBP. The frequency is 1 to 3 sessions a week for 4 weeks as long as objective functional improvement and symptom reduction is occurring. For those who failed acute treatment, a trial of more intensive reconditioning that includes strengthening exercises is recommended. Particular attention should be paid to psychosocial factors that may impair compliance with exercise recommendations among those with

subacute LBP, as it is believed possible to reduce risk for the LBP to become chronic. Providers should educate patients to help motivate, encourage, and facilitate recovery. The frequency is 2 to 5 sessions a week for 4 weeks as long as there is objective functional improvement, symptom reduction, patient compliance, and efficacy. Progress should be reassessed after 8 sessions. Visit frequency depends on work status, symptom severity, comorbidities, and functional status.

General Exercise Approach: Subacute Radicular Pain
Subacute radicular pain is treated similarly to subacute LBP unless there is rapid progression of radicular symptoms and objective signs. If this occurs, it may be necessary to consider further diagnostic testing.

General Exercise Approach: Post-operative Exercising
Post-operative progressive exercise programs should initially emphasize progressive aerobic exercises. Flexibility should begin after appropriate tissue healing, which may be prolonged in the case of fusion surgery and requires careful coordination with the treating surgeon. Strengthening is similarly begun after appropriate tissue healing. Treatment frequency of 1 to 3 sessions a week progressing to 2 to 4 sessions a week is recommended depending on patient compliance, objective functional improvement, and symptom reduction. Reassessment should occur after 10 sessions with continuation based on demonstration of functional improvement. The upper range is 20 sessions.

General Exercise Approach: Chronic Episodic Low Back Pain and Radicular Pain
For patients with mild symptoms or a flare-up of symptoms, the treatment focus is on education regarding home management and exercise. Individuals with mild symptoms and minimal functional limitations may receive a therapy evaluation and 1 follow-up visit to adjust the home therapy program. For individuals with moderate to severe flare-up with mild to severe disability, treatment should consist of a progressive exercise program first emphasizing flexibility and aerobic exercises and progressing to strengthening treatment frequency of 1 to 3 visits a week up to a maximum of 12 visits. Reassessment should occur after Visit 6, with continuation based on patient compliance, objective functional improvement, and symptom reduction. For patients with spinal stenosis, 1 to 3 visits a week up to a maximum of 12 visits to teach flexion exercises and aerobic exercises has evidence of efficacy comparable with surgery for many patients.(598)

General Exercise Approach: Chronic Low Back Pain and Radicular Pain
For patients with mild symptoms and minimal disability, treatment should consist of a therapy evaluation to instruct the patient in a home-based exercise program, with 1 to 2 follow-up visits. For patients whose prior treatment failed and who have moderate symptoms and some functional deficits but no previous exposure to exercise therapy, he or she should be treated the same as a patient with subacute symptoms (outlined above). If the patient failed prior exercise therapy, consider 6 additional exercise visits, or consider an interdisciplinary approach (see Chronic Pain Guideline for managing patients with severe chronic pain or disability).

Evidence for the Use of Aerobic Exercise
There are 18 moderate-quality studies incorporated into this analysis.(595, 598-614) There are 2 low-quality studies in Appendix 1.(615, 616)

We searched PubMed, Cochrane Review, Google Scholar and EBSCO with no limits on publication dates and with the following search terms "Aerobic exercise Sub-acute low back pain, chronic low back pain" to find 71144 articles. Of 71,144 articles, we reviewed 6 articles and included 16 articles. (Original studies 15 RCTs and 1 review).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Acute						
Childs 2004 RCT Grant Support by Foundation for Physical Therapy, Inc., and Wilford Hall Medical Center Commander's Intramural Research Funding Program. No COI.	7.0	N = 131 with acute and subacute LBP	Manipulation plus exercise (thrust spinal manipulation and ROM exercise only (n = 70) vs. Exercise alone low stress aerobic and lumbar spine strengthening program for 4 weeks (n = 61).	Modified Oswestry Disability Questionnaire Score change (1 week/4 weeks/6 months): manipulation vs. exercise (9.2, p <0.001/8.3, p = 0.006/10.1, p = 0.001). Responses to questions at 6 month follow-up. Have you taken any medications for back pain in the past week: manipulation 36.5 vs. exercise 60.0, p <0.05. Are you presently seeking treatment for back pain: 11.5 vs. 42.5, p <0.05. Have you missed any time at work in past 6 weeks because of back pain: 9.6 vs. 25.0, p <0.05.	"The spinal manipulation clinical prediction rule can be used to improve decision making for patients with low back pain."	Data suggest clinical prediction rule provides large differentiation in outcomes. Patients who were positive on clinical predictive rule reported benefit from exercise plus 2 sessions of manipulation compared to exercises alone.
Fritz 2003 RCT Industry sponsored (Clinical Research Center grant from Foundation for Physical Therapy). No COIs.	4.5	N = 78 with work-related LBP <3 weeks	Guideline group, low-stress aerobic exercise, general muscle reconditioning, remain active (n = 37) vs. Classification group, examined by PT, placed into group, treatment based on classification assignment (n = 41). All 2-3 therapy sessions a week; reassessed by physician on weekly or biweekly basis.	Mean (95% CI) for Modified Oswestry: between group difference: baseline to 4 week: 10.9 (1.9-19.9), p = 0.018; SF-36 physical component summary: 5.6 (0.6-10.7), p = 0.030; SF-36 mental component summary: 5.7 (1.8-9.5), p = 0.005; patient satisfaction: 2 (1-3), p = 0.006. Mean (95% CI) for Modified Oswestry: between group difference: 1-year: 9.0 (0.30-17.7), p = 0.044.	"For patients with acute, work-related low back pain, the use of a classification-based approach resulted in improved disability and return to work status after 4 weeks, as compared with therapy based on clinical practice guidelines. Further research is needed on the optimal timing and methods of intervention for patients with acute low back pain."	Meaningful differences between groups at 4 weeks but minimal differences at 1 year.
Subacute						
Storheim 2003 Storheim 2005 (follow-up report) RCT Supported by grants from Norwegian Foundation for Health and Rehabilitation and	7.0	N = 93 with subacute LBP not at work full-time for 8-12-weeks	Exercise of back training at large PT practice twice a week for 15 weeks (n = 30) vs. Cognitive therapy of 2 consultations between 30 and 60 minutes (n= 34) vs. Control group treated by their GP with no restrictions on treatment referral (n = 29). Final follow-up at 18 weeks.	Dropouts highest in exercise group and had higher fear avoidance behavior questionnaires (p = 0.05). LBP ratings best in cognitive group then exercise then controls – -20.9 (S.E., 4.3); -14.9 (4.1); -10.0 (3.7). Disability scores similarly ordered: -3.5 (0.7); -2.1 (0.7); -1.6 (0.7) as was life satisfaction: 1.0 (0.5); 0.4 (0.2);	"Cognitive intervention improved disability and may be feasible for most patients sick-listed in the sub0acute phase. Physical exercise reduced patients' symptoms, but requires high motivation by patients. Despite positive effects in intervention groups on variables considered as negative prognostic factors	Disability and life satisfaction scores similarly ordered. Data suggest cognitive therapy better than exercise which is better than GP treatment. May be biased against GP treatment however, as potentially 'more of the same' and

Norwegian Fund for Postgraduate Education in Physiotherapy. No mention of COI.				-0.2 (0.3). Disability scores similarly ordered: -3.5 (0.7); -2.1 (0.7); -1.6 (0.7) as was life satisfaction: 1.0 (0.5); 0.4 (0.2); -0.2 (0.3).	for long-term disability and sickness absence, interventions had no effect on sick-listing."	also may not include proven treatments.
Evjenth 1984 RCT	6.0	N = 49 with subacute and chronic LBP; severe manifestations as assessed by being off work due to LBP from 8 weeks to 6 months	Manual therapy vs. exercise therapy.	All encouraged to walk, bike, or participate in other aerobic exercise ≥3 times a week and RTW ASAP. Manual therapy group had spinal manipulation, specific mobilization, and stretching techniques with thoracic-lumbar junction thrust (seated), rotation-lateral flexion thrust to segments from T10 to L5 (side-lying), and a sacroiliac manipulation/mobilization technique that was primarily a ventral or dorsal rotational technique (lying prone or side).	"Most of the benefit in the manual treatment group occurred after the first visit, where those on sick leave decreased from 27 to 9 (compared with a decrease from 22 to 16 off work). After 2 months of treatment, 67% of those in the manual therapy group vs. 27% of those in the exercise group had returned to work. Improvements were found in both intervention groups, but manual therapy showed significantly greater improvement than exercise therapy in patients with chronic LBP."	Duration of pain was greater at baseline in the manual therapy group (median 16 vs. 10 weeks), though not statistically significant. Lack of structure to interventions, particularly exercise group, as well as mixing exercises with manual therapy significantly limit strength of conclusions.
Chronic						
Delitto 2015 RCT Sponsored by National Institutes of Health. Dr. Delitto reports grants from NIH/NIAMS. Dr. Welch reports grants from NIH, Zimmer Spine, personal fees from ISTO, other from Transcendental Spine, outside submitted work and Dr. Piva reports grants from National Institute of Health.	7.5	N = 169 with diagnosis of LSS identified by computed tomography sge 50 or older	Surgery included decompressive laminectomies, partial facet resection, and neuroforaminotomies performed at levels of radiographic stenosis (n = 87) vs. physical therapy or PT emphasized lumbar flexion exercises, general conditioning exercises, and patient education for 6 weeks, 2 visits per week (n = 82). Follow-up at 6, 12 and 24-month.	Mean changes in physical function for surgery and PT groups: 22.4 (95% CI, 16.9 - 27.9) and 19.2 (CI, 13.6 - 24. No difference between surgery and PT groups at all points of follow-up, (p >0.50 8). Of 44 who crossed over from PT to surgery, 24 (55%) achieved successful outcome, and 29 in PT group who did cross over, 15 (52%) had successful outcome.	"Surgical decompression yielded similar effects to a PT regimen among patients with LSS who were surgical candidates."	57% patients in PT group crossed over to receive surgery, through 2 years. Excluded, spondylolisthesis >5mm of slippage, PT was flexion exercise plus cycle/treadmill.
Chan 2011 RCT	7.0	N = 46 with chronic LBP or chronic LBP in	Intervention group received additionally aerobic training program for 8 weeks,	Significant improvements in pain and functional disability were reported in both groups, p <	"The addition of aerobic training to conventional physiotherapy treatment did	Small sample size. Lack of blinding. Data suggests no added benefit of

Supported by Department of Rehabilitation Sciences, Hong Kong Polytechnic University and Department of Physiotherapy, David Trench Rehabilitation Centre. No COIs declared.		reducing pain and disability.	individually prescribed and supervised by physiotherapist (n = 22) vs. Control or conventional physiotherapy (n = 24). Both groups received conventional physiotherapy treatment (ultrasound, heat pack, interferential therapy).	0.001. Improvements in disability were sustained in both groups at 12 months when compared to the baseline, $p < 0.001$.	not enhance either short- or longterm improvement of pain and disability in patients with chronic LBP."	aerobic exercise to passive modalities.
Shnayderman 2012 RCT Research received no specific grant from any funding agency in public, commercial of not-for-profit sectors.	6.5	N = 52 with chronic LBP (≥3 months) with or without radiation to lower limb.	Walking group exercise consisted of 5-minute warm up, followed by moderate intense treadmill walking 40 minutes twice a week (n = 26) vs. Control group, specific low back exercise twice a week (n = 26). 6-minute walk primary outcome for 6 weeks.	Improvement in both groups not statistically significantly different between groups. Mean difference in meters covered during 6 minutes increased by 70.7 (95% CI, 12.3-119.7) in the walking group vs. 43.8 (95% CI, 19.6-68.0) in the exercise group.	"A six-week walk training programme was as effective as six weeks of specific strengthening exercises programme for the low back."	Data suggest no significant differences between interventions at six weeks.
Smeets 2008 RCT Study is supported by Zorgonderzoek Nederland/Medische Wetenschappen (ZonMw) Grant No. 014-32-007. No COI	6.0	N = 172 with LBP for 3+ months resulting in disability according to Roland Disability questionnaire (score>3) with ability to walk at least 100m in Denmark	Under physiotherapist supervision: Active physical treatment (APT) 30 minutes aerobic exercise on bicycle and 75 minutes strength and endurance training of lower back and upper leg muscles (3 series of 15-18 reps) 3 x week for 10 weeks (n = 53) vs. Graded activity with problem solving training (GAP) operant-behavioral graded activity (GA) training and problem solving training (PST) for 3 group sessions followed by 17 individual sessions of 30 minutes. Session frequency gradually decreased from 3 to 1 week. Occurred for 10 sessions of 1 1/2 hours; minimum 4 patients at a time (n = 58) vs. Combination treatment (CT) specifically tried to integrate	Mean and standard deviation of Roland Disability questionnaire from mean improvement of baseline: Post-treatment; APT: 2.42 (1.14-3.69) GAP: 3.04 (1.79-4.29) CT: 2.47 (1.25-3.86). 6 Months follow-up; APT: 3.15 (1.88-4.43) GAP: 3.65 (2.40-4.90) CT: 2.54 (1.31-3.76). 12 months follow-up; APT: 3.28 (2.00-4.58) GAP: 3.74 (2.48-5.01) CT: 2.12 (.89-3.36)	"[W]e conclude that the combination treatment integrating physical, graded activity with problem solving training is not a better treatment option for patients with chronic low back pain."	All treatment arms active. Combined treatment not superior to either PT-treatment or graded exercise in small group setting.

			all APT, GA and PST. CT started with APT and PST offered in same frequency and duration as ATPT and GAP. APT given 3x/week, PST once a week, GA initially 3 time a week and gradually decreasing to 1x a week for 10 weeks (n = 61).			
Cuesta-Vargas 2012 RCT Study received funds from the National Health Service of Andalusia. No COI.	6.0	N = 58 with non-specific chronic LBP	Deep water running or DWR additionally received 3 times/week sessions for 4 months for 30 minutes (n = 23) vs. Standard general practice or GP received educational booklet only (n = 23). Both groups received 25-educational booklet/ verbal presentation on basic anatomy/physiology of spine, principles of ergonomics for LBP patients. Outcome measures include pain, disability, general health.	Differences between treatment effects for baseline and 1 year follow-up was VAS pain -26.0 (-40.0 to -11.1) ($p < 0.01$) and -2.5 (-5.7 to -0.2) points on RMQ for disability ($p < 0.05$).	"For patients with NSCLBP, the addition of DWR to GP was more effective in reducing pain and disability than standard GP alone, suggesting the effectiveness and acceptability of this approach with this group of patients.	Study indicates single blinding but did not describe. No comparison with other supervised aerobic exercise limits conclusion of efficacy with other forms of exercise.
Murtezani 2011 RCT No mention of sponsorship or COIs.	5.5	N = 101 with LBP	Aerobic exercise group began with 10-15 minutes warm-up period stationary bicycling, 3 days/week, 30-45 minutes (n = 50) vs. Passive modalities group received interferential current, TENS, ultrasound, heat, involving thrice-weekly attendance without any form of physical activity (n = 51). Follow-up 12 weeks.	Significant improvements in comparison with basic values in pain intensity, disability, anxiety and depression, fingertip-to-floor distance, $p < 0.001$. The $p < 0.0001$, rejects hypothesis of equal equivalence.	"The addition of aerobic training to conventional physiotherapy treatment did not enhance either short- or long-term improvement of pain and disability in patients with chronic LBP."	No blinding described. Lack of details for control of cointerventions, compliance. Data suggests workers with chronic LBP improved in pain and function with aerobic exercise compared to passive modalities.
Weiner 2008 RCT Industry Sponsored (National Center for Complementary and Alternative Medicine and National Institutes	5.5	N = 184 over age 65 with LBP every day or almost every day for >3 months	PENS: 32g 40mm needles SQ, approximately 15mm depth. 10 needles for each session, placed bilaterally at levels corresponding to T-12, L3, L5 and S2. Electrical stimulation 30 minutes using alt. positive and negative leads at moderate intensity 2x/week 6 weeks (n = 47) vs. control-PENS 10x32g 40mm	Baseline to post-intervention; Mean and SD. Pain and Function MPQ total: Pens;-2.9±9.2 ($p = 0.03$) PENS+CGAE -4.1±8.2 ($p = 0.0017$); Sham Only -2.3±6.3 ($p = 0.0145$); Sham +CGAE -3.1±7.9 ($p = 0.0123$). Roland Questionnaire: PENS only -2.6±4.5 ($p = 0.0002$) PENS+CGAE -2.6±4.6 ($p = 0.0005$) Sham Only -2.7±3.8 (p	"[L]umbar PENS administered twice a week for 6 weeks to community dwelling older adults with CLBP is safe and well-tolerated. It reduces pain and improves self-reported pain-associated disability, and these benefits are sustained after 6 months. Minimal electrical stimulation (i.e., 5	All groups improved. Data suggest PENS ineffective.

of Health). No mention of COIs.			acupuncture needles in identical location/depths. 2 needles also bilaterally at T-12 for 30 minutes. Electrical stimulation only at T-12. 100Hz all 12 treatment sessions. 5 minutes following initiation unit turned off (n = 45) vs. General conditional and aerobic exercise (GCAE) PT supervised at home and on-site. On-site sessions 60 minutes. Aerobic exercises 30 minutes HEP of flexibility and graded walking program (30 minutes day) performed 3x week for 6 weeks. (n = 48) vs. PENS + GCAE (n = 44).	<.0001) Sham+CGAE -3.0±4.7 (p = 0.0001).	min as compared with 30 min.) has similar benefits."	
Sculco 2001 RCT No mention of industrial sponsorship. No COI.	5.0	N = 35 with diagnoses included herniated discs at 1 or more levels with varying degrees of radicular compression, degenerative discopathy with and without bulging, lumbosacral strain and spinal canal and/or foraminal stenosis.	Low to moderate aerobic exercise (AE, n = 17) vs. control (n = 18). Exercise group prescribed a 10-week home-based aerobic training program consisting of walking or cycling, 4 times week at 60% of predicted maximum heart rate (20 minutes during Week 1, 30 minutes during Week 2, 45 minutes during the remaining weeks). After 10 weeks of randomization, all instructed to exercise and followed for 2.5 years.	Depression mean (SD) for control vs. exercise group at baseline/5 weeks/10 weeks: 6.16 (8.35)/5.88 (10.17)/9.44 (12.31) vs. 3.64 (4.06)/2.35 (4.12)/3.64 (5.74), p <0.05; anger: 4.11 (5.49)/5.77 (7.10)/8.16 (11.27) vs. 2.35 (2.99)/0.94 (2.19)/11.82 (3.57), p <0.05. Tension mean (SD) at baseline/5 weeks for control vs. exercise: 4.16 (6.80)/4.50 (6.64) vs. 2.05 (3.63)/0.12 (4.13), p <0.05. Total mood disturbance at baseline/10 weeks for control vs. exercise: 11.22 (32.15)/19.11 (43.72) vs. -2.11 (17.31)/-9.58 (19.89), p <0.05. Those exercising over 30-month follow-up incurred fewer prescriptions for pain (p <0.02) and PT (p <0.002).	"There were no differences in epidural blocks or office visits. Work status was improved in the exercise group."	Relatively small group sizes. Some baseline differences in epidural injection. Specific exercise-dose prescription used. Data suggest aerobic exercise successful for depression scores and pain treatments.
Chatzitheodorou 2007 RCT	5.0	N = 20 with chronic LBP (15 disc disruption, 3 spondylosis, 2 facet joint pain)	12-week, high-intensity aerobic exercise program (n = 10) vs. 12-weeks passive interventions without any form of physical activity (n = 10). Aerobic exercise treadmill running at 60% of	Mean (SD) McGill Pain Questionnaire baseline/12 week for exercise group vs. control group: 53.9 (10.4)/32.3 (7.9) vs. 53.0 (11.7)/53.3 (10.0), p <0.05. Roland-Morris Disability Questionnaire disability: 13.8	"Regular high-intensity aerobic exercise alleviated pain, disability, and psychological strain in subjects with chronic low back pain but did not	Data suggest reductions in pain with aerobic exercise, disability, and psychological strain, all strongly in favor of high intensity aerobic exercise. Trial also had specific

No mention of sponsorship or COIs.			HR maximum for 30 minutes 3 times a week for 1st 3 weeks, then 85% HR maximum, 50 minutes 3 times week for 9 weeks and supervised by physiotherapist. Controls received diathermy, ultrasound, laser, difase fixe, and electrotherapy.	(2.4)/9.6 (2.6) vs. 14.4 (2.8)/14.3 (3.6), p <0.05. Hospital anxiety and depression scale: 24.8 (5.0)/16.2 (3.4) vs. 22.6 (4.1)/21.9 (4.5), p <0.05.	improve serum cortisol concentrations."	exercise-dose prescription.
Tritilanunt 2001 RCT No mention of industry sponsorship. No COIs declared.	5.0	N = 72 with chronic LBP >3 months	Aerobic exercise and health education (n = 36) vs. lumbar flexion back exercise and health education (n = 36). Aerobic exercise included a series of 3 health education sessions including group discussion, modeling and demonstration and self-practice. Back exercise included regular health education, postural and behavioral instruction and lumbar flexion exercise training program; 12 weeks follow-up.	Aerobic group's mean pain scores decreased at 3 months from 5.6±1.8 to 2.3±1.8 vs. 5.42±1.8 to 4.0±1.9 in flexion group (both p <0.001). Resting heart rates decreased in aerobic group (70.1±3.8 to 66.8±3.8, p <0.001) vs. no change in flexion group (71.5±5.90 to 70.2±6.22). HDL cholesterol increased with aerobic exercise (54.6±11.4 to 57.1±12.0, p <0.005), but decreased in flexion group (57.64±11.84 to 56.12 ±11.58, p <0.005).	"[T]he results of the study demonstrated that aerobic exercise and a health education program are useful in the treatment of chronic low back pain, particularly in pain relief."	Exercise program not well described. Data imply aerobic exercise beneficial based on biological indices; however, strong conclusions not warranted.
Dogan 2008 RCT No mention of industry sponsorship. No COIs declared.	5.0	N = 60 with chronic LBP.	Group 1, aerobic+home exercise (n = 20) vs. Group 2, Physical therapy+home exercise (n = 20) vs. Group 3, home exercise only (n = 20).	At 1-month follow-up; pain sensitivity/GHQ scores / MET levels; p = 0.002/0.053 vs. p = 0.001 vs. p = 0.006/Group 1, p = 0.053 vs. 2 p = 0.010/Group 1. p = 0.000 vs. 3, p = 0.001.	"[T]hree different treatment approaches are found to be effective in decreasing the pain in patients with the chronic low back pain."	Questionable randomization success.
Goldby 2006 RCT No industry sponsorship. No mention of COI.	4.5	N = 323 with chronic LBP	10 courses of manual therapy (n = 89) vs. 10 week course of spinal stabilization rehab program or SSR (n = 84) vs. Minimal intervention "education" or ED controls (n = 40). Stabilization exercises taught in 10 classes, once a week for 1 hour. MT technique based on diagnosis and clinical reasoning.	No differences in back pain intensity. At 6 months, fewer in spinal stabilization reported pain in prior 2 days vs. MT and Education (SSR = 47.9% vs. MT = 72.4% vs. ED = 56%, p = 0.009). At 12 months, SSR had 38.8% reduction in disability vs. 24.5% in MT and 19.8% in ED (p = 0.0098). At 12 months, SSR had fewest taking medication (16.9%) vs. MT (27.8%) vs. ED (39.3%) (p = 0.007).	"A 10-week spinal stabilization program is significantly more effective than manual therapy at reducing pain, disability, dysfunction, medication intake, and improving the quality of life in patients with chronic low back disorder. The application of manual therapy is significantly more effective at reducing pain in patients with higher levels of	All groups had a 3-hour back school, but attendance was 43-64% which raises questions about compliance throughout as there also were fewer classes attended in MT vs. spinal stabilization.

					low back pain than a minimal intervention control group."	
Kell 2009 RCT Industry sponsored (Saskatchewan Health Research Foundation (New Investigator Grant) and the University of Alberta, Augustana Campus (travel grant)). No mention of conflict of interest (COI).	4.5	N = 27 recruited via advertisement from Regina and suffered from chronic (≥3 months) nonspecific low-back (lumbar 5 to lumbar 1) pain.	All testing sessions conducted by same 2 researchers. Group 1 Resistance Training (RT): tested 3 times (baseline, 8 and 16 weeks) 10-repetition maximum testing on 11 resistance exercises using free weights, machines, body weight for 3 per week (n = 9) vs. aerobic training (AT) Tested 3 times (baseline, 8 and 16 weeks) consisted of 3 sessions per week, Borg scale range of 8-12, session duration of 20-35 minutes. Any mode of aerobic exercise used, as was participant's choice (except for swimming) (n = 9) vs. control group (C) tested at baseline and week 16. Control group data used to oppose treatment groups data (n = 9).	Baseline, Week 8, and Week 16 Mean SD: Visual analog scale of pain: RT; 5.4(0.9), 3.9 (.8) 3.3 (0.5). AT; 5.1 (0.8), 4.8 (.7), 4.8 (0.8) C; 4.9 (0.6), nt (nt), 4.8 (0.7). Oswestry disability index RT; 40.4 (2.4), 28.2 (2.0), 24.2 (2.0). AT; 39.8 (2.3), 38.1 (2.2), 35.9 (2.5). C; 39.2 (3.4), nt (nt), 39.1, 3.3. Physical component score: RT; 41.1 (3.2), 46.3 (3.0), 47.4 (3.2). AT; 42.1 (2.5), 42.3 (3.2), 41.8 (2.5). C; 39.3 (3.3), nt(nt), 39.1 (3.3). Mental Component summary: RT; 43.0(4.1), 49.8 (2.0), 50.6(3.0), AT: 44.3 (2.3), 45.6 (2.7), 45.8 (1.4), C; 42.0 (3.0) nt (nt), 41.56 (2.3).	"[T]he primary finding was that periodized RT disability was successful at improving many fitness, pain, disability, and QOL outcome measures, whereas, AT was not. This study indicates that whole-body perdiodized RT can be sued by training and conditioning personnel in the rehabilitation of those clients suffering with CLBP."	Relatively high drop out with unknown differences between groups.
Jousset 2004 RCT Institutional funds were received from Union Re´ gionale des Caisses d'Assurance Maladie des Pays de Loire. No COI.	4.0	N = 86 with chronic LBP	Functional Restoration or FRP; warm-up, stretching, strengthening exercise, aerobic exercise, 3 hours a day for 5 weeks (n = 44) vs. Active Individual Therapy or AIT, 1 hour treatment session with therapist of choice, teaching of program of exercises (n = 42).	Dallas-HAD scale-Social Interest-Pain Intensity-endurance; p <0.001, significantly improved for FRP group, vs. less positive results for these parameters found in AIT group at 6 months.	"This study demonstrates the effectiveness of a functional restoration program on important outcome measures, such as sick leave, in a country that has a social system that protects people facing difficulties at work."	Multiple differences between groups at baseline.

DIRECTIONAL EXERCISE

Recommendation: Directional Exercises for Treatment of Acute, Subacute, Chronic, or Radicular Low Back Pain

Directional exercises are recommended for patients found to have directional preference (i.e., centralization or abolishment of pain in a direction).(617) For chronic pain, directional exercises are generally not the primary or sole exercise treatment as aerobic and strength deficits are usually present.

Indications – For acute, subacute, or chronic LBP, directional preference exercises are recommended.

Frequency/Duration – Exercise frequency is determined by the stage of recovery. They are initially performed every 2 hours (8 to 10 repetitions) to fully centralize and abolish the pain, along with posture modifications that also honor patients' directional preference and protect the patient from symptoms returning when not exercising. Once the pain is eliminated even for a short period of time, the same exercises and posture changes should continue proactively to attempt to prevent the pain from returning. Proactive exercise remains important in maintaining a pain-free status as the opposite direction of spinal movement and positioning are progressively re-introduced. The duration of this sequence is typically a few days or weeks.

Indications for Discontinuation – Directional exercises should be discontinued if there is worsening pain in the course of treatment or failure to improve.

Benefits – Often rapid elimination of the pain and earlier return to function.
Harms – None reported in quality studies. Theoretical risk of increased pain from over-stretching.

Strength of Evidence – **Recommended, Evidence (C)** [Acute]
Recommended, Insufficient Evidence (I) [Chronic, Subacute, Radicular]
Level of Confidence – Moderate

STRETCHING AND FLEXIBILITY

1. *Recommendation: Slump Stretching for Treatment of Acute, Subacute, or Chronic Low Back Pain*
   Slump stretching is recommended for those with acute, subacute, or chronic low back pain, but without directional preference (see Directional exercise above).
   Indications – For acute, subacute, or chronic LBP among patients without directional preference, stretching exercises are recommended. Generic stretching exercises are not recommended. Among those with directional preference, directional exercise is believed to be preferable to slump stretching.
   Frequency/Duration – Three to 5 times a day for acute LBP; 2 to 3 times a day for subacute or chronic LBP.
   Indications for Discontinuation – Resolution, worsening pain or failure to improve.
   Benefits – Improvement in low back pain.
   Harms – Increased pain especially short term, and particularly if stretch in a direction of worsening (see Directional Exercise). Theoretical risk of muscle strain from over-stretching.

   Strength of Evidence – **Recommended, Evidence (C)** [Acute]
   Strength of Evidence – **Recommended, Insufficient Evidence (I)** [Subacute, Chronic]
   Level of Confidence – Low

2. *Recommendation: Aggressive Stretching for Treatment of Low Back Pain*
   Aggressive stretching is not recommended for treatment of low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

3. *Recommendation: Stretching Exercises for Prevention of Low Back Pain*
   Stretching exercises as an isolated prescription or program for purposes of preventing low back pain are not recommended.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Low

4. *Recommendation: Stretching Exercises for Treatment of Chronic Low Back Pain*
Stretching exercises are not recommended for treatment of chronic low back pain in the absence of significant range of motion deficits. In select cases, stretching exercises may be added for self-treatment if needed.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

STRENGTHENING AND STABILIZATION EXERCISES

1. *Recommendation: Strengthening Exercises for Acute (Late Recovery), Subacute, Chronic, or Post-Operative Low Back Pain*
Strengthening exercises are recommended for patients with acute (late recovery), subacute, chronic, or post-operative low back pain. Specific strengthening exercises, such as stabilization exercises, are helpful for the prevention and treatment (including post-operative treatment) of low back pain.(618-621)

Indications – Nearly all LBP patients other than those with acute LBP that resolves rapidly or acute LBP in the acute treatment phase when strengthening could aggravate the pain. As evidence of efficacy of aerobic exercises appears greater (see above), these exercises should be added after aerobic exercises have already been instituted and additional treatment is needed or in situations where both are felt to be required. Exercises should be taught and then performed by the patient in a home exercise program. For those patients who do not improve, follow-up appointments to verify technique and compliance (by exercise log books) are recommended. Some patients, particularly those lacking motivation to be in a home exercise program or those with fear avoidant behaviors may benefit from a supervised exercise program, although strong questions about long-term compliance are apparent among such patients particularly with chronic LBP. More intensive programs with more intensive exercises and direct supervision with active coaching appear warranted for chronic LBP.

Frequency/Duration – Home program frequency is 1 to 2 times a day for acute LBP, and 2 to 3 times a day for subacute or chronic LBP. Supervised treatment frequency and duration is dependent of symptom severity and acuity and the presence of comorbid conditions and yellow flags (see recommendations under General Exercise Approaches and Recommendation).
Indications for Discontinuation – Indications to discontinue strengthening exercises include development of a strain in the course of treatment or failure to improve.
Benefits – Improvement in LBP, improved strength and fitness.
Harms – Increased pain, especially short-term; theoretical risk of musculoskeletal injury.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

2. *Recommendation: Abdominal Strengthening Exercises for Treatment or Prevention of Low Back Pain*
Abdominal strengthening exercises as a sole or central goal of a strengthening program are not recommended for treatment or prevention of low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

3. *Recommendation: Fear Avoidance Belief Training During Rehabilitation*
   Inclusion of fear avoidance belief training during the course of rehabilitation is recommended.
   Benefits – Improvement in exercise and activity compliance,with resultant improved LBP and fitness.
   Harms – None reported.
   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
General Summary of Exercise Issues
There is a large body of RCTs on exercise to treat LBP. However, the majority of studies combined different exercises. Others left exercise programmatic components unstructured and/or did not clearly describe the interventions. These limitations restrict the utilization of a substantial body of the literature for purposes of drawing evidence based conclusions regarding any single intervention. Still, there is a considerable, remaining body of evidence to draw evidence-based conclusions on the relative value of aerobic, stretching, and strengthening exercises.

There are two major patterns which are apparent in reviewing this body of evidence. First, aerobic exercise is uniformly beneficial and appears to be the most promising modality of exercise. The second pattern is that the more vigorous the strengthening exercises, the more benefit appears to be derived from those exercises. These are discussed in more detail below.

A common issue for all exercise programs is the propensity for individuals to not participate. Even in RCTs where motivation to participate may be higher than in a clinical population, participation rates are frequently suboptimal. Some trials defined compliance as meeting a benchmark of participation that was less than that prescribed (e.g., accomplishing exercises at least 3 times a week versus 5 times a week as prescribed). This raises questions about the value of higher degrees of compliance compared with lesser compliance rates. There is some evidence that results from those attending supervised programs are superior to performing unsupervised programs, yet other studies show a lack of improvement with supervised programs compared with home-based exercise programs. Those with chronic pain seem to do better in supervised programs and those with acute pain appear to do no better with supervised programs, perhaps reflecting the natural excellent prognosis for acute LBP.

Thus, treatment is by inference from treatment of chronic LBP patients. For most patients, a structured, progressive walking program is recommended. There has been some controversy about whether bicycling is helpful or harmful from a biomechanical perspective (lordosis) and the back muscles are less active with bicycling, thus it may be theoretically less appropriate except for lumbar stenosis where bicycling is usually superior to walking. For those patients who desire other aerobic exercises, there are no specific data, although there are indications of a direct correlation between benefit and the amount of aerobic activity that results in higher MET expenditure. Therefore, the activity that the patient will adhere to is believed to be the one most likely to be effective, given that compliance is a recognized problem. Theoretical benefits of aerobic exercise include improved aerobic capacity, improved blood flow, lower depression, higher pain thresholds and pain tolerance. These exercises include walking, running, bicycling and many other activities. Whether there is benefit from weight-bearing versus non-weight bearing aerobic exercises remains unclear. There is evidence that a treadmill is superior to upper extremity or bicycle ergometers in assessing aerobic capacity in chronic LBP patients.(622) However, an exercise test is not necessary to evaluate and treat the majority of LBP patients.

While many studies included some aerobic exercises as part of a battery of exercises, there are some studies that appear to either solely or largely rely upon significant durations of aerobic exercise for treatment of LBP.(27, 623-626) All of these studies show favorable benefits from aerobic exercises, including reductions in LBP measures and some functional outcomes such as lost time, disability scores, or measures of depression. Most used walking programs, others either used bicycles or simply encouraged aerobic activities. Aerobic exercise, particularly self-directed, is low cost, not invasive and has low potential for adverse effects. Available evidence suggests that aerobic exercises may be more efficacious than other types of exercise for treatment of LBP. Weak evidence suggests weight bearing exercise may be superior. There is no quality evidence to support aerobic exercise for patients with post-operative pain. This review assumes that other chronic pain conditions respond similarly to aerobic exercise.

Rationale for Recommendations: Aerobic
Theoretical benefits of aerobic exercise include improved aerobic capacity, improved blood flow, lower depression, and higher pain thresholds and pain tolerance. These exercises include walking, running, bicycling, and many other activities. Whether there is benefit from weight-bearing versus non-weight bearing aerobic exercises remains unclear. There is evidence that a treadmill is superior to upper extremity or bicycle ergometers in assessing aerobic capacity in chronic LBP patients.(622) However, an exercise test is not believed to be necessary for the evaluation and treatment of the vast majority of LBP patients. For most patients, a structured, progressive walking program on level ground or no incline on a treadmill is recommended. There has been some controversy about whether bicycling is helpful or harmful from a biomechanical perspective (lordosis) as the back muscles are less active with bicycling, thus it may be less appropriate other than for spinal stenosis. Yet, if bicycling is the preferred exercise for the patient, it is believed to be far superior to obtaining no aerobic exercise. For patients who desire other aerobic exercises, there are no specific data, although there are indications that infer that there is a direct correlation between benefit and the amount of aerobic activity that results in higher MET expenditure. Therefore, the activity that the patient will adhere to is believed to be the one most likely to be effective, given that compliance is a recognized problem.

Rationale for Recommendations: Stretching
Stretching exercises may be the most widely utilized of the three major exercise domains. Stretching exercises include active movements to improve joint mobility and centralize symptoms, and flexibility exercises to increase the length of a target muscle group. There is longstanding dogma that this is the most important of the exercise domains, e.g. "one of the main goals of therapeutic exercise in low back disorder is to maintain and promote normal flexibility."(627) Stretching exercises also have been utilized for both treatment as well as prevention, and are used in some manufacturing settings as part of an "ergonomics program" or injury prevention program.

Rationale for Recommendations: Directional Exercises
Directional exercises are used most commonly to "centralize" and abolish symptoms when it has been determined that a patient has a *directional preference,* whether for extension, flexion, lateral bending or axial rotation.(86, 555, 617, 628-632) "Directional preference" is defined as back pain that centralizes or decreases with movement in one direction (e.g., flexion or left bending resulting in relief of the buttocks pain and centralizing that pain to only central lumbosacral pain) and that increases with motion in the opposite direction (e.g., extension or right bending). Directional preference exercises are then prescribed to be performed in the direction which centralizes and abolishes the pain. It is believed important to also modify sitting posture temporarily consistent with the directional preference identified during patient assessment.

Historically, the two most widely used directional programs of exercises are referred to as Williams flexion exercises and McKenzie exercises.(617, 633) However, the direction of McKenzie exercises for each patient varies, determined by the directional examination findings that reflect the mechanical characteristics of the pain-generator. Directional exercises as part of McKenzie care are entirely passive in the lumbar spine, with either the patient, or occasionally a provider, providing the remote or external force to achieve the required end-range positioning or repetitions. There are many additional stretching exercises and these all involve standing or recumbent positions.

There is one primary theory, and considerable evidence to support it, regarding why directional exercises are effective. The cause of axial and more proximal leg pain is uncertain, yet the axial and more proximal pain frequently responds to directional testing and exercises. Repeated flexion loading on a disc may theoretically cause posterior nuclear displacement into a fissure or even creates a protrusion.(634, 635) Changing to repeated extension loading has been suggested to reverse or reduce that displacement.(636) This is consistent with patients in whom a directional preference is elicited who so often centralize their referred or radiating pain and then recover rapidly and fully using directional exercises and posture modifications.

There are several theories proffered to support the use of stretching exercises for purposes of preventing LBP or other musculoskeletal disorders. These include providing more flexibility and warming up the muscles. These theories have weaknesses. Providing more flexibility does not change a sarcomere, does not increase strength, will result in the performance of a task at the same percentage of maximum voluntary contraction, and thus is unlikely to provide an increased margin of safety. Stretching exercises also are unlikely to substantially warm up muscles as the aerobic demands of such activities are so minor. Perhaps these exercises may be useful for highly strenuous or otherwise demanding tasks to improve focus on the task at hand and use a smooth lifting technique that lowers peak physical demands. Another concern is the potential for adverse effects in an otherwise asymptomatic population. Flexibility varies in the population, yet there is a social drive to achieve a theoretically standard normal range of motion. Overstretching is more likely in those normal individuals with less flexibility. Such overstretching may result in a true strain which is painful and slow to heal.

There is a lack of evidence that generic stretching exercises are of assistance in treating patients with acute LBP.(637) There is relatively weak evidence suggesting that specific exercises(86, 638) may be of assistance among those with subacute or chronic LBP.

In addition, flexibility exercises are frequently targeted at muscles that are shortened in length, which often include the piriformis, quadratus lumborum, hamstring, hip flexor, and iliotibial band groups. Stretching exercises actively performed by patients for purposes of treatment and rehabilitation of LBP are low cost when performed as a home exercise program, are not invasive, and have low potential for adverse effects. They may help alleviate the stiffness that occurs with LBP that is thought to contribute to increased pain.

There is one reported low-quality RCT of aggressive stretching exercises for the treatment of chronic "myofascial" LBP,(639) but no duplication of those results in the literature. Thus, there is no quality evidence base for aggressive stretching. There are concerns that over-stretching may result in additional injuries to patients. Aggressive stretching requires a health care provider for each session and thus costs are considerably greater than those for self-performed stretching exercises. While they were not invasive, there are concerns that the potential for harm outweighs the potential for benefit. There are many other interventions with evidence of efficacy.

Rationale for Recommendations: Strengthening

Strengthening exercises may be theoretically used for purposes of improving maximum strength. Such improved strength would result in the ability to perform the same task at a lower percentage of maximum voluntary contraction, which in theory improves the individual's margin of safety. The evidence to support the theory is not particularly strong. A caution is that in the process of strengthening, sustaining a strain is possible. Another

issue is that long-term compliance is required, is extremely difficult to achieve for all but the most highly motivated individuals. Fear avoidance belief training and principles appear important in the management of patients with LBP (see Fear Avoidance Belief Training). Inclusion of these principles in the course of exercise training or supervision appears highly desirable. This would also strengthen the education of the patient about LBP that should be a message in unison with other members of the team treating the patient.

There are multiple, heterogeneous studies that have evaluated exercise programs that either largely consisted of, or heavily relied upon, strengthening.(619-621, 640-647) Generally, these studies have demonstrated benefits, yet not all have demonstrated efficacy. For example, one study among subacute LBP patients showed a cognitive program was superior to the exercise arm.(614) As there are no high-quality studies of strengthening exercises and the study designs employed do not generally allow for a conclusion of efficaciousness above that obtained with the natural history of LBP, there is at least some concern that the strengthening exercises may have relatively low magnitudes of benefits.

There has been a trend towards stabilization or "core" strengthening exercises over the past decade. Stabilization exercises attempt to develop improved muscle strength and endurance of muscles that surround the spinal column (such as multifidus and transverse abdominus). There is some support for this theory,(619) but there are no high-quality studies demonstrating that stabilization exercises are superior to other strengthening exercise regimens. As there is evidence that a home exercise program is as effective as a supervised program for treatment of chronic LBP,(648) a home-based exercise program may be particularly cost effective while presumably resulting in the same benefits as a supervised program.

Dogma holds that strengthening abdominal muscles will variously successfully treat LBP, are effective for primary prevention, or prevent recurrence of LBP. However, abdominal muscles (rectus, obliques) are not materially involved in lifting tasks as they flex rather than extend the back; still, some believe they support the spine without a clearly defined mechanism of action. There also is no quality evidence that strengthening abdominal muscles is effective for either treatment or primary, secondary, or tertiary prevention of LBP. Abdominal strengthening exercises have been labeled an ergonomic myth.(649) That said, many providers instruct LBP patients in the activation of abdominal, trunk, and hip extensor muscles for the purpose of stabilizing the pelvis during lifting and activities of daily living. Traditional abdominal strengthening exercises such as sit-ups are not utilized in these stabilization programs.

Unfortunately, despite a plethora of literature, the vast numbers of possible permutations and combinations of exercises impairs the ability to identify specific exercises that demonstrate particular benefit. Additionally, there is some preliminary evidence that patients with differing clinical presentations of LBP do not benefit equally from all types of therapeutics. Rather, some patients are more likely to benefit from stabilization exercises,(650) while others benefit from specific directional exercises.(86) There are many different types of exercise that have been assessed in many different settings with heterogeneous populations of patients. Outcomes used are similarly quite heterogeneous (e.g., pain, modified duty, lost time, or disability ratings). While applicable throughout the spinal literature, there also has been a recognized problem with a concentration on finding statistical significance instead of clinical importance in the literature on exercise.(651)

There are also different schools of thought with different rationale for various sequences and combinations of exercises. Taken in composite, the evidence of a beneficial effect of exercise for the treatment of LBP is moderately strong, but taken individually, the evidence for any one exercise is generally weak or absent. A systematic approach to research investigating exercises for the treatment of LBP is clearly needed. Exercises can be segregated into different categories, but for purposes of this discussion, the three broad categories or "domains" of exercise will be utilized – aerobic, stretching/flexibility, and strengthening/stabilization.

Evidence for the Use of Exercise

There are 2 high-(652, 653) and 107 moderate-quality RCTs (one with multiple reports) incorporated into this analysis (see evidence table below).(28, 86, 534, 554, 555, 570, 591, 602, 605, 606, 610, 614, 618-620, 624, 625, 627, 629, 637, 638, 640, 642-645, 648, 650, 654-729, 730, 731, 732) Most articles have mixed various forms of exercise, thus this summary evidence overview does not attempt to segregate the evidence into the three broad domains of exercise – aerobic, stretching/flexibility, and strengthening/stabilization. Instead, summaries of the quality evidence are provided and later reviewed for each of the three exercise domains. One study was scored high quality; however, while it had quality study design features, it also had significant problems with heterogeneity of treatments in both the interventions and controls. There is a plethora of moderate-quality studies. The studies below are organized based on the type of study, acuity, and score. There are 36 low-quality RCTs in Appendix 1.(61, 542, 543, 615, 616, 626, 639, 641, 646, 678, 733-758)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: stretching and flexibility exercises, strengthening, strengthening exercise, abdominal strengthening exercises, abdominal exercises, abdominal, home exercise, program, subacute low back pain, chronic low back pain, acute low back pain, clinical trial, randomized controlled trial or random, post-operative, postoperative or post-surgery, systematic reviews, or reviews, and population study, epidemiological study, or prospective cohort Of the 110,821 articles found and reviewed, we included 141 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Prevention: Stretching Exercises						
Pope 2000 RCT No mention of sponsorship or conflict of interests or COIs.	5.0	N = 1,538 healthy military recruits	Stretching (n = 735) vs. No stretching pre-exercises (n = 803).	Hazard ratio [HR] = 0.95 (95% CI, 0.77 – 1.18); no differences in injury risks. No differences in soft tissue injuries (HR = 0.83, 95% CI 0.63 – 1.09) and bone injuries (HR = 1.23, 95% CI 0.86 – 1.76).	"[P]exercise muscle stretching does not produce a clinically worthwhile reduction in the risk of lower-limb injury. Injury risk is strongly associated with age and 20mSRT scores. This suggests that fitness may be a modifiable risk factor for injury."	Study suggests no clinically significant reduction in injuries from performing pre-exercise stretching of six lower extremity muscle groups in a military basic training population.
Acute						
Anema 2007 RCT Federal funds received in support of this work. No benefits in any form have been received.	5.5	N = 196 sick-listed 2-6 weeks due to non-specific LBP in The Netherlands.	Workplace intervention: worksite assessments and work adjustments (n = 96) vs. Usual care: Dutch occupational guidelines for LBP, education, coping with LBP (n = 100) for 8 weeks, followed by second randomized trial of graded exercise for those not returning to work (n = 112) start of therapy median 69 days after lost time began. Follow-up to 1 year.	Time to full and lasting RTW in graded activity group 144 days vs. 111 days in usual care group, p = 0.030. Total number of sick leave days during 12 month follow-up for graded activity was 145 vs. 111 for usual care group, p <0.001.	"Workplace intervention is advised for multidisciplinary rehabilitation of subacute LBP. Graded activity or combined intervention is not advised."	Sick-listed study in Amsterdam; unclear if applicable to U.S. or elsewhere. Workplace intervention first; removed ~43% before 2nd randomization. Time to onset of exercise ~2 months after lost time began, compliance poor (65%), and exercise program structure highly variable based on wide range in number of sessions suggesting robust conclusions on graded exercise components not warranted.
Hallegraeff 2009 RCT No mention of sponsorship or COIs.	5.0	N = 64 with acute non-specific LBP <16 days.	Experimental group, low amplitude, manipulative therapy (n = 33) vs. Control group, gradually increasing level of physical activity (n = 31).	VAS/ODL/Sit-and-Reach Test; 43 vs. 54/24% vs. 26%/29.7 vs. 31.6, at baseline.	"[Results] showed a statistical significance effect for disability, but no statistically significant benefit of additional manipulative therapy over physical therapy found for pain and mobility within 4 treatments."	Short duration that limits conclusion. Data suggest manipulation not of additive effect.
Stankovic 1990 RCT	4.5	N = 100 with acute LBP or LBP	McKenzie exercises for 20 minutes for 2 weeks (n = 50) vs. Mini-back school lesson 1 time for 45 minutes (n = 50).	All in McKenzie group returned to work within 6 weeks, all mini-back school group returned within 11 (p <0.001) Mean duration of sick	"Treatment according to the McKenzie principle is in this study superior to 'mini back school'."	Study suggests benefit of stretching/exercise per McKenzie protocol for acute LBP provides greater benefit than education

No mention of sponsorship or COIs.			Assessments at 0, 3, and 52 weeks.	leave shorter in McKenzie (11.9±6.5 days vs. 21.6±15.3, p <0.001). More LBP recurrences over 1 year in mini-back school (27 vs. 9, p <0.001). McKenzie had fewer LBP episodes (30 vs. 37, p <0.01) and sick leave (24/47 (51.1%) vs. 31/42 (73.8%), p <0.03).		alone. No details on co-intervention control and low compliance to protocol limits conclusions.
Stankovic 1995 RCT See Stankovic 1990 above No mention of sponsorship or COIs.	4.5	See above	See above.	After 4 years, McKenzie Group less LBP recurrences than mini back school group (p <0.01). McKenzie group less sick leave (p <0.03). No differences between groups for help with treatment, ability to self help, number of attacks during recurrences, positions/activities that caused pain to recur, or physical activities and smoking.	"Two conclusions can be drawn from the study: 1) the difference between groups was much less after 5 years compared with 1 year, and 2) patients who received treatment according to McKenzie principle 5 years earlier had significantly less recurrences of pain and had significantly less sick leave."	Five-year follow-up.
Kilpikoski 2009 Original report by Paatelma Markku, primary analysis. RCT No industry sponsorship. No COIs.	4.5	N = 119 with first or recurrent episode of LBP classified as centralizers	Orthopaedic manual therapy or OMT underwent spinal manipulation (n = 42) vs. McKenzie consisted of educational component, instructions in exercises repeated several times a day (n = 48) vs. "Advice only to stay active'' or advice-only group got 30-45 minutes physiotherapist counselling about the good prognosis of LBP, pain tolerance, medication and early return to work (n = 29). Follow-up for 1 year.	LBP decreased significantly more, p = 0.001 in the McKenzie group than in the Advice-only group (VAS -15 mm; 95% CI -24 to -5). At 3 months, significant, p <0.001 improvement had occurred in every group. At 12 months, no significant differences between groups in LBP, leg pain, disability and functional status.	"[R]esults suggest that centralizers have tendency to achieve better treatment outcomes when treated by individually designed therapy than ''given advice only to stay active."	McKenzie treatment had lower disability at 12 month, same providers throughout the study.
Long 2004 RCT Industry Sponsored (Community Ethics Board of the Alberta	4.0	N = 204 with LBP	Matched, unidirectional lumbar exercises matching direction of their directional preference (DP) at baseline, remain active, avoid activities that increase symptoms (n =	Mean (SD) for VAS back pain: matched vs. opposite vs. EBC: pre: 5.86 (2.39) vs. 6.0 (2.17) vs. 5.97 (2.06), p <0.001; post: 2.51 (1.96) vs. 4.65 (2.33) vs.4.34 (2.51), p <0.001; Leg pain: matched vs.	"Consistent with prior evidence, a standardized mechanical assessment identified a large subgroup of LBP patients with a DP. Regardless of subjects' direction of preference, the	Exercise prescription is poorly described. Directional preference may play a role in pain relief regarding exercise treatment.

Heritage Foundation for Medical Research, Physiotherapy Foundation of Canada, McKenzie Institute International, and Cambridge Physiotherapy Associates). No COIs.			70) vs. Opposite, unidirectional exercises opposite to DP at baseline (n = 62) vs. Evidence-based care (EBC): multidirectional, midrange lumbar exercises, stretches for hip and thigh muscles (n = 69). Follow-up maximum of 6 for a 2-week study period.	opposite vs. EBC: pre: 4.58 (2.50) vs. 4.74 (2.48) vs. 4.78 (2.56), p <0.003; post: 1.61 (1.83) vs. 3.29 (2.71) vs. 3.56 (3.13), p <0.003. RMDQ: pre: 17.85 (5.66) vs. 16.69 (5.97) vs. 18.37 (5.34), p <0.01; post: 11.37 (7.55) vs. 15.44 (6.932) vs. 15.45 (7.34), p <0.01.	response to contrasting exercise prescriptions was significantly different: exercises matching subjects' DP significantly and rapidly decreased pain and medication use and improved in all other outcomes. If repeatable, such subgroup validation has important implications for LBP management."	
Grunnesjö 2004 RCT Study supported by grants from National Social Insurance Board, Stockholm Clinic-Stay Active, Stockholm and Uppsala University. No mention of COIs.	4.0	N = 160 with acute or subacute LBP with or without pain radiating to 1 of both legs, for 3 months or less.	Reference therapy or stay active concept vs. experimental therapy or manual therapy, muscle stretching and steroid injections for 10 weeks.	Experimental group had fastest decrease of pain; for last week and during last 24 hours after 5 weeks of follow up, and for DRI scores; p <0.05, p <0.05, and p <0.05, respectively.	"The manual therapy concept was more effective than the standardized but optimized stay-active concept in acute and subacute low back pain patients regarding pain reduction and improvement of everyday function."	Many details sparse. Data favor aerobic exercise.
Subacute						
Staal 2004 RCT Industry Sponsored. Dutch Health Insurance Executive Council (CVZ). No COIs.	8.5	N = 105 with subacute LBP (median 8-8.5 weeks duration, range 6 to 14 weeks) among airline employees	Behavioral-oriented, graded exercise therapy (n = 67) vs. highly heterogeneous group of usual care methods (n = 38 physiotherapy, n = 6 manual therapy, n = 6 Mensendieck exercise therapy, n = 3 chiropractor, n = 1 back school, n = 7 unknown). Intervention group with twice a week 1 hour exercise sessions with physiotherapists emphasizing operant conditioning, focusing on achieving goals to improve function. Sessions until RTW or 3 months.	At 6 months, pain ratings not different, but improved more in graded exercise group (3 months/6 months: 2.8 2.4/2.9±3.1 vs. 2.5±2.8/2.7±2.8, p >0.2). Over 6 months of follow-up, median lost time 58 vs. 87 days.	"Graded activity was more effective than usual care in reducing the number of days of absence from work because of low back pain."	Despite high-quality score on grading, due to inclusion of multiple research study design techniques, study so heterogeneous that firm conclusions are not warranted for any single intervention.

Moffett 1999 RCT Industry Sponsored (Arthritis Research Campaign, Northern and Yorkshire Regional Health Authority and the National Back Pain Association). No COIs.	6.0	N = 187 with subacute and chronic LBP	Graded exercise (n = 85, program of 8 exercise classes) vs. routine general practitioner management (n = 98).	Roland Disability scores in controls and exercise groups reduced at 6 months (-1.64 and -2.99 respectively, p = 0.03) and 1 year (-1.77 and -3.19, respectively, p = 0.02) compared to baseline; 378 lost workdays in intervention group vs. 607 in controls.	"Our exercise programme did not seem to influence the intensity of pain but did affect the participants' ability to cope with the pain in the short term and even more so in the longer term. It used a cognitive-behavioral model…and with minimal extra training a physiotherapist can run it. Patients' preferences did not seem to influence the outcome."	Trial uses usual care as control, which may be biased against that arm. Treatments in usual care also not standardized and may not represent modern practice. Total costs 50% greater in controls, with cost differences mostly due to lost time. Data suggest graded exercise program superior to usual care.
Steenstra 2006 RCT Industry Sponsored (Netherlands Organization for Health Research and Development, Dutch Ministries of Health Welfare and Sports of Social Affairs and Employment). No COIs.	5.0	N = 112 with LBP on sick leave >8 weeks.	Usual care according to the Dutch OP guidelines (n = 57) vs. Graded activity, aimed to restore occupational function over 26 one-hour sessions, 2 sessions a week (n = 55).	Median time to lasting return to work for graded activity was 139 days vs. usual care group 111 days, p <0.01.	"Graded activity was not effective for any of the outcome measures. Different interventions combined can lead to a delay in RTW. Delay in referral to graded activity delays RTW. In implementing graded activity special attention should be pain to the structure and process of care."	Usual care of mixed interventions that follow guidelines but make comparisons difficult outside the Netherlands. Better results with usual care.
Lindström Phys Ther 1992 Lindström Spine 1992 RCT Study supported by Arbetsmarknadens forsak-ringsaktiebolag (AFA), Stockholm, Sweden, The Volvo Company, Coteborg, Sweden, AMF-Trygghetsforsakring, Stockholm, Sweden, Medical Faculty of	4.5	N = 103 with subacute LBP off work for 6 weeks	Graded activity (n = 51) vs. Controls: no treatment (n = 52) for 1 year. Graded activity group with measured functional capacity (mobility, strength and fitness), workplace visit, back school education, and an individual, submaximal gradually increased exercise program with operant conditioning.	Increases in arm strength, abdominal muscle strength, back muscles, and many other outcome measures preserved at 1 year in activity group. Activity group RTW 5.1 weeks earlier, p = 0.03.	"The patients with subacute, nonspecific, mechanical LBP who participated in the graded activity program regained occupational function faster than did the patients in the control group, who were given traditional care."	Involved orthopedic surgery and PT. GPs gave routine care, but otherwise not involved. Social worker performed psychosocial screening. Suggests graded activity program reduced long-term sick leave, especially in males. Intensive exercises, work-hardening exercises, or expensive equipment not necessary to regain occupational function.

University of Goteborg, Sweden, Greta and Einar Askar Foundation, Goteborg, Sweden, and Bertha and Felix Neuberg Foundation, Goteborg, Sweden. No mention of COIs.						
Hartvigsen 2010 RCT No COIs. No mention of industry sponsorship.	4.5	N = 136 with LBP/or leg pain, >8 weeks duration.	Nordic Walking (NW) in groups of 8, for 8 weeks under supervision (n = 45) vs. Non-supervised NW group (n = 46) vs. Advice about active living and exercise (n = 45).	Intervention period: 8.8 vs. 3.4 vs. 4.8. At 26 weeks, 11 and 52 weeks; supervised NW significant at all times; p = 0.009/0.01/0.03 vs. p = 0.08/0.01/0.03 vs. advice group significant except 52 weeks; p = 0.04/0.01/0.18.	"We found no statistically significant effect in chronic LBP patients of supervised NW when this was compared to unsupervised NW or advice to remain active in a randomized clinical trial."	Comparison of supervised NW Walk, unsupervised NW, and advice to remain active with most results negative.
Maitland 1985	4.5	See Cleland 2006				
Long 2004 RCT Industry sponsored (Community Ethics Review Board of Alberta Heritage Foundation for Medical Research, Physiotherapy Foundation of Canada, McKenzie Institute International, and Cambridge Physiotherapy Associates). No COIs.	4.5	N = 230 with subacute and chronic LBP (mean 13.7 to 17.7 weeks duration)	Matched exercises (n = 80) taught unidirectional end-range lumbar exercises matching direction of their identified DP vs. opposite (n = 70) group taught unidirectional end-range lumbar exercises opposite of identified DP vs. evidence-based care (n = 80) taught commonly prescribed multi-directional and midrange lumbar exercises, and stretches for hips and thighs.	Matched exercises superior for LBP (matched: 5.86±2.39 decreased to 2.51±1.96 vs. opposite: 6.08±2.17 to 4.65±2.33 vs. evidence-based: 5.97±2.06 to 4.34±2.51, p <0.001). Medication (matched: 3.37±2.92 pills/day decreased to 0.81±2.25 vs. opposite: 3.29±2.74 to 2.57±2.77 vs. evidence-based: 2.65±2.38 to 1.73±1.73, p <0.016) and interference with work (matched: 3.41±1.10 decreased to 2.24±0.92 vs. opposite: 3.49±1.05 to 3.06±1.09 vs. evidence-based: 3.39± 0.92 to 2.88±1.15).	"Exercises concordant with patients' [directional preference] significantly improved outcomes compared with nonconcordant exercises and advice, and appear to be an effective pain control/elimination treatment strategy."	Baseline difference in off work 37/45/47% from matched group. Data suggest directional preference exercises can improve outcome at 2 weeks.
Grunnesjö 2004 RCT Project supported by grants from National Social Insurance Board, Stockholm Clinic-Stay Active, Stockholm and	4.0	N = 160 with acute or subacute LBP with or without pain radiating to 1 of both legs, for 3 months or less.	Reference therapy or stay active concept vs. experimental therapy or manual therapy, muscle stretching and steroid injections for 10 weeks.	Experimental group had fastest decrease of pain; for last week and during last 24 hours after 5 weeks of follow up, and for DRI scores; p <0.05, p <0.05, and p <0.05, respectively.	"The manual therapy concept was more effective than the standardized but optimized stay-active concept in acute and subacute low back pain patients regarding pain reduction and improvement of everyday function."	Many details sparse. Data favor aerobic exercise.

Uppsala University. No mention of COIs.						
Lindström 1995 RCT See also Lindström Phys Ther, 1992 and Lindström Spine 1992 Study supported by Arbetsmarknadens forsak-ringsaktiebolag (AFA), Stockholm, Sweden, The Volvo Company, Coteborg, Sweden, AMF-Trygghetsforsakring, Stockholm, Sweden, Medical Faculty of University of Goteborg, Sweden, Greta and Einar Askar Foundation, Goteborg, Sweden, and Bertha and Felix Neuberg Foundation, Goteborg, Sweden. No mention of COIs.	4.0	N = 103 with subacute LBP	See above; 1 year follow-up.	At 1 year follow-up, intervention vs. control: pain (NS), pain behavior (NS), subjective disability (0.8±1.6 vs 2.0±2.3, p ≤0.01).	"The intervention significantly reduced the patients' intra-individual physical performance. Another effect of the intervention program was that more patients in the intervention group than in the control group were free from complaints of LBP. The intervention program was successful for patients with subacute LBP."	Patients sick-listed in Sweden for 8 weeks, thus unclear if applicable elsewhere. Mostly (75%) immigrants. Patients not well described. Data suggest back school reduced LBP disability. Unclear if lost time differed by intervention, but was correlated with baseline LBP severity.
Hlobil 2007 RCT No mention of industry sponsorship or (COI)	4.0	N = 134 with LBP with minimum of 4 weeks	UC or usual care (n = 67) vs. GA or graded activity (n = 67).	Number of disabled subjects decreased by 11; 6 vs. 5 subjects at the end of 3rd year in comparison to first year; 13, 5 vs. 8.	"The GA intervention for non-specific LBP may be a cost-beneficial RTW intervention from the employer's point of view."	Economic Evaluation of RCT.
Moffett 2006 RCT Industry Sponsored (Arthritis Research Campaign). No COIs.	4.0	N = 315 with neck and back pain	McKenzie exercises (n = 161) vs. brief physiotherapy pain management treatment based on cognitive behavioral principles (n = 154, solution-finding approach, SFA).	Roland-Morris metrics: (baseline, 6 weeks, 12 months, no booklet) SFA (12.5±5.0, 9.5, 8.1) vs. McKenzie (11.2± 4.9, 7.4, 7.0). No difference between groups. Satisfaction higher for McKenzie (90% vs. 70%, p = 0.008). TSK activity avoidance at 6 weeks/6 months/12 months for SFA vs. McKenzie: 17.575/17.454/	"The [McKenzie] approach resulted in higher patient satisfaction overall but the [Solution-Finding Approach] could be more cost-effective, as fewer (three vs. four) sessions were needed."	Inclusion of neck pain and mixing chronic patients all may limit conclusions relative to the back outcomes.

				17.090 vs. 17.00/16.164/ 16.495, p = 0.032.		
Chronic						
Hancock 2008 RCT NHMRC project grant funded the trial. No mention of COIs.	7.5	N = 239 with LBP >6 months	Spinal Manipulation Therapy OR SMT (n = 119) vs. placebo, 2-3 times a week, up to 4 weeks (n = 120). All received general practitioner care (advice+paracetamol).	Primary/Secondary analysis; pain (p = 0.805) and disability (p = 0.600) scores similar between SMT and placebo / no clinical or statistical significance between the two groups.	"The clinical prediction rule performed no better than chance in identifying patients with acute, non-specific low back pain most likely to respond to spinal manipulative therapy (pain P = 0.805, disability P = 0.600)."	Data suggest clinical prediction role (Flynn 2002) unable to be validated.
Lewis 2011 RCT No mention of sponsorship. No COIs declared.	6.5	N = 89 with pain in lumbar and/or sacral regions <3 months following 1 month period without pain and minimum of 4 digitally tender points	Exercise program: 3 exercises (side-lying abdominal bracing, alternate knee-to-chest holds, side-to-side lumbar rotation with strain-counterstrain), 2x a week for 2 consecutive weeks (n = 44) vs. Control group standardized exercises 2x a week for 2 consecutive weeks.	No significant difference between groups.	"[F]or non-specific acute low back pain there does not appear to be any short-term or medium-term advantage from the addition of Strain-Counter strain treatment to appropriate analgesic medication, advice, range of motion exercises, and transversus abdominis exercises."	Data suggest strain counterstrain manipulation is no more effective than exercise alone for acute low back pain.
Helmhout 2004 RCT No mention of industrial sponsorship or COI.	6.5	N = 81 with history of continuous, recurrent episodes of back pain between posterior iliac crests and angulus inferior scapulae	High-intensity treatment group or HIT (n = 41) vs. Low-intensity treatment group or LIT (n = 40) for 12 weeks.	At 1,2,3,6, 9 months, no significance differences between groups except back strength measurement; HIT scored 24-58 Nm higher than LIT. For TSK scale 2, 9 months; LIT scored 2.5 and 3.4 points, lower than HIT.	"[We] were unable to demonstrate that progressive, high-intensity training of the isolated back extensors was superior to a non-progressive, low-intensity variant in restoring back function."	Data suggest largely comparable results between the high- and low-intensity training groups.
Häkkinen 2005 Supported by the Jyväskylä Central Hospital, Jyväskylä, Finland. No COI declared.	4.0	N = 126 with lumbar disk herniation.	Combined stretching and strength training group (STG) (n = 65) vs. Control group (CG) (n = 61).	STG groups improved significantly in trunk extension and flexion forces compared to control (p <0.05). However, by 12-month follow-up no difference between groups in all measures.	"[A]fter 12 months of training, the overall outcome measured by physical function, pain, and disability, and by length of sick leaves, was comparable between the groups."	High dropout, specialized population may not be generalizable. Methodological details sparse. Strengthening and stretching details poorly described.
Stabilization Exercises						
Acute						
Hides 2001 RCT Study supported Manual Therapy	4.5	N = 39 with acute LBP <3 weeks	Stabilization exercise program designed to activate and train isometric holding function of multifidus muscle at affected vertebral segment	Control group 12.4 times more likely to have LBP recurrence in 1st year, p <0.001. Two to3 years after initial LBP episode, 9 times risk, p <0.01 At 1 year, 3/16 (19%) LBP recurrences	"[S]ubjects with acute, first-episode LBP who received specific exercise therapy in addition to medical management and resumption of normal activity	Patients recruited from hospital ER. Small numbers. Co-interventions not well described. Exercises compared to advice appear effective in LBP. Article

Special Group (Australia). No mention of COIs.			(n = 20) vs. Control group, medical management, advice on bed rest, absence from work, prescription medication) (n = 19). Follow-up at 1 and 3 years.	in controls identified as traumatic vs. 4/6 (67%) for exercise group. During years 2-3, trauma-related LBP incidents 42% vs. 100%.	experienced fewer recurrences of LBP in the long-term than subjects who received only medical management and resumed normal activity."	unclear regarding benefit at 1 year, possibly a misinterpretation. Chi square for relative risk.
Subacute						
Yelland 2004 RCT No industry sponsorship or conflict of interest (COI).	10.0	N = 110 with chronic LBP mean durations 13.8 to 14.8 years	2 arms: prolotherapy injections (20% glucose/0.2% lignocaine (with 4ml 50% glucose, 1ml 2% lignocaine, 5ml water) (n = 54) vs. normal saline injections (n = 56). 2 sagittal loading exercises (10 reps, 4 times a day for 6 months) vs. normal activity. Follow-up 6 months.	Only difference found at months with group proportions, with 0 disability 0.15 for glucose-lignocaine and 0.02 for saline.	"In chronic nonspecific low-back pain, significant and sustained reductions in pain and disability occur with ligament injections, irrespective of the solution injected or the concurrent use of exercises."	Study suggests no differences in placebo, prolotherapy, or described exercises for chronic LBP. Data suggest prolotherapy ineffective.
Frost 1995 RCT No mention of sponsorship or COIs.	7.5	N = 81 moderately disabled with chronic LBP for at least 6 months	Fitness program plus back school (n = 36) vs. back school (n = 35). Fitness program consisted of 8 1-hour sessions for 4 weeks (warm up, stretching, then 15 progressive exercises, then stretching and "light aerobic" exercise, psychological principles taught by physiotherapist, and avoidance of discussion of pain). All subjects had exercises to perform at home.	Sensory pain score mean±SD before/after fitness vs. education group: 20.9±12.3/ 12.1±9.9 vs. 25.6±17.9/ 22.1±20.1, p <0.05. Disability Oswestry scores: 23.6±9.7/ 17.6±10.9 vs. 23.6±12.3/ 21.7±13.6, p <0.005. Walking distance (m): 445±140.8/553.7±154.5 vs. 408.9±166.4/421.4± 167.4, p <0.005.	"[M]oderately disabled patients with chronic low back pain who attend a back school and fitness programme benefit more in the short and long term than patients who attend a back school and exercise independently at home."	2-year follow-up (score = 6.5/11) found benefits of fitness program persisted, e.g., Oswestry scores (fitness group: 23.1±9.5 decreased to 16.0±9.2 (6 months) to 15.4±11.3 (2 years) vs. 24.9±12.8 to 21.7±14.2 to 22.5±15.4 for controls). Data suggest fitness class of additive benefit to back school and HEP for chronic LBP with lower disability indices.
Ferreira 2007 RCT Trial funded by Arthritis Foundation of New South Wales, Motor Accidents Authority of New South Wales, and University of Sydney. No mention of COIs.	7.5	N = 240 with chronic LBP	8 weeks general exercise (n = 80) vs. motor control exercise (n = 80) prescribed exercises to improve function of specific trunk muscles vs. spinal manipulative therapy (n = 80) joint mobilization or manipulation techniques applied to spine or pelvis. Both groups given cognitive-behavioral therapy.	Primary outcome patient-specific function and global perceived effect at 8 weeks. No group superior. Outcomes similar at 6 and 12 months follow-up.	"Motor control exercise and spinal manipulative therapy produce slightly better short-term function and perceptions of effect than general exercise, but not better medium or long-term effects, in patients with chronic non-specific back pain."	Interventions not well described. While authors concluded motor control exercise and spinal manipulative therapy produce slightly better short-term function and perceptions of effect than general exercise" statistics are not significant.

Dufour 2010 RCT No COI or industry sponsorship.	6.5	N = 286 with chronic LBP. Follow-up at 3, 6, 12, and 24 months.	Biopsychosocial rehabilitation (group A, n = 142) vs. intensive individual therapist-assisted back muscle strengthening exercises (group B, n = 144).	Roland-Morris Disability Questionnaire significantly improved at end of treatment in both groups ($p < 0.05$). MOS Short Form-36 Health Survey significantly improved at end of treatment for both groups ($p < 0.05$).	"Both groups showed long-term improvements in pain and disability scores, with only minor statistically significant differences between the 2 groups. The minor outcome difference in favor of the group-based multidisciplinary rehabilitation, treatment, clinical trial."	Data suggest both approaches associated with improvements.
Koumantakis 2005 RCT Industry Sponsored (Greek State Scholarships Foundation (IKY), Athens, Greece, Hospital Savings Association (HAS), London, UK). No COIs.	6.5	N = 55 S&G (specific and general) group n = 29, G (general) group n = 26); history of LBP of a non specific nature.	S&G group given leaflets on how to stabilize specific muscles and exercise just those in different positions such as 4-point kneeling, supine, lying, sitting, and standing. Changing up number of reps and length of hold time. G group given exercises to activate extensor (paraspinals) and flexors (abdominals). General exercises selected on basis of maximizing contraction benefits/spinal loading ratio according to recommendations provided from experimental studies.	No between-groups significant differences in pretreatment except for gender distribution ($P = 0.045$), and nMF slope-L4/5 data ($p = 0.04$). For number of class sessions attended data similar for both groups (mean 12.2 (SD 2.7) for S&G group and mean 11.3 (SD 2.7) for G group, $p = 0.28$). In home sessions, no significance (median 23.5 (IQR 20.0–24.0) for S&G group and median 22.0 (IQR 15.0–24.0) for G group, $p = 0.57$).	"An 8-week stabilization exercise-enhanced approach presented equal benefits to a general endurance-based exercise programme for patients with recurrent non-specific back pain. A slightly steeper slope for the erector spinae in the G group was the only electromyographic fatigue alteration noted. Concomitant strength improvement probably reflects neural input changes rather than histochemical muscle changes. Physical exercise alone and not the exercise type was the key determinant for improvement in this patient group."	Actual treatments vague. High dropout rate. Data suggest stabilization exercises not of additive benefit.
Nagrale 2012 RCT No mention of industry sponsorship or COI.	6.5	N = 60 with non-radicular LBP	Lumbar spine mobilization and stabilization exercises (n = 30) vs. slump stretching with lumbar spine mobilization and stabilization exercise (n = 30).	At 3 weeks and 6 weeks slump stretching group had significant improvement on pain rating ($p = 0.00$), Oswestry disability index ($p = 0.00$), and fear-avoidance belief ($p = 0.00$) compared to lumbar mobilization and stabilization alone.	"In patients with NRLBP who demonstrate a positive slump test on examination, slump stretching in a clinical and home exercise program along with lumbar mobilization and stabilization exercises appears to be more beneficial for rate and magnitude of recovery of self-reported disability, pain, and fear-avoidance behavior compared to treatment without slump stretching."	18-60 years. Data suggest Group 2 superior.
Garcia 2013 RCT	6.5	N = 148 with chronic non-specific LBP	McKenzie Group consisting in comprehensive clinical	Participants in McKenzie group had greater improvement in disability after	"Patients allocated to the McKenzie group experienced greater improvements in	Data suggest McKenzie superior to Back School.

Funded by Fundacao de Amparo a Pesquisa do Estado de Sao Paulo (FAPESP), Brazil, but no mention of COI.			exam of posture and range of motion of spine, associated with symptomatic responses of responses (n = 74) vs. Back School Group consisting on exercises that improve mobility and flexibility (n = 74).	treatment (1-month follow up), than Back School group (Treatment effect = 2.37 points, 95% CI 0.76 to 3.99). Difference in physical domain of quality of life after 3 months that favored McKenzie group (mean = -4.67 points, 95% CI = -9.26 to -0.07),	disability, but not in pain intensity, after treatment compared with patients allocated to the Back School group, but the magnitude of this effect was small and possibly of doubtful clinical importance."	
Wajswelner 2012 RCT/ Single assessor blinded Dr. Bennell was in part supported by Australian Research Council Future Fellowship. Study funded by Craig Phillips of DMA Clinical Pilates Physiotherapy in Brunswick, Melbourne, Victoria, Australia, but no mention of COI.	6.5	N = 87 with pain or stiffness in the lower back with or without limb symptoms for >3 months, and average pain score of ≥4on an 11point scale.	Pilates Group which consisted on a tailor-made direction-specific series of exercise performed on trapeze equipment. Program consisted of 1-4 home-based clinical Pilates exercises, and 6-12 equipment based exercise (n = 44) vs. General Group assigned to stationary bike, leg stretches, upper body weights, theraband, Swiss ball, floor exercises that were multidirectional and non-specific in nature (n = 43).	Improvement for both groups shown in primary outcome for pain/ disability measured with Quebec scale at 6 weeks vs. baseline with difference of 3.5 between groups (95% CI = -7.3 to 0.3, F = 3.33, p = 0.07). Mean±SD of completed exercises 11±3 for both groups (p = 0.90). Mean±SD of days of exercises performed at home for Pilates' group vs. General group: 38±6 vs. 35±10 (p = 0.15). Mean±SD for adherence at week 12 and week 24was 4±3 and 4±3 vs. 5±3 and 5±3 (p = 0.43 and p = 0.68, respectively).	"This study showed that specific clinical Pilates exercise programs are as effective in reducing pain and disability and improving function in adults with CLBP as traditional general exercises when both programs are used by physiotherapists."	Differences in follow up time. No measurements on significant changes between groups.
Costa 2009 RCT Study funded by Research and Development grant from The University of Sydney and by Physiotherapy Research Foundation–Australian Physiotherapy Association. No mention of COIs.	6.5	N = 154, with chronic LBP >12 weeks duration.	Exercise group, coordinated activity of trunk muscles, and train these skills in static tasks (n = 77) vs. Placebo group, detuned US and short-wave therapy (n = 77).	Exercise activity, improved activity limitations; at 2 months; 2.7 points, 95% CI 4.4-0.9, & 6 months; 2.2 points, 95% CI 4.0-0.5), with smaller difference and no longer significant at 12 months;1.0 point, 95% CI 2.8 to 0.8).	"Motor control exercise produced short-term improvements in global impression of recovery and activity, but not pain, for people with chronic low back pain."	Comparison of exercise to sham US plus sham diathermy. Data not compared to placebo exercise. Data suggest exercise superior to this placebo.
Carr 2005 RCT	6.5	N = 237 with chronic LBP (59% >6 months duration) and some subacute LBP (at	Group exercise program (n = 118) vs. Individual physiotherapy in materially deprived area of U.K. (n = 119).	No differences in baseline scores between those who did/not attend for treatment, except for age. Non-participants tended to be	"[N]o differences in clinical outcomes were found between the group receiving the Back to Fitness programme and those receiving individual	Heterogeneous group of interventions significantly limit strength of conclusions. Some baseline differences in duration of

No mention of industry sponsorship or COI.		least 6 weeks duration)		younger (mean difference = 8.08 years, CI = 711.54 to 74.49). Those in exercise program improved slightly more than individual physiotherapy (mean difference = 71.07, CI = 72.50 to 0.36).	physiotherapy in this study. Importantly, neither therapy was very effective in reducing disability scores in this study of a socially deprived back pain sample. However, group therapy was less costly and therefore more cost effective."	pain. Individual physiotherapy different with each participant. About 50% in both groups attended 5 plus sessions. Outcomes similar but group programs less costly.
Filiz 2005 RCT No mention of sponsorship or COIs.	6.5	N = 60 attending outpatient clinic of Istanbul Faculty of Medicine, age 20-50 who had lumbar disc operation for first time. Exclusion criteria included patients with complaints compatible with nerve trace in neurological exam, with neurological deficits, with additional musculoskeletal pathologies such as spondylosis, spondylolisthesis or osteoporosis, and with cardiovascular pathology that could prevent exercises	Group A (n = 20) received intensive exercise program and back school education. Intensive exercise program 8 weeks 3 days a week for 1.5 hours. Exercise program taught dynamic lumbar stabilization exercises (included strengthening abdominal muscles), afterwards aerobic exercise on exercise cycle for 15 minutes vs. Group B (n = 20) received home exercise program and back school education which included education on basic body mechanics. Exercises 3 times a week at home and followed-up with phone call once a week vs. Group C (n = 20) did not receive education or exercise, but advised to be as active as possible with daily routines. All exercise programs started 30 (±3) days post-op.	No significant difference with respect to clinical parameter observed between groups at beginning of treatment. Modified Oswestry Disability Index Group A and Group B vs. Group C (post treatment): 7.05±4.87 and 11.65±7.21 vs. 15.10±8.55 p <0.001. Low back pain rating scale: Group A vs. Group B and Group C: 7.40±6.92 vs. 22.45± 13.94 and 39.6±20.54 p <0.001. Group B vs. Group C: 22.45±13.94 vs. 39.60±20.54 p <0.001. VAS Group A vs. Group B and Group C: 4.50±1.59 vs. 12.00±3.67 and 13.25±7.34 p<0.001	"[I]t seems that intensive exercise is more effective in reduction of pain and disability, but whether it is cost-effective is not clear."	Some non-significant baseline differences likely favored intensive exercise group. Data suggest intensive exercise superior to other groups for earlier RTW.
Shnayderman 2012 RCT Author mentions this research received no specific grant from any funding agency in public, commercial or not-for-profit sectors.	6.5	N = 52 with chronic LBP (≥3 months) with or without radiation to lower limb.	Walking group exercise 5-minute warm-up followed by moderate intense treadmill walking 40 minutes 2x a week (n = 26) vs. Control group, specific low back exercise 2x a week (n = 26). 6-minute walk	Improvement in both groups not statistically significantly different between groups. Mean difference in meters covered during 6 minutes increased by 70.7 (95% CI, 12.3-119.7) in walking group vs. 43.8 (95% CI, 19.6-68.0) in exercise group.	"A six-week walk training programme was as effective as six weeks of specific strengthening exercises programme for the low back."	Data suggest no significant differences between interventions at 6 weeks.

			primary outcome for 6 weeks.			
Harts 2008 RCT No mention of industry sponsorship or COI.	6.5	N = 65 males of Royally Netherland Army age 18-54 who experienced LPB for >12 weeks available for visits 1-2 times a week and willing to give up other back pain interventions. Participants excluded if spinal surgery in last 2 years, reported severe back pain or had radiation below knee with signs of root compression.	High-intensity training group (n = 23) 8 weeks progressive resistance exercise program for isolated lumbar extensor muscle groups. Initial load set at approximately 50% of maximal isometric lumbar extension strength of participant, measured at baseline (goal every session 15-20 reps on lower back, if accomplished then 2.5kg weight added) vs. Low intensity (n = 21) 8 weeks non-progressive low intensity resistance, exercise program. Maximum of 20% of maximal isometric lumbar extension strengthen as measured at baseline vs. Waiting list (n = 21), no intervention for their LBP during first 8 weeks.	When compared to low intensity group, high intensity had a 7% (95% CI 1 to 13) mean difference improvement in SF-36 overall score at 8 weeks. Same difference found when comparing high intensity group to wait list group. Self-assessed decrease of back symptoms was on average 39% (95% CI 14 to 64) greater in high intensity training group when compared to waiting list group.	"[A]lthough some beneficial effects were found, the results of this high-intensity strengthening program of the isolated lumbar extensor muscles do not clearly support the generally -claimed beneficial influence of exercise for chronic non-specific low back pain."	High dropout in high intensity training.
Shirado 2010 RCT No funds received in support of this work. No COI declared.	6.0	N = 201 with non-specific chronic LBP	Exercise groups (n = 103) with trunk muscle strengthening and stretching vs. NSAID group (n = 98) of loxoprofen sodium 60mg or diclofenac sodium 25mg or zaltoprofen 80mg. Follow up at 2, 8, and 12 weeks.	Japan LBP evaluation questionnaire change at 8 weeks for exercise -0.58 vs. NSAID -0.44, p = 0.021. Roland-Morris disability questionnaire change at 8 weeks for exercise -0.72 vs. NSAID -0.47, p = 0.023.	"The home-based exercise prescribed and monitored by board-certified orthopedic surgeons was more effective than NSAIDs for Japanese patients with [chronic low back pain]."	Design for homogeneous ethnic population. Exercise group likely had more researcher contact vs. group with choices of 3 NSAIDs (low dose). Observer bias may be present as only 201 enrolled from 92 clinics. Data suggest exercise more effective than NSAID.
Lewis 2005 RCT No funds received in support of this work. No benefits in any	6.0	N = 80 with chronic LBP or LBP	Individualized treatment (n = 40, manual therapy/spinal mobilization and spinal stabilization exercises) vs. exercise (n = 40, 10-station exercise class treadmill). Most subjects received 6	Exercise group's pain scores decreased pre-to post-treatment. Compliance rates decreased to 70% at 6 months. Exercising had greater improvements. Non-smokers had lower questionnaire scores and greater improvement at 12	"The findings of this study suggest that similar results are likely using either an individual treatment or a group exercise approach, with up to 78% of participants expressing improvement, 12-	Baseline differences may have favored individual treatment group. Number and heterogeneity of interventions limits ability to draw conclusions on efficacy of any single intervention.

form have been received.			mobilization sessions over 8-week period.	months. Exercise group "40% more cost effective" than individual treatments.	months after the conclusion of the intervention."	
O'Sullivan 1997 RCT No mention of sponsorship or COIs.	6.0	N = 44 with chronic LBP	Specific stabilizing exercise program (n = 22, 10-week treatment program focused on contracting deep abdominal muscles) vs. non-directed treatment by provider (n = 22, regular weekly general exercise). Outcome assessments at 3, 6, and 30 months.	Pain intensity before/after control group vs. specific exercise group: 53/48 vs. 59/19, p <0.0001. Pain descriptors: 15/12 vs. 15/7, p = 0.0088. Oswestry disability: 26/25 vs. 29/15, p <0.0001.	"A 'specific exercise' treatment approach appears more effective than other commonly prescribed conservative treatment programs in patients with chronically symptomatic spondylolysis or spondylolisthesis."	Design of usual treatment for controls biases in favor of intervention. Conclusion that 22 control patients can adequately represent "conservative treatment programs" seems questionable. Data suggest specific exercises superior.
Manniche 1993 RCT Study supported by grants from Danish Health Foundations. No mention of COIs.	6.0	N = 62 having had first discectomy	Hyperextension exercises 1-1.5 hours twice a week for 24 sessions over 3-months (n = 31) vs. no hyperextension (n = 31).	Twelve of 43 (27.9%) had reduced pain scores, with no differences between groups (response rates 68% vs. 55%, p = 0.49). Results at 1 year also favored no hyperextension group.	"[C]hronic back patients after first time discectomy may benefit from an intensive rehabilitation protocol including intensive exercises. The added use of hyperextension exercises does not confer any independent benefit. Furthermore, the training had to continue for more than 2 to 3 months before a statistical significant decrease in back pain was reported in the patient pain diary."	Entry criteria likely eliminated most severe LBP cases. Long delay between surgeries and intervention of up to 4 years suggests both potential spectrum and selection biases. Generalizability of study findings would appear to be at best to a more chronically affected post-operative patient population. Results suggest modest differences in this study.
Browder 2007 RCT Funding for study provided by research grant from Foundation for Physical Therapy to Dr Childs. No mention of COIs.	6.0	N = 48 with primary complaint of LBP already receiving PT	Extension-oriented treatment approach (EOTA, n = 26) vs. strengthening group (n = 22). Both groups attended PT 2x/ a week for first 2 weeks, then once a week next 2 weeks; 6 month follow up.	1 week/4 week/6 month change (95% CI) for Oswestry LBP disability questionnaire for strengthening group vs. EOTA group: 4.2 (-0.70 to 11.1)/5.8 (-3.5 to 15.2)/8.2 (-1.7 to 18.0) vs. 13.1 (6.9 to 19.4)/20.2 (11.6 to 28.8)/22.7 (13.7 to 31.7); for numeric pain rating scale: 0.30 (-0.70 to 1.3)/1.0 (-0.30 to 2.3)/1.4 (-0.10 to 2.9) vs. 1.7 (0.80 to 2.7)/2.3 (1.0 to 3.6)/2.5 (1.1 to 3.9).	"In a subgroup of subjects identified a priori as expecting to benefit from an EOTA, subjects who received an EOTA experienced significantly greater improvements in disability than subjects who received an alternative trunk strengthening program that also has evidence for its effectiveness in a different subgroup of patients. No differences were found between the groups for reductions in pain beyond 1 week."	Study to test extension exercise approach for select patients. No compliance data. Baseline differences present of surgical vs. non-surgical histories. Study conducted in higher select population (centralization of pain distal to buttocks). Data suggest extension exercise approach modestly superior for patients whose pain centralizes with those exercises.

França 2012 RCT Industry Sponsored (Sãu Paulo Research Foundation (FAPESP). No COIs.	6.0	N = 30 with chronic LBP	Segmental stabilization strengthening (SS) exercises (n = 15) vs. stretching (ST) exercises. Two 30-minute classes, twice weekly for 6 weeks.	Both groups improved from pre- to post-test scores. For SS group, VAS pain scores significantly improved (p <0.001), McGill pain scores (p <0.001), functional disability (p <0.001), concentration of transversus abdominis (TrA) muscle (p <0.001). For ST group, VAS pain scores improved significantly (p <0.001), McGill pain scores (p <0.001), and functional disability (p <0.001). For ST, TrA concentrations did not improve (p = 0.94).	"Muscular stretching and SSE decreased pain and functional disability in study participants with cLBP. Segmental stabilization but not stretching improved TrA muscle activation capacity. Segmental stabilization seemed to be more effective than stretching for cLBP in this study."	Suggests segmental stabilization is better than stretches.
Shirado 2010 RCT Industry Sponsored (JOA, Tokyo, Japan). No COIs.	6.0	N = 201 with non-specific chronic LBP lasting more than 3 months.	Trunk strengthening and stretching exercises (n = 103) vs. Oral NSAID, for 8 weeks (n = 98).	NSAID more effective in treating pain outcomes on Japan Low Back Pain Evaluation Questionnaire (JLEQ) (pain on walking, sitting, standing up, backward/forward bend) (p <0.01). Exercise group more effective in treating activity and mental status (sleeplessness, missed work, difficulty going out, difficulty doing light duty and ADLs) (p <0.01).	"The superiority of exercise over NSAID in QOL, as measured by the JLEQ was maintained until the final evaluation at 12 months."	Study design for homogeneous ethnic population. Exercise group likely had more researcher contact vs. group with choices of 3 NSAIDs (low dose). Observer bias may be present in that only 201 subjects enrolled from 92 clinics. Data suggest exercise more effective than NSAID
Bi 2013 RCT Supported by grants from Science and Technology Development Fund of Shanghai Pudong (PKJ2008-Y39), Program of Shanghai Pudong Subject Chief Scientist (PWRd2010-06), and the Science and Technology Development Fund of	6.0	N = 47 with chronic, nonspecific LBP for ≥3 months with or without radiculopathy.	Control group treated with ultrasonography (1MHz continuous at 1.2 W/cm2 for 5 minutes), short-wave diathermy (continuous mode 15 minutes) and lumbar strengthening exercises (10 reps each of prone leg elevation, prone chest elevation and supine bridging) 3 times a week for 24 weeks. (n = 24) vs. Intervention Group: contrition of pelvic floor muscles for 6 seconds following by resting for 6	Mean± SD on pain severity at baseline and at 24-weeks: 5.22±2.64 and 2.97±2.27 for control group vs. 5.35± 3.57 and 2.08±1.63 (p = 0.045). Mean ± SD of Oswestry Disability Index at baseline and 24-weeks: 31.27±7.85 and 19.57±9.83 in control group vs. 32.57±6.25 and 2.08±1.63 for intervention group (p = 0.034).	"In conclusion, pelvic floor exercises in combination with routine treatment provide significant benefits in terms of pain relief and disability over routine treatment alone."	24 week follow up.

Shanghai Pudong (PKJ2011-Y05), but authors declared no COI.			seconds, resulting in 5 contraction cycles/minute, but number of contractions increased over 24 week treatment period (n = 23).			
Díaz-Arribas 2009 RCT Funded by Spanish National Institute of Health (NIH). No COIs declared.	6.0	N = 137 with chronic LBP	Conventional physiotherapy control group (n = 70) underwent 15 treatment session 2-3 per week vs. Physiotherapy for balancing muscular and articular chains in lumbar-pelvic region experimental group (n = 67) for 15 sessions. Follow up end of treatment, 3 and 6 months.	VAS improvement % change (95% CI) for control group at end of treatment: -30.96 (-39.47 to -22.45), at 3 months: -12.01 (-22.06 to -1.97), 6 months: 24.80 (2.84 to 46.77); Oswestry functional disability end of treatment: 035.44 (-46.67 to -24.22) and 3 months: -25.20 (-40.29 to -10.01); SF-36 physical component at 3 months: 23.57 (8.65 to 38.18); SF-36 mental component end of treatment: 41.11 (18.41 to 63.62), and 3 months: 23.39 (8.65 to 38.13). VAS % change (95% CI) treatment group at end of treatment: -58.61 (-67.46 to -49.76) at 3 months: -67.18 (-75.24 to -59.13), and 6 months: -61.83 (-72.24 to -51.08); Oswestry disability end of treatment: -53.72 (-64.27 to -43.17), at 3 months: -63.17 (-72.22 to -53.56), and 6 months: -58.83 (-71.17 to -46.50). SF-36 physical at end of treatment: 31.40 (21.11 to 41.68), at 3 months: 71.90 (50.72 to 93.09), 6 months: 72.07 (48.35 to 95.79). SF-36 mental at end of treatment: 45.35 (24.53 to 67.36), at 3 months: 53.48 (33.77 to 73.20); at 6 months: 51.00 (27.90 to 74.11).	"Treatment of nonspecific LBP using the GDS method provides greater improvements in the mid-term (6 months) in terms of the pain, functional ability, and quality of life perceived by patients than the conventional treatment based administered in primary care."	Standardized assessment. Potential usual care bias.
Johnson 2007 RCT	6.0	N = 234 with persistent disabling LBP of >3 months duration at enrollment	Active exercise, education and CBT 2-hour group sessions over 6-week period (n = 116) vs. control treatment (n = 118).	Patients who preferred intervention and assigned to it experienced significant reductions in pain and disability scores. Those	"This intervention program produces only modest effects in reducing LBP and disability over a 1-year period. The observation that	Study also reviewed in psychological section as it does not appear to rely primarily on exercise for treatment. Compliance 63%

Industry Sponsored (Arthritis Research Campaign, Chesterfield, UK and the Epidemiology Unit at University of Manchester, UK). No COI's.				preferring controls had worse outcomes. For those with no preference, little intervention effects. No differences between groups over 15 months of follow-up.	patient preference for treatment influences outcome warrants further investigation."	in intervention group. No significant effect found. Other co-interventions not well described.
Macedo 2012 RCT Trial received funding from Australia's National Health and Medical Research Council. Dr Latimer's and Dr Maher's research fellowships funded by Australian Research Council. Dr Hodges' research fellowship funded by Australia's National Health and Medical Research Council. No mention of COIs.	6.0	N = 172 with chronic (>12 weeks) non-specific LBP (with or without leg pain), seeking care for LBP had score of moderate or greater on question 7 (how much bodily pain in the past week) or 8 (during past week, how much did pain interfere with your normal work, including both house work and work outside the home) of 36 Item Short-Form Health Survey questionnaire.	Motor control exercises aimed at enabling patient to regain control/coordination of spine and pelvis using principles of motor learning (n = 86) vs. Graded activity aimed at increasing activity tolerance by performing individualized and submaximal exercise in addition to ignoring illness behaviors and reinforcing wellness behavior; 14 individually supervised sessions of approximately 1 hour (n = 86). Treatment: 12 initial treatment sessions over 8 weeks and 2 booster sessions at 4 and 10 months following randomization. Initial 12 sessions 2x a week first 4 weeks and 1x a week following weeks.	Primary outcome of pain (0-10 visual analog scale) were 0.0 (-0.7 to 0.8) at 2 months and 0.0 (-0.8 to 0.8) at 6 months and for primary outcome of function was 5% (95%, CI = -5% to 15% in favor of grated activity vs. motor control exercise. 44% vs. 41% in the motor control exercise group experienced recovery according to the more lax criterion.	"[T]he results of this study suggest motor control exercise and graded activity have similar effects for patients with chronic nonspecific low back pain."	Many activities performed in both groups.
Dufour 2010 RCT Study funded by Apotekerfonden af 1999, Sygekassernes Helsefond, and Danish National Board of Health. No COI.	6.0	N = 286 with LBP >12 weeks with or without radiating pain into legs, age 18-60	Group based multi-disciplinary biopsychosocial rehabilitation program: treatment in groups of 6, program consisted of exercise, education, and pain management for 12 weeks and divided into 3 periods of 4 weeks (group A, n = 142) vs. intensive individual therapy assisted	VAS pain scores: NS between groups throughout study. Roland Morris Disability Questionnaire mean±SD (3 months/6 months/12 months/24 months): Group A (3.3±5.5/ 3.4±6.0/4.0±5.8/3.9±6.9) vs. Group B (1.6±4.5/1.3±4.7/ 0.8±5.1/1.5±5.4), p = 0.001. SF-36 mean±SD (3 months/6 months/12 months/24 months): Physical functioning – Group A	"Both groups showed long-term improvements in pain and disability scores, with only minor statistically significant differences between the 2 groups."	High dropout over time. Data suggest comparable results although trends in favoring multidisciplinary program.

			back muscle strengthening exercise 1 hour twice a week for 12 weeks (group B, n = 144). Assessments at baseline and 3 months after treatment. Follow ups at 6, 12, and 24 months.	(12.2±21.2/10.6±22.0/12.1±24.0 /11.2±23.3) vs. Group B (6.0±17.7/4.4±18.0/2.0±19.0/1.6 ±20.4), p = 0.000; Physical component summary – Group A (5.0±7.7/4.2±7.9/5.1±8.3/5.0± 8.2) vs. Group B (2.8±7.3/2.2± 7.7/1.9±7.4/1.7±7.8), p = 0.001.		
Pozo-Cruz 2012 RCT Prospective single-blinded No funding and no COIs declared.	5.5	N = 100 with non-specific subacute LBP pain (with or without radiating leg pain)	Reminder group intervention besides preventive medical care access, also had education, daily reminders and exercise that includes, strengthening, flexibility, mobility and stretching exercise (n = 50) vs. Control group intervention had access to preventive medical care (n = 50). Follow-up for more than 6 but less than 12 weeks.	Intervention group more likely to exhibit improvement in functional disability or ODI/risk of chronicity: 85%, p = 0.001/75%, p <0.001, most of EQ-5D-3L: VAS/EQ-5D-3L utility score clinical change, mobility, self-care, pain, discomfort, anxiety, depression: 73%, p < 0.001/78%, p < 0.001/ 77%, p < 0.001/79%, p = 0.003/88%, p < 0.001/and pain/depression 84%, p <0.001. Compared to control, intervention group more likely to self-report risk of chronicity improved and experienced changed in EQ-5D-3L pain, discomfort dimension, anxiety, depression/EQ-5D-3L VAS: 80%, p <0.004/ 73%, p = 0.050/74%, p = 0.020.	"The intervention showed clinical improvements in quality of life and selected lower back pain outcomes in the experimental group compare to the control group."	Studied office workers. Non-interventional control bias precludes strong conclusions.
Aure 2003 RCT Industry Sponsored (Foundation for Education and Research in Physiotherapy, Norway). No COIs.	5.5	N = 49 "sick-listed" in Norway with back syndrome without radiating pain or back syndrome with radiating pain with duration 8 weeks to 6 months	Exercise therapy individualized with general training (n = 22) vs. Manual Therapy with spinal manipulation, specific mobilization, and stretching techniques for 45 minute sessions (n = 27).	Mean (CI) VAS score baseline end of study: Manual Therapy; 55 (48-62) to 21 (17-28) vs. Exercise Therapy; 54 (45-64) to 35 (25-45) (p <.0.01). Dartmouth COOP; Manual Therapy; 23 (21-24) to 14 (12-15) vs. Exercise Therapy; 24 (22-25) to 18 (15-21) (p <0.01). Oswestry: Manual Therapy; 39(34-43) to17 (12-22) vs. Exercise Therapy; 39 (33-44) to 26 (20-32) (p <0.01).	"[I}improvements were found in both intervention groups, but manual therapy showed significantly greater improvement than exercise therapy in patients with chronic low back pain. The effects were reflected on all outcome measures, both on short and long-term follow-up."	Trend to longer duration in MT group. Apparently no aerobic exercise component. Unclear if generalizable outside Norway or comparable system. High dropouts. Lack of standardized exercise regimen and no aerobic component may limit conclusions.

Pozo-Cruz 2012 RCT Industry Sponsored (University of Extremandura (Quality of Life Research Group and Occupational Preventative Medicine) and Government of Extremandura and European Union Regional Development Funds). No COIs.	5.5	N = 100 with subacute non-specific LBP.	Online occupational postural and exercises (n = 44) vs. Control group of standard preventive medicine care (n = 46).	Scores on STarT Back Screening Tool (SBST) improved in treatment group vs. controls (95% CI -1.01 [-1.79 to 0.118] p = 0.019).	"[T]his intervention was effective to reduce the risk of progression to chronicity among office workers with subacute non-specific LBP."	Studied office workers. Non-interventional control bias precludes strong conclusions.
Niemistö 2003 RCT The Social Insurance Institute of Finland and Finska La¨karsa¨ llskapet supported study. No COI declared.	5.5	N = 204 with chronic LBP	Manipulation, stabilizing exercise and physician consultation (n = 102, 60 minute evaluation, treatment, and exercise sessions plus educational booklet) vs. physician consultation alone (n = 102, educational booklet). Physician consultation group appears to have received individual instructions regarding posture and 3 to 4 exercises aimed at increasing spinal mobility, muscle stretch, and/or trunk muscle stability based on clinical evaluation. Treatment sessions each group 4 times over 4 weeks.	Baseline differences modestly favored manipulation group. Visual analogue pain score mean (SD) in mm at baseline/5 months/12 months for manipulative-treatment vs. consultation group: 59.5 (21.2)/25.2 (23.3)/25.7 (23.3) vs. 53.3 (21.2)/36.1 (23.3)/ 32.2 (23.3), p<0.001. Oswestry Disability Index: 29.5 (9.7)/14.7 (11.6)/13.7 (11.6) vs. 28.8 (9.7)/18.6 (11.6)/16.5 (11.6), p = 0.002.	"The manipulation treatment with stabilizing exercises was more effective in reducing pain intensity and disability than the physician consultation alone. The present study showed that short, specific treatment programs with proper patient information may alter the course of chronic low back pain."	Lack of significant content of physician consultations. If usual care, trial likely biased against that group. Manipulation treatment combined with exercise, precluding assessment of which is responsible for results and impairs the ability to draw strong conclusions.
França 2012 RCT Industry Sponsored: State of Sãu Paulo Research Foundation (FAPESP). No COIs.	5.5	N = 30 with non-specific LBP	Segmental stabilization (SS) (n = 15) vs. Superficial strengthening (ST) (n = 15).	All variables Pain-VAS, Pain-McGill, and functional disability improved from pre- to post-test in both groups (p <0.001). SS group had greater improvement in all variables compared to ST (p <0.001).	"…Both treatments were effective in relieving pain and in decreasing functional impairment, but only the SS treatment improved TrA muscle activation."	Small sample size (n=30). Data suggest strengthening superior to stretching.

Gatti 2011 RCT No mention of sponsorship and COIs.	5.5	N = 79 with history of chronic LBP	Experimental group (EG): trunk balance exercises in addition to standard trunk flexibility exercises (n = 34) vs Control group (CG): strengthening exercises and standard trunk flexibility exercises (n = 45). Follow-ups were at baseline and 1 week after final treatment.	Time-by-group interaction significant on Roland-Morris Questionnaire (Preintervention: EG = 7.8 ±44 vs. CG = 8.4±4.4; Post-intervention: EG = 4.4±3.3 vs. CG = 7.1± 4.5, p = 0.011), SF-12 Component (Pre-intervention: EG = 39.0± 5.9 vs. CG = 41.4±8.5; Post-intervention: EG = 44.5±8.3 vs. CG = 43.7 ±7.9, p = 0.48)	"The use of trunk balance exercise, compared to that of muscle-strengthening exercises of the limbs and trunk, appeared to be effective in reducing disability and led to improvements on the physical component of the quality of life due to CLBP."	Data suggest adding trunk balance exercise effective.
Hansen 1993 RCT Industry Sponsored (Danish Rheumatism Association, Copenhagen, Health Insurance Foundation, Copenhagen, and Rockwool Foundation, Hedehusene, Denmark). No mention of conflict of interest.	5.0	N = 150 with subacute and chronic LBP	Intensive dynamic back muscle training (n = 60) vs. standardized PT (n = 59, soft tissue treatment, manual traction, flexibility exercises, ergonomics counseling, etc., numerous additional unstructured components) vs. placebo control (n = 61, semi-hot packs, traction at 10% of body weight).	Both active treatment arms improved. Males performed better in physiotherapy and females gained more benefit in dynamic exercise program. Controls had decreased LBP days over 1 year (200 to 55 vs. 180 to 30 for dynamic exercise and 200 to 55 for physiotherapy).	"[P]hysiotherapy was the superior treatment for the male participants, whereas the intensive back exercises appeared to be most efficient for the female participants. Patients with moderate or hard physical occupations tended toward a better response with physiotherapy, whereas intensive back exercises seemed most effective for those with sedentary/light job functions."	Differences at baseline, especially in disability in year before enrollment. No aerobic exercises included. Co-interventions not well described and compliance not well described at 12 month follow-up. Weaknesses in this study, along with uncertain clinical significance of outcome results, preclude strong conclusions.
Petersen 2002 RCT Industry sponsored (Danish Physiotherapy Organization, Madsens Fund, and Danish Rheumatology Association). No COIs.	5.0	N = 260 with subacute or chronic LBP	McKenzie therapy (n = 135) vs. intensive strength training (n = 135). Initial 1-hour session and subsequent sessions typically 1/2 hour; intervals between treatments "at the discretion of the physical therapist." Both groups received a maximum of 18 treatments over 8 weeks.	Low back and leg pain ratings decreased in intent to treat analyses from 18.5 to 10.0 (McKenzie) vs. 19 to 14. Disability favored McKenzie at 2 months, but no differences in measures or disability at 8 months.	"[N]o statistically significant differences between McKenzie treatment and strengthening training with regard to change of disability at any follow up assessment."	High dropouts (80/260, 30.8%). Lack of program structure, combined with other weaknesses in this study, preclude strong conclusions.
Hurwitz 2002 RCT Industry sponsored (Agency for Healthcare Research	5.0	N = 681 with LBP, workers' comp excluded	Groups: 1) chiropractic care with physical modalities (DCPm, n = 172); 2) chiropractic care without physical modalities (DC, n = 169); 3) medical care with physical therapy	Six-month follow-up with improvements in all categories (similar results for medical and chiropractic groups and slightly less pain in PT groups). Those performing more physical activity had less	"Differences in outcomes between medical and chiropractic care without physical therapy or modalities are not clinically meaningful, although chiropractic may result in a greater likelihood	Lack of control for numerous co-interventions limits conclusions about any 1 intervention. Results for performance of back exercises difficult to interpret. A 18 months found

and Quality and the Southern California University of Health Sciences). No COIs.			(MDPt, n = 170); or 4) medical care without physical therapy (MD, n = 170). Follow-up at 6 and 18 months.	back disability. Borderline results with less psychological distress (no test for trend). Risks for severe pain not significant, though psychological distress and average pain trended lower across categories of METS. Risks for subsequent severe LBP higher among those performing back exercises, but risks for subsequent psychological distress borderline lower.	of perceived improvement, perhaps reflecting satisfaction or lack of blinding. Physical therapy may be more effective than medical care alone for some patients, while physical modalities appear to have no benefit in chiropractic care."	"differences in outcomes between medical and chiropractic care without physical therapy or modalities are not clinically meaningful…" Also PT "may be more effective than medical care alone for some patients, while physical modalities appear to have no benefit in chiropractic care."
Diab 2012 RCT No mention of industry sponsorship or COI.	5.0	N = 80 with chronic mechanical LBP	Traction group attended sessions 3 times a week for 10 weeks with traction beginning at 3 minutes and increasing by 1 minute per session to 20 minutes (n = 40) vs. comparison group told to do a stretching program 3 times a week and infrared radiation for 15 minutes per session (n = 40). Follow-up after 10 weeks and at 3 months.	Variation among mean values significantly greater than chance ($p < 0.0001$) for traction and comparison groups and stable at follow-up ($p < 0.05$) in pain, but no differences between groups in pain. Only difference in absolute rotatory angle was for traction group ($p = 0.00$), but lost from 10 week to 3 month follow-up ($p = 0.6$). For traction, difference among 3 measurement intervals for all measured levels, but for comparison group only seen for L3-L4 and L5-S1 ($p = 0.000$ and 0.005) levels in translational displacement.	"Lumbar extension traction with stretching exercises and infrared radiation was superior to stretching exercises and infrared radiation alone for improving the sagittal lumbar curve, pain, and intervertebral movement in CMLBP."	Assessment of traction as additive treatment, biases in favor of traction. Outcomes not blinded and included ROM, susceptible to data errors. Conclusions on intervention efficacy that used in both groups unwarranted. Despite design bias in favor of traction, no differences in pain and ODI at 10 weeks suggesting no significant benefit. That later modest differences at 6 months present is not well explained.
Ljunggren 1997 RCT No mention of sponsorship. No COIs declared.	5.0	N = 153 with history of back problems (inclusion criteria non-specific-back problems of undefined duration, severity, or diagnosis)	Conventional physiotherapy exercise program (n = 64) vs. exercise on machine (TerapiMaster, n = 62); 8 follow-up appointments to encourage compliance. Home exercises for 15 to 30 minutes, 3 times a week encouraged.	No significant differences between groups according to absenteeism at any time.	"Both exercise programs reduced absenteeism (61.6 to 15.4 days vs. 82.5 to 17.2 days) and there were no discernible differences in the effects of the two programs."	Baseline differences and effects difficult to predict. Compared conventional stretching/ strengthening with commercial apparatus. No control group and non-specific nature of pain in study group limits conclusions. Data suggest no differences.
Ewert 2009 RCT	5.0	N = 202 with at least one LBP	General physical exercise program (EP, n=102) of 11 one hour sessions vs.	No significant difference between groups.	"MP is not superior to an EP in influencing the process leading to chronic LBP. The	Secondary prevention study. Randomization allocation details sparse. No blinding.

No mention of sponsorship. No COIs declared.		episode in previous 2 years	multimodal program (MP, n = 100) of 17 1.75 hours sessions plus one 45 minute session. Follow up after intervention, 3 and 12 months.		most likely explanation is a common psychological mechanism leading to improved pain interference irrespective of the program. Considering the lower resources of the EP program, an expensive MP is not justified for secondary prevention of LBP and disability."	Data suggests no difference for short-term follow up.
Lewis 2010 RCT No mention of sponsorship. No COIs declared.	5.0	N = 30 with 2 or more digital tender points.	Group 1 received control intervention (C) followed by sham-strain counterstrain (P) followed by strain counterstrain intervention (T) (n = 5) vs. group 1 (n = 2) received PCT vs. group (n = 7) received TPC vs. group 4 (n = 8) received PTC ordering. Participants attended on 3 occasions over 5 days. Follow up at 5 days.	No significant difference between groups.	"This is the first rigorously controlled study to demonstrate that [strain counterstrain] intervention elicits an immediate increase in [pressure pain threshold] (reduction in tenderness) at [digital tender points] but this increase is not significantly greater than that following sham-[strain counterstrain] intervention. This suggests that some of the increase in [pressure pain threshold] at [digital tender points] following [strain counterstrain] intervention is likely to be due to the manual-contact component of the procedures, that is, sustained light pressure at the [digital tender point] and intermittent digital reassessment of the [digital tender point] during passive holding."	Sparse details for randomization, allocation, baseline comparability. Small sample sizes.
Limke 2008 RCT No funding acquired for this research. No mention of COIs.	5.0	N = 116 with spine pain >3-months.	One set of resistance training exercise (n = 51) vs. 2 sets of same exercise. Group sessions scheduled twice a week, average of 6 weeks, for 1.5 hours per session. Follow up at 6 weeks.	No significant difference between groups.	"This study provides support for prescribing a single set of resistance exercises as part of a spine rehabilitation program. This has already been the recommended dose for a healthy adult population without back pain. It is now appropriate to apply this guideline to patients with	No blinding. Data suggest no differences in performing 1 or 2 sets of resistance exercises as part of a physical therapy program.

					moderately disabling back pain enrolled in a structured outpatient spine rehabilitation program."	
Kluge 2011 RCT Authors have no conflicts of interest. No mention of COIs.	5.0	N = 50 women with LBP during current pregnancy (between 16 -24 weeks) age 20-40	Study Group: Group received back care advice and pamphlet, routine prenatal care, and 10-week exercise program. (n = 26) vs. Control Group: Group received back care advice and pamphlet, and routine prenatal care (n = 24).	Significant improvement in pain intensity (p = 0.76) and functional ability (p = 0.29) both groups. Pain intensity before intervention: Study group 30.0 (3-47)/ Experimental group 31.0 (9–54). Functional ability before intervention: Study group 71.0 (5-143)/Experimental group 77.5 (16–142). Significant improvement in pain intensity (p <0.01) and functional ability (p = 0.03) for both groups. Pain intensity after intervention: Study group 18.5 (0-40)/ Experimental group 33.0 (5-50). Functional ability before intervention: Study group 39.5 (0-135)/Experimental group 77.0 (4-140).	"A specific exercise program decreased back pain intensity and increased functional ability during pregnancy in South African women with lumbar and pelvic girdle pain. The findings of the present study may be limited by the small sample size and suboptimal compliance with the exercise program, and the lack of differences in secondary outcome may reflect the small size of the trial. Although randomized, blinding was not possible; however, the study demonstrated that it is possible to help women with low back pain during pregnancy, despite the difficulties in implementing an exercise program."	Only pregnant women.
Tavafian 2011 RCT Industry Sponsored (Tehran University of Medical Sciences, Tehran, Iran). No COIs.	5.0	N = 197 with chronic LBP	Intervention Group receiving group based multidisciplinary rehabilitation program plus oral medication (n = 97) vs. Control group receiving oral medication (n =100).	Significant difference on all SF-36 subscales within each group by time (p <0.01), except mental health (p = 0.7). Mean±SD for QDS scores at baseline intervention group vs. control group: 35.45±20.19 vs. 33.08±19.69; 6 months follow up: 18.65±16.14 vs. 27.19± 17.85 (p = 0.01). Mean±SD for RDQ scores intervention group vs. control group at baseline: 9.80±5.07 vs. 10.04±5.28; and 6 months follow-up: 7.03±5.49 vs. 8.80±5.68	"This study revealed that the multidisciplinary rehabilitation program added to a typical oral medication regimen can improve QOL and disability of patients with CLBP in a 6-month period of follow-up."	Unclear how blinding occurred. Contact time bias. Data suggests possible modest efficacy.
Wright 2005 RCT	5.0	N = 80 with new episode of back and off work or on light	Group 1: *The Back Book*, verbal advice, plus advice had to modify physical	Median number of days to return to work was 20 for group 1 as compared with 13	"[T]he study demonstrated that an intervention including information, advice, and	Usual care in UK comparison biases in favor of intervention. Data

No mention of industry sponsorship or COI.		duties ("new" defined as as onset within past 12 months)	activities specific to work situation while maintaining current care vs. Group 2: *Back Book* with treatment depending on physiotherapist assessment (manipulate, joint/soft tissue mobility, steroid injection, specific exercise, and group exercise sessions 1 hour 3x a week in gym. Exercise comprised of circuit stations, aerobic exercise and focus on procrioception, spinal ability, and strengthening exercises. Patients scheduled to attend 3 times a week for 2 weeks.	for group2 (p = 0.034). On average group 2 patients return to work 7 days earlier than group 1. Those who had achieved a change in their work status 50% in group 1 compared with 72% in group 2.	simple back program that offered manipulation, steroid injection, an group exercise therapy resulted in a speediest return to work than intervention than proved information, advice, and the normal route of care as directed by the general practitioner."	suggest back care is effective. Missing number of participants who received each specialized treatment. High dropout rate.
Balthazard 2012 RCT Study financed by DO-RE Funds of Swiss National Science Foundation (13DPD3-109903). No mention of COIs.	5.0	N = 42 with chronic non-specific LBP	MT group: Spinal manipulation/mobilization plus active exercises (AE) (n = 22) vs. ST group: Detuned ultrasound plus AE (n = 20). 8 sessions delivered in 4-8 weeks. Follow-up before treatments, after 8th therapeutic session, and at 3 and 6 months.	MT group with greater decrease in mean pain level vs. ST (-0.76 VAS units; 95% CI -1.22 to -0.3). For MT+AE/ST+AE treatment larger decrease in pain, reduced disability favored in MT group vs. ST group (VAS-pain mean group difference: -1.24; 95%; CI: -2.37 to -0.30; p = 0.032) and (ODI mean group difference: -7.14; 95% CI: -12.8 to -1.52; p = 0.013). No other significant effects.	"The present study confirms the immediate analgesic effect of manual therapy for CNSLBP."	Pilot study. Higher baseline VAS in ST (6.5 vs. 5.3). Data suggest manual therapy of additive benefit, however, exercise did not emphasize strengthening and aerobic.
Kuukkanen 2007 RCT No mention of sponsorship. No COIs declared.	5.0	N = 57 with non-specific LBP.	Control (n = 2 8) vs. Home exercise program (n = 29) presented in written and illustrated form of three progressive monthly programs. Follow up at 3, 6, and 12 years and 5 years.	Borg CR-10 change (95% CI) at 5 years for control vs. exercise was 0.5 (-1.0 to 2.0) vs. -1.0 (-2.0 to -0.5), p=0.01.	"The present randomized study indicates that supervised, controlled home exercises lead to reduced low back pain, and that positive effects were preserved over five years."	Difference in contact time between treatment groups.

Lindström 1992 Lindström Spine 1992 RCT Industry Sponsored (Arbetsmarknadens försakringsaktiebolag (AFA), Stockholm, Sweden, Volvo Company, Göteborg, Sweden, AMF-Trygghetsförsakring, Stockholm, Sweden, Medical Faculty of University of Göteborg, Sweden, Greta and Einar Askar Foundation, Göeborg, Sweden, and Bertha and Felix Neuberg Foundation, Göteborg, Sweden). No mention of COI.	4.5	N = 103 with subacute, non-specific LBP off work for 6 weeks	Graded activity (n = 51) vs. controls (n = 52) in Sweden. Graded activity was measured functional capacity (mobility, strength and fitness), workplace visit, back school education, and an individual, submaximal gradually increased exercise program with operant conditioning; 1 year follow-up.	At 1 year follow-up: activity vs. control: modified Schober (9.4±3.3cm vs. 7.1±4.1cm, p <0.01), backward bending (3.7±1.9cm vs. 2.8±1.3cm, p <0.01), ROM (77.2±15.0cm vs. 52.8±28.2cm, p <0.01), lateral bending (18.3±5.8cm vs. 14.6±6.2cm, p <0.01), and rotation (55.9±19.7cm vs. 44.3±17.3cm, p <0.01). No significant differences at 1 year follow-up for whole body mobility.	"[T]he patients with subacute, nonspecific, mechanical LBP who participated in the graded activity program regained occupational function faster than did the patients in the control group, who were given traditional care."	Data suggest graded activity superior to controls, including reduced long-term sick leave, especially in males. Intensive exercises, work-hardening exercises, or expensive equipment not found necessary to regain occupational function. Involved disciplines orthopedic surgery and physiotherapy. GPs administered routine care, but otherwise not involved. Social worker performed psychosocial screening.
Maitland 1985	4.5	See Cleland 2006				
Long 2004 RCT Industry Sponsored (Community Ethics Review Board of Alberta Heritage Foundation for Medical Research, Physiotherapy Foundation of Canada, McKenzie Institute International, and Cambridge Physiotherapy Associates). No COIs.	4.5	N = 230 with subacute and chronic LBP mean 13.7-17.7 weeks duration	Matched exercises (n = 80) taught unidirectional end-range lumbar exercises matching direction of their identified DP vs. opposite (n = 70) group taught unidirectional end-range lumbar exercises opposite of identified DP vs. evidence-based care (n = 80) taught commonly prescribed multi-directional and midrange lumbar exercises, and stretches for hips and thighs.	Matched exercises superior for LBP (matched: 5.86±2.39 decreased to 2.51±1.96 vs. opposite: 6.08±2.17 to 4.65±2.33 vs. evidence-based: 5.97±2.06 to 4.34±2.51, p <0.001). Medication (matched: 3.37±2.92 pills/day decreased to 0.81±2.25 vs. opposite: 3.29±2.74 to 2.57±2.77 vs. evidence-based: 2.65±2.38 to 1.73±1.73, p <0.016) and interference with work (matched: 3.41±1.10 decreased to 2.24±0.92 vs. opposite: 3.49±1.05 to 3.06±1.09 vs. evidence-based: 3.39±0.92 to 2.88±1.15).	"Exercises concordant with patients' [directional preference] significantly improved outcomes compared with nonconcordant exercises and advice, and appear to be an effective pain control/elimination treatment strategy."	Baseline difference in off work 37/45/47% from matched group. Data suggest directional preference exercises can improve outcome at 2 weeks.
Petersen 2011	5.0	N = 350 with pain duration >6 weeks	McKenzie therapy by certified therapists vs.	At 2 months, McKenzie treatment was superior (71%	"McKenzie method slightly more effective than	Pragmatic trial. High dropouts. More baseline

RCT BackCenter Copenhagen, Denmark. Reports non-commercial grant/foundation funding.		with pain centralization or peripheralization	spinal manipulation by chiropractors. All received adjunctive information and advice.	success vs. 59%) (p = 0.018). McKenzie care showed improvement in level of disability compared to manipulation group at 2 and 12 months (p = 0.030, Significant difference of 13% in number of patients reporting global perceived effect at end of treatment (p = 0.016).	manipulation when used adjunctive to information and advice."	sick leave in McKenzie (37 v 27%, p = 0.039). Patients who were non-centralizers at baseline purportedly excluded but no accounting of them. Data suggest McKenzie exercises superior to manipulation, persisting to 1 year.
Rydeard 2006 RCT No mention of industry sponsorship or COI.	4.5	N = 39 with chronic LBP	Pilates on apparatus in clinic 3x a week for 1-hour, 12-minute home training 6 days a week for 4 weeks (n = 21) vs. Usual care defined as consultation with physician and other specialist and health care professionals as necessary (n = 18). Treatment intervention over 4-week period.	Mean (SEM) functional disability scores decreased from 3.1 (0.6) to 2.0 (0.3), p = 0.023 in pilates group vs. 4.2 (0.8) to 3.2 (0.4), p = 0.002, in controls.	"[R]esults…support the hypothesis that an exercise therapy approach based on the Pilates method and directed at neuromuscular control mechanisms was efficacious in the treatment of a group of individuals with nonspecific chronic LBP. A 4-week treatment intervention was more efficacious than usual care in reducing average pain intensity and functional disability levels, changes were maintained over a 12-month period."	Baseline differences in functional disability, pain scores and leg pain all favored exercise group. Small groups. Six- and 12-month dropout rates (42.9 and 38.1%) too high for reliable results and preclude strong conclusions.
Snook 1998 RCT Industry Sponsored (Liberty Mutual Insurance Company, Boston, MA). No mention of COI.	4.5	N = 85 with present or recurring LBP	Treatment group, early morning flexion (n = 42) vs. Control group, sham treatment, 6 commonly prescribed exercises (pelvic tilt, modified sit-up, double knee to chest, side leg raise, cat and camel, hamstring stretch), (n = 43); for 45 minutes for each group.	Pain intensity/reduction in days in pain; significant reduction in treatment group, p <0.01 with 33%; 95% CI, 11-55%/p <0.05 with 36%; 95%, CI 12-60%.	"Controlling lumbar flexion in the early morning is a form of self-care with potential for reducing pain and costs associated with chronic, nonspecific low back pain."	High drop out. Data suggest early AM flexion may be modestly effective.
Gundewall 1993 RCT Industry Sponsored (Swedish Work Environmental Fund, The Local Health Authority in	4.5	N = 69 with history of LBP during previous 12 months, 0-10. Mostly female nurses, one male.	Training group, using wall bars, electric bands and light weights (n = 28) vs. Control group, no exercise (n = 32) for 13 months.	Muscle strength in training group increased on average of 20%, or p <0.01. Training group vs. control group comparison in muscle strength, p <0.04. Lost working days and days with complaints, p <0.0044 and p <0.018, respectively.	"An exercise program performed during working hours improved back muscle strength, lowered considerably the absence because of the complaints and the intensity of low back pain in a group of nurses and nurse's aides in comparison to	Data suggest exercise superior to no-exercise for prevention.

Kungsbacka, Sweden and Association of Physiotherapists in Sweden). No mention of COI.					a similar group not involved in the program."	
Winters 2004 RCT No mention of industry sponsorship. No COIs.	4.5	N = 33 with limited hip flexor ROM with thigh >0° when lying; had either LBP or a lower extremity injury	Two active (n = 22) vs. 2 passive stretching exercises of hip flexor muscles (n = 23).	ROM not different between two groups.	"The results of our study support the use of either an active or passive stretching program to increase ROM presumably by increasing the flexibility of tight hip flexors in relatively young patients with low back pain and lower-extremity complaints."	Lack of details for allocation, baseline comparability, control of co-interventions. Withdrawal/loss to follow-up 25%. Study suggests no difference in hip ROM improvement between techniques. Lack of control arm limits conclusion on effectiveness of intervention.
Diab 2013 RCT No mention of industry sponsorship or COI.	4.5	N = 80 chronic mechanical LPB with symptoms lasting 3+months. Exclusion criteria: spinal canal stenosis, rheumatoid arthritis, osteoporosis, inability to tolerate lumbar extension position, scoliotic deformity and any lower extremity deformity.	Traction Group (n = 40) Lumbar extension traction using Harrison's protocol 3 times a week for 10 weeks starting with 3 minutes a session, increasing to 1 minute a session to 20 minutes vs. Control Group (n = 40) Follow up at 6 months Both groups received stretching exercises (stretched erector spinae muscles and hamstring muscles held each for 30 seconds repeated 3 times, 3 times a week for 10 weeks) and infrared radiation (15 minutes per session 3 times a week for 10 weeks), instructed to avoid other exercise programs.	Mean±SD pre-treat/10 weeks post-treat/6 months follow-up. Lumbar lordosis: traction (13.9±3.1) vs. control (13.7±2.9)/traction (20.1±3.8) vs. control (15.2±3.6), p = 0.000/traction (18.3±3.6) vs. control (14.7±3), p = 0.000. Thoracic kyphosis: traction (31.4±4.1) vs. control (30±4.8), traction (34.3±4.2) vs. control (29.7±5.4), p = 0.013/traction (33.9±3.9) vs. control (29.9±4.8), p = 0.0001. Plumb line: traction (39.8±6.7) vs. control (38.7±6.6), traction (36.3±7.1) vs. control (37.9±6), p = 0.001/traction (36.7±6.9) vs. control (38.1±6.1), p = 0.001. Sacral slope: traction (23.5±3.4) vs. control (24.3±2.5), traction (25.5±3.3) vs. control (24.7±2.3), p = 0.001/traction (25.2±3.2) vs. control (24.5±2.6), p = 0.001. Pain: traction (6±1) vs. control (5.5±1.7), traction (3.2±1.4) vs. control (3.5±1.2), p = 0.29/	"The results of the present study show that the lumbar extension traction in addition to stretching exercises and infrared radiation have positive impact on lumbar lordotic curve, pain intensity, disability, and whole spine sagittal balance parameters in CMLBP."	No effect on pain or ODI until after treatment at 6 months is not readily explainable.

				traction (2.6±1.1) vs. control (3.5±1.2), p = 0.004. ODI: traction (32.4 ±3.1) vs. control (31.1±4.8), traction (21.8±3.1) vs. control (23.4±3.4), p = 0.1/traction (23.8±2.7) vs. control (27.1±3) p = 0.001.		
Soukup 1999 RCT Industry sponsored (The Norwegian Fund for Post Graduate Training in Physiotherapy, The Royal Norwegian Ministry of Health and Social Affairs). No mention of COI.	4.5	N = 77 with recurrent episodes of LBP in Norway	Mensendieck exercise program (n = 34) vs. Control group (n = 35). Primary goal for Mensendieck exercise program to teach ergonomic principles for movements of daily activities and to improve knowledge related to prevention of LBP, 20 group sessions of 60 minutes for 13 weeks.	No differences in numbers on sick leave over 1 year. Fewer average days of sick leave present when an outlier (186 days, 62% of sick leave) excluded (12.6 days vs. 37.8 days instead of 29.9 vs. 37.8 when including outlier). Fewer incident cases of LBP in exercise group at 12-months in Mensendieck vs. controls (32% vs. 57%, p <0.05). Survival analyses to incidence LBP case showed longer time in exercise group. Mean (SD) sick days for Mensendieck group with outlier was 29.9 (55.2) vs. 37.8 (28.0) for controls.	"A secondary prophylaxis Mensendieck exercise program of 20 group sessions significantly reduced the incidence of low back pain recurrences in a population with history of the condition. However, there were no differences between the groups with regard to days of sick leave, low back pain, and function."	Follow-up study (score = 4.0/11) evaluating results after 3 years also reported. Baseline differences present with more regular exercise in control vs. exercise group (26% vs. 17%). One outlier in exercise group excluded from analyses which influenced outcomes. Exercise program reduced LBP episodes but not sick leave, pain, or function. Data suggest Mensendieck program emphasizing ergonomic principles not substantially effective.
Machado 2007 RCT No mention of industry sponsorship or COI.	4.5	N = 33 with chronic LBP at least 3 months duration in Australia (radicular syndromes excluded)	Exercise: 40 minute sessions twice a week for 9 weeks (n = 17) vs. Non-directive psychological interventions, 80 minute treatment sessions twice a week for 9 weeks (n = 16). Assessment at baseline, 9 weeks, 6 months.	Exercise group had greater improvements than psychotherapy group in disability scores at 3 months (-4.9 point different, 95% CI -9.08 to -0.72, p = 0.02). Results not significant at 6 months.	"[C]lient-centered therapy is less effective than exercise in reducing disability at short term."	Reported compliance rates (44% exercise and 33% psychotherapy) are so low that validity and reliability of results appear questionable.
Kankaanpää 1999 RCT Industry sponsored (Ministry of Education and Academy of Finland (TULES Graduate School); Finnish Work Environmental Fund, The Finnish	4.5	N = 59 with chronic LBP (mean times since first episode ranged 5.8-10.9 years); those with pain radiating below knee excluded	Active rehabilitation (n = 30) vs. Passive modalities (n = 24). Active treatment consisted of 24 1.5 hour, small group exercise sessions with progressive increases over 12 weeks. Controls received thermal therapy and massage as they are "assumed to be ineffective."	Mean (SD) pain intensity (100mm VAS) at baseline/after/6-months/1-year for active group vs. control: 55.2 (22.8)/35.5 (26.3)/26.6 (28.4)/23.9 (17.8) vs. 47.0 (29.3)/43.8 (25.0)/43.3 (19.8)/45.1 (22.2), after p = 0.033, at 6 months p = 0.000, at 1 year p = 0.000. Mean (SD) functional disability (PDI	"The active progressive treatment program was more successful in reducing pain and self experienced disability and also in improving lumbar endurance than was the passive control treatment. However, the group difference in lumbar endurance tended to diminish at the 1-year follow-up."	Data suggest active exercise superior to passive modalities. Lumbar endurance measured by sEMG improved in active treatment group.

Medical Society Duodecim; Yrjö Johansson, Eemil Aaltonen, and Instrumentarium Science Foundations; Kuopio University EVO Fund). No mention of COI.				score):13.2 (10.2)/10.8 (11.2)/5.7 (6.6)/5.7 (8.1) vs. 9.5 (8.3)/10.9 (10.7)/12.6 (10.2)/11.4 (11.4), after p = 0.043, at 6 months p = 0.006, at 1 year p = 0.004.		
Kumar 2009 RCT Part of study supported by Indian Council of Medical Research (Grant No. 5/4-5/13/Neuro/ 2004-NCD-1); other from Indian Council of Medical Research, New Delhi, India. Authors report no COI.	4.0	N = 102 with non-specific, subacute (6-12 weeks) or chronic (>12 weeks) LPB.	Conventional treatment included ultrasound, short wave diathermy and lumbar strengthening exercises (n = 51) vs. Dynamic muscular stabilization techniques or DMST (n = 51) over 20 days. Participants further stratified by occupational subgroup, 1-sedentary, 2-desk workers, 3-movement job, 4-shopkeepers, 5-other. Follow-up 180 days.	Pain significantly decreased for all subgroups in both treatment groups (p <0.01 all points). Back pressure changes for physical strength significantly increased for all subgroups in both treatment groups (p <0.01 all points). Anterior pressure change for physical strength significantly increased for all groups except group 3 in DMST group (p <0.01 for all points).	"Study concluded that for the management of occupational LBP, DMST is more effective than conventional treatment. The Pain of Sedentary and Shopkeepers and physical strength of Movement job and Others may need more clinical attention. Findings of this study may be helpful in the management of occupational LBP."	Possible randomization failure.
Moffett 2006 RCT Industry sponsored (Arthritis Research Campaign). No COIs.	4.0	N = 315 with neck and back pain	McKenzie exercises (n = 161) vs. brief physiotherapy pain management treatment based on cognitive behavioral principles (n = 154, solution-finding approach, SFA).	Roland-Morris metrics: (baseline, 6 weeks, 12 months, no booklet) SFA (12.5±5.0, 9.5, 8.1) vs. McKenzie (11.2±4.9, 7.4, 7.0). No difference between groups. Satisfaction higher for McKenzie (90% vs. 70%, p = 0.008). TSK activity avoidance 6 weeks, 6 months, 12 months for SFA vs. McKenzie: 17.575/ 17.454/17.090 vs. 17.00/ 16.164/ 16.495, p = 0.032.	"The [McKenzie] approach resulted in higher patient satisfaction overall but the [Solution-Finding Approach] could be more cost-effective, as fewer (three vs. four) sessions were needed."	Inclusion of neck pain and mixing chronic patients all may limit conclusions relative to the back outcomes.
Bentsen 1997 RCT Industry sponsored (AMF-trygghetsförsakring, Stockholm, Sweden). No mention of COI.	4.0	N = 74 females age 57 with chronic LBP in Sweden	Dynamic strength back exercise program (n = 41) at fitness center for ½ hour, twice a week for 12 weeks vs. home training program (n = 33) 3-4 times a week for ≥8 weeks by 3 month follow-up and at least 6 of previous 9 months by 12 month follow-up.	Adherence somewhat superior in those supervised (45% vs. 38% completing respective programs). Dynamic group improved at 3 (p <0.00006) and 12 months (p <0.002). Home training group improved only at 3-month follow up (p = 0.015).	"The home training program was as effective as the supervised dynamic strength muscle training program and yielded lasting improvement after at least 1 year of adherence."	Minority of participants disabled (11%) while remaining 89% employed. All females. Very low compliance. Baseline difference in restricted activity. Data suggest supervised exercise did not improve symptoms or function.

Elnaggar 1991 RCT No mention of industry sponsorship or COI.	4.0	N = 56 with chronic LBP >3 months duration	Flexion emphasizing Williams' exercises vs. extension exercises derived from McKenzie. Physiotherapy 3 times a week plus 4 days with home exercises.	Flexion group had slightly more reduction in pain (37% vs. 33% reduction).	"Either the spinal flexion or extension exercises could be used to reduce chronic mechanical low-back pain severity, but the flexion exercises had an advantage in increasing the sagittal mobility within a short period of time."	Baseline differences may favor flexion exercises. Extension exercises active, not passive as described by McKenzie ROM improved more rapidly with flexion exercises. Data modestly supportive of flexion over extension exercises.
Risch 1993 RCT No mention of industry sponsorship or COI.	4.0	N = 54 with chronic LBP and sciatica, mean 8 years duration	Ten-week lumbar extensor strength exercise program (n = 31) vs. a waiting list (n = 23). Intervention involved protocol with MedX machine.	Physical dysfunction aspect of Sickness Impact Profile (SIP) decreased in treatment group from 9.1±9.3 to 7.7±9.4 vs. increase in wait-listed group from 15.2±10.4 to 19.3±15.6, p <0.03. Psychosocial dysfunction aspect of SIP decreased with treatment 12.5±14.3 to 10.3±12.8 vs. increase in controls 20.8±18.0 to 24.8±23.7, p <0.03. Pain subscale decreased with treatment 3.4±1.6 to 2.9±1.7 vs. controls from 3.7±1.6 to 4.1±1.5, p <0.002.	"These results show that lumbar extension exercise is beneficial for strengthening the lumbar extensors and results in decreased pain and improved perceptions of physical and psychosocial functioning in chronic back pain patients."	Measures of strength and psychosocial function improved. Baseline differences included control group having more time off work because of LBP (p <0.05) and more in control group receiving social security retirement benefits (p <0.05). Conclusions difficult because of these differences, but data suggest exercise beneficial over control.
Friedrich 2005 RCT No industry sponsorship or COIs.	4.0	N = 93 with chronic and recurrent LBP	Standard exercise program (n = 49) vs. exercise plus motivational program (n = 44) over 5-years. Exercise program with 10 25-minute sessions of individual submaximal gradually increased exercises focused on spinal mobility, trunk and lower limb "muscle length," force, endurance and coordination. Motivational program extensive counseling for importance of regular exercise, reinforcement of techniques used, treatment contracts, posting of treatment contract at home, exercise diary.	Effects of motivational group on disability measure at 3.5 weeks (p <0.001) and persisted for 5 years (p = 0.003). Pain ratings lower in motivational group at 5 years (p = 0.001). LBP episodes requiring therapy lower over 5 years in motivational group. Work ability measures better in motivational group at 5 years (p = 0.005).	"Regarding long-term efficacy, the combined exercise and motivation program was superior to the standard exercise program. Five years after the supervised combined exercise and motivational program, patients had significant improvements in disability, pain intensity, and working ability."	Compliance higher in motivational group. High dropout rate over 5 years at 40%. Data suggest combined motivational and exercise program better to reduce disability and pain and increase work ability in patients with chronic pain.

Kuukkanen 2000 RCT Industry sponsored (University of Jyvaskyla, Juho Vainio Foundation, TULES Graduate School and Academy of Finland). No mention of COI.	4.0	N = 86 employed subjects with chronic LBP	Intensive training (n = 20) vs. Home exercise (n = 29) vs. controls (n = 28). Intensive exercise group received supervised exercise 3 times a week plus daily HEP. Follow-up at 1 year.	After 9 months without supervised exercise, lumbar flexion and extension not different from baseline measures for any group. Intensive training and home exercise groups had greater reductions in ODI over 1 year and reduced pain. ODI back pain ratings did not correlate with flexibility. Spinal rotation increased in intensive training, p <0.002. ODI and back pain reduced all groups, but no differences between groups.	"[F]lexibility does not play an important role in coping with chronic low back pain for subjects whose functional limitations are not severe."	Data suggest no difference between intensive and home exercise programs.
Vad 2007 RCT No industry sponsorship or COI.	4.0	N = 50 with LBP greater than leg pain, at least 3-month duration.	Group I or Back Rx program: 15 minutes a day, 3 times a week (n = 25) vs. Group II. Both groups received celecoxib (200mg) + hydrocodone (5mg) + acetaminophen (500mg) as needed and lumbar cryobrace for 15 minutes before bed. For 12 weeks.	At minimal 12 month-period; 70% successful outcome reported in Group I vs. 33% in Group II. Average daily use of hydrocodone + acetaminophen + time off from work for Group I were less compared to Group II, all p <0.05. No difference between groups for average usage of celecoxib.	"These preliminary results suggest that a well-designed exercise program combined with use of a back cryobrace and oral medications may yield superior results for patients with axial diskogenic LBP when compared with oral medications and back cryobrace alone..."	Study of multiple interventions. Data suggest exercise superior to no exercise as additive treatment.
Cambron 2006 RCT Industry sponsored (Health Resources and Services Administration, National Chiropractic Mutual Insurance Company). No COI.	4.0	N = 191 with primarily complaint of LBP, >3 months with no contraindications to manual therapy.	Chiropractic care, or FD with series of flexion distractive procedures, administrated by chiropractors (n = 107) vs. formal physical therapy or EP active trunk exercise, administrated by physical therapist (n = 84). For 4 weeks, 2-4 times a week.	Percent seeking care/ average number of visits/ self-medical treatments/ self-care/changes in daily living: 38% vs. 54%/ lower number of visits by FD group, p = 0.06/77% vs. 87%, & 14% vs. 11%, OTC and prescription medications, respectively/ 99% vs. 100%/66% vs. 73%.	Based on one-year follow-up data imputed for complete analysis, participants who received physical therapy (exercise program) during a clinical trial attended a higher number of visits to any health care provider and to general practitioners during the year after care when compared to participants who received chiropractic care (flexion distraction) within the trial."	Many methodological weaknesses and sparse details. Physical therapy program not well defined and appears pragmatic, limiting conclusions.
Hemmilä 2002 RCT Industry sponsored (Finnish Slot Machine Association (RAY),	4.0	N = 132 with back pain. Follow up 6 weeks, 3, 6 and 12 months.	Physiotherapy (n = 34) vs. bone-setting (n = 45) vs. exercise (n = 35). A maximum of 10 one-hour treatment sessions of each therapy offered over 6-week period.	Improvement of Oswestry Disability scores at baseline mean (SD)/6 weeks mean (95%CI)/3 months/6 months/12 months for physiotherapy vs. bone-setting vs. exercise: 18.1 (7.7)/2.0 (-	"Traditional bone-setting seemed more effective than exercise or physiotherapy on back pain and disability, even 1 year after therapy."	Many weaknesses. Baseline differences in ODI concerning.

Folk Medicine Centre of Kaustinen, Finland). No mention of COI.				1.1 to 5.1)/4.0 (1.3 to 6.7)/4.7 (1.5 to 7.9)/4.4 (1.2 to 7.6) vs. 23.7 (11.6)/7.0 (3.4 to 10.2)/5.1 (1.8 to 8.4)/9.4 (6.7 to 12.1)/8.4 (5.2 to 11.6) vs. 19.4 (9.5)/3.2 (0.4 to 6.1)/2.9 (-0.2 to 5.9)/3.5 (0.2 to 6.8)/2.2 (-1.2 to 5.7), p = 0.06/0.09/0.6/0.01/0.4.		
Manniche 1993 RCT Industry sponsored (The Danish Rheumatism Association and the Health Foundation: Sygekassernes Helsefond). No mention of COI.	4.0	N = 98 with discectomy for herniated lumbar intervertebral discs.	Group A, Traditional exercise, combination of 15 mild exercises, 10 repetitions each,2x a week, 30 minute sessions vs. Group B, Intensive exercise, 5 heavy exercises, 50 repetitions, 1 hour sessions, 2x a week.	At 26/52 and 26 (before follow-up) weeks; LBP/ leg pain/disability/ physical impairments: (A/B; p = 0.44/0.28, & A; p = 0.88, B; p = 1.00, before follow-up) / (A/B; p = 0.66/0.74, and A; p = 0.44, B; p = 0.46)/(A/B; p = 0.029/0.094, &, A; p = 0.0007, B; p = 0.00002) / (A/B; p = 0.42, and A; p = 0.00024, B; p = 0.00001, at 6 weeks).	"[It] must be concluded that intensive dynamic exercise performed for a relatively short period, beginning 4-5 weeks after spinal operation, provide patients with behavioral support that in the long term could improve functional levels."	Details sparse, intervention not highly detailed.
Salah Frih 2009 RCT No mention of sponsorship or COIs.	4.0	N = 107 with chronic LBP, 82 women.	Group A or home-based rehab programme received 4 sessions, 2 hours each total of 18 exercises (n = 54) vs. Group B or standard rehab program with 90 minutes of treatment a day, 3x a week (n = 53). Follow-up for a month.	Between time 0 and 4 points: pain intensity/ FTF distance and TL angle: Gr A, -25.1, p < 0.001 and Gr B -13.9, p < 0.001/7.3cm vs. 5cm, p <0.001 and 8.4º vs. 9.9º in group B, p <0.001. Pain intensity between months 3 and 6, p <0.05 and 6 and 12, p = 0.199. Quebec functional index between 6 months and 1 year: Gr A -0.5 and Gr B 3.9, p = 0.018.	"[A] home-based rehabilitation programme is as effective as standard physical therapy."	Multiple outcomes measured at timepoints.
Engbert 2011 RCT No funds received in support of this work. No COI reported.	4.0	N = 28 with chronic LBP	Therapeutic Climbing (TC) group received 4 weeks of training 4 times a week on an indoor training wall (4m x 2.5 m) (n = 14) vs. Standard exercise regime (SRE) group also received 4 training sessions a week for 4 weeks (n = 14). Follow-ups were at baseline and after 4 weeks of treatment.	After 4 weeks of training, significant difference in SF-36: Physical Health subscales of physical functioning (TC: 86.50±15.1 vs. SRE: 75.50±16.7, p = 0.01) and general health (TC: 71.10 ± 13.6 vs. SRE: 62.85 ± 12.4, p = 0.01).	"This study demonstrates that therapeutic climbing may be suitable for patients with chronic low back pain. The therapeutic climbing regime especially improved the perceived health and physical functioning of patients, possibly through changes in attentional focus and new learning experiences regarding movement and pain."	Small sample size. Methodological details sparse.

Multiple Modes of Exercise

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Sherman 2011 RCT No mention of industry sponsorship or COI.	8.0	N = 228 with chronic LBP, mean age 48.4+/-9.79 years.	Yoga (n = 83) vs. stretching exercises (n = 80) vs. self-care (n = 45).	No significant differences between yoga and stretching groups. Compared to self-care group, yoga group had statistically significant better outcomes at week 12 (mean difference 95% CI -2.5 [-3.7 to -1.3]) and 26 weeks (95% CI -1.8 [-3.1 to -1.5]). Stretching vs. self-care also significantly better outcomes week 6 (95% CI -1.7 [-3.0 to -0.4), 12 weeks (-2.2 [-3.4 to -1.0]), 26 weeks (-1.5 [-2.8 to -0.2).	"At each follow-up, 2-6% of participants in the 3 groups reported 7 or more days of activity restrictions over the previous 4 weeks, 5-6% of participants reported any days in bed and 4-8% reported any work loss."	26 month follow up.
Faas 1993 RCT Study was supported by the Praeventie Fonds. No mention of COIs.	7.0	N = 473 in Netherlands with acute LBP ≤3 weeks	Usual care, analgesics, warmth, physical activity, need for return appointments (n = 155) vs. placebo 20 minutes a week for 5 weeks (n = 162) vs. Exercise therapy, instructed by physiotherapist 20 minutes a week for 5 weeks, stretching and isometric abdominals; advice on bending, lifting, carrying, etc, and advice to perform QD exercises (n = 156).	No differences in LBP recurrences over following 3 months (i.e., no recurrences 30% usual care, 34% placebo and 30% exercise; >3 recurrences 10%, 14% and 14% respectively).	"[I]n case of nonspecific acute back pain, exercise therapy should not be recommended."	Exercises did not include aerobic exercise. Data suggest most patients improved regardless of intervention.
Storheim 2003 RCT Supported by grants from Norwegian Foundation for Health and Rehabilitation and Norwegian Fund for Postgraduate Education in	7.0	N = 93 with subacute LBP not at work full-time for 8- to 12-weeks	Exercise of back training at large PT practice 2x a week for 15 weeks (n=30) vs. Cognitive therapy of 2 consultations between 30-60 minutes (n = 34) vs. control group treated by their GP with no restrictions on treatment referral (n = 29).	Dropouts highest in exercise group. Dropouts had higher FABs (p = 0.05). LBP ratings best in cognitive then exercise then controls: -20.9 (S.E., 4.3); -14.9 (4.1); -10.0 (3.7). Disability scores similarly sequenced: -3.5 (0.7); -2.1 (0.7); -1.6 (0.7) as was life satisfaction: 1.0 (0.5); 0.4 (0.2); -0.2 (0.3). Disability scores similarly	"Cognitive intervention improved disability and may be feasible for most patients sick-listed in the subacute phase. Physical exercise reduced patients' symptoms, but requires high motivation by patients. Despite positive effects in intervention groups on variables considered as negative	GP group had uncontrolled interventions. Disability and life satisfaction scores suggest cognitive therapy better than exercise which is better than GP treatment.

Physical Therapy. No mention of COIs.				ordered: -3.5 (0.7); -2.1 (0.7); -1.6 (0.7) as was life satisfaction: 1.0 (0.5); 0.4 (0.2); -0.2 (0.3).	prognostic factors for long-term disability and sickness absence, interventions had no effect on sick-listing."	
Mannion 1999 RCT Supported in party by the Swiss National Science Foundation (Grant No. 32-50979.97), the Schulthess Klinik Research Fund, and DBC International. No mention of COIs.	7.0	N = 148 with chronic LBP mean 9.7 to 13.0 years	Three interventions: active physiotherapy (n = 46, 30 minute individual sessions focus on improving functional capacity) vs. muscle reconditioning with training devices (n = 41, 1 hour group sessions) vs. low-impact aerobics (n = 45, 1 hour group sessions).	Pain scores decreased for all 3 interventions, between intervention results not different at 6 months. Roland-Morris disability scores lower in aerobics group (5.4±4.4) and devices group (5.7±4.8) than physiotherapy group (7.7±5.3). Aerobics noted to be <1/3 cost of other treatments. Main results stable at 1year follow-up.	"[T]he different active therapies induced significant improvements in the physical performance measures of trunk strength, endurance, and lumbar muscle activation, with no major influence from the specific therapy method employed."	Another publication from same study reviewed results of electromyographic components of study, found significant improvements in all 3 groups. Value of these findings unclear. Data suggest physiotherapy inferior to aerobics and devices.
Cherkin 1998 RCT Industry Sponsored (Agency for Health Care Policy and Research). No mention of COI.	7.0	N = 321 who saw primary care physician and still had LBP 7 days after a primary care visit	McKenzie approach physical therapy (9 sessions, n = 133) vs. chiropractic manipulation (short-lever, high-velocity thrust/9 sessions, n = 122) vs. educational booklet (n = 66) for duration of 4 weeks. Final follow-up at 2 years.	Booklet (n = 65) vs. chiropractic (n = 119) vs. PT (n = 129) bothersome of symptoms mean (95% CI), and Roland Disability mean (95% CI) at baseline: 5.3 (4.9-5.7)/5.5 (5.1-5.8)/6.0 (5.6-6.5)/p unadjusted = 0.04, 11.7 (10.4-13.0)/12.1 (11.2-13.1)/12.2 (11.2-13.1)/p unadjusted = 0.83. Booklet (n = 63) vs. chiropractic (n = 118) vs. PT (n = 117) at 12 weeks: 3.2 (2.4-4.0)/2.0 (1.6-2.4)/2.7 (2.2-3.2)/p unadjusted = 0.02/p adjusted = 0.06, 4.3 (3.1-5.5)/3.1 (2.4-3.9)/4.1 (3.2-5.0)/p unadjusted = 0.15/p adjusted = 0.28.	"[T]he McKenzie method of physical therapy and chiropractic manipulation had similar effects and costs, and patients receiving these treatments had only marginally better outcomes than those receiving the minimal intervention of an educational booklet."	Considerable prescription of exercise in chiropractic group, thus assessment of value of manipulation not possible. Data suggest PT and manipulation/ exercise superior to educational booklet, although magnitudes of benefits modest. Baseline differences with less pain in chiropractic group. No significant differences in outcomes other than costs reported between chiropractic booklet and McKenzie exercise protocol.
Goren 2010 RCT No mention of industry	7.0	N = 50 with lumbar spinal stenosis	Ultrasound plus exercise group (group 1, n = 17) vs. sham ultrasound plus exercise (group 2, n = 17) vs. no treatment/no exercise group (control, n = 16). Follow up 15 weeks.	VAS back pain (mean±SD) pre-treat/post-treat group 1 vs. group 2 vs. group 3: 5.53 ± 1.96/3.33± 2.79 (p = 0.015) vs. 6.20±2.60/4.26± 3.26 (p = 0.018) vs. 5.26±3.36/5.66±2.90 (p =	"[O]ur study showed that therapeutic exercise including stretching, strengthening and low-intensity cycling exercise were beneficial with respect to improvement in	Possible randomization failure, short treatment and follow up time.

sponsorship or COI.				0.280). VAS leg pain: 5.80±2.90/4.33±2.99 (p = 0.074) vs. 6.33±3.33/3.86 ±3.02 (p = 0.027) vs. 6.60± 2.80/7.13±3.04 (p = 0.184), post-treat p = 0.006, group 1>control p = 0.007, group 2>control p = 0.011; Oswestry Disability index: 25.46±7.70/21.50±9.30 (p = 0.041) vs. 26.90±10.19/ 19.10±8.00 (p = 0.012) vs. 32.20±9.60/28.60±9.20 (p = 0.366), post-treat p = 0.024, group 1>control p = 0.014, group 2>control p = 0.011.	level of pain and disability in patients with lumbar spinal stenosis. Supplementation of ultrasound with therapeutic exercises is found to reduce the amount of analgesic consumption."	
Faas 1995 RCT No mention of sponsorship or COIs.	6.5	N = 363 from above Faas study (1993)	Exercise (n = 122) vs. Usual care (n = 122) vs. placebo, treatments as above (n = 119).	More lost workdays during back pain among exercise therapy group (65.8% for exercise therapy vs. 38.2% for placebo vs. 33% for usual care, p = 0.047 for exercise vs. usual care, p = 0.035 for exercise therapy vs. placebo). Differences Months 1-3, but not Months 4-12.	"[C]oncerning sickness absence, exercise therapy in patients with acute low back pain had no advantages over usual care of the general practitioner."	Included only those with paid job. Exercise group consisted of core strengthening/stretching. Low compliance with 40/122 (32.8%) but good compliance in exercise group. Because of low-compliance, robust conclusions on value of exercise may be invalid.
Malmivaara 1995 RCT No mention of sponsorship or COIs.	6.5	N = 134 Finnish patients with acute LBP <3 weeks	Two days bed rest (n = 67) vs. Back-mobilizing exercises (n = 52) vs. Ordinary activities (n = 67). Controls attended 3 exercise sessions vs. 61 for exercise group and 8 for bed rest.	Sick days consumed favored ordinary activities group (4.7 days vs. 7.2 vs. 9.2), as did pain scale at follow-up (1.3 vs. 1.8 vs. 2.1). Flexion scores: 6.6 vs. 6.0 vs. 6.3 (NS). Patient satisfaction trended in favor of exercise (7.7 vs. 8.1 vs. 7.3, NS). Cost analyses (Finland) per person: $123 vs. $165 vs. $144, favoring ordinary activities over bed rest and then exercises.	"Among patients with acute low back pain, continuing ordinary activities within the limits permitted by the pain leads to more rapid recovery than either bed rest or back-mobilizing exercises."	Baseline variable may theoretically favor against control group with 22/67 in controls with heavy physical work ≥5 hours/day versus 10/67 bed rest and 13/52 exercise. Data suggest bed rest ineffective and ordinary activities superior.
Pengel 2007 RCT	6.5	N = 260 with subacute LBP	Exercise and advice (n = 63) vs. Sham exercise and advice (n = 63) vs. Exercise and sham advice (n = 65) vs. Sham exercise and sham	Pain relative change at 6 weeks for exercise vs. no exercise -0.8. Global perceived effect relative change at 6 weeks 0.5 at 3	"In participants with subacute low back pain, physiotherapist-directed exercise and advice were each slightly more	Authors stated control groups included sham exercises but no exercises described. Rather, sham appears to

Research fellowships funded by National Health and Medical Research Council of Australia. No COIs declared.			advice (n = 68). 12 physiotherapy-directed exercises or sham exercises and 3 physiotherapy-directed advice or sham advice sessions for 6 weeks (12 sessions). Exercise included individualized, progressive submaximal activities. Sham exercise was sham-pulsed US and short-wave diathermy. Advice to encourage graded return to normal activities. Sham advice given no advice on pain.	months. Pain relative change for advice vs. no advice at 6 weeks -0.7 (95% CI, -1.2 to -0.2), p = 0.011; at 3 months, -0.6 (95% CI, -1.2 to 0.0), p = 0.050.	effective than placebo at 6 weeks. The effect was greatest when the interventions were combined. At 12 months, the only effect that persisted was a small effect on participant-reported function."	be sham US and sham diathermy. Also, advice (education) compared with empathetic listening. Study suggests modest short-term benefit from described protocol for subacute LBP.
Manniche 1988 RCT Work supported partially by grant from Guido Riva Foundation. No mention of COIs.	6.5	N = 105 with chronic LBP median 15 years duration	Group A hot compresses, massage and isometric lumbar exercises vs. Group C intensive back strengthening group vs. Group B (placebo).	Pain scores (disability scores) reduced in Group A from median 11.7 (disability score 10.2) to 9.2 (8.5) after treatment to 11.5 (7.8) at follow-up. Group B median pain scores 14.0 (11.4) to 10.3 (8.8) to 11.1 (8.3). Group C scores: 13.3 (10.3) to 5.7 (9.0) to 5.0 (5.9).	"The results consistently favored intensive exercise, which had no adverse effects."	Authors felt differences in treatment length may have influenced results. At 1-year, those who continued to exercise significantly better. Data support intensive strengthening exercise.
Filiz 2005 RCT No mention of sponsorship or COIs.	6.5	N = 60 attending outpatient clinic after single-level discectomy	Intensive exercise plus back school education (4 back sessions a week plus 1.5 hour intensive exercise 3x a week for 8 weeks, (n = 20) vs. Home exercise plus back school education (4 back sessions/wk plus McKenzie exercises 3x a week (n = 20) vs. Control (n = 20). Subjects received interventions 30 days post-discectomy.	Exercise groups experienced decrease in pain severity and disability, functional parameters showed better improvement than control group. Modified Oswestry Disability Index Group A and Group B vs. Group C (post treat): 7.05±4.87 and 11.65±7.21 vs. 15.10±8.55 p <0.001. LBP rating scale: Group A vs. Group B and Group C: 7.40±6.92 vs. 22.45±13.94 and 39.6± 20.54 p <0.001. Group B vs. Group C: 22.45±13.94 vs. 39.60±20.54 p <0.001. VAS Group A vs. Group B and Group C: 4.50±1.59 vs.	"[P]ostoperatively applied education and exercise applications should be part of treatment with respect to the patients' earlier return to work and quicker recovery."	Some non-significant baseline differences likely favored intensive exercise group. Data suggest intensive exercise superior to other groups for earlier RTW.

				12.00±3.67 and 13.25±7.34 p <0.001.		
Unsgaard-Tøndel 2010 RCT Norwegian Fund for Post-Graduate Training in Physiotherapy financed study. No mention of COIs.	6.5	N = 109 with chronic nonspecific LBP at least 3 months duration..	Low-load, individually instructed, ultrasound-guided motor control exercises (MCE group, n = 36) vs. high-load, individually instructed sling exercises (SE, n = 36) vs. general exercises (GE, n = 37). All participants attended group treatments once a week for 8 weeks. Follow up at 8 weeks and 1 year.	No significant difference between groups.	"This study gave no evidence that 8 treatments with individually instructed motor control exercises or sling exercises were superior to general exercises for chronic low back pain."	Partial assessor blinding. No compliance data for home exercises. Data suggest no significant differences in exercise groups for non-specific chronic LBP. All groups had modest improvement, although baseline pain scores were low to begin with.
Marshall 2008 RCT No funds were received in support of this work. No COIs declared.	6.5	N = 50 with LBP at least 12 weeks duration	After 4 weeks of Manipulative control or MC, (n = 13) vs. Non-manipulative Swiss Ball or M-SB, (n = 12), individuals were assigned to Non-manipulative control (n = 13) vs. Non-manipulative Swiss Ball (n = 12).	SF-12 physical (PCS)/SF-12 mental (MCS) component, time effect and time exercise (0-8 weeks); F = 4.9, p <0.003, F = 3.4, p = 0.02/F = 3.2, p = 0.026 and F = 0.61, p = 0.66; time treatment and time exercise treatment (16-56); F = 1.2, p = 0.34, F = 1.9, p = 0.14/F = 1.9, p = 0.14, F = 32, p = 0.03.	"Supervised exercise is a more successful subsequent to manual treatment compared with exercise advice."	Multiple differences between groups at baseline.
Smeets 2009 RCT Industry Sponsored (Zorgonderzoek Nederanl/Medische Wetenschappen (ZonMw). No mention of COIs.	6.5	N = 309 with non-specific LBP for more than 3 months resulting in disability, age 18-65.	Active Physical Treatment (APT): (n = 53) aerobic training and muscle reconditioning vs. Graded Activity with problem solving Training (GAP): (n = 58) Consists problem solving training to help patients redefine their problems of pain and help focus on daily life goals. Vs Combined Treatment (CT): (n = 61) Integration of all treatment programs; APT, GAP, and problem solving	No significant differences between the CT, ATP, and GAP. CT wasn't more cost effective than GAP at 89% in northwest quadrant of QALY. While the GAP is in regarding reduction of disability.	"Based on the incremental cost effectiveness ratios (ICERs) and cost-effectiveness acceptability curves CT is not cost-effective at all. However, GAP is cost effective regarding the reduction of disability and gain in QALY, and to a lesser degree APT is more cost-effective than CT in reducing disability."	Secondary analysis of earlier publication (Kumar 2008).

			training vs Waiting List (WL): (n = 51) patients waiting 10 weeks and not allowed to participate in diagnostic or treatment. Not included in cost-effectiveness analysis.			
Bronfort 1996 RCT Support for this research was granted by the Foundation for Chiropractic Education and Research Award (#9]-3-1). No mention of COIs.	6.0	N = 174 with chronic and some subacute LBP	Spinal manipulative therapy by chiropractor, high-velocity low-amplitude, individualized treatment, 10 appointments first 5 weeks plus trunk strengthening exercise (n = 71) vs. NSAID (naproxen 500mg BID) and trunk strengthening exercise (n = 52) vs. Spinal manipulative therapy and stretching exercise, 11 weeks treatment (n = 51).	Pain ratings all decreased over 11-week interval and did not differ significantly between the groups (2.7±2.0 vs. 3.5±2.2 vs. 3.3±2.3).	"We were unable to demonstrate clearly that SMT combined with TSE was superior to NSAIDs combined with TSE or to SMT combined with stretching exercise."	Study results inconclusive as manipulation is mixed with exercises, NSAID; does not appear to be any difference between interventions. Mixtures preclude robust conclusions. Concluded that all interventions superior to natural history. But this is questionable as no placebo.
Vasseljen 2012 RCT No mention of industry sponsorship or COI.	6.0	N = 102 with chronic non-specific LBP lasting 3 months or more, pain score of 2 or more on numeric rating scale (0-10).	Core stability exercises (n = 33) vs. Sling exercises (n= 34) vs. General exercises (n = 35).	No significant differences between all 3 groups for changes in pain or abdominal muscle feed-forward activation.	"…No overall improvement in abdominal muscle onset was found after 8 weeks of different exercises….No association was found between changes in pain and feed-forward onset in the intervention period."	LBP ≥3 months.
Brennan 2006 RCT Industry sponsored by research grant from Deseret Foundation. No COI.	6.0	N = 123 with acute and subacute LBP	Manipulation including thrust manipulation or low amplitude mobilization (n = 40) vs. specific exercise instruction in repeated ROM exercises into lumbar flexion or extension; directional exercises determined by therapist (n = 37) vs. Stabilization trunk strengthening and stabilization exercises twice weekly for 4 weeks with maximum of 8 sessions (n =	Improvements in Oswestry Disability Index (ODI) for those with matched treatment 29.9 vs. 23.3 for non-matched. More who were matched advanced to next stage (78% vs. 60%). No significant differences between randomized groups.	"Nonspecific LBP should not be viewed as a homogenous condition and that outcomes can be improved when subgrouping is used to guide treatment decision-making."	Data support conclusions. Outcomes for those who were "not matched" to purported proper treatment also realized sizable improvements in ODI scores.

			46). Follow-up 1 year after completion of treatment.			
Torstensen 1998 RCT Supported by Ministry of Health and Social Affairs, Norwegian national budget, chapter no. 0720.63/97, project no. 10310, program trygd og rehabilitering (May 1993-June 1997), and by Foundation for Education and Research in Physiotherapy, Norway (July 1997 – December 1997). No mention of COIs.	5.5	N = 208 with chronic LBP or radicular pain sick-listed for more than 8 weeks and less than 52 weeks	Evaluated relative benefits of progressively graded exercises (n = 71) vs. conventional physiotherapy group (n = 67) vs. self-exercise group among patients sick-listed for 8-52 weeks in Norway with 1 year follow-up (n = 70).	No difference between first 2 groups, but both better than self-exercise group. Medical exercise therapy saved $122,531, and conventional physiotherapy group saved $254,200.	"The efficiency of medical exercise therapy and conventional physiotherapy is shown. Leaving patients with chronic low back pain untampered poses a risk of worsening the disability, resulting in longer periods of sick leave."	Pragmatic design in conventional PT arm (mix mostly passive modalities), but possibly largely excluded most exercises and no aerobic exercise in arm. Self-exercise group lower contact time; no targeted heart rate, biasing against arm. Suggests relatively unstructured self-exercise inferior to supervised exercise/PT. Compliance with self-exercise not reported and satisfaction much lower in that arm (34% vs. 32% vs. 10%), possibly related to beliefs and/or different contact time. Lack of detail for co-interventions, compliance. Suggests modest benefit from physiotherapy and medical exercise therapy techniques in pain, function, patient satisfaction vs. no treatment.
Doğan 2008 RCT No mention of industrial sponsorship or COI.	5.0	N = 60 with chronic LBP exceeding 3 months. Follow up for 1 month.	Group 1 (n = 20) aerobic exercise for 40-50 minutes 3 times a week for 6 weeks vs. Group 2 (n = 20) physical therapy with hot packs, ultrasound, and transcutaneous electrical nerve stimulation 3 times a week for 6 weeks vs. Group 3 (n = 20) home exercise for 6 weeks.	Mean±SD VAS (mm) at baseline/post-treatment/1 month follow-up group 1 vs. group 2 vs. group 3: 57.05± 24.5/34.9±30.8/34.1 ±27.6 (p = 0.002) vs. 61.2±20.5/ 38.9±23.4/28.8±28.1 (p = 0.0001) vs. 56.0±19.9/40.0 ±21.8/33.6±24.3 (p = 0.001). Roland-Morris disability questionnaire: 11.9±5.4/ 8.9±6.8/9.2±7.3 (p = 0.083)	"[T]hree different treatment approaches are found to be effective in decreasing the pain in patients with the chronic low back pain. This study showed that the patients should absolutely be recommended home exercise programs, which is the lowest cost alternative. However, the	Possible randomization failure, short treatment and follow up time.

				vs. 11.9±5.9/8.9±6.0/8.3 ±5.8 (p = 0.011) vs. 13.6± 7.4/13.6±6.6/13.3±7.3 (p = 0.81). General health questionnaire: 15.1±6.8/11.6 ±7.3/11.7±8.1 (p = 0.027) vs. 14.3±5.9/9.7±4.8/8.8± 6.06 (p = 0.01) vs. 12.8±7.5/11.5 ±7.5/12.2±6.6 (p = 0.65). Beck depression inventory: 14.1±9.2/14.2±10.5/12.7± 9.8 (p = 1.79) vs. 12.2±8.7/ 8.6±7.01/8.5±7.6 (p = 0.044) vs. 12.8±9.2/13.3±9.8/ 12.5±8.06 (p = 0.743).	home exercise program alone did not have any effect on the disability and the psychological state, whereas physical therapy plus home exercise program provides improvement in disability and psychological condition. There is a correlation between the increased fitness level and the decreased pain or vice versa."	
Goldby 2006 RCT No industry sponsorship or COI.	4.5	N = 323 with chronic LBP	Ten courses of manual therapy or MT (n = 89) vs. 10 week course of spinal stabilization rehabilitation program or SSR (n = 84) vs. Minimal intervention "education" or ED controls (n = 40). Stabilization exercises taught in 10 classes, once a week for 1 hour. MT technique based on diagnosis and clinical reasoning.	No differences in back pain intensity. At 6 months, fewer in spinal stabilization reported pain in prior 2 days vs. MT and Education (SSR = 47.9% vs. MT = 72.4% vs. ED = 56%, p = 0.009). At 12 months, SSR 38.8% reduction in disability vs. 24.5% in MT and 19.8% in ED (p = 0.0098). At 12 months, SSR had fewest taking medication (16.9%) vs. MT (27.8%) vs. ED (39.3%) (p = 0.007).	"A 10-week spinal stabilization program is significantly more effective than manual therapy at reducing pain, disability, dysfunction, medication intake, and improving the quality of life in patients with chronic low back disorder. The application of manual therapy is significantly more effective at reducing pain in patients with higher levels of low back pain than a minimal intervention control group."	All groups had 3-hour back school, but attendance 43-64% which raises questions about compliance throughout as there also were fewer classes attended in MT vs. spinal stabilization.
Kuukkanen 2000 RCT Study supported by University of Jyväskylä, Juho Visio Foundation, TULES Graduate School and Academy of Finland. No mention of COIs.	4.0	N = 90, with non-specific, subacute LBP age 20-55. On average, 10±8.4 years earlier, first onset of pain.	I or intensive training group (n = 29) vs. H or home exercise group (n = 29) vs. C or Control group (n = 28). For 12 months.	At baseline; I group had faster medio-lateral sway velocity for eyes closed test when compared to control group, p <0.04.	"In conclusion, this type of measurement method may be suitable as an outcome measure for the detection of changes in balance performance among low back pain subjects."	Data suggest no difference between intensive and home exercise programs.

Functional Restoration for Chronic Pain

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Subacute						
Henchoz 2010c No funding; no competing interests.	6.0	N = 109 with sub-acute (>6 weeks) or chronic (>12 weeks) LBP, phases 2 to 6 of Krause classification.	Functional multidisciplinary rehabilitation (FMR, n = 56) vs. Outpatients physiotherapy (OP, n = 53).	Disability at baseline, 3 and 9 weeks, 6, 9, 12 months for FMR group: 37.6 (15.8)/30.1 (16.5)/25.7 (15.8)/28.6 (18.4)/29.6 (17.9)/26.2 (18.0), significant for all follow up time ($p<0.01$) vs. OP group at 39.1 (14.7)/37.2 (13.5)/35.0 (12.3)/35.4 (15.0)/39.8 (17.3), significant only at 6 months ($p = 0.016$). Significant between group differences at 9 weeks ($p = 0.012$), 9 months ($p = 0.023$), 12 months ($p = 0.011$).	"Functional multidisciplinary rehabilitation was better than outpatient physiotherapy in improving functional and work status."	Data suggest efficacy with greater RTW.
Henchoz 2010b RCT No mention of sponsorship or COIs.	4.5	N = 105 with subacute to chronic LBP, phases 2 to 6 of Krause classification. Follow-up of 1-year.	Functional multidisciplinary rehabilitation or FMR for 5 to 7 hours per day, 5 days a week, for 3-weeks (n = 49) vs. Exercise program sessions lasted 90 min (n = 56).	No significant difference between groups.	"Adding an exercise programme after functional multi-disciplinary rehabilitation compared with usual care does not offer significant long-term benefits in quality of life and direct and indirect costs."	Short follow-up time.

Henchoz 2010a RCT No funding; no competing interests.	4.5	N = 105 with subacute to chronic LBP, phases 2 to 6 of Krause classification.	Functional multidisciplinary rehabilitation or FMR for 5-7 hours per day, 5 days a week, for 3 weeks (n = 49) vs. Exercise program sessions lasted 90 minutes (n = 56). Follow up of 1-year.	Beginning of FMR/End of FMR mean (SD) for Shirado test(s) for exercise program 54.46 (47.51)/66.13 (45.95), p <0.01; routine follow-up 42.79 (30.34)/65.45 (41.86), p <0.001. Sörensen tests (s) for exercise program 46.44 (40.97)/64.82 (49.83), p <0.001; for routine follow-up 38.09 (36.65)/67.12 (50.63), p <0.001, MMS test, extension (cm) exercise program -1.4 (0.89)/-1.63 (0.78), p <0.05; routine follow-up -1.33 (0.73)/-1.46 (0.7), p = 0.127. Fingertip-floor distance (cm) exercise program 17.56 (15.91)/11.32 (13.13), p <0.001; for routine follow-up 21.6 (18.59)/17.31 (18.44), p <0.001. Modified Bruce test (min) exercise program 9.81 (2.31)/11.23 (2.20), p <0.001; routine follow-up 53.24 (18.27)/37.45 (21.73), p <0.001. Back pain VAS (%) 53.24 (18.27)/37.45 (21.73), p <0.001; routine follow-up 51.56 (21.54)/35.93 (23.67), p <0.001. SFS (0-200) exercise program 114.16 (40.8)/126.53 (32.08), p <0.01; for routine follow-up 109.69 (37.36)/129.12 (37.85), p <0.001.	"A favorable long-term outcome was observed after functional multidisciplinary rehabilitation in both patient groups. Patients who participated in an exercise program obtained some additional benefits."	Data suggest no meaningful differences in outcome measures between groups at same time point. Both groups improved over time.

Chronic Pain						
Bendix 1996 RCT Study supported by Danish Rheumatism Association. No mention of COIs.	5.5	N = 106 with chronic LBP in Denmark	Multidisciplinary functional restoration (n = 55) vs. Control (n = 51). Multi-disciplinary program included aerobics, weight training, work stimulation/work hardening, relaxation, psychological group, stretching, theoretical class, recreation. Intervention full-time program with 135 hours for 6 weeks. Controls sent for treatment elsewhere.	Patients in intervention group returned to work at much higher rate (64% vs. 29%). Median contacts with health care system were median 1.6 for treatment group vs. 5.3 for control, p <0.001. Sick leave days were median of 10 for treatment group vs. 122 for control, p = 0.02. Back pain ratings 5.7 for treatment group vs. 6.9 for control group, p = 0.05.	"Although such programs are expensive, they can reduce pension expenditures, sick leave days, health care contacts, and pain."	Large differences in contact time and untreated controls bias in favor of intervention. Program with many co-interventions and was intensive. Data suggest effective to reduce lost time in Denmark and applicability elsewhere uncertain.
Jousset 2004 RCT Industry Sponsored (Union Régionale des Caisses d'Assurance Maladie des Pays de Loire). No COIs.	4.0	N = 86 with chronic LBP.	Functional Restoration or FRP; warm-up, stretching, strengthening exercise, aerobic exercise, 3 hours a day for 5 weeks (n = 44) vs. Active Individual Therapy or AIT, 1 hour treatment session, with therapist of choice, teaching of program of exercises (n = 42).	Dallas-HAD scale-Social Interest-Pain Intensity-endurance; p <0.001, significantly improved for FRP group, vs. less positive results for these parameters found in AIT group, at 6 months.	"This study demonstrates the effectiveness of a functional restoration program on important outcome measures, such as sick leave, in a country that has a social system that protects people facing difficulties at work."	Multiple differences between groups at baseline suggest randomization failure.

AQUATIC THERAPY (INCLUDING SWIMMING)

Aquatic therapy involves the performance of aerobic and/or flexibility and/or strengthening exercises in a pool to minimize the effects of gravity, particularly where reduced weight-bearing status is desirable.(759-765, 766, 767)

1. *Recommendation: Aquatic Therapy for Select Patients with Subacute or Chronic Low Back Pain*
   A trial of aquatic therapy is recommended for the treatment of subacute or chronic low back pain in select patients.
   Indications – If patient has subacute or chronic LBP and meets criteria for a referral for supervised exercise therapy and has co-morbidities (e.g., extreme obesity, significant degenerative joint disease, etc.) that preclude effective participation in a weight-bearing physical activity, then a trial of aquatic therapy is recommended for the treatment of subacute or chronic LBP.
   Frequency/Duration – Program should generally begin with 3 to 4 visits per week. Patient should have demonstrated evidence of functional improvement within the first 2 weeks to justify additional visits. Program should include up to 4 weeks of aquatic therapy with progression towards a land-based, self-directed physical activity or self-directed aquatic therapy program by 6 weeks.
   Indications for Discontinuation – Non-tolerance, failure to progress, or reaching a 4 to 6 week timeframe.
   Benefits – Ability to engage in exercise and rehabilitation when unable to sufficiently tolerate weight-bearing exercises in a traditional physical therapy program.
   Harms – Aggravation of pain during rehabilitation among a minority of patients.
   Strength of Evidence – **Recommended, Evidence (C)** [Chronic]
   Recommended, Insufficient Evidence (I) [Subacute]
   Level of Confidence – Moderate

2. *Recommendation: Aquatic Therapy for Acute and All Other Subacute or Chronic Low Back Pain*
   Aquatic therapy is not recommended for all other subacute or chronic low back pain patients or for all acute low back pain, as other therapies are believed to be more efficacious.
   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations

All quality studies address chronic LBP and none address efficacy for acute or subacute LBP. One moderate-quality trial found mostly comparable results with a land-based therapy program(768) while another reported modest efficacy compared with wait-listed controls.(769) One trial compared exercise plus spa therapy with physical therapy exercise plus passive modalities and found few differences between the groups combined treatment.(770) Two moderate-quality trials compared mineral water with tap water and suggested benefits; however, they may be culturally biased.(771, 772) Aerobic exercise is felt to be beneficial for the rehabilitation of acute, subacute, and chronic LBP. However, a few select patients are unable to tolerate those land-based therapies. Aquatic therapy is moderate cost, not invasive, and has little potential for adverse effects.

Evidence for Use of Aquatic Therapy

There are 7 moderate-quality RCTs incorporated into this analysis.(599, 602, 768-772) There is 1 low-quality RCT in Appendix 1.(760)

We searched PubMed, EBSCO, Cochrane Review, and Google scholar without the limits on publication dates. We used the following search terms "(Aquatic therapy) AND (subacute OR chronic low back pain)" & "(Aquatic therapy OR Swimming AND (subacute OR chronic low back pain)" to

find 7,435 articles. We included 10 articles (9 RCTs, 1 review).We also used the following search terms: balneotherapy, fangotherapy, water massage, subacute back pain, chronic back pain, low back pain, and postoperative to find 728 articles. Of the 728 articles, we reviewed 7 articles and included 5 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Chronic Pain						
Chan 2011 RCT Supported by Department of Rehabilitation Sciences, Hong Kong Polytechnic University and Department of Physiotherapy, David Trench Rehabilitation Centre. No COI.	7.0	N = 46 with chronic LBP	Intervention group received additional aerobic training program for 8 weeks, individually prescribed, supervised by physiotherapist, aerobic capacity testing performed according to modified Bruce protocol on treadmill. Exercise intensity set at 40-60% of heart rate reserve (progressed to 85% at 5% increment each week); 20 minutes exercise, 3x a week (n = 22) vs. Control or conventional physiotherapy (n = 24). Both groups received conventional physiotherapy treatment (ultrasound, heat pack, interferential therapy).	Significant improvements in pain and functional disability reported in both groups, p <0.001. Improvements in disability sustained in both groups at 12 months vs. baseline, p <0.001.	"The addition of aerobic training to conventional physiotherapy treatment did not enhance either short- or long-term improvement of pain and disability in patients with chronic LBP."	Small sample size. Lack of blinding. Data suggest no added benefit of aerobic exercise to passive modalities.
Balogh 2005 RCT No mention of industrial sponsorship or COI.	6.5	N = 60 with LBP ≥12 months no musculoskeletal complaints at baseline, had never had Kehidakustyán mineral water nor balneotherapy in prior year.	Group A Reduced sulphurous mineral water, n = 30, Group B Modified tap water, n = 30.	Group A significant improvement of p<0.01 VAS scores, muscle spasm, paravertebral tenderness, flexion of spine, extension of spine, Schober's index, lateral flexion of spine to right, lateral flexion of spine to left, rotation of spine to right, rotation of spine to left. Results lasted 3 months. Group B had reduced VAS p <0.01 and effects diminished more rapidly.	"Balneotherapy in itself can alleviate low back pain. As demonstrated by this study, the analgesic efficacy and improvement of mobility accomplished by the use of mineral water is significantly superior to that afforded by hydrotherapy with tap water."	No non-aquatic controls. Both groups had aquatic therapies. More improvements in mineral water group. Blinding appears dubious. Cultural belief structures may produce differences.
McIlveen 1998 RCT No mention of industrial sponsorship or COI.	5.5	N = 109 with LBP or leg pain for longer than 3 months.	Hydrotherapy with 60 minute group sessions, 2x a week for 4 weeks (n = 45) vs. control (delayed hydrotherapy) (n = 50). Follow-up after 4 weeks.	Functional status favored hydrotherapy group, ($x^2 = 3.9$; p = 0.04). No other differences seen.	"[H]ydrotherapy can benefit subjects with CLBP or back and leg pain."	Wait-listed controls bias in favor of intervention. Limited patient descriptions. Data suggest modest efficacy.
Tefner 2012 RCT	5.0	N = 60 age 40-79 with chronic LBP at least 12 weeks.	Thermal mineral water (n = 30) vs. tap water (controls, n = 30) 15-30 minute long sessions 5 days a week for 3 weeks. Assessments	VAS score of lumbar pain at rest (baseline/weeks 3/6/13): thermal mineral water (34.83±27.6/19.83±21.9)/	"As its primary objective, our study demonstrated – in comparison with treatment with tap water –	Patients not well described. Some baseline differences in outcome measures. Not

No mention of industry sponsorship. No COIs.			at baseline, at end of treatment, 3 and 10 weeks after treatment.	19.83±21.8/20.17±24.6) vs. control (40.37±24.3/39.85± 25.4/43.63±23.7/41.41±27.2), p <0.01 weeks 3, 6, 13. VAS score of lumbar pain on exertion: thermal mineral water (69.80±17.5/48.50± 18.5/48.60±17.9/49.40±22.4) vs. control (71.41±18.5/ 72.0±17.2/72.0±17.6/71.63±18. 0), p <0.001 weeks 3, 6, 13. Oswestry Index: thermal mineral water (39.51±18.0/ 30.31±17.6/28.38±17.8/29.24± 17.1) vs. control (40.43± 15.2/40.51±15.2/41.69±15.9/41 .70±16.8, p <0.05 week 3, p <0.01 weeks 6, 13. Schober's sign: thermal mineral water (3.88±0.9/ 5.28±0.9/5.40±0.9/5.18±1.1) vs. (3.98±1.1/3.94±1.3/ 3.98±1.3/4.02±1.2), p <0.01 weeks 3, 6, 13. Lateral flexion lumbar spine to right: 9.12±3.6/12.35±3.3/12.50± 3.4/11.08±3.6 vs. 9.78±3.1/ 9.72±3.1/9.61±2.9/ 9.11±3.4, p <0.01 weeks 3, 6, p <0.05 week 13. Lateral flexion of lumbar spine to left: 9.12± 3.5/12.45±3.7/12.88±3.7/ 12.10±4.0 vs. 10.0±3.1/10.15 ±2.9/10.11±2.9/10.04±3.2, p <0.05 weeks 3, 13, p <0.01 week 6. EQ-5D index: 0.54± 0.25/0.637±0.23/0.643±0.24/ 0.595±2.78) vs. 0.504±0.26/ 0.401±0.34/0.390±0.33/ 0.423±0.30, p <0.01 weeks 3, 6, p <0.05 week 13. VAS score perceived overall health status: 47.50±13.6/62.17± 15.2/62.33±/62.50±18.0 vs. 53.19±14.7/49.30±14.5/49.26± 14.3/49.44±14.2, p<0.01 all time points. SF-36 physical	the beneficial effect of balneotherapy on clinical parameters in chronic low back pain."	blinded. Lack of blinding and likely confounding by cultural beliefs limits conclusions.

				functioning: 34.50±19.7/ 49.33±16.6/51.83±18.5/50.33± 19.7 vs. 36.67±20.2/34.63± 18.8/33.89±19.2/29.81±18.9, p <0.01 at all time points. SF-36 role-physical: 2.71±5.6/ 8.75±9.2/ 9.58±9.1/6.88±9.8 vs. 2.08±3.0/1.85±4.2/ 1.62±5.4/3.01±6.1, p<0.01 weeks 3, 6. SF-36 bodily pain: 35.67±16.3/52.17± 19.3/54.25±19.9/46.83±21.2 vs. 36.76±18.5/34.72±15.0/ 35.83±25.1/31.30±19.5, p <0.01 all time points. SF-36 general health: 33.06±13.8/ 35.14±15.0/38.47±15.8/37.36± 15.4 vs. 33.02±15.0/26.54± 13.3/26.70±16.0/26.08±15.2, p <0.05 week 3, p <0.01 weeks 6, 13. SF-36 vitality: 36.50±20.2/50.17±22.0/47.67± 22.9/47.83±24.3 vs. 39.26± 18.8/35.74±18.5/36.11±24.1/32 .96±20.7, p <0.05 weeks 3 and 13, NS week 6. SF-36 social functioning: 60.42± 27.7/67.50±23.6/67.5026.0/60. 42±27.3 vs. 68.52±18.5/ 52.78±24.4/50.0±26.2/48.15+2 8.3, p <0.05 weeks 3 and 6. SF-36 role-emotional: 6.94± 9.0/12.50±11.5/12.50±10.7/12. 22±11.7 vs. 7.10±10.3/5.56 ±9.2/4.01±7.8/4.63±9.3, p <0.05 week 3, p <0.01 weeks 6 and 13. SF-36 mental health: 56.13±26.4/68.27± 23.6/62.27±25.0/60.93±27.6 vs. 54.67±20.6/49.19±21.7/ 46.81±22.6/44.59±26.6, p <0.01 at week 3, p <0.05 weeks 6 and 13.		
Kesiktas 2012 RCT	5.0	N = 60 with chronic degenerative LBP age 45-65 with	10 sessions of physical therapy once daily 5x a week excluding weekends that included TENS, US, IR, and exercise (Group I, n =	Significant variables between groups. Paracetamol tab/day (before therapy/after therapy/ 3 months follow-up): Group I	"[I]mprovements in back extensor muscle test, lumbar flexibility, functional capacity, and	Claims single blind, but not described well. Most control interventions minimally

No mention of industrial sponsorship. No COI.		mechanical character lumbar and leg pain for more than 3 months	30) vs. 10 session of balneotherapy for 30 minutes daily combined with exercise program, water temperature was 36°C (Group II, n = 30) with a 3 month follow-up.	(1.45±0.9/0.51±1/ 1.01±0.75) v. Group II (1.47±1/0.41±0.9/ 0.35±0.75), p = 0.001 before therapy to 3 months). ODI (before therapy/after therapy/ 3 months follow-up): Group I (45±15/39±19/33±16) v. Group II (46±17/34±17/31± 16), p = 0.01. Back extensor: Group I (2.91±0.38/3.20± 0.46/3.25±0.55) vs. Group II (2.88±0.21/3.54±0.54/3.55± 0.55) p = 0.001 before to after treatment, p = 0.001 before treatment to 3 months after treatment. Modified Schober (MS) test: Group I (5.40±1.49/5.90±1.48/6.40± 2.87) v. Group II (5.48±1.15/ 6.41±1.15/ 6.34±1.15), p = 0.01 before/after treatment.	quality of life, and reduction in the severity of the pain perceived were observed in patients with LBP receiving balneotherapy with thermal mineral water containing calcium carbonate and sodium chloride at Karalli thermal springs (Sanliurfa, Turkey) for 10 days. These effects were observed to persist in the balneotherapy group 3 months later."	or not effective and compared with balneotherapy plus exercise, therefore conclusions on efficacy spa therapy may not be valid. Minimal differences between groups.
Dogan 2008 RCT No mention of industrial sponsorship or COI.	5.0	N= 60 with chronic LBP	Group 1, aeorobic+home exercise (n = 20) vs. Group 2, Physical therapy+home exercise (n= 20) vs. Group 3, home exercise only (n=20).	1-month follow-up; pain sensitivity/GHQ scores/MET levels; p = 0.002/0.053 vs. p = 0.001 vs. p = 0.006/Group 1, p = 0.053 vs. 2 p = 0.010/ Group 1. p = 0.000 vs. 3, p = 0.001.	"[T]hree different treatment approaches are found to be effective in decreasing the pain in patients with the chronic low back pain."	Data suggest potential randomization failure.
Dundar 2009 RCT No funds received for this project. No mention of COI.	4.5	N = 65 with LBP at least 3 months.	Aquatic exercise program (20 sessions, 5x week x 4 weeks) in a swimming pool at 33C (n = 32) vs. land based exercise (60 minute program with warming up, basic flexion, extension, mobilization and stretching, strengthening, relaxation, aerobic, and cooling down exercises) for 4 weeks, performing each exercise once a day with 15 to 20 repetitions (n = 33). Follow-up at 0/4/12 weeks.	Both groups had significant improvement all parameters. At 4 and 12 weeks, aquatic group better per modified Oswestry Low Back Disability questionnaire (MOLBDQ), physical function and role limitations due to physical functioning subpart of SF-36 (p <0.001). MOLBDQ scores group 1 and 2 at 12 weeks: -0.52±0.02 and -0.27±0.01 respectively, for SF-36, PF 0.26±0.02 and 0.13±0.01, and for SF-36, RL 0.50±0.01 and 0.24±0.05.	"[W]ater-based exercises produced better improvement in disability and quality of life of the patients with CLBP than land-based exercise."	Quasi-randomization based on order of recruitments. Most data suggest comparable results. Modified ODI favored aquatics. However, land-based program may have included less active-exercises.

LUMBAR EXTENSION MACHINES

Lumbar extension machines are intended to address LBP through the development of muscle strength in specific muscle groups through specific exercises.(773-775)

Recommendation: Lumbar Extension Machines for Acute, Subacute, or Chronic Low Back Pain or Any Radicular Pain Syndrome

Lumbar extension machines to strengthen the lumbar spine are not recommended for acute, subacute, or chronic low back pain or for any radicular pain syndrome.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There is one moderate quality study of lumbar extension machines, but it has significant methodological issues and does not clearly demonstrate their utility in the treatment of LBP;(708) there are a few studies of low quality.(776, 777) The one moderate-quality RCT is also of relatively lower quality and has major flaws. There is no moderate- or high-quality evidence that strengthening on these machines is more effective than other strengthening exercises or other low-tech, low-cost exercise interventions.

Evidence for the Use of the Lumbar Extension Machines

There is 1 moderate-quality RCT incorporated into this analysis.(708) There are 5 low-quality RCTs in Appendix 1.(755, 778-781)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: lumbar extension machines, low back pain to find 211 articles. Of the 211 articles we reviewed 8 articles (6 original RCT's and 2 reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Chronic LBP						
Risch 1993 RCT No mention of COIs or industry sponsorship.	4.0	N = 54 with chronic LBP and sciatica (mean 8 years)	Ten-week lumbar extensor strength exercise program (n = 31) vs. a waiting list (n = 23). Intervention involved protocol with MedX machine.	Physical dysfunction aspect of Sickness Impact Profile (SIP) decreased in treatment group from 9.1 ±9.3 to 7.7±9.4 vs. increase in wait-listed group 15.2±10.4 to 19.3±15.6, p <0.03. Psychosocial dysfunction aspect of SIP decreased with treatment 12.5±14.3 to 10.3±12.8 vs. increase in controls 20.8±18.0 to 24.8±23.7, p <0.03. Pain subscale decreased with treatment 3.4±1.6 to 2.9±1.7 vs. controls from 3.7±1.6 to 4.1±1.5, p <0.002.	"These results show that lumbar extension exercise is beneficial for strengthening the lumbar extensors and results in decreased pain and improved perceptions of physical and psychosocial functioning in chronic back pain patients."	Use of wait-listed controls biases in favor of treatment, and limits ability to draw firm conclusions on efficacy. Wait-listed controls also had measures on same machine would likely have reminded controls they were not being treated, producing additional bias which may be apparent in rare finding of worsening ratings. Study appears biased in favor of intervention.

YOGA, TAI CHI, and PILATES

Yoga and Tai Chi have been used for treatment of chronic LBP.(584, 782-784) Yoga for purposes of treating LBP has not been standardized, but tends to involve postures, stretches, breath control, and relaxation. Traditional yoga is different and involves rules for personal conduct, postures, breath control, sense withdrawal, concentration, meditation, and self-realization,(785, 786) and different versions are practiced (e.g., Ashtanga, Iyengar, Hatha). This review focuses on the exercise aspects of yoga and tai chi and does not endorse or support spiritual elements or specific religious beliefs.

1. *Recommendation: Yoga for Chronic Low Back Pain*
   Yoga is recommended for select, highly motivated patients with chronic low back pain.

   Indications – Chronic LBP patients who are motivated to try and adhere to a program of yoga.

   Indications for Discontinuation – Non-tolerance and/or non-compliance.
   Benefits – *Modest* reductions in pain.
   Harms – May reduce compliance with aerobic and strengthening exercises due to time commitment. One report of back strain.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Yoga for Acute or Subacute Low Back Pain*
   There is no recommendation for or against the use of yoga for the treatment of acute or subacute low back pain.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

3. *Recommendation: Tai Chi for Chronic Low Back Pain*
   Tai Chi is recommended for select highly motivated patients with chronic low back pain.

   Indications – Chronic LBP patients who are motivated to try and adhere to a program of Tai Chi.

   Indications for Discontinuation – Non-tolerance and/or non-compliance.

   Benefits – Modest reductions in pain.
   Harms – None reported. May reduce compliance with aerobic and strengthening exercises due to time commitment.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

4. *Recommendation: Tai Chi for Acute or Subacute Low Back Pain*
   There is no recommendation for or against the use of Tai Chi for the treatment of acute or subacute low back pain.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

6. *Recommendation: Pilates for Chronic Low Back Pain*
   There is no recommendation for or against the use of Pilates for treatment of acute, subacute, chronic or post-operative back pain.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
All quality studies of yoga address chronic LBP and none address efficacy for acute or subacute LBP. Different types of yoga have been assessed. There are some small studies that are likely underpowered.(787-789) The sizable studies generally show efficacy compared with an educational book,(789, 790) usual care,(791) breathing exercises and relaxation,(792, 793) and self-directed medical care.(794) However, yoga was not found superior to stretching classes,(652) raising questions about whether yoga may be inferior to aerobic and strengthening exercise. Due to these weaknesses the recommendation is downgraded to "C" level evidence.(788, 790) Patient motivation, compliance and adherence must be high and there is much self-selection in the studies. Yoga is not invasive, has low potential for adverse effects, and is low cost (self-administered is very low cost). It is recommended for highly select and motivated patients.

Tai Chi has been assessed in one study and some evidence of efficacy is suggested. As Tai Chi is not invasive, has few adverse effects and is low cost, it is recommended for highly select and motivated patients.

The few studies on Pilates have poor compliance rates and other methodological challenges(709, 795) that limit conclusions and result in no recommendation.

Evidence for the Use of Yoga, Tai Chi, and Pilates
There are 2 high-(652, 790) and 9 moderate-quality(709, 786-789, 791, 794-796) RCTs incorporated into this analysis. There is 1 low-quality RCTs in Appendix 1.(797)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: yoga, hatha yoga, subacute low back pain and chronic low back pain to find 13,685 articles. Of the 13,685 articles we reviewed 17 articles and included 16 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Chronic Pain						
Sherman 2005 RCT No mention of industry sponsorship or COI.	8.0	N = 101 mostly LBP >1 year, 83% highly educated (97% at least some college)	Exercise (n = 35) created for trial) vs. educational booklet (n = 30) vs. Viniyoga (n = 36) tailored for LBP and consisting of 12 weekly 75-minute classes.	Yoga group more successful at reducing Roland-Morris scores than self-care book (mean score difference -3.6, 95% CI -5.4 to -1.8, p <0.001 at 26 weeks) or exercise group.	"Yoga was more effective than a self-care book for improving function and reducing chronic low back pain, and the benefits persisted for at least several months."	Prior probable exercise treatment for chronic LBP may bias against that arm. One participant developed back "strain" and was treated by chiropractor. Data suggest yoga superior to exercise.
Sherman 2011 RCT No mention of industry sponsorship or COIs.	8.0	N = 228 with chronic LBP	Yoga: 12 weekly classes (n = 92) vs. Conventional stretching exercises (n = 91) vs. Self-care book (n = 45). Follow-up at baseline, 6, 12, and 26 weeks.	RDQ score different among 3 groups at all follow-ups (6 weeks: p = .04; 12 weeks: P < 0.001; 26 was: p = 0.03). Yoga group had improved function at 12 (mean difference,−2.5 [95% CI, −3.7 to −1.3]) and 26 weeks (−1.8 [95% CI, −3.1 to −0.5]), vs. self-care group. Stretching group with better function at 6 (−1.7 [95% CI, −3.0 to −0.4]), 12 (−2.2 [95% CI, −3.4 to −1.0]), and 26 weeks (−1.5 [95%CI, −2.8 to −0.2]).	"Yoga classes were more effective than a self-care book, but not more effective than stretching classes, in improving function and reducing symptoms due to chronic low back pain, with benefits lasting at least several months."	26 month follow-up. Data suggest yoga comparable with exercise classes emphasizing stretching. Results appear at least somewhat durable beyond classes.
Williams 2009 RCT No mention of industry sponsorship or COI.	7.5	N = 90 with LBP >3 months	Iyengar yoga group (n = 43) who participated in 24 weeks of yoga, twice weekly, 90-minutes a time vs. control group (n = 47) who continued self-directed standard medical care. Follow up at 12, 24, and 48 weeks.	Mean change ± SEM at 12 and 24 weeks, 6 months for yoga vs. control for ODI: -3.1± 1.43/-7.3±1.77/-6.0± 2.11 vs. -0.8±0.89/-2.3± 1.09/0.4±1.44, p = 0.262, p = 0.011, p = 0.001. VAS -8.8±2.44/-17.6±2.57/-13.9±3.28 vs. -3.9±2.30/-4.4 ± 2.08/-2.7±2.25 p = 0.143, p = 0.0001, p = 0.0009. Beck Depression Inventory -2.7±0.65/-4.2±0.73/-4.4 ± 0.92 vs. -0.2±0.63/-0.5 ±0.60/-0.8±0.86 p = 0.0132, p = 0.0002, p = 0.0004.	"Yoga improves functional disability, pain intensity, and depression in adults with CLBP. There was also a clinically important trend for the yoga group to reduce their pain medication usage compared to the control group."	Data suggest yoga associated with improved outcomes, however, the control group was self-directed standard medical care, which limits conclusions.

Tilbrook 2011 Parallel-group RCT	6.0	N = 313 with chronic or recurrent LBP	Yoga group (British Wheel of Yoga, Iyengar Yoga): 12 yoga classes, once a week for 75 minutes, plus pain education book (n = 156) vs. Usual care group with just a pain education book (n = 157). Follow-up at 3, 6, and 12 months.	Yoga group improved back functions in mean RMDQ scores (95% CI) in main analysis and sensitivity analysis vs. usual care group at 3 months: 2.17 points lower in yoga group (1.03 vs. 3.31 points), 6 months: 1.48 points lower in yoga group (0.33 vs. 2.62 points), and 12 months: 1.57 points lower (0.42 vs. 2.71 points) PSEQ scores significant different between yoga vs. usual care at 3 and 6 months, but not 12 months (3 months: 2.96 (0.35 to 5.58) p = 0.027, 6 months: 3.33 (0.68 to 5.97) p = 0.014, 12 months; 1.75 (-0.87 to 4.38) p = 0.190].	"Offering a 12-week yoga program to adults with chronic or recurrent low back pain led to greater improvements in back function than did usual care."	Compliance poor with 60% attending 50%. Usual care/non-attention bias limits conclusions. Data suggest modest efficacy.
Saper 2009 RCT No mention of industry sponsorship or COI.	5.5	N = 30 with back pain persisting longer than 12 weeks	Hatha yoga (n = 15) 12 weekly 75-minutes classes divided into four 3-week segments vs. usual care group (n = 15) routine medical care and medication then offered yoga intervention after 26 weeks. Follow-up at 6, 12, and 26 weeks.	Mean pain scores decreased 2.3±2.1 yoga group vs. 0.4±1.8 for controls at 12 weeks, p = 002. Mean Roland scores decreased 6.3± 6.9 vs. 3.7±4.9 in controls, p = 0.28. Proportion of experiencing minimal clinically significant decrease in pain at 12 weeks 67% vs.13% in controls (n = 0.008).	"[L]ong-term retention and adherence to treatment assignment was poor. Yoga was more effective than usual care at least in the short term for reducing pain and pain medication use."	Pilot study, small numbers, missing some details. Adherence problems noted. Data suggest efficacy.
Galantino 2004 RCT No mention of industry sponsorship or COI.	4.5	N = 22 with at least 6 months CLBP. Follow-up at 3 months.	Hatha yoga (n = 11) for 1 hour, 2 times per week for 6-week period vs. control wait group (n = 11).	Mean Beck Depression Inventory pre/post for control group compared to yoga: 15.55±8.27/17.36±9.79 vs. 7.45 ±5.20/7.18±6.90, p = 0.008.	"A modified yoga-based intervention may benefit individuals with CLB, but a larger study is necessary to provide definitive evidence. Also, the impact on depression and disability could be considered as important outcomes for further study."	Pilot study. Small sample size (n = 22), details sparse. No patients continued to attend classes at 3 months. Baseline differences suggest randomization failure. Non-interventional control bias.
Cox 2010 RCT	4.0	N = 20 with LBP in prior 18 months and ≥4 on Roland-	Iyengar Yoga group (n = 10) of 12 weekly 75-minute	No significant difference between groups.	"This study did not find evidence for the clinical effectiveness of yoga for	Pilot study, small numbers (n = 20), missing some details. Likely underpowered.

Study funded by York Trials Unit, University of York. No mention of COI.		Morris Disability Scale. Follow-up at 4 and 12 weeks.	classes vs. usual care (n = 10).		CLBP due to inadequate power."	
Williams 2005 RCT Project funded by Clinical Studies request for proposals at West Virginia University.	4.5	N = 60 with non-specific chronic LPB	Yoga intervention group (n = 30) vs. Educational Control Group (n = 30).	Functional disability mean scores at baseline, 16 weeks, 3 months, yoga vs. control group. 14.3 (13.6) vs 21.2 (20.5) , 3.3 (5.1) vs. 12.8 (11.9) (p = 0.005), 3.9 (5.3) vs. 12.7 (11.4) (p = 0.009). Difference in mean VAS score significant at 3 months when yoga had 70% decrease in present pain vs. 38% controls. (p = 0.039)	"The significant improvements by yoga subjects were maintained at the 3-month follow-up, indicating that the yoga intervention is associated with longer lasting reductions in disability and pain outcomes than an educational intervention."	Data suggest modest efficacy of yoga that persisted beyond the trial.
Pilates						
Donzelli 2006 RCT No mention of industry sponsorship or COI.	5.0	N = 43 with chronic LBP without radicular symptoms	Back school (n = 22) vs. pilates CovaTech (n = 21). Back school rehab program 1 hour for 10 sessions, included postural education exercises, respiratory education, muscular extension and strengthening of paravertebral muscles and lower limbs, mobilizing exercises for spinal column and antalgic postures.	Subjective reporting at follow ups [Group (Worse, Same, Better)]. At 1 month: pilates (3,1,17) vs. back school (5,3,14). At 3 months: pilates (2, 3, 16) vs. back school (6, 8, 8). At 6 months: pilates (2, 4, 15) vs. back school (7, 7, 8).	"[T]he Pilates CovaTech method is a valid alternative in the treatment of non specific chronic low back pain."	Compliance with exercises so low (45% back school, 26% Pilates) that meaningful conclusions regarding efficacy appear rather challenging.
Rydeard 2006 RCT No mention of industry sponsorship or COI.	4.5	N = 39 with chronic LBP	Pilates, on an apparatus in clinic for 3 times 1-hour sessions a week, 12-minute home training 6 days a week for 4 weeks (n = 21) vs. Usual care defined as consultation with physician and other specialist and health care professionals as necessary (n = 18). Treatment intervention over 4-week period.	Mean (SEM) functional disability scores decreased from 3.1 (0.6) to 2.0 (0.3), p = 0.023 in pilates group vs. 4.2 (0.8) to 3.2 (0.4), p = 0.002, in controls.	"[R]esults…support the hypothesis that an exercise therapy approach based on the Pilates method and directed at neuromuscular control mechanisms was efficacious in the treatment of a group of individuals with nonspecific chronic LBP. A 4-week treatment intervention was more efficacious than usual care in reducing average pain intensity and functional disability	Baseline differences in functional disability, pain scores and leg pain all favored exercise group. Small groups. Six- and 12-month dropout rates (42.9 and 38.1%) too high for reliable results and preclude strong conclusions.

					levels, changes were maintained over a 12-month period."	
Tai Chi						
Hall 2011 RCT No mention of industry sponsorship or COI.	5.5	N = 160 with chronic LPB all >3 months	Tai chi group: 18 sessions of 40 minutes for 10 weeks (2 times per week for 8 weeks followed by once per week for 2 weeks) (n = 80) vs. wait-list control group: usual health care (n = 80).	Pain symptoms and pain-related disability decreased in tai chi vs. control group indicated by mean difference of Bothersome [1.7 (0.9, 2.5); p = 0.000], Pain [1.3 (0.7, 1.9); p = 0.000], PDI [5.7 (1.8, 9.6); p = 0.005], RMDQ [2.6 (1.1, 3.7); p = 0.000], QBPDS [6.6 (2.4, 10.7); p = 0.002], PSFS [-1.0 (-1.7, -0.4); p = 0.001], and GPE [-0.8 (-1.5, -0.0); p = 0.05].	"This is the first pragmatic randomized controlled trial of tai chi exercise for people with low back pain. It showed that a 10-week tai chi program improved pain and disability outcomes and can be considered a safe and effective intervention for those experiencing long-term low back pain symptoms."	Some baseline differences. Poor compliance (28.8% attended 75+%). Wait-list control bias limits conclusions. Data suggest potential efficacy.

General Treatment Approach

Many patients, but particularly chronic LBP patients tend to receive excessive treatments that are either minimally or completely ineffective. The pattern of treatments appears to follow the practitioner's practice, experience and qualifications. Examples of such excesses include polypharmacy, excessive therapy, ongoing manipulation, recurring injections, and multiple surgical procedures. Instead, the following are **Recommended (I)** approaches (see also Algorithms).

It is **Recommended, Insufficient Evidence (I)** that patients receive one or at most two medications and assess the benefits. A lack of clear functional benefits suggests a need to either discontinue the medication, try a different medication after discontinuation of the ineffective medication(s) or try a different treatment approach.

Similarly, physical therapy, manipulation and other physical treatment methods are **Recommended, Insufficient Evidence (I)** to be tried for at most 5 to 6 appointments. A lack of clear functional improvement indicates the treatment should be changed markedly or stopped altogether.

Ongoing invasive pain procedures are also **Recommended, Insufficient Evidence (I)** to not be repeated without objective evidence of major functional improvements.

Medications……

NON-STEROIDAL ANTI-INFLAMMATORY DRUGS (NSAIDs) AND ACETAMINOPHEN

Nonsteroidal anti-inflammatory drugs (NSAIDs) have been widely used for treatment of painful back conditions, including acute LBP, subacute LBP, chronic LBP, radicular, and post-operative patients and other back disorders.(798-806)

1. *Recommendation: NSAIDs for Treatment of Acute, Subacute, Chronic, Radicular, or Post-operative Low Back Pain*

   NSAIDs are recommended for treatment of acute, subacute, chronic, radicular, or post-operative low back pain. Evidence is strong for acute LBP, chronic LBP, and radicular pain syndromes (**Evidence (A)**) and moderately strong for subacute and post-operative LBP (**Evidence (B)**). Acetaminophen is a reasonable alternative, although evidence indicates it is modestly less efficacious.

   Generally, generic ibuprofen, naproxen or other older generation NSAIDs are recommended as first-line medications. Second-line medications should generally include one of the other generic NSAIDs. While COX-2 selective agents generally have been recommended as either third- or fourth-line medications to use when there is a risk of gastrointestinal complications, proton pump inhibitors, high-dose misoprostol, and sucralfate are also gastro-protective. COX-2 selective agents may still be used for those with contraindications to other medications, especially those with a history of gastrointestinal bleeding or past history of peptic ulcer disease.

   Indications – For acute, subacute, chronic, radicular, or post-operative LBP, NSAIDs are recommended for treatment. Over-the-counter (OTC) agents may suffice and may be tried first.

   Frequency/Duration – In most acute LBP patients, scheduled dosage rather than as needed is generally preferable. As needed prescriptions may be reasonable for mild or moderate LBP. The NSAID should generally be scheduled, rather than as-needed for treatment of more severe LBP especially if there is consideration for adjunctive treatment with muscle relaxants, opioids, or other potentially impairing medications. Once the patient moves to a supportive long-term care plan for chronic back pain, the patient may revert to selective use for "flare ups," with some patients also using NSAIDs to maintain work status and function.

Indications for Discontinuation – Resolution of LBP, lack of efficacy, or development of adverse effects that necessitate discontinuation.
Benefits – Modest reduction in low back pain disorders and earlier recovery.
Harms – Gastrointestinal bleeding, other bleeding, and possible delayed fracture healing. Possible elevated cardiovascular risks including myocardial infarction, especially for high-dose COX-2 inhibitors. Renal failure may occur particularly in the elderly or those with otherwise compromised function.

Strength of Evidence – **Strongly Recommended, Evidence (A)** – acute and chronic LBP, radicular pain

Moderately Recommended, Evidence (B) – subacute, post-operative

Level of Confidence – High

2. *Recommendation: NSAIDs for Patients at Risk for GI Adverse Effects*
Concomitant prescriptions of cytoprotective medications are recommended for patients treated with non-selective NSAIDs at substantially increased risk for gastrointestinal bleeding. There are four commonly used cytoprotective classes of drugs: misoprostol, sucralfate, double-dose histamine Type 2 receptor blockers (famotidine, ranitidine, cimetidine, etc.), and proton pump inhibitors (esomeprazole, lansoprazole, omeprazole, pantoprazole, rabeprazole).(807) There also are combination products of NSAIDs/misoprostol.

Indications – For patients with a high-risk factor profile who also have indications for NSAIDs, cytoprotective medications should be considered, particularly if longer term treatment with non-selective COX inhibiting NSAIDs is contemplated. At-risk patients include those with a history of prior gastrointestinal bleeding, the elderly, diabetics, and cigarette smokers.

Frequency/Duration – Frequency as recommended by manufacturer.

Indications for Discontinuation – Intolerance, development of adverse effects, or discontinuation of NSAID.
Benefits – Reduced risk of gastrointestinal bleeding when used with an NSAID.
Harms – Misoprostol may cause diarrhea. Other medications typically well tolerated, although as with all medications, allergic intolerances have been reported.

Strength of Evidence – **Strongly Recommended, Evidence (A) –** Proton pump inhibitors, misoprostol

Moderately Recommended, Evidence (B) – Sucralfate

Recommended, Evidence (C) – H2 blockers

Level of Confidence – High

3. *Recommendation: NSAIDs for Patients at Risk for Cardiovascular Adverse Effects*
It is recommended that patients with known cardiovascular disease or multiple risk factors for cardiovascular disease have the risks and benefits of NSAID therapy for pain discussed. Degree of risk is believed to be associated with degree of COX inhibition. Lower risk of myocardial infarction is believed to be associated with naproxen and ibuprofen. Diclofenac is believed to have intermediate risk. High dose celecoxib is believed to have higher risk for myocardial infarction.
Benefit – Counter risk of adverse event.
Harms – None.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

4. *Recommendation: Acetaminophen/Aspirin for Patients at Risk for Cardiovascular Events*

Acetaminophen or aspirin is strongly recommended as the first-line therapy for patients with high risk of cardiovascular events as these appear to be the safest.
Benefits – Addresses LBP without increased risk of cardiovascular event.
Harms – Less effective than NSAID. Aspirin also more prone towards gastrointestinal bleeding and other hemorrhage.

Strength of Evidence – **Strongly Recommended, Evidence (A)**
Level of Confidence – High

If needed, NSAIDs that are non-selective are preferred over COX-2 selective drugs. In patients receiving low-dose aspirin for primary or secondary cardiovascular disease prevention, to minimize the potential for the NSAID to counteract the beneficial effects of aspirin, the NSAID should be taken at least 30 minutes after or 8 hours before the daily aspirin.(808)

5. *Recommendation: Acetaminophen for Treatment of Low Back Pain*
Acetaminophen is recommended for treatment of low back pain with or without radicular symptoms, particularly for those with contraindications for NSAIDs.

Benefit – Addresses LBP among those unable to tolerate an NSAID.
Harms – Less effective than NSAID.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

Rationale for Recommendations
There are many quality trials that NSAIDs improve pain and some report higher subjective functional status (see evidence table). Evidence is strong and nearly consistent among the high-quality studies for treatment of acute LBP,(809) chronic LBP,(810-812) and radicular pain.(813) Evidence is moderate for subacute and post-operative pain.(814-816) There is only one high-quality trial with negative results for NSAIDs compared with placebo.(817)

There are several classes of NSAIDs: 1) salicylates [aspirin, diflunisal, salicyl salicylate (salsalate)], 2) arylalkanoic acids (diclofenac, etodolac, ketorolac, nabumetone, sulindac, tolmetin), 3) 2-arylpropionic acids (ibuprofen, fenoprofen, ketoprofen, naproxen), 4) n-arylanthranilic acids (mefenamic acid), 5) oxicams (piroxicam, meloxicam), 6) COX-2 inhibitors (celecoxib, rofecoxib, etoricoxib), and 7) sulphonanilides (nimesulide). Acetaminophen is considered an analgesic that is not an anti-inflammatory agent. Acetaminophen blocks the activation of COX by another enzyme, peroxidase. Tissues with high levels of peroxidase (i.e., platelets and immune cells) are "resistant" to acetaminophen, but tissues with low levels of peroxidase (i.e., nerve and endothelial cells that participate in pain and fever) are "sensitive" to acetaminophen.(818)

There are two isoenzymes of cyclooxygenase, COX-1 and COX-2. NSAIDs are (non) selective to different degrees. COX-2 selective agents were designed to reduce inflammation while not increasing risks for gastrointestinal bleeding. It appears that certain COX-2 selective agents may increase the risk of cardiovascular events.

There is a dearth of trials comparing the various NSAIDs, and the doses used are at times submaximal in some of the comparative arms of the trials, raising major problems with direct comparability to help guide specific NSAID selection. As piroxicam is the only medication to have a trial showing lack of benefit compared with placebo,(819) and there is quality evidence that suggests it is inferior for management of lateral epicondylitis, piroxicam should generally be avoided as either a first-, second-line agent in the management of musculoskeletal disorders including LBP.(820-822) It appears that despite widespread usage, diclofenac does not have superiority for LBP, and as it may have increased risks for adverse cardiovascular events,(823) it generally should not be used as a first or second-line agent. Otherwise, evidence that one medication is superior to another is lacking.

Cardiovascular risks of NSAIDs are somewhat controversial.(808) Most studies have suggested elevated risks with high-dose rofecoxib, few have shown elevated risks with ibuprofen or naproxen, and there is some evidence for increasing risks with greater degrees of COX-2 inhibition.(823-830) The sequence of NSAIDs from lowest COX-2 to highest varies somewhat between studies but is reportedly: flurbiprofen, ketoprofen, fenoprofen, tolmetin, aspirin, oxaprozin, naproxen, indomethacin, ibuprofen, ketorolac, piroxicam, nabumetone, etodolac, celecoxib, meloxicam, mefenamic acid, diclofenac, rofecoxib and nimesulide.(831)

There are few quality studies of acetaminophen as a single agent. However, paracetamol, a close analog, has been studied more extensively and has some evidence of mild efficacy in most trials,(832) although a recent review concluded it lacks efficacy.(806) Most studies have used these agents, particularly paracetamol, as rescue agents in RCTs. The direct evidence of efficacy from the two available studies suggests paracetamol is not quite as successful at alleviating LBP as diflunisal,(833) mefenamic acid,(814) indomethacin,(814) or aspirin.(814) It also has relieved pain less successfully than the muscle relaxants orphenadrine(834) and parazolidin.(835) It is interesting that paracetamol appears more effective in combination with orphenadrine than as a single agent.(836) There is one trial suggesting it is more efficacious than physiotherapy and manipulation,(837) and worse than electroacupuncture.(838) Acetaminophen (4,000mg per day) was modestly superior to ibuprofen in the heat wrap study, but the trial's utilization of a relatively low ibuprofen dose of 1,200mg a day precludes a direct comparison.(839) Acetaminophen was worse than chlorzoxazone(840) and was inferior to diflunisal even when combined with codeine.(841) Thus, while the evidence suggests efficacy of acetaminophen and paracetamol, it appears these medications are modestly less efficacious than NSAIDs (although safer).

NSAIDs are not invasive, have low side effect profiles in a healthy working-age patient population, and when generic medications are used are low cost. The potential for NSAIDs to increase the risk of cardiovascular events needs to be carefully considered in high-risk patients and will likely require additional quality studies to fully address. There is substantial, quality evidence that COX-2 selective NSAIDs reduce the risk of adverse GI effects.(825, 842-845) Additionally, the four commonly used cytoprotective classes of drugs are proton pump inhibitors, misoprostol, sucralfate, and double-dose histamine-type 2 receptor blockers (see Hip and Groin Disorders Guideline for details).

Evidence for the Use of Non-steroidal Anti-inflammatory Drugs (NSAIDs) and Acetaminophen
There are 12 high-(809, 811-813, 817, 846-852) and 37 moderate-quality RCTs (one with two reports)(688, 810, 814-816, 819, 822, 833, 839, 853-877, 878, 879-881) incorporated into this analysis. There are 2 low-quality RCTs(882, 883) and 3 other studies(884-886) in Appendix 1.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: NSAIDs, nonsteroidal anti-inflammatory drugs, aspirin, acetaminophen, diflunisal, salsalate, Ibuprofen, Dexibuprofen, Dexdetoprofen, Naproxen, Fenoprofen, Ketoprofen, Dexketoprofen, Flurbiprofen, Oxaprozin, Loxoprofen, Indomethacin, Tolmetin, Sulindac, Etodolac, Ketorolac, Diclofenac and, Nabumetone, Piroxicam, Meloxicam, Tenoxicam, Droxicam, Lornoxicam, Isoxicam, Celecoxib, Etodolac , Etoricoxib , Firocoxib , Licofelone , Lornoxicam , Lumiracoxib , Meclofenamic acid , Mefenamic acid, Nimesulide, Parecoxib, Rofecoxib, Tolfenamic acid, Valdecoxib and low back pain to find 131,158 articles. Of the 131,158 articles we included 31 articles. We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: acetaminophen, paracetamol, ibuprofen, and low back pain to find 122,114 articles. Of the 122,114 articles we reviewed 9 articles and all were included.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
NSAIDs vs. Placebo						
Herrmann 2009 RCT One author is employee of the company who funded the study.	8.5	N = 171 with acute sciatica or lumbo-sciatica with onset <72 hours, with previous attacks resolved within last 3 months	50mg of diclofenac (n = 57) vs. 8mg lornoxicam (LNX) (n = 57) vs. placebo (n = 57) for 5 days.	Lornoxicam and diclofenac superior to placebo for pain intensity difference by 3 hours, with differences increasing over time. At 8 hours, pain intensity difference was lornoxicam (-22.0) vs. placebo (-13.7) vs. diclofenac (-24.1), p<0.01. No differences between diclofenac and lornoxicam.	"LNX has an efficacy and tolerability profile comparable to that of the well established NSAID diclofenac and is an effective addition to this group of drugs."	Data suggest lornoxicam efficacious vs. placebo for acute sciatica and equivalent to diclofenac.
Weber 1993 RCT No mention of COI or industry sponsorship.	6.5	N = 214 with acute L5 or S1 sciatica	Piroxicam 40mg QD for 2 days then 20mg QD (n = 120) vs. placebo (n = 94) for duration of 3 years.	VAS scores for LBP and leg pain fell over 4 weeks (54-19), but not significant (NS) between groups. NS in additional analgesic use; 12 (placebo) vs. 3 (piroxicam) referred to specialists, with 6 vs. 0 referred to outpatient clinic. During 4-week period, 52 (43.3%) in piroxicam vs. 41 (43.6%) of controls returned to work.	"No difference was recorded between the piroxicam-treated group and the control group regarding the presence of pain in the back and leg and the functional ability. Nor was there any difference regarding the need for additional analgesics."	Study suggests piroxicam not superior to placebo for acute sciatica. However, some data (referrals to specialists) lower with piroxicam. Natural history of improvement shown. Unclear how or if requiring 1 week strict bed rest followed by slow mobilization may bias results. Findings suggest weak efficacy of piroxicam for sciatica.
Szpalski 1994 RCT No mention of COI or industry sponsorship.	6.5	N = 47 with acute LBP <2 weeks duration	Tenoxicam 20mg (n = 37) vs. placebo IM (n = 36), followed by daily oral medication for 14 days.	VAS scores (tenoxicam vs. placebo): Day 1, 7.36±1.46 vs. 7.14±1.98 (NS); Day 8, 1.94±2.03 vs. 2.81±1.96 (p = 0.043), Day 15 0.56±1.14 vs. 0.79±1.09 (NS). Tenoxicam group had higher values for all variables with significant differences for velocity (p = 0.007) and isometric torque in extension (p = 0.022).	"Tenoxicam has an effect on pain during the first part of the treatment and may help to restore full function even if the symptoms have disappeared."	Use of bed rest in protocol may limit the reliability. Lack of improvement on Day 1 a concern given purpose to treat acute LBP. Data suggest natural tendency is for spontaneous resolution. Differences in pain relief modest with large reductions in pain with either tenoxicam or placebo.
Goldie 1968 RCT No mention of COI or industry sponsorship.	5.5	N = 50 with mostly sciatica <3 weeks	Indomethacin (25mg 3 times a day TID, n = 25) vs. placebo (n = 25) for 14 days.	No greater difference in alleviation of pain between two groups after 14 days treatment.	"In this investigation it was thus not possible to demonstrate any obvious effect of indomethacin treatment in cases of low back pain and sciatica."	Patients not well described. Appears to have been no differences in pain relief at 7 or 14 days of treatment.
NSAIDs Compared to Other NSAIDs (or Different Dosages of Same NSAID) with Placebo						
Birbara 2003 RCT Supported by grant from	9.0	N = 319 with chronic LBP of at least 3 months duration	Etoricoxib 60mg (n = 101) vs. etoricoxib 90mg (n = 106) vs. placebo (n = 107) daily for the duration of 12 weeks.	Etoricoxib 60mg and 90mg both reduced LBP intensity compared to placebo (-12.94 and -10.29 points, p <0.001); superior performance with Roland-Morris disability scale (p	"[T]his 12-week treatment trial, etoricoxib significantly reduced pain scores, lessened disability, reduced impact of back pain on sense of well being and was well tolerated."	Data suggest superior to placebo for CLBP. Long time to efficacy suggests may be inferior in short term to faster-acting medications.

Merck & Co. No mention of COI.				<0.01) vs. placebo for both doses over first 4 weeks.		
Dreiser 2003 RCT No mention of COI or industry sponsorship.	9.0	N = 372 with acute untreated LBP	Diclofenac (12.5mg, n = 24) vs. ibuprofen (200mg, n = 122) vs. placebo (n = 126); instructions 1-2 tablets every 4-6 hours with up to 6 tablets per day for 7 days.	Diclofenac-K superior to ibuprofen on Day 7 (p = 0.03) on global assessment scale, and superior at end of first dose (1.3±1.1 vs. 1.0±0.9, p <0.001 and p = 0.03 compared with placebo). Ibuprofen superior to placebo through Day 2.	"The flexible multiple dosing regimen of diclofenac-K 12.5 mg (initial dose of 2 tablets followed by 1-2 tablets every 4-6 hours, max. 75 mg/day) is an effective and safe treatment of acute low back pain."	Prior LBP history somewhat favored placebo. PRN dosing schedule somewhat unusual. Data suggest OTC dose NSAIDs superior to placebo for acute LBP. Suggests flexible dosage regimen with diclofenac-K 12.5mg effective and at least comparable to ibuprofen 200mg. Ibuprofen superior through Day 2, suggesting preferable medication at those doses for acute LBP.
Hancock 2007 RCT Supported by grant from Australia's National Health and Medical Research Council. No mention of COIs.	9.0	N = 240 with acute back pain lasting <6 weeks with and without leg pain	Diclofenac 50mg twice daily and placebo manipulative therapy (n = 60) vs. spinal manipulative therapy and placebo drug (n = 60) vs. diclofenac 50 mg twice daily and spinal manipulative therapy (n = 60) vs. double placebo (n = 60). Follow-up for maximum of 4 weeks.	Patients who received active spinal manipulative therapy did not recover more quickly than placebo manipulation for both recovery measures (pain score of 0 or 1 for 7 consecutive days) (p = 0.954, p = 0.870). Combination diclofenac and manipulation did not shorten recovery time (CI 0.76-1.60, p = 0.606).	"Neither diclofenac nor spinal manipulative therapy gave clinically useful effects on the primary outcome of time to recovery….no significant effects on pain, disability, or global perceived effect at 1, 2, 4, or 12 weeks."	Twenty-eight patients had co-interventions during study period. Data suggest no benefit over placebo for spinal manipulation, NSAID, or combination of SMT plus NSAID in outcome of days to recovery.
Pallay 2004 RCT Supported by grant from Merck & Co. Some authors listed as Merck employees.	8.5	N = 325 with chronic LBP at least 3 months duration	Etoricoxib 90mg (n =106) vs. etoricoxib 60mg (n = 109) vs. placebo (n = 110) for 3 months.	Treatment with etoricoxib (60mg and 90mg) demonstrated significant reduction (p <0.001) in LBP intensity vs. placebo at all times (1 week, 4 weeks, 3 months), Roland-Morris -2.82 vs. -2.38 for 60mg and 90mg compared with placebo.	"[T]he use of etoricoxib as a treatment option in the medical management of chronic LBP."	Data suggest NSAID superior to placebo (etoricoxib). 30% dropout rate. Physical activity unclear. Study nearly identical to Birbara 2003 (same issues). Reductions in chronic LBP severity corresponded to improvements in physical functioning and quality of life.
Berry 1982 RCT No mention of COI or industry sponsorship.	7.5	N = 37 with chronic LBP	Naproxen sodium (550mg BID) vs. diflunisal (500mg BID) vs. placebo. Each treatment given for 14 days after 1 week washout period.	Naproxen and diflunisal showed significant final treatment preference vs. placebo, p = 0.05. VAS difference significant between naproxen and diflunisal, p <0.05. Differences with 4-point scale plus VAS significant between naproxen and placebo, p< 0.01.	"The final preference of the patients was significantly in favour of the active treatments."	Small sample. Suggests reduced pain scores with naproxen or diflunisal vs. placebo for chronic LBP. Naproxen consistently better than analgesic. Small number (4) completing study assigned to placebo impairs ability to make comparisons between active treatment and placebo.

Katz 2003, Katz 2004 RCT Supported by a grant from Merck Co. No mention of COI.	7.5	N = 690 with chronic LBP	Two replicate studies done for combined study population of 690: rofecoxib 25mg (n = 233) vs. rofecoxib 50mg (n = 229) vs. placebo (n = 228). Study lasted 4 weeks.	Significantly more patients treated with rofecoxib later had 50% reduction in pain (p <0.001). Fifty-percent reduction obtained in 34.7% (placebo) vs. 60.4% and 58.4% of rofecoxib groups. Median onset times 2, 2, and 3 days in rofecoxib 25mg, 50mg, and placebo groups, respectively (p <0.01).	"Rofecoxib significantly reduced chronic low back pain in adults and was well tolerated. These data indicated that rofecoxib 25 mg and 50 mg once daily each had similar effects, although 25 mg was slightly better tolerated."	Rofecoxib superior to placebo. Long-term safety not addressed. No mention of physical activity level between groups. Headaches more common in placebo; 1 myocardial infarction 50mg rofecoxib group. Two different strengths of rofecoxib did not differ materially in efficacy suggests 25mg highest dose to be normally used for chronic LBP.
Coats 2004 RCT No mention of COI or industry sponsorship.	7.5	N = 293 with chronic LBP (mean 10.9 and 11.6 years)	Valdecoxib 40mg a day, n = 148) vs. placebo (n = 145). Follow-up for 4 weeks.	Valdecoxib superior to placebo through all 4 weeks by VAS (p <0.001) and Roland-Morris Disability Questionnaire (p <0.003).	"In this study of patients with chronic low back pain, valdecoxib 40 mg/d provided rapid relief (within 1 week) and consistent relief (over 4 weeks). In addition, significant improvement in function and decreased disability were found with valdecoxib compared with placebo."	No mention of co-interventions other than medications. Valdecoxib decreased pain compared to placebo. Valdecoxib 40mg superior to placebo for chronic LBP. Does not address long-term safety.
Konstantinovic 2010 RCT No mention of COI or industry sponsorship.	7.5	N = 546 with acute LBP and unilateral radiculopathy caused by prolapsed intervertebral disc (PID)	Group A: COX-2 inhibitor nimesulide 200mg day with low level laser therapy (LLLT) (n = 182) vs. Group B nimesulide 200mg day (n = 182) vs. Group C nimesulide 200mg day, placebo LLLT (n = 182). Follow-up 5x weekly for 3 weeks.	Group A showed better results compared to Group B (p <0.0005) and Group C (p <0.0005). Group C had better results than Group B (p <0.0005).	"Our results show statistically significant improvement in all groups, with better results for all investigated parameters in group A compared with other groups."	Study population was mostly hospitalized suggesting non-applicability to western population. Data suggest improvement in all groups, with best improvement in NSAID plus LLLT, then NSAID plus sham, then NSAID alone, suggesting some placebo effect of LLLT.
Shirado 2010 RCT Supported by grants from Japanese Orthopedic Association. No mention of COIs.	6.0	N = 201 with non-specific chronic LBP	Exercise group (n = 103) with trunk muscle strengthening and stretching vs. NSAIDs (n = 98) loxoprofen 60mg or diclofenac 25mg or zaltoprofen 80mg. Follow up at 2, 8, 12 weeks.	Japan low back pain evaluation questionnaire change at 8 weeks for exercise -0.58 vs. NSAID -0.44, p = 0.021. Roland-Morris Disability questionnaire change at 8 weeks for exercise -0.72 vs. NSAID -0.47, p = 0.023.	"The home-based exercise prescribed and monitored by board-certified orthopedic surgeons was more effective than NSAIDs for Japanese patients with [chronic low back pain]."	Study design for homogeneous ethnic population. Exercise group likely more researcher contact vs. group with choices of 3 NSAIDs (low dose). Observer bias may be present as only 201 subjects enrolled from 92 clinics. Data suggest exercise more effective than NSAID.
NSAIDs Compared with Other NSAIDs (or Different Doses of the Same NSAID) without Placebo						
Schattenkirchner 2003 RCT	10.5	N = 227 with acute LBP associated with	Aceclofenac (100mg twice daily, n = 100) vs. diclofenac (75mg twice daily, n = 105)	Differences in pain favored aceclofenac at 1 hour. VAS pain scores at baseline compared with 6 hours later: 61.6mm±24.5 for	"[N]on-inferiority of the analgesic efficacy of aceclofenac compared with diclofenac resinate was	Differences in pain ratings, while statistically significant appear clinically minor. Non-inferiority trial suggests

No mention of COI or industry sponsorship.		degenerative spinal disorders	for up to 10 days; 205 completed study.	aceclofenac vs. 57.3±22.8 for diclofenac. Greater reduction in pain in aceclofenac. For per protocol population, mean change in VAS pain score at rest at Visit 3 vs. baseline was 61.6 mm for aceclofenac vs. 57.3 for diclofenac.	demonstrated in patients with localised, uncomplicated acute lumbosacral pain."	aceclofenac not inferior compared with diclofenac resinate in reducing acute LBP. Suggests trend towards better safety and tolerability of aceclofenac. Does not address whether either is superior to placebo or other treatments.
Pohjolainen 2000 RCT Supported by grants from Rhone-Polenc Rorer and Helsinn Healthcare SA.	9.0	N = 104 with acute LBP 1-30 days duration	Nimesulide (100mg BID, n = 52) vs. ibuprofen (600mg TID, n = 52) for 10 days.	Nimesulide superior to ibuprofen as assessed by Oswestry Scale (-0.12±0.01 vs. -0.062±0.0, p = 0.026) and flexibility test (p = 0.026). GI side effects also lower in Nimesulide group. Significant improvement in patient capacity for daily tasks in both groups.	"The results confirmed that the COX-2-selective inhibitor nimesulide is an effective and well-tolerated agent for use in general practices to treat acute low back pain. The incidence of gastrointestinal side effects seems to be lower with nimesulide than with ibuprofen."	Submaximal ibuprofen dose favored nimesulide for pain outcomes. GI adverse effects lower, but clinical relevance unclear. Nimesulide (a COX-2 selective agent) superior to ibuprofen 600mg as assessed by Oswestry Scale and a flexibility test.
Zerbini 2005 RCT No mention of COI or industry sponsorship.	8.0	N = 446 with chronic LBP (mean 8.3 years)	Etoricoxib (60mg a day, n = 224) vs. diclofenac (150mg a day, n = 222) for 4 weeks; 446 completed study.	Least-squares mean time-weighted change from baseline LBP Intensity Scale score over 4 weeks -32.94mm for etoricoxib, indicating substantial efficacy in pain relief. Treatment difference for primary outcome 2.51mm. Etoricoxib improved secondary and other efficacy outcomes.	"The results of this study confirm that, for adult patients with CLBP, etoricoxib 60 mg once daily over 4 weeks is effective for relief of pain and improvement of physical function and comparable to high-dose diclofenac 150 mg daily."	Equivalency study suggests similar outcomes with both NSAIDs. Lack of control arm limits control on efficacy. For adults with CLBP, etoricoxib 60mg 1x daily for 4 weeks effective for pain relief and improvement of physical function; comparable to high-dose diclofenac 150mg daily.
Bakshi 1994 RCT No mention of COI or industry sponsorship.	6.5	N = 132 with acute LBP and/or sciatica	Diclofenac resinate (75mg BID, n = 66) vs. piroxicam (20mg BID, n = 66) for 2 days then QD for remainder of 2-week study.	Diclofenac and piroxicam led to early sustained reduction in pain intensity scores at rest and on movement. Estimated treatment difference for diclofenac minus piroxicam on primary efficacy variables -2.8 for pain at rest; -1.8 for pain on movement at 2nd exam. No significant difference between treatment groups on this or later assessment days.	"[D]iclofenac in a daily dosage of 150mg has efficacy similar to piroxicam 20mg/day for the symptomatic treatment of acute LBP due to mechanical causes."	Diclofenac and piroxicam similarly efficacious. No placebo. Initiating 2-day, double-dose regimen unusual in U.S. though could have basis in pharmacokinetics.
Pownall 1985 RCT No mention of COI or industry sponsorship.	6.5	N = 60 with chronic and some subacute LBP	Four different ibuprofen schedules. Group A (n = 29): 1200mg ibuprofen in AM plus 600mg at noon plus 600mg in PM vs. Group B (n = 29): 1200mg ibuprofen in PM plus 600mg in AM	Pain at rest decreased in both regimens: 1) baseline 2.44 (S.E.0.16) to end of 1st treatment period 1.89 (0.12) to end of 2nd treatment period 1.51 (0.12); and 2) baseline 2.27 (S.E.0.13) to 2.00 (0.13) to 1.48 (0.10). More patients in both groups recorded more relief	"Pain relief improved with duration of treatment and patients felt a high degree of satisfaction with either treatment schedule."	Cross-over study. No placebo. Overall improvement reported with 2400mg ibuprofen daily. No comparison with equal 800mg 3 times a day used in this study. Co-intervention not evaluated. Either treatment schedule with ibuprofen appears equally efficacious.

			plus 600mg at noon; 28 day study.	from pain at end of 2nd treatment period.		
Blázek 1986 RCT No mention of COI or industry sponsorship.	5.5	N = 28 with acute lumbo-ischialgia and femoralgia	Proquazone 1,200mg for 4 days, then 900mg (n = 14) vs. diclofenac 100mg for 4 days, then 75mg (n = 14) for a total 12-day period.	No significant differences in pain ratings. Marked improvement observed compared with initial presentations. Both patients and physician gave higher, but not significantly higher scores for proquazone than diclofenac.	"The results of our examination proved that Biarison is a valuable anti-inflammatory and analgesic agent in acute ischialgias and femoralgias due to herniated disc."	Small numbers. No baseline characteristics given. Medication not used in U.S. Neither treatment clearly superior, although there was a suggestion that proquazone superior.
Orava 1986 RCT No mention of COI or industry sponsorship.	5.5	N = 133 with acute LBP	Diflunisal (500mg BID, n = 66) vs. indomethacin (50mg TID, n = 67) for 1 week.	Diflunisal significantly superior to indomethacin in regards to number of subjects without any adverse effects, and efficacy of treatment in subjects, p <0.05.	"In acute lumbago rapid relief of pain and other harmful symptoms hastens improvement. For such indications the choice of drug therapy in general practice should be based in particular on considerations of safety and lack of potential side-effects in addition to efficacy."	More patients had abdominal pain, headaches, and vertigo in the indomethacin group than diflunisal. Diflunisal appears superior to indomethacin especially when considering its lower side effect profile.
Videman Curr Med Res Opin 1984 RCT No mention of COI or industry sponsorship.	5.0	N = 70 with acute LBP 1-30 days duration	Diflunisal (250mg QID, n = 35) vs. meptazinol (200mg QID, n = 35). Both interventions were given 4 times a day for 3 weeks.	While ROM improved and pain scores decreased significantly from baseline in both groups, differences in pain scores between the two at 3 weeks not statistically significant (decreased from 48 to 8 in meptazinol group vs. from 51 to 6 in diflunisal group).	"Both treatments produced marked improvement in most of the parameters assessed, often within the first week and, overall, the results were similar with the two drugs. Few side-effects were reported and those that were recorded were slight and similar in incidence apart from nausea in 5 meptazinol-treated patients and smarting and burning on urination in 2 patients receiving diflunisal."	Randomization, allocation, baseline comparability details sparse. No control group. Study suggests improvement in lumbar mobility and analgesia with no difference in efficacy although sample size and power small. Results suggest modest superiority of diflunisal over meptazinol at 1 week (e.g., graphic representation of increased forward bending distance).
Videman Ann Clin Res 1984 RCT No mention of COI or industry sponsorship.	4.5	N = 28 with chronic severe lumbar pain	Piroxicam (20mg QAM), plus placebo BID to keep relative dosing schedule same (n = 35) vs. indomethacin 25mg TID (n = 35) for 6 weeks.	Pain ratings dropped over 6 weeks on piroxicam from 18.0 to 9.9, p <0.01, and on indomethacin from 17.6 to 8.2, p <0.001 (not significant between groups). Both medications comparable in efficacy.	"[P]iroxicam adds one more tool to the treatment of chronic low back pain, with no more side effects than indomethacin."	Eight had sciatica, 5 post-op, 2 spinal stenosis/sacroiliitis, remainder chronic LBP. Pain ratings dropped over 6 weeks on piroxicam and indomethacin, suggesting equal efficacy. Overall efficacy statistically similar.
Matsumo 1981 RCT No mention of COI or industry sponsorship.	4.5	N = 155 with subacute or chronic LBP or sciatica >1 month	Ketoprofen (150mg a day, n = 77) vs. diclofenac (75mg a day, n = 78) for 2 weeks.	Percentage of patients improved in ketoprofen group at 1 and 2 weeks: 71.4% and 85.7% vs. 62.3% and 78.8% for diclofenac group (significant at 1 week, but not significant at 2 weeks).	"From these results it is considered that ketoprofen is clinically useful for chronic lumbago."	Patients' LBP not well characterized and many other study details not well described.
NSAIDs Compared with Other Agents (Medication or Other) with or without Placebo						

Veenema 2000 RCT No mention of COI or industry sponsorship.	7.5	N = 155 with acute and chronic LBP in ER	153 ER patients completed study; 1mg/kg meperidine intramuscularly (IM, n = 75) vs. 60mg ketorolac IM (n = 80) for 19 months.	A minimum 30% pain reduction achieved by 63% of ketorolac group compared with 67% in meperidine group. Satisfaction slightly higher in meperidine group (74% vs. 68%, not significant). Rescue analgesia required in 35% of ketorolac vs. 37% meperidine. Meperidine more likely to cause sedation (24% vs. 71%). One meperidine subject required naloxone for severe respiratory depression.	"Ketorolac shows comparable single dose analgesic efficacy to a single moderate dose of meperidine with less sedation and adverse effects in an ED population with severe musculoskeletal LBP. The trend for greater pain reduction and patient satisfaction with meperidine needs further investigation."	Included both acute and chronic LBP patients and results not stratified. Ketorolac generally equivalent to meperidine.
O'Donnell 2009 RCT Supported by grant from Pfizer Inc. Some authors listed as employees.	7.5	Study 1: n = 791; Study 2: n = 792 with chronic LBP, score of >4 on NRS-pain and regular use of analgesics.	Celecoxib 200mg twice daily (n = 404/398) vs. tramadol HCI 50mg 4x daily (n = 392/404) for 6 weeks.	Celecoxib group in both studies improved significantly from baseline to week 6 on NRS-pain scale having improved ≥30% compared to tramadol (Study 1: p <0.001, Study 2: p = 0.008).	"Although pain was reduced in both treatment groups, significantly more celecoxib-treated patients in study 1 and 2 achieved the primary endpoint criteria of ≥ 30% improvement from baseline on the NRS-pain scale after 6 weeks than subjects treated with tramadol HCI."	Study 1: Tramadol group had a greater dropout rate compared to celecoxib (30.6% vs. 14.4%). Study 2: Tramadol group had a 25.8% dropout compared to celecoxib (13.6%). Lack of placebo/control limits conclusion of efficacy. Data suggests higher percentage of patients in NSAID achieved ≥3% pain relief at 6 weeks than tramadol, although difference is small. Tramadol had more adverse effects.
Auvinet 1995 RCT No mention of COI or industry sponsorship.	7.0	N = 113 with acute sciatica	Single 15mg meloxicam given intramuscularly (IM) (n = 54) vs. orally (n = 59), age 18-60. Last follow-up at 24 hours.	No difference in time to medication efficacy, 80±14 minutes for IM group and 89±15 minutes for oral group. At 30 minutes, both groups had decrease in pain intensity vs. baseline (p <0.01), but no differences between groups. Trend favored IM meloxicam if muscle strength deficit, (p = 0.16). No differences in mean time to maximum spontaneous pain relief (3.0±0.2 hours for IM and 3.1±0.2 hours for oral and mean intensities of maximum spontaneous pain relief during 1st 6 hours (-37±3mm and -35±3mm in IM and oral groups, respectively) or during 24 hours (-42±3mm and -38±3mm). 43.5% in IM vs. 15.1% of oral reached maximum improvement in induced pain within 1st hour. 38.9% vs 25.4% patients in IM and Oral	"The IM formulation may have a more rapid onset of action than the oral formulation."	Short duration of follow-up of 1 day. No placebo, as only compared oral vs. IM of same medication. Data suggest comparable results.

				group, respectively, reported meloxicam as very good (p = 0.12).		
Babej-Dölle 1994 RCT Supported by grant form Hoechst AG. No mention of COI.	6.5	N = 260 with acute LBP or sciatica	Injections of dipyrone 2.5g (n = 88) vs. diclofenac 75mg (n = 86) vs. placebo (n = 86) for 48 hours.	Mean (SD) pain reduction in all patients comparing dipyrone vs. diclofenac vs. placebo after 1 hour: 45.1±23.6 vs. 54.4±24.5 vs. 63.8±21.9; p = 0.01. After 6 hours: 33.4±25.5 vs. 41.7±25.9 vs. 54.8±25.3; p = 0.04.	"[I]ntramuscular injections of 2.5g dipyrone were safe and highly effective in the analgesic treatment of acute lumbago or sciatic pain."	Not stratified by diagnosis. Intramuscular injection of dipyrone more efficacious than diclofenac. Adverse effects low.
Giles 2003 RCT Supported by Queensland State Government Health Department and partly supported by Townsville Hospital. No mention of COIs.	6.5	N = 115 with mostly chronic LBP or neck pain	Post-randomization individualized treatment all 3 arms: acupuncture (near and far technique) (n = 36); manipulation; high velocity, low amplitude thrust spinal manipulation to joint 2x a week (n = 36) and medication (63% celecoxib, 26% rofecoxib. 11% paracetamol; apparently unblinded) (n = 43) for 9 weeks.	Manipulation had improvements in 50% (p = 0.01) on ODI, 38% (p = 0.08) on NDI, 47% (p <0.001) on the SF-36, and 50% (p <0.01) on VAS for back pain, 38% (p <0.001) for lumbar standing flexion, 20% (p <0.001) for lumbar sitting flexion, 25% (p = 0.1) for cervical sitting flexion, and 18% (p = 0.02) for cervical sitting extension. Acupuncture better results on VAS for neck pain (50% and 42%). Asymptomatic status: manipulation (n = 9) vs. acupuncture (n = 3) vs. medication (n = 2), p = 0.05.	"In summary, the significance of the study is that for chronic spinal pain syndromes, it appears that spinal manipulation provided the best overall short-term results, despite the fact that the spinal manipulation group had experienced the longest pretreatment duration of pain."	Individualization of treatments results in lack of standardization and substantially precludes drawing robust conclusions. Post-randomized individualized treatment in all 3 arms. Ill-defined mixture of diagnoses, combined with non-randomization arguably relegates study to a non-RCT.
Innes 1998 RCT Supported by grant from Hoffmann-LaRoche of Canada. No mention of COI.	6.5	N = 122 ER patients with acute musculo-skeletal LBP. mostly young healthy males (mean 34.5 years).	Ketorolac (10mg every 4-6 hours as needed; maximum 4 doses a day, n = 62) vs. acetaminophen-codeine (600-60mg every 4-6 hours as needed (maximum 6 doses a day, n = 60) for acute LBP (<72 hours). Treatment phase 6 hours, and pain/functional capacity measured up to Day 7.	No significant differences between 2 medications for any time interval over 1 week. Significantly more acetaminophen-codeine patients (64%) reported at least 1 adverse drug event during treatment, compared to 34% of ketorolac patients (p = 0.0005).	"Based on comparable efficacy and a superior adverse event profile, ketorolac was preferable to acetaminophen with codeine for the treatment of acute low back pain in the ED."	No significant differences between 2 medications as measured by pain scales or pain relief for any time interval over 1 week. Workers' comp (WC) injury patients found both medications to be less effective than non-WC patients.
Pareek 2009 RCT Study sponsored by Ipca Laboratories Limited. First	6.5	N = 197 (120 male, 77 female) age 18-70, with localized, uncomplicated acute lumbosacral pain associated with	Patients received either aceclofenac (100mg)-tizanidine (2mg) BID or aceclofenac (100mg) alone BID for 7 days.	At day 3, difference in CG vs. MG in Pain on Movement (-2.94±1.59 vs. -1.81±1.04, p <0.01), Pain at Rest (-3.01±1.51 vs. -1.90±1.13, p < 0.01) and Pain at Night (-3.02±1.51 vs. -1.92±1.26, p <0.01). At day 7, differences presenting Pain on Movement (-6.09±2.34 vs. -3.98±	"[T]izanidine is a useful adjunct to the aceclofenac in the treatment of acute LBP in general practice. The combination was found to be superior to aceclofenac monotherapy with respect to efficacy."	Very short trial of 7 days. Data suggest tizanidine of additive benefit to aceclofenac.

two authors employees of Ipca Laboratories Ltd.		degenerative spinal disorders (confirmed by x-ray) of recent onset (1-30 days).		1.86, p <0.01), Pain at Rest (-5.88 ± 2.14 vs. -4.35±2.06, p <0.01), and Pain at Night (-5.76±2.12 vs. -4.40 ±2.15, p <0.01).		
Nadler 2002 RCT Supported by grant from Proctor and Gamble Company. Authors listed as employees from company.	6.0	N = 371 with acute LBP	Randomly assigned to ThermaCare 40C, 8 hours/day (n = 113), acetaminophen 4000mg a day (n = 113), or ibuprofen 1200mg a day (n = 106) for efficacy evaluation, or to oral placebo (n = 20) or unheated back wrap (n = 19) for blinding; 2 day treatment.	Pain relief from heat treatment superior at Day 1 to acetaminophen (mean 1.32; p = 0.0001) or ibuprofen (mean 1.51; p = 0.0007). Reductions in Roland-Morris disability scores at Day 2 borderline better than acetaminophen (mean, 3; p = 0.08) and better than ibuprofen (mean 2.6; p = 0.009). Disability reduced with heat wrap (mean, 4.9) compared with ibuprofen (mean, 2.7; p = 0.01) and acetaminophen (mean, 2.9; p = 0.0007), Day 4.	"Continuous low-level heat wrap therapy was superior to both acetaminophen and ibuprofen for treating low back pain."	Low-level heat wrap superior to medications at assigned doses. Selection of submaximal ibuprofen doses vs. near-maximal dose acetaminophen results in possible suggestion that heat treatment may lack superiority or be inferior to full strength ibuprofen, but this is unknown.
Evans 1980 Randomized Crossover Trial Study was financed by Parke-Davis. No mention of COI.	6.0	N = 60 with recurrence of LBP; lower extremity pain included	Six drugs used unblinded with up to 3 treatments for any 1 patient: A) ASA 900mg QID; B) dextropropoxyphene 32.5mg plus 325mg paracetamol 2 tabs QID; C) indomethacin 50mg TID; D) mefenamic acid 500mg TID; E) paracetamol 1,000mg QID; F) phenylbutazone 100mg TID. Each treatment 10 times each in 1st, 2nd and 3rd period up to 21 days.	Average daily pain scores: (D) 1.375, (A) 1.425, (F) 1.433, (C) 1.487, (E) 1.660 and (B) 1.713. Differences statistically significant comparing (D) to (E) and (B) (p <0.05) and (A) compared with (B). Compliance lowest with narcotic (71.7%) and indomethacin (76.2%), aspirin (80.2%). Others approximately 90%. Patients chose F and D significantly more (p <0.05) than A.	"Overall, there were consistently superior performances by mefenamic acid and phenylbutazone with little to choose between the two."	Contrast between patient preferences and pain scores interesting, although patient preferences assessed at trial conclusion, thus subject to potential recall bias, whereas pain ratings averaged from daily diaries. Overall, mefenamic acid and phenylbutazone superior and narcotic did not perform well with both higher pain scores and lower compliance, presumably indicative of high side effects.
Romanò 2009 RCT No mention of COI or industry sponsorship.	5.5	N = 36 with chronic LBP due to disc prolapse, lumbar spondylosis and/or spinal stenosis, and VAS >40	Celecoxib (3-6 mg/kg/d) plus placebo (n = 12) vs. pregabalin (1mg/kg/d) for 1week followed by placebo vs. celecoxib (3-6mg/kg/d) plus pregabalin (1mg/kg/d) for 4 weeks.	Drug combination group (celecoxib plus pregabalin) showed statistically significant improvement compared to pregabalin plus placebo (p = 0.0001) and celecoxib plus placebo (p = 0.001).	"[C]elecoxib and pregabalin proved to be superior to either single agent, with comparable side-effects and reduced mean consumption of any single drug (calculated as mean administered dosage per patient weight)."	Quasi-randomized by order of enrollment. Enrollment criteria pre-supposed etiology of CLBP use of LANSS tool described as possible predictor of efficacy. Data suggest no benefit from celecoxib or pregabalin alone, with clinical improvement with combination. Small sample and heterogeneous patients (spinal stenosis/LBP) limit conclusions.

Dincer 2007 RCT No mention of COI or industry sponsorship.	5.5	N = 64 with subacute or chronic LBP accompanied by radicular pain lasting 30 days to 1 year.	Caudal epidural injection (CEI) plus therapeutic exercise (n = 34) vs. diclofenac (NSAID) 75mg BID plus therapeutic exercise for 15 days. Followed by paracetamol only (if needed).	Both groups improved in straight leg raise (SLR) test, VAS and Oswestry questionnaire scores at 15th day, 1st and 3rd month follow-up compared to baseline ($p < 0.001$). CEI showed faster improvements compared to NSAID.	"[C]audal epidural injection in the management of the subacute/chronic low back and radicular pain is a preferable choice since it is simple to perform and cost effective, it carries low risk of complication and there is no need for hospitalization."	No placebo/short follow-up. Did not account for amount of paracetamol used if taken during follow-up. No baseline data on duration of pain. Comparison at 1 month and 2 months favored ESI based on VAS, SLR improvement, although NSAID group not allowed to take NSAIDs until day 15 which limits comparison of treatment to 2 week initial period.
Koes Br Med J 1992 RCT Study funded by Dutch Ministry of Welfare, Health, and Cultural Affairs and by Dutch National Health Insurance Council. No mention of COI.	5.0	N = 256 with subacute and chronic LBP ≥6 weeks; herniated discs excluded	Manual therapy, manipulation and mobilization, Dutch Society for Manual Therapy (n = 65) vs. physiotherapy, exercises, massage, heat, electrotherapy, ultrasound, diathermy (n = 66) vs. placebo therapy, (physical exam, placebo ultrasound and placebo diathermy) (n = 64) vs. GP, analgesics, NSAIDs, advice about posture, home exercises, participation in sports, bedrest, etc.) for 3 months (n = 61).	Manipulative group showed better results in physical functioning when compared to physiotherapy group at 12 month follow-up 0.9 (95% CI 0.1-1.7). Manipulative group had largest improvement at 12 month follow-up (4.5 SD 2.2).	"Manipulative therapy and physiotherapy are better than general practitioner and placebo treatment. Furthermore, manipulative therapy is slightly better than physiotherapy after 12 months."	Study details not well described. General practice arm in particular may include suboptimal management.
Hickey 1982 RCT No mention of COI or industry sponsorship.	4.5	N = 30 with chronic LBP	N = 16 completed study on diflunisal 500mg BID and n = 13 on paracetamol 1000mg QID; 4 week treatment.	At Week 4, patients with no or mild LBP were 13/16 = 81.2% on diflunisal vs. 7/12 = 58.3% on paracetamol. Four of 12 paracetamol patients considered therapy good or excellent, five fair, and three poor. Ten of 6 diflunisal patients considered efficacy good or excellent, four fair, and two poor ($p = 0.01$).	"Diflunisal is considered to be safe, effective and well tolerated treatment of chronic low back pain."	Diflunisal provided substantially greater efficacy than paracetamol. Allocation, randomization, blinding, co-intervention details sparse. Data suggest subjective benefit with diflunisal compared to paracetamol but no benefit in radiation of pain, functional disability. No clear clinical benefit demonstrated.
Sweetman 1987 RCT	4.0	N = 122 with acute LBP, no severe nerve root compression	Mefenamic acid 500mg TID (n = 40), chlormezanone 100mg-paracetamol 450mg two TID (n = 42), and combination	Patient's overall assessment of pain Day 7 showed marked improvement in mefenamic acid 9/32 = 28.1% vs. chlormezanone-paracetamol 14/31 = 45.2% vs. ethoheptazine/aspirin/ meprobamate 12/32 = 37.5%, (NS).	"This study has shown that mefenamic acid is an effective alternative to these two preparations and one which is better tolerated than	Baseline differences in duration of LBP marked: (15 vs. 10 vs. 7 days, most favorable for combination and against mefenamic acid). For an acute LBP study of 7 days treatment,

No mention of COI or industry sponsorship			of ethoheptazine 75mg-aspirin 250mg-meprobamate 150mg 2 tablets TID (n = 40); 7 day treatment.	Differences between effects of test medications on lateral flexion and rotation NS, but for flexion, chlormezanone-paracetamol most effective, and for extension, ethoheptazine-aspirin-meprobamate least effective (p <0.05 both cases).	ethoheptazine-aspirin-meprobamate."	this raises significant concerns about adequacy of randomization processes and suggested conclusions are tentative. Mefenamic acid appears equivalent and better tolerated than ethoheptazine-aspirin-meprobamate.
Post-Operative NSAIDs						
Grundmann 2006 RCT Double-blind placebo-controlled study No mention of COI or industry sponsorship.	8.0	N = 80 undergoing 1-level lumbar micro-discectomy	Parecoxib 40 mg (n = 20) vs. Paracetamol 1g (n = 20) vs. Metamizol 1g (n = 20) vs. placebo 100 mL NS (n = 20). Follow-up not specified.	No differences in adverse effects. VAS at Postanesthesia care unit arrival (Parecoxib/paracetamol/ metamizol/placebo):32.5/36.4/14.2/ 29.9. VAS on discharge: 13.3/20/9/9.4/11.4.	"[I]n patients undergoing lumbar microdiscectomy, the IV administration of a single dose of metamizol 1 g provides significantly better pain control in the early postoperative period compared with other non-opioids without increasing adverse side effects."	Data suggest metamizol superior.
Pookarnjanamorakot 2002 RCT Double-blind No benefits received for this study. No mention of COI.	8.0	N = 50 undergoing discectomy or single-level laminectomy	Piroxicam FDDF group received first dose of 40mg SL 1-3 hours before surgery (n = 29) vs. placebo (n = 21). Follow-up for 1, 2, and 3 days.	Piroxicam with better pain relief vs. placebo, on postoperative days 1 and 2, p < 0.05, but not on day 3. No differences between 2 groups in postoperative blood loss, length of wound, and duration of surgery.	"Sublingual administration of piroxicam fast-dissolving dosage form after simple spine surgery is effective and efficient in relief of postoperative pain."	Data suggest superior pain control and trend to lower morphine use with piroxicam.
Aubrun 2000 RCT Placebo controlled Study supported by grant from Specia Laboratory. No mention of COI.	8.0	N = 50 undergoing spinal fusion surgery	Ketoprofen 100mg Q8 hours (n = 25) vs. control group 125ml of 5% dextrose (n = 25) postoperatively.	Pain relief assessed by VASpr after 4 hours 84±24 vs 81±24mm, p = NS). Ramsay's score decreased from 4.0±2.0 to 2.6±1.3 in Ketoprofen group and from 4.2±2.1 to 2.4±1.2 in placebo group 2.0 to 2.6±1.3 in Ketoprofen group and from 4.2±2.1 to 2.4±1.2 with placebo.	"Ketoprofen reduced morphine requirements and improved postoperative analgesia in patients undergoing major spinal surgery and receiving propacetamol."	Higher pain and anxiety in ketoprofen group concerning for confounding/randomization failure. Data suggest improved pain control and opioid sparing.
Fletcher 1997 RCT No mention of COI or industry sponsorship.	8.0	N = 60 with one herniated lumbar disc scheduled for surgery	Group 1, placebo (n = 15) vs. Group 2 Propacetamol IV (n = 15) vs. Group 3 Ketoprofen 50 mg Q6hrs. (n = 15) vs. Group 4 Propacetamol 2g IV plus ketoprofen 50mg in 2 separate	Pain intensity at rest: located mainly at back 67-87% or less frequently in leg and back (13-33%). At 48 hours, Group 4 received drug combination vs. Groups 1, 2 and 3 (p = 0.01 vs. Group 1 p = 0.001 vs Group 2, p = 0.04 in Group 3). Pain intensity on movement: in Group 4 receiving drug combination, reduced vs. other groups for study duration p =	"The combination of propacetamol and ketoprofen reduced pain scores both at rest and on movement."	Small numbers in each group. Underpowered for adverse effects. Data suggest best pain control in combination group.

			injections (n = 15). Follow-up for 2 days.	0.0001 vs. Group 1, p = 0.0001 vs. Group 2, p = 0.003 vs. Group 3. No differences in adverse effects.		
Bekker 2002 RCT Double-blind, Placebo-controlled Study supported in part by research grant from Merck & Co., Inc. Authors have no personal or institutional financial interest in study drug.	6.5	N = 61 undergoing single level lumbar discectomy, age 27-81	Rofecoxib 50mg night before surgery and 30 minutes before anesthesia induction (n = 30) vs. placebo post-operatively (n = 30). Follow-up not specified.	More patients in placebo group rated postoperative pain as >7/10. No difference in need for post-op analgesia or difference between groups in mean hospital stay. Reduced morphine use in ICU (7.9±5.8 vs. 5.0±4.0, p <0.05).	"Preoperative rofecoxib is effective in reducing postoperative narcotic consumption in patients undergoing lumbar laminectomy."	Data suggest efficacy to modestly reduce opioid use.
Mack 2001 RCT Double-blind No mention of COI or industry sponsorship.	6.5	N = 30 undergoing single-level microsurgical lumbar discectomy under general anesthesia	Ketorolac 1mL or 30mg IV over 4 minutes, plus NS placebo 15mL infiltrated into paraspinous muscle (n = 10) vs. Bupivacaine 0.25% 15mL infiltrated into wound, and NS 1mL IV over 4 minutes (n = 20) vs. NS 1mL IV over 4 minutes, plus NS 15mL infiltrated into wound (n = 30). Follow-up for 24 hours after surgery.	No relation between group assignment and either postoperative use of MSO4 via patient-controlled anesthesia or demand for MSO4, p = not provided. Significant relation between preoperative pain and cumulative post-op narcotic demand, r = 0.46, p <0.01 and usage r = 0.37, p <0.05.	"Neither ketorolac nor bupivacaine decreased the postoperative narcotic requirement in patients undergoing microsurgical lumbar discectomy."	Small sample sizes per group likely underpowering. Major differences in pre-op opioid and NSAID uses suggest randomization failure.
Thienthong 2004 RCT Double-blind Study funded by Khon Kaen University. No mention of COI.	6.0	N = 56 with lumbar spine surgery experience moderate to severe pain in recovery room or post-anesthesia care unit (PACU)	Group L or Lornoxicam 16 mg IV at beginning of surgical wound closure (n = 28) vs. Group P/ placebo (NS) (n = 28). Follow-up for first 2 hours after surgery.	At T0, T1, and T2 not significantly different, especially main outcome which was VNRS >5 at T0 (44.4T in the Group P vs 50.0% in Group L, and CI difference; -32.4%, 21.3% p = 0.68). Mean VNRS scores at T0, T1 >5 and at T2 <5 in both groups.	"Lornoxicam 16 mg given intravenously before wound closure provides inadequate pain relief immediately after discectomy or laminectomy in the PACU."	Very short follow-up of 2 hours. More laminectomies than discectomy between groups (60.7% vs. 42.9%) may confound results which were no difference.
Le Roux 1999 RCT	6.0	N = 53 undergoing lumbar discectomy	30mg IM ketorolac at surgical closure and Q6 hours for 36 hours and narcotic analgesics PRN (n = 27) vs. only	Pain intensity average p <0.001, maximum p <0.001, and minimum scores p <0.001, 24 hours after surgery lower in ketorolac than narcotics group. Number of narcotic	"These results suggest that ketorolac, when used with PRN narcotics, is more effective than PRN narcotics alone for postoperative pain	Approximately 80% reduction in morphine and less pain. Less LBP at 6 weeks with ketorolac. More adverse effects with narcotics only.

No mention of COI or industry sponsorship.			narcotic analgesics PRN (n = 26). Follow-up for 6 weeks.	analgesics post-op lower ketorolac group, p <0.001. None on ketorolac described back pain, p = 0.03.	following lumbar disc surgery."	
Nissen 1992 RCT Double-blind Placebo-controlled clinical investigation No mention of COI or industry sponsorship.	6.0	N = 56 undergoing conventional lumbar disc surgery	Indomethacin group 100mg IV before surgery, plus 100mg rectally 6 and 12 hours after surgery; 08:00, 16:00, 23:00 next day (n = 28) vs.placebo group 100mg IV before surgery, plus 100mg rectally 6, 12 hours after surgery; 08:00, 16:00 and 23:00 next day (n = 28). Follow-up for 2 days.	No difference between groups in preoperative or 3-hours postoperative pain scores. At 6 hours and subsequently, die difference was significant, Wilcoxon's two-sample test, two-sided, p < 0.05.	"Patients receiving placebo had significantly greater pain scores and significantly more patients in the placebo group required supplementary analgesics."	Data suggest better pain control and less opioid use with indomethacin.
Reuben 1998 RCT No mention of COI or industry sponsorship.	4.5	N = 70 scheduled to undergo elective decompressive lumbar laminectomy with spinal fusion by single surgeon	Seven IV ketorolac K_5 5mg, $K_{7.5}$ 7.5mg, K_{10} 10mg, $K_{12.5}$ 12.5mg, K_{15} 15mg, K_{30} or 30mg group (n = not specified) vs. Control or K_0 IV saline group every 6 hours (n = not specified). Follow-up for 24 hours post-op.	Pain scores different among groups: 4, 8, 12, 16, 20, 24 hours, p <0.006/p <0.001, p <0.002), p <0.004, p <0.0001, p <0.0005 after surgery. No statistical difference with respect to incidence of pruritus or incidence of nausea, vomiting among any groups. At 8 hours, pain score significantly higher in K_0 vs. K_{10} group.	"Using smaller doses of ketorolac (e.g., 75 mg every 6 h) as a supplement to morphine patient-controlled analgesia is as effective as larger doses in patients who have undergone spine stabilization surgery."	Author with >20 retracted articles. Dose-ranging. Many details sparse. Data suggest morphine-sparing, but not beyond 10mg.
Reuben 1997 RCT No mention of COI or industry sponsorship.	4.5	N = 80 inpatients undergoing spine stabilization by one surgeon were evaluated after excluding patients with contra-indications to the use of ketorolac or morphine	Group 1 or M intravenous saline or control group, plus patient-controlled analgesia (PCA) (n = 20) vs. Group 2 or MK_{PCA}, ketorolac plus added PCA morphine on milligram per milligram basis (n = 20) vs. Group 3, or MK_{15} received an intravenous injection of 15mg ketorolac every 6 hours (n = 20) vs. Group 4, or MK_{30} intravenous injection 30mg ketorolac every 6 hours (n = 20). Follow-up for 24 hours after initiation of PCA.	Total dose of morphine, the total dose of the six time periods, and pain scores were statistically higher in the M group than in the other three groups. Sedation scores were higher in the M group than in the other three groups at two of the six time periods at 4 and 24 hours, p < 0.001. Higher incidence of pruritus in the MK15 group at the first evaluation period than in the other groups, p <0.001.	"This results in decreased morphine consumption, decreased somnolence, and enhanced analgesia in comparison with patients who do not receive ketorolac."	Author with >20 retracted articles. Many details sparse. Data suggest less opioid use and reduced pain with ketorolac.

Yamashita 2006 RCT No mention of COI or industry sponsorship.	4.5	N = 36 with American Society of Anesthesio-logists physical status I-II scheduled for spinal fusion, (posterolateral fusion-pedicle screw fixation, PLF-PSF) of one vertebral space between L4/L5 or L5/S1	Group A post-op flurbiprofen axetil, 1 $mg \cdot kg^{-1}$ (n = 12) vs. Group B postop flurbiprofen axetil, $1mg \cdot kg^{-1}$ (n = 12) vs. Group C IV FA, 1 $mg \cdot kg^{-1}$ lipid emulsion 0.1 $mg \cdot kg^{-1}$ (n = 12). Follow-up for 24 hours after surgery.	VAS not different between Groups B and C, from T2 (2 hours) and T5 (24 hours). Postop morphine consumption in Group A lower than Group B and C at T0 to T3, and no differences between groups, no patients showed any adverse effect associated with FA.	"As compared with postoperative administration, preoperative administration of intravenous flurbiprofen axetil provides better postoperative analgesia and an opioid-sparing effect in patients undergoing spinal fusion surgery under general anesthesia."	Blinding somewhat unclear (re. timing). Data suggest pre-op flurbiprofen superior to postop use.

ANTIBIOTICS

Antibiotics have been used for treatment of LBP with Modic changes and bone edema.(887, 888)

1. *Recommendation: Antibiotics for Chronic Low Back Pain with Modic I Changes*
   Antibiotics are moderately recommended for treatment of chronic low back pain with Modic I changes lacking objective signs of infection.
   Indications – Chronic LBP and all of: 1) at least 6 months duration; 2) prior history of disc herniation; 3) Modic I changes with vertebral edema; and 4) failure to improve with other approved treatment guideline.

   Frequency/Duration – Amoxicillin-clavulanate (500mg/125mg) TID for 100 days.

   Indications for Discontinuation – Development of adverse effects.
   Benefits – Improvements in LBP.
   Harms – Allergic reactions, diarrhea, clostridium difficile.

   Strength of Evidence – **Moderately Recommended, Evidence (B)**
   Level of Confidence – Low

2. *Recommendation: Antibiotics for Acute, Subacute, and Other Chronic or Radicular Low Back Pain*
   There is no recommendation for or against the use of antibiotics for treatment of acute, subacute, and other chronic or radicular LBP.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendations

There is one high-quality trial evaluating efficacy of antibiotics for a narrow indication of chronic LBP with Modic changes(888) that was performed after favorable results reported in another population that had failed treatment in a separate clinical trial.(887) Thus, there is one trial suggesting potential efficacy in a narrowly defined population with Modic I changes-vertebral edema.(888) This treatment is unusual, 100 days of antibiotics is extensive, and this study requires replication. Nevertheless, the trial is positive and antibotics are less harmful than a number of other more invasive treatments used for LBP patients. Antibiotics of this duration are not invasive, have relatively low adverse effects, and are moderately costly for 100 days. Amoxicillin/clavulanate is recommended for this narrow indication.

Evidence for the Use of Antibiotics

There is 1 high-(888) and 1 moderate-quality RCT(889) incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: antibiotics, antibacterial agents, low back pain, radicular pain syndromes, radiculopathy nerve compression syndromes, sciatica, sciatica neuropathy, spinal stenosis to find 238 articles in PubMed, 11 articles on EBSCO, 1 article on Cochrane Review, and 12,030 in Google Scholar, for a total of 12,280 articles. Of the 12,030 articles, we reviewed 4 articles, and included 2 articles (RCTs).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Antibiotics						
Albert 2013 RCT No mention of COI or industry sponsorship.	8.5	N = 162 with chronic LBP (duration >6 months) occurring after prior disc herniation and who also had bone edema, i.e., Modic type 1 vertebral changes adjacent to prior herniation	100 days of antibiotic treatment (Bioclavid; amoxicillin/clavulanic acid) vs. placebo; 1 year follow-up.	Had LBP comparing baseline/1 year: Antibiotic 100/67.5% vs. placebo 100/94%; p = 0.0001. Had constant pain: Antibiotic 75.3/19.5% vs. placebo 73.1/67.2%; p = 0.0001.	"The antibiotic protocol in this study was significantly more effective for this group of patients (CLBP associated with Modic I) than placebo in all the primary and secondary outcomes."	Prohibited exercise. More Modic changes in placebo at baseline. 1 year follow-up. Data suggest efficacy. No corroborating data.
Anti-viral Medication						
Medrik-Goldberg 1999 Randomized Crossover Trial No mention of COI or industry sponsorship.	6.0	N = 30 age 18-60 with sciatica. Painful lumbar radiculopathy of 3-36 months duration, herniated disc on CT or MRI, correlated clinical findings with imaging (24 at 1-level; 4 at 2-level, 3 at 3-levels) and no prior back surgery	One of 6 possible combinations over 3 clinic sessions at least 2 days apart. Amantadine 2.5mg/kg IV vs. Lidocaine 5mg/kg vs. NS IV placebo. 28 completed all 3 infusions.	Lidocaine reduced spontaneous pain as compared with amantadine and with the placebo for all measurements and at a significant level at the 30 (P < .05), 120, and 180 (P < .01) minute time points. Maximal pain reduction from baseline was lidocaine: 62 +/- 7%, amantadine: 43 +/- 7%, and placebo: 47 +/- 7%.	"Intravenous lidocaine, rather than amantadine, reduces both spontaneous and evoked sciatic pain."	Experimental study. Data suggest modestly less pain with lidocaine, but not amantadine vs. placebo. As short-term experimental trial, implications for clinical management unclear.

ANTI-DEPRESSANTS

Anti-depressants have been widely utilized for the treatment of chronic pain, including chronic LBP. This review addresses uses for LBP (see the Chronic Pain Guideline for a more detailed discussion). These recommendations are segregated into whether the anti-depressant blockes norepinephrine or not (including dual serotonin-norepinephrine agents), as that appears to be the critical feature that produces efficacy for treatment of pain.

1. *Recommendation: Serotonin-Norepinephrine Reuptake Inhibitors (SNRIs) aka "Dual Action Agents," and Tricyclic Antidepressants (TCAs) for Acute, Subacute, and Chronic Low Back Pain*
   Norepinephrine reuptake inhibitor anti-depressants (e.g., tricyclic anti-depressants – amitriptyline, imipramine, nortriptyline, desipramine, maprotiline, doxepin) and mixed serotonin norepinephrine reuptake inhibitors (e.g., duloxetine) are recommended for the treatment of acute, subacute, and chronic low back pain. This recommendation does not include "SSRIs."

   Indications – Chronic LBP that is not fully resolved with NSAIDs and an exercise program. Some evidence of efficacy for acute and subacute LBP. There is some evidence of efficacy for LBP with radiation to proximal extremity, but distal radiation (i.e., sciatica) has not been clearly studied in quality studies. This intervention may be more helpful where there is insomnia (especially where habituating agents are not recommended), nocturnal sleep disruption, depression, dysthymia and anxiety.

   Frequency/Duration – Generally prescribed at a low dose at night and gradually increased (e.g., amitriptyline 25mg QHS, increase by 25mg each week) until a sub-maximal or maximal dose is achieved, sufficient effects are achieved, or adverse effects occur. Most practitioners use lower doses, (e.g., amitriptyline 25 to 75mg a day to avoid adverse effects and necessity of blood level monitoring), as there is no evidence of increased pain relief at higher doses. Imipramine is less sedating, thus if there is carryover daytime sedation, it may be a better option. If the patient cannot sleep at night, amitriptyline is the recommended initial medication to prescribe.

   Indications for Discontinuation – Resolution of pain, intolerance, or development of adverse effects.
   Benefits – Modest improvements in LBP. May improve sleep quality.
   Harms – Daytime somnolence, interference with work, dry mouth, cardiac risks, and other adverse effects.

   Strength of Evidence – **Strongly Recommended, Evidence (A)** (Chronic)
   Strength of Evidence – **Recommended, Evidence (C)** (Acute, Subacute)
   Level of Confidence – Moderate

2. *Recommendation: Serotonin-Norepinephrine Reuptake Inhibitors (SNRIs) aka "Dual Action Agents," and Tricyclic Antidepressants (TCAs) for Post-operative and Radicular Low Back Pain*
   There is no recommendation for or against use of norepinephrine reuptake inhibitor anti-depressants (e.g., tricyclic anti-depressants – amitriptyline, imipramine, nortriptyline, desipramine, maprotiline, doxepin) and mixed serotonin norepinephrine reuptake inhibitors (e.g., duloxetine) for treatment of post-operative or radicular low back pain absent other indicators for treatment, as there is no quality evidence supporting their efficacy. They may be a reasonable option for select cases particularly with sleep disruption with concerns regarding habituating agents or inability to manage with NSAIDs or other agents. There is some evidence of efficacy for treatment of patients with proximal limb radiation.(899,906)

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

3. *Recommendation: SSRIs for Acute, Subacute, Pos-operative, Radicular and Chronic Low Back Pain*
   Selective serotonin reuptake inhibitors (e.g., citalopram, escitalopram, fluoxetine, paroxetine, sertraline) are strongly not recommended for treatment of chronic low back pain. (They may be effective for treatment of depression, dysthymia and other psychiatric conditions.) **They also are not recommended for treatment of acute, subacute, radicular or post-operative LBP.**

Strength of Evidence – **Strongly Not Recommended, Evidence (A)** (Chronic)
Strength of Evidence – **Not Recommended, Insufficient Evidence (I)** (Acute, subacute, radicular, post-operative LBP)
Level of Confidence – Moderate

Rationale for Recommendations
There are multiple placebo-controlled trials evaluating efficacy of anti-depressants for treatment of LBP, with nearly all studies evaluating chronic LBP (see evidence table). Some included patients with depression while some specifically sought to exclude those with depression. Effects appear to differ by class of agent.

Selective Serotonin-Reuptake Inhibitor Anti-depressants (SSRIs): Bupropion and Trazodone
There were four trials of anti-depressants that primarily inhibit serotonin reuptake for the treatment of chronic LBP. Two high-quality studies evaluated paroxetine 20mg or 30mg in the treatment of chronic LBP and neither found evidence of efficacy.(890, 891) One study enlisted patients with depression and found no benefit except a tendency toward increased use of analgesics while on paroxetine. The other study did not include patients with depression. One moderate-quality trial of trazodone (150mg a day) did not show benefit in any measure of pain or function among subjects with at least 1 year of LBP.(892) One moderate-quality crossover trial of bupropion (300mg a day for 16 weeks) among subjects with at least 6 months of LBP failed to find improvement in back pain or other measures of function.(893)

Norepinephrine-Reuptake Inhibitor Anti-depressants (Tricyclic Anti-depressants) and Dual Reuptake Inhibitors (SNRIs)
Six quality RCTs of tricyclic anti-depressants (TCAs) in the treatment of chronic LBP were found. Two moderate-quality studies evaluated imipramine. One compared 150mg nightly for 8 weeks with placebo for LBP of at least 6-weeks duration and found that those taking imipramine had significantly fewer limitations with work or activities.(894) A second study evaluated 75mg for 1 month and found non-significant improvements in pain scores.(895) A moderate-quality randomized crossover study evaluated the efficacy of varying doses of amitriptyline for 6 weeks for treatment of LBP (at least 1 year duration) and found subjective improvements, no change in activity level, and declines in analgesic usage of approximately 50% while on treatment.(896) One high-quality study of nortriptyline evaluated 100mg a day among primary care subjects with chronic LBP and found significant improvements in pain scores and borderline disability scores.(897) One high-quality study of maprotiline found it superior to either placebo or paroxetine for LBP.(890) Doxepin (over 200mg nightly) was evaluated in a moderate-quality study and found to improve pain scores.(898) There is limited evidence that TCAs result in modest reductions in pain ratings in the treatment of radicular pain compared with placebo. There is no quality evidence of an association between serum levels and pain relief, suggesting that doses less than those used for depression may be sufficient.(894, 897) Two trials with 3 reports have reported efficacy of duloxetine for treatment of chronic pain.(899-901)

One study specifically sought to treat those with sciatica and found no significant benefits from morphine, nortriptyline, or a combination compared with a control for radicular pain.(902) However, other studies have included some with radiating pain into an extremity. Thus, evidence for use of antidepressants for treatment of radicular pain is unclear.

Norepinephrine reuptake inhibitor anti-depressants are not invasive, have low to moderate dose-dependent adverse effects at low doses, and are not costly in their generic formulations. The degree to which depression or dysthymia is present may suggest earlier use of these medications. Discussions with mental health professionals may be helpful, particularly when mental health conditions are more severe. Norepinephrine reuptake inhibiting anti-depressants are recommended for treatment of chronic LBP.

Evidence for the Use of Anti-depressants
There are 4 high-(890, 891, 897, 902) and 14 moderate-quality(892-896, 898-901, 903-907) RCTs or crossover trials incorporated into this analysis. There is 1 1ow-quality RCT with two reports in Appendix 1.(908, 909)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: anti-depressants, antidepressants, Citalopram, Escitalopram, Paroxetine, Fluoxetine, Fluvoxamine, Sertraline, Desvenlafaxine, Duloxetine, Milnacipran, Tramadol, Sibutramine, Etoperidone, Lubazodone, Nefazodone, Trazodone, Jegguzine, Atomoxetine, Reboxetine, Viloxazine, Bupropion, Dexmethylphenidate, Methylphenidate, Amphetamine, Dextroamphetamine, Dextromethamphetamine, Lisdexamfetamine, Amitriptyline, Butriptyline, Clomipramine, Desipramine, Dosulepin, Doxepin, Imipramine, Iprindole, Lofepramine, Melitracen, Nortriptyline, Opipramol, Protriptyline, Trimipramine, Amoxapine, Maprotiline, Mianserin, Mirtazapine, Isocarboxazid, Moclobemide, Phenelzine, Pirlindole, Selegiline, Tranylcypromine, and low back pain to find 368,696 articles. Of the 368,696 articles we reviewed 8 articles and all were included. For Serotonin Reuptake Inhibitors- We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: serotonin reuptake inhibitors, paroxetine, bupropion, trazodone, duloxetine, chronic low back pain to find 62,545 articles. Of the 62,545 articles, we reviewed eight articles and included seven articles. For Norepinephrine reuptake inhibitors- We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: norepinephrine reuptake inhibitor antidepressants, tricyclic antidepressant, amitriptyline, imipramine, nortriptyline, maprotiline, doxepin, SNRI, chronic low back pain, radicular pain, and sciatica to find 24,991 articles. Of the 24,991 articles, we reviewed 21 articles, and included 21 articles (15 RCTs and 6 reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Norepinephrine vs. Placebo						
Atkinson 1998 RCT Supported in part by U.S. Department of Veteran Affairs and by NIH grant MO1-RR00827. No mention of COI.	8.5	N = 78 with chronic LBP without depression	Nortriptyline (n = 38) vs. placebo (n = 40) for 8 weeks.	Reductions in pain scores: 2.59±4.0 for nortriptyline vs. 0.91±3.43 for placebo.	"This modest reduction in pain intensity suggests that physicians should carefully weigh the risks and benefits of nortriptyline in chronic back pain without depression."	Non-depressed population. Data suggest modest improvement with nortriptyline vs. placebo.
Katz 2005 RCT Supported in part by investigator-initiated research grant from GlaxoSmithKline to R.H.D., who has also received research support, consulting fees, or lecture honoraria in the past year from Abbott Laboratories, Eli Lilly & Co., Endo Pharmaceuticals, EpiCept Corporation, NeurogesX, Novartis Pharmaceuticals, Organon, Ortho-McNeil Pharmaceutical, Pfizer, Purdue Pharma, Ranbaxy Corporation, Reliant Pharmaceuticals, Renovis, and UCB Pharma.	7.5	N = 60 with chronic LBP without depression over 16-week interval	Bupropion SR (n = 21) vs. placebo (n = 23) for 16 weeks.	Mean daily pain ratings at baseline: 4.49±1.70 which were 3.25±1.93 on bupropion vs. 3.42±1.86 on placebo.	"[B]upropion SR was not found to be significantly better than placebo in treating patients with non-neuropathic chronic LBP."	Data suggest no significant benefit from use of bupropion for non-specific LBP.
Hameroff 1982 RCT No mention of COI or industry sponsorship.	7.0	N = 30 with chronic LBP or cervical pain plus clinical depression; numerous diagnoses included	Doxepin: doses began at 50mg QHS and increased to 300mg unless either marked improvement or adverse effects encountered vs. placebo for 6 weeks.	Mean doxepin dose 2.5mg/kg. Significant improvements in doxepin group for global assessment ($p = 0.026$), Hamilton Depression Scale Scores ($p = 0.030$), Profile of Mood States ($p = 0.011$), percent of time pain was felt ($p = 0.05$), and effect of pain on sleep ($p = 0.005$).	"[D]epression in outpatients with chronic pain may respond differently. Documented benefit and lack of significant side effects for a group of patients for whom other modalities had been almost exhausted indicate that doxepin is a valuable treatment for chronic pain and depression."	Multiple diagnoses included but breakdown of patients by diagnosis not given. Data suggest doxepin efficacious in patients with chronic spine pain and depression.

Alcoff 1982 RCT Industry sponsored by Bureau of Medicine and Surgery, Department of Navy, Clinical Investigation Program (#0-08-1461). No mention of COI.	6.5	N = 50 with chronic LBP	Imipramine (75mg 1st 3 days then increased to 180mg/day, n = 28) vs. placebo (n = 22) for 8 weeks.	Significant differences between groups for number of days had to lie down for 2 hours or more, number of days with at least some restriction of normal activity, limitation of work, and limitation of recreational activities: p = 0.002, p = 0.004, p = 0.004, p = 0.001.	"[I]mipramine may possibly be useful in the treatment of chronic low back pain, especially so when it exists as a component of depression."	Data suggest imipramine effective for CLBP. Efficacy of blind measures uncertain. Small sample size. Clinical benefit uncertain.
Jenkins 1976 RCT No mention of COI or industry sponsorship.	6.0	N = 59 with chronic LBP >4 weeks	Imipramine 25mg TID (n = 23) vs. placebo (n = 21). Both medications given 3 times a day for 4 weeks.	In patients without prior history of disease, pain ratings decreased in Tofranil group from 43.9 to 38.0 vs. 41.9 to 34.8 with placebo.	"[T]ofranil produced a marked improvement in pain and stiffness in patients with disc lesion only diagnoses, while the placebo did not produce improvement."	Study of patients admitted for LBP. Data suggest significant benefit for imipramine.
Hameroff 1984 RCT No mention of COI or industry sponsorship.	5.5	N = 60 with chronic LBP and other chronic pain conditions	Doxepin (n = 30) vs. placebo (n = 30) for 6 weeks. Doxepin began at 50mg and was increased gradually to 300mg QHS unless marked symptomatic improvement.	At 4 weeks, placebo significantly higher vs. doxepin for mean daily dose, p = 0.036. Hamilton depression scores improved at Week 6 for both groups: doxepin (p = 0.001), placebo (p = 0.031). At Week 6, doxepin significantly better than placebo for profile of mood states, effect of pain on sleep, effect of pain on muscle tension: p = 0.011, p = 0.05, p = 0.03.	"[D]oxepin is a valuable treatment for patients with chronic pain and depression."	Mixture of low back and chronic pain. Data suggest benefits from doxepin for depression, global assessment and effect on pain as early as 1 week and at 6 weeks after treatment. Minimal baseline characteristics. Co-interventions not well described.
Pheasant 1983 Crossover Trial No mention of COI or industry sponsorship.	4.0	N = 16 with chronic LBP	Amitriptyline (50mg tablets, n = 6) vs. atropine/placebo (0.2mg tablets, n = 10) each for 6 weeks.	Patients to take as many tablets "as possible without developing unpleasant (anticholinergic) side effects." Analgesics per week: 8.7±4.8 atropine vs. 4.7±3.4 (p <0.005) amitriptyline. Functional evaluation NS. Activity questionnaire part A: atropine 2.58±0.50 vs. amitriptyline 2.71±0.30, p<0.10.	"Among those who completed the study, there was a 46% decrease in the use of analgesics while on amitriptyline when compared to placebo (p<0.005)."	Many details sparse. Placebo active agent (atropine). Co-interventions not controlled, compliance, dropout (7/16) rate high; small sample size limits conclusions. High dose used, likely unnecessary, may limit conclusions.
Treatment vs. Usual Care						
Kroenke 2009 RCT No mention of COI or industry sponsorship.	6.0	N = 250 with comorbid musculoskeletal LBP, hip or knee pain for 3+ months and having depression	Intervention group (n = 123) - venlafaxine 75mg with possible increases to 150mg or 225mg or fluoxetine 20mg with increases to 30 and 40mg or sertraline 50mg, 100 and 150mg, or	Depression outcomes. HSCL-20 for depression (mean±SD), baseline/6 months/12 months: intervention 1.83±0.66/1.16±0.77/ 1.14±0.69 vs. usual care 1.94±0.65/1.64±0.7/ 1.69±0.74, p = 0.20/<0.001/<0.001. Major depressive disorder, No., baseline/12 months: 90/50 vs. 97/87,	"Optimized antidepressant therapy followed by a pain self management program resulted in substantial improvement in depression as well as moderate reductions in pain severity and disability."	Pragmatic trial. Some differences in anti-depressant use at baseline. Mostly LBP cases (~60%), remainder knee or hip pain. Higher dropouts in usual care at 12 months. Data suggest

			citalopram 20mg, 30 and 40mg, or bupropion 200mg, 300 and 400mg, or mirtazapine 15mg, 30 and 45mg, or nortriptyline 25mg, 50 and 75mg for 12 weeks vs. usual care (n = 127): informed they had depressive symptoms and should seek treatment advice. Follow up at 6, 12, 16, and 20 weeks and 6 and 12 months.	p = 0.56/<0.001. Depression responder, No., 6 months/12 months: 47/46 vs. 18/21, p <0.001/<0.001. Pain outcomes. BPI severity (mean± SD), baseline/6 months/ 12 months: 6.16±1.76/5.24±2.51/5.08±2.54 vs. 6.14±1.78/5.86±2.20/6.03±2.08, p = 0.92/0.04/0.001. BPI interference: 6.84±2.15/5.05±2.84/4.96±2.75 vs. 7.09±1.97/6.30±2.53/6.48±2.43, p = 0.34/<0.001/<0.001. BPI total: 6.62±1.85/5.04±2.57/4.94±2.54 vs. 6.77±1.74/6.14±2.31/6.33±2.18, p = 0.51/<0.001/<0.001. Pain responder No., 6 months/12 months: 47/51 vs. 22/22, p <0.001/<0.001. Composite outcome. Composite responder, No., 6 months/12 months: 29/32 vs. 10/10, p <0.001/<0.001. Roland Pain Disability Scale score, baseline/12 months: 17.3±4.5/14.0±6.5 vs. 17.6± 4.1/17.2±5.3, p = 0.57/<0.001. Graded Chronic Pain Scale severity score: 72.7±17.7/67.8±22.8 vs. 72.8± 15.4/74.7±17.2, p = 0.97/0.007. Graded Chronic Pain Scale disability score: NS. Generalized Anxiety Disorder scale score: 8.7±4.5/5.8±5.0 vs. 9.1±4.4/8.0±5.1, p = 0.48/<0.001. Short Form 36: general health perceptions score 33.1±27.9/35.2± 29.7 vs. 28.4±26.6/24.2±25.5, p = 0.20/ 0.002; social functioning score NS; bodily pain score 26.5±16.0/37.3 ±21.1 vs. 27.2±14.1/28.8±16.9, p = 0.70/<0.001; vitality score 25.8±16.6/ 36.6±22.7 vs. 24.6±17.3/27.8±18.9, p = 0.57/0.001. Medication use months antidepressants 12 months: intervention 9.2±4.2 vs. usual care 2.0±3.3, p <0.001. Health care use, number of outpatient visits: medical speciality 1.3±2.3 vs. 1.6±2.8, p = 0.03; mental health 1.6±7.9 vs. 0.7± 2.9, p <0.001; ER visits 1.8±3.5 vs. 1.2±2.1, p <0.001; time in hospital (days) 1.5±5.9 vs. 0.8±2.5, p <0.001.		intervention modestly effective, although heterogeneous interventions inhibit assessment of efficacy of any one intervention.
Acute Low Back Pain						

Stein 1996 RCT No mention of COI or industry sponsorship.	5.0	N=39 patients with acute low back pain with or without sciatic radiation lasting up to 6 months	Amitriptyline 37.5 mg QID (treatment group, n=20) vs. acetaminophen 500 mg QID (control group, n=19) for 5 weeks.	No differences between treatments. Pain reduction approximately 7.9 to 4.8 for acetaminophen vs. 7.6 to 3.0 for amitriptyline (interpretations of graphic data).	"[A]mitriptyline may increase the speed of symptomatic improvement in acute LBP when compared with a standard analgesic."	No placebo control. High dose amitriptyline for MSDs. Data suggest amitriptyline trending superior to acetaminophen for pain reduction.
SSRIs vs. Placebo						
Dickens 2000 RCT No mention of COI or industry sponsorship.	9.5	N = 92 with chronic LBP for 56 days	Paroxetine (20mg a day, n = 44) vs. placebo (n = 48) for 56 days.	Pain scale ratings: baseline (paroxetine 55.1±22.8 vs. placebo 56.1±21.4) vs. Day 14 (52.1±25.5 vs. 56.4±22.3) vs. Day 56 (57±23.8 vs. 57±24.3).	"[T]here is little point in using paroxetine for either treating depression or achieving pain relief in patients with chronic low back pain at the doses prescribed in our study."	Data suggest paroxetine ineffective. Data consistent with association between pain and depression being wholly modulated by disability and illness attitudes with no direct relationship between pain and depression.
SNRIs vs. Placebo						
Skljarevski 2009 RCT Authors V. Skljarevski, M. Ossanna, H. Liu-Seifert, Q. Zhang, A. Chappell, S. Iyengar and M. Detke are or were at time of submission employees of Eli Lilly & Co.; may be minor shareholders.	6.5	N = 404 with chronic LBP with or without radiation to proximal lower extremity; pain ≥6 months and average weekly pain ratings ≥4. 13 week study.	Placebo (n = 117), vs Duloxetine 20mg/day (n = 59), vs. Duloxetine 60mg/day (n = 116), vs. Duloxetine 120mg/day (n = 112) for 13 weeks.	Brief Pain Inventory-Interference scale (placebo/20mg/60mg/120mg): average pain -1.87/-1.79/-2.5/-2.45. Most statistically significant results for 60mg group.	"Duloxetine was superior to placebo on the primary objective from weeks 3-11, but superiority was not maintained at end-point. Duloxetine was superior to placebo on many secondary measures, and was well-tolerated."	Dose-ranging study. Some differences at baseline in 20mg group. High dropouts, especially 120mg/day group (45%). Data suggest efficacy.
Skljarevski 2010a RCT Drs. Skljarevski and Desaiah, Ms. Zhang, and Ms. Alaka are employees of Eli Lilly & Co., and hold company stocks.	6.5	N = 401, >18 years of age, with chronic LBP, >6 months, and 24 hour average pain ≥4	Duloxetine 60mg/day (n = 198) vs. placebo (n = 203) for 12 weeks.	Significant pain reduction (p ≤0.001) between placebo and duloxetine groups, greater with duloxetine.	"[T]reatment with duloxetine at a fixed dose (60 mg once daily) in this study was associated with a significantly greater reduction of CLBP, compared with placebo."	High dropouts mostly adverse drug reaction-related (15% drop out in duloxetine). Compliance worse with duloxetine. Data suggest modest efficacy.
Skljarevski 2010b RCT Sponsored by Eli Lilly & Co., Indianapolis, IN. One or more authors received or will receive benefits for personal or professional use from commercial party	6.5	N = 236, >18 years old, with chronic LBP, >6 months, and 24 hour average pain ≥4	Duloxetine 60/120mg/day (n = 115) vs. placebo (n = 121) for 13 weeks.	No significant differences between duloxetine and placebo. Significant pain improvement for placebo-switched group (to duloxetine) (p <0.01).	"Duloxetine significantly reduced pain and improved functioning in patients with CLBP."	High dropouts in duloxetine group. Study suggests efficacy. Follow-up study (Skljarevski 2010) suggests benefits maintained at 41 weeks.

related directly or indirectly to subject of manuscript.						
Other Agents vs. Placebo						
Goodkin 1990 RCT Supported by NIH grants MH16744 and NIMH Mental Health Clinical Research and Development Fund, and grant from Western Research and Development Office of the Veterans Administration. No mention of COI.	7.0	N = 42 with chronic LBP ≥1 year or 2 prior LBP episodes of ≥2 weeks without depression	Trazodone (201mg a day, n = 22) vs. placebo (238mg a day, n = 20) for 6 weeks.	"There were no differences between treatment groups on any outcome measure at baseline."	"This study demonstrated no significant advantage for trazodone hydrochloride in the treatment of chronic low back pain syndrome."	Small sample size. Data suggest trend to lower pain ratings with trazadone, likely underpowered.
Norepinephrine vs. SSRIs vs. Placebo						
Atkinson 2007 RCT Supported by the Department of Veteran Affairs and National Institute of Health grant MO 1 RR00827. No mention of COI.	7.5	N = 121 with chronic LBP without depression	Desipramine low (50ng/ml, n = 17) vs. medium (110ng/ml, n = 17) vs. high (150ng/ml, n = 18) vs. fluoxetine low (100ng/ml, n = 14) vs. medium (200ng/ml, n = 14) vs. high (400ng/ml, n = 15) vs. placebo (benztropine mesylate 0.5mg daily, n = 26) for 12 weeks.	Post-treatment descriptor differential scale pain intensity means by concentration treatment group: placebo (6.2±0.6) vs. desipramine <60ng/ml (4.5±0.6) vs. desipramine >60ng/ml (7.9±0.8) vs. fluoxetine (7.1±0.5).	"Preliminary evidence for a low-concentration 'therapeutic window' for noradrenergic analgesia may warrant additional study."	Study had 4 weeks of escalation and 8 weeks of maintenance. Reported successful blinding for participants and physicians. Numbers in each treatment group small; 32% dropout rate on desipramine largely due to adverse events.
Norepinephrine vs. SSRI vs. Other Medications						
Atkinson 1999 RCT Supported in part by Department of Veteran Affairs and National Institute of Health grant MO 1 RR00827. No mention of COI.	8.5	N = 103 with chronic LBP >6 months	Maprotiline (up to 150mg a day, n = 33) vs. paroxetine (up to 30mg a day, n = 34) vs. an active placebo group of diphenhydramine (n = 36) for 8 weeks.	Dropout rates somewhat high – 74/103 completed 8-week trial. Targeted doses 150mg/30mg/37.5mg respectively. Pain scores for maprotiline decreased 5.41±4.99 vs. 2.34±3.52 for paroxetine vs. 2.83±3.31 for placebo.	"[R]esults suggest that at standard dosages noradrenergic agents may provide more effective analgesia in back pain than do selective serotonergic reuptake inhibitors."	High withdrawal rate in paroxetine (12/34) and maprotiline (13/33) groups. Small sample size. Data suggest maprotiline superior to paroxetine.
Mazza 2010 RCT No COI or industry sponsorship.	4.5	N = 85, age >18 years, with chronic LBP with or without radiation to proximal lower limb; 13 week study.	Duloxetine 60mg/day (n = 44) vs. Escitalopram 20mg/day (n = 41) for 13 weeks.	No significant difference in pain reduction between 2 groups. Baseline to end point (p = 0.15) pain reduction.	"[T]his study did not demonstrate a difference between escitalopram 20 mg daily and duloxetine 60 mg daily on the reduction of average weekly pain in the treatment of CLBP."	No placebo group. Open label. Sparse results. Data suggest equal efficacy.
Norepinephrine vs. Other Medications vs. Placebo						

Khoromi 2007 Blinded Crossover Trial Study supported by intramural grant from National Institute of Dental and Craniofacial Research. MS Contin placebo tablets were gift from Purdue Pharma. No mention of COI.	8.0	N = 55 with chronic lumbar radiculopathy at least 3 months	Sustained-release morphine (15-90mg), nortriptyline (25-100mg), combined morphine and nortriptyline, and active control (benztropine 0.25- 1mg, chosen for similar adverse effects of dry mouth and mild constipation to better mimic drug vs. inert placebo).	Average leg pain in 28 who completed study (baseline, placebo, morphine, nortriptyline, combination): 4.9±2.4, 3.7±2.7, 3.4±2.8, 3.0±2.7, 3.4±2.5. Average back pain ratings same pattern as worst pain ratings. Morphine-nortriptyline combination also ineffective. Morphine least effective on all measures vs. placebo.	"[N]ortriptyline, morphine and their combination may have limited effectiveness in the treatment of chronic sciatica."	Data suggest no significant benefits of morphine, nortriptyline, or combination for radicular pain.

ANTI-CONVULSANT AGENTS

Anti-convulsant agents have been utilized off-label for some chronic pain syndromes since the 1960s, prominently including neuropathic pain, chronic radicular syndromes and diabetic neuropathy.(910-915) Reported uses have expanded to include treatment of nociceptive pain, fibromyalgia, and non-specific pain syndromes. Gabapentin, a GABA analog, is an anti-convulsant originally approved by the U.S. Food and Drug Administration (FDA) for treating seizures, particularly in conjunction with other anti-convulsants. The FDA later approved its use as a treatment of neuropathic pain. The mechanism of action is unknown. It is believed to act directly on the central nervous system, although not at the GABA receptor. Pregabalin is also an anti-convulsant and is used to treat neuropathic pain (see Chronic Pain Guideline for more details).

1. *Recommendation: Anti-convulsants for Peri-operative Pain Management*
   Gabapentin or pregabalin are strongly recommended for peri-operative management of pain to reduce the need for opioids, particularly in patients with adverse effects from opioids.

   Indications – Peri-operative pain management.
   Frequency/Dose – Varying doses used. Highest quality studies suggest gabapentin 300mg,(916) 600mg,(917) 800mg,(918) and 1200mg(919) 1 to 2 hours pre-operatively. Two studies suggested re-dosing 12 hours post-op of either gabapentin or pregabalin.(920, 921)

   Indications for Discontinuation – Resolution or intolerance. Careful monitoring of employed patients is indicated due in part to elevated risks for CNS-sedating adverse effects.
   Benefits –Reduced opioid use, which may potentially speed recovery and produce better outcomes.
   Harms – Drowsiness, dizziness and other CNS sedating effects are the most common adverse effects. Increased fatalities associated with opioids (2392).

   Strength of Evidence – **Strongly Recommended, Evidence (A)**
   Level of Confidence – High

2. *Recommendation: Anti-convulsants for Peri-operative Pain Management*
   There is no recommendation for or against the use of other anti-convulsant agents for peri-operative management of pain to reduce need for opioids, particularly in patients with adverse effects from opioids.

   Strength of Evidence –**No Recommendation, Insufficient Evidence (I)**

3. *Recommendation: Topiramate for Chronic Low Back Pain*
   Topiramate is recommended for chronic non-neuropathic pain or low back pain among patients with depression or anxiety.

   Indications for Initiation – Chronic LBP patients with depression or anxiety. Failure of multiple other modalities including trials of different NSAIDs, aerobic exercise, specific stretching exercise, strengthening exercise, anti-depressants, and distractants.

   Frequency/Dose – This medication is initiated by gradually increasing the dose – beginning at 50mg and increasing by 50mg/day each week.(922) The most appropriate steady dose is unclear, but appears to be 300mg. Patients should be carefully monitored for the development of adverse events.

   Indications for Discontinuation – Resolution, development of adverse effects, lack of improvement, or failure to adhere to a functional restoration program. Careful monitoring of employed patients is indicated due in part to elevated risks for central nervous system- (CNS) sedating adverse effects.

   Benefits – Modest reductions in pain and may improve psychological profile. Potential to spare need for more impairing medications.

Harms – Sedative effects are the highest risks especially in safety-sensitive or cognitively demanding positions.

Strength of Evidence **– Recommended, Evidence (C)**
Level of Confidence – Moderate

4. *Recommendation: Anti-convulsants for Acute, Subacute, or Chronic Low Back Pain*
Other anti-convulsants, including gabapentin, are not recommended for acute, subacute, or chronic low back pain (924, 2403-2405)**.**

Strength of Evidence **– Not Recommended, Evidence (C)**

5. *Recommendation: Anti-convulsants for Radicular Pain Syndromes*
Anti-convulsants, including gabapentin and pregabalin, are not recommended for chronic radicular pain syndromes (923-925, 2406) While there is evidence of efficacy for peripheral neuropathies (see Chronic Pain Guideline), the highest quality study of pregabalin for radicular pain was negative (2406).

Strength of Evidence – **Not Recommended, Evidence (C)**

6. *Recommendation: Gabapentin for Severe Neurogenic Claudication*
Gabapentin is recommended for treatment of severe neurogenic claudication with limited walking distance.

Indications – Severe neurogenic claudication from spinal stenosis or chronic radicular pain syndromes.

Indications for Discontinuation – Resolution or intolerance. Careful monitoring of employed patients indicated due in part to elevated risks for CNS-sedating adverse effects. If gabapentin dose is reduced, discontinued, or substituted with an alternative medication, this is recommended to be done gradually over a minimum of 1 week (a longer period may be needed at the discretion of the prescriber).
Benefits – Improved walking distance
Harms – Drowsiness, dizziness and other CNS sedating effects are the most common adverse effects. Increased fatalities associated with opioids (2392).
Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendations
There are a few quality studies evaluating other anti-epileptic medications for LBP and related disorders.(922, 926, 927, 2403) This class of medications has long been thought to be effective in treating neuropathic pain. However, that may not be correct,(922) as there appears no clear pattern to indicate that a single conclusion of efficacy for this class of medications for a group of disorders is accurate. Instead, treatments appear to require specification or individualization. There is quality evidence that topiramate is effective for treating chronic LBP,(922) thus an anti-epileptic has been shown to be effective for nociceptive pain instead of neuropathic pain.

The most commonly used medication in this class may be carbamazepine. However, as it has been available in a generic formulation, it has not been studied in large-, moderate-, or high-quality studies for purposes of treating chronic pain. There is however some evidence from both an experimental design,(926) as well as from inference from a chemically related compound, oxcarbazepine,(911) that it is useful for treatment of neuropathic pain. Thus, it presumably has some efficacy for treatment of chronic radicular pain syndromes.

Gabapentin and the closely related compound pregabalin have been evaluated in quality studies for treatment of multiple pain syndromes. However, results are not uniformly positive for all conditions (see Chronic Pain Guideline for other conditions). A meta-analysis failed to find statistical benefit of gabapentinioids for treatment of LBP and reported several adverse effects (924, 2403-2405) One study analyzed neurogenic claudication and found significant improvements in distances walked.(928) Studies do not clearly indicate whether the overall risk/benefit analysis favors use of gabapentin for treatment of LBP (other than perhaps pre-operatively) given that its use can be associated with moderately significant side effects, such as nausea (19%), dizziness (24%) and mentation problems.(924, 928, 929) Results for other spine conditions conflict.

Gabapentin has been shown to reduce post-operative pain and the need for opioids in patients undergoing back surgery (2407). Almost all of these studies except one,(918) showed efficacy, with one showing significant, dose-dependent reductions across a range of 4 different doses.(917) Thus, quality evidence documents that gabapentin reduces the need for post-operative opioids. It has not been shown effective for LBP. One study on chronic radicular pain is of short-term duration(925) and another 1 month study of pregabalin found little efficacy for treatment of chronic radicular symptoms.(923) Gabapentin has beneficial effects (distance walked) for patients with severe spinal stenosis.(928) Gabapentin and pregabalin are not invasive, have moderately significant side effects, and are moderately costly. Side effects are largely CNS-related and are of concern in employed populations. Gabapentin and pregabalin are not controlled substances, but do have psychoactive properties and therefore do carry slight risks of abuse.

Anti-epileptic agents may be reasonable fourth- or fifth-line treatments (e.g., after trials of different NSAIDs, aerobic exercise, other exercise) to attempt to treat chronic radicular symptoms. Physicians prescribing such agents in patients employed in safety-sensitive positions should be aware that such medications may raise concerns about fitness for duty due to the possibility of a seizure disorder. These drugs are not invasive, have some adverse effects, and may be moderately costly. There is no evidence for efficacy in chronic radicular pain syndromes, but these medications have been used for treatment, although not as first- or second-line treatments, as NSAIDs, muscle relaxants, aerobic exercise, other exercise, and manipulation are all likely more efficacious.

Evidence for the Use of Anti-convulsant Agents
We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with limits on publication dates from 2011-2012 and then an updated search was conducted using PubMed for publications between 1/1/2013 and 11/15/2017. We used the following search terms: radicular pain syndrome, sciatica, carbamazepine, anti-convulsant agents, and neuropathic pain, randomized clinical trial or randomized controlled trial or random, systematic review or reviews, population study or epidemiological study or prospective cohort to find 2,022 articles. Of the 5,420 articles, we reviewed 20 articles and included 20 articles (16 randomized controlled trials and 4 systematic reviews.

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Topiramate vs. Placebo: Non-specific LBP										
Muehlbacher 2006 (score= 9.0)	Anticonvulsant agents/ Topiramate	RCT	The authors declared no sponsorship. No mention of COI.	N = 96 patients with chronic LBP and depressive disorders (26%) and anxiety disorders (7.3%)	Mean age: 48.8 years; 60 males, 36 females	Topiramate group: patients received treatment with 50 mg topiramate per week for 5 weeks and 300mg per day for 4 weeks (n = 48) vs. Placebo group: patients received weekly 50 mg placebo for 10 weeks (n = 48).	No mention of follow-up time length..	Elevated rates of adverse effects above placebo present for CNS depressive symptoms of somnolence, vision problems, psychomotor slowing, memory problems, dizziness, but not statistically elevated risks. Pain ratings initial to final: topiramate (35.7±2.6 to 22.9±1.4) vs. placebo (35.9±2.4 to 34.3±2.3). Body weight also reduced in active treatment vs. controls as were State-Trait anger expression inventory measures.	"Topiramate treatment of patients with CLBP showed reduction of pain symptoms and aggressive mood, in addition to improvement in their ability to manage everyday life and in health-related quality of life. Topiramate was significantly more effective than placebo in reducing the PRI (MPQ)."	Data suggest topiramate modestly efficacious.
Gabapentin vs. Placebo: Perioperative										
Turan 2004 (score= 8.5)	Gabapentin	RCT	Sponsored by the Trakya University Medical Faculty and Department of Anacsthesiology. No mention of COI.	N = 50 undergoing spinal surgery	Mean age: 46.5 years; 28 males, 22 females	Gabapentin group: patients received 1200 mg gabapentin 1 hour before operation (n = 25) vs. placebo group: patients received placebo for peri-operation management (n = 25).	Follow-up at 24 hours.	Gabapentin vs. placebo morphine consumption (mg) for 1, 2, 4, 6, 12, 24 hours and total morphine consumption: 4.3±1.8/6.7±2.1, 2.7±1.8/5±2.4, 2.4±1.8/6.4±4.3, 2.4±2.4/6.2±3.9, 2.9±2.3/8±5.1, 3.8±4.6/11.4±5.4, 16.3±8.9/42.8±10.9. Overall lower MS with gabapentin, p <0.0001.	"[G]abapentin decreased pain scores in the early postoperative period and decreased postoperative morphine consumption while decreasing the side effects associated with morphine in patients undergoing spinal surgery."	Small numbers. Details of surgery not described. Pre-op medication/opioid use not described. Data suggest 1200mg gabapentin given 1 hour prior to surgery reduced early post-op pain and reduced need for opioid analgesia.

Pandey 2005 (score= 8.5)	Gabapentin	RCT	No mention of sponsorship nor COI	N = 100 patients with lumbar discectomy.	Mean age: 41.2 years; 67 males; 33 females.	Group 1: patients received placebo with 5 capsules (n=20) vs. Group II: patients received 1 capsule 300 mg gabapentin and placebo with 4 capsules (n=20) vs. Group III: patients received 2 capsules 600 mg gabapentin and placebo with 3 capsules (n=20) vs. Group IV: patients received 3 capsules 900 mg gabapentin and placebo with 2 capsules (n=20) vs. Group V: patients received 4 capsules 1200 mg gabapentin and placebo with 1 capsule (n=20).	Follow-up at 24 hours.	Preemptive gabapentin 300 to 1,200mg reduced pain severity after single-level lumbar discectomy at 6, 12, 18, and 24 hours, and decreased fentanyl consumption in initial 24 hours vs. placebo.	"[6]00-mg single preemptive oral dose of gabapentin significantly decreased the severity of pain occurrence until 24 hours postoperatively in single-level lumbar discectomy and decreased the total fentanyl consumption in comparison with placebo and gabapentin 300mg."	No mention of co-intervention such as radiculopathy diabetes or other neuropathy at baseline. Post-op analgesia decreased by gabapentin 600mg. Follow-up to previous study. Author suggests optimal dose of pre-op gabapentin for analgesia is 600mg 2 hours prior to surgery.
Radhakrishnan 2005 (score= 8.0)	Gabapentin	RCT	No mention of sponsorship nor COI.	N = 60 patients following laminectomy and discectomy	Mean age: 40.65 years; 40 males; 20 females.	Gabapentin group: patients received 2 capsules 800 mg of gabapentin (n = 30) vs. placebo group: patients received 2 capsules of placebo (n = 30).	Follow-up for 8 hours.	Amount of morphine used in post-op period did not differ.	"[O]ur study did not demonstrate any opioid sparing effect of gabapentin (800 mg in two equally divided doses) administered preoperatively."	Study used higher dosage than previously reported positive studies. Data suggest no benefit from pre-op gabapentin for low back surgery (lumbar laminectomy, discectomy).
Pandey 2004 (score= 8.0)	Gabapentin	RCT	No mention of sponsorship nor COI.	N = 56 patients who underwent lumbar discectomy	Mean age: 38.8 years; 38 males; 18 females.	Gabapentin group: patients received 300 mg of gabapentin 2 hours prior to surgery (n = 28) vs. Placebo group: patients received placebo 2 hours prior to surgery (n = 28).	No mention of follow-up.	VAS pain scores 3.5±2.3 vs. 6.1±1.7 at 0 to 6 hours, and remained significantly different at 18 to 24 hours (1.2±1.3 vs. 2.1±1.2).	"[A] preemptive 300 mg oral dose of gabapentin decreases significantly the incidence of pain postoperatively in patients who undergo lumbar discoidectomy without significant adverse effects."	Placebo controlled study suggesting decreased post-op pain for first 24 hours within use of gabapentin. Data suggest improved post-op analgesia from pre-op oral gabapentin.
Khan 2011 (score= 6.5)	Gabapentin	RCT	No mention of sponsorship. The authors	N = 175 patients who underwent lumbar	Mean age: 41.8 years; 113 males, 62 females.	Group I: patients received only placebo (n = 25) vs. Group II: patients received 600mg of gabapentin	No mention of follow-up.	Post-operative MS in first 24 hours was less in groups 4-7 vs. Groups 1-3 ($p < 0.05$). During first 12 hours,	"Gabapentin 900 or 1200mg, administered either pre- or post-incision, was found to be effective in pain	Short follow-up. Data suggest gabapentin spared MS use.

			declared no COI.	laminectomy		before incision (n = 25) vs. Group III: patients received 600 mg of gabapentin after incision (n = 25) vs. Group IV: patients received 900 mg of gabapentin before incision (n = 25) vs. Group V: patients received 900 mg of gabapentin after incision (n = 25) vs. Group VI: patients received 1200 mg of gabapentin before incision (n = 25) vs. Group VII: patients received 1200 mg of gabapentin after incision (n = 25).		Groups 4-7 showed lower VAS pain scores vs. Groups 1-3 ($p < 0.05$). However, VAS scores were comparable in Groups 1-3 and 4-7. ANOVA test was significant ($p<0.001$ and $p<0.001$, respectively).	management following lumbar laminectomy. Similar doses of gabapentin provide the same post-operative analgesia whether administered pre- or post-incision."	
Kim 2011 (score= 6.5)	Pregabalin	RCT	The authors declared no sponsorship nor COI.	N = 84 patients who were scheduled for elective posterior lumbar spinal fusion	Mean age: 44 years; 84 males, 0 female.	Placebo group (n = 28) vs. Pregabalin or P75 group at 75mg (n = 28) vs. Pregabalin or P150 group at 150mg (n = 28). Each group received treatment 1 hour before surgery and 12 hours after surgery.	No mention of specific follow-up time length.	VAS pain scores without significant differences at any time points. P150 group showed less cumulated PCA volume (Patient-Controlled Analgesia) infused until 24 hours ($p = 0.025$) and 48 hours ($p = 0.028$). Frequency of additional anodynes administered lower in P150 group vs. controls at 6 hours ($p = 0.049$) and 24 hours ($p = 0.045$).	"Perioperative administration of pregabalin 150 mg before and 12 hours after surgery, but not 75 mg, significantly reduced opioid consumption and the use of additional pain rescue for 48 hours after surgery without significant side effects in patients undergoing spinal fusion surgery."	Short follow-up. Data suggest reduced opioid consumption
Ozgencil 2011 (score= 5.5)	Pregabalin/ Gabapentin	Randomized, double-blind, placebo-controlled study	No mention of COI or industry sponsorship	N = 90 who underwent lumbar laminectomy and discectomy.	Mean age: 50.4 years; 40 males, 50 females.	Pregabalin group at 150mg (n = 30) vs. Gabapentin group at 600mg (n = 30) vs. Placebo group (n = 30). Dosesadministered every 12	No mention of follow-up.	Morphine consumed similar in 3 groups from 1st-4th hour post-op. At 6 hours, morphine consumption significantly lower in	"This study showed that both pregabalin 300 mg day−1 and gabapentin 1,200 mg day−1 have more analgesic, anxiolytic and opioid-sparing	24 hour follow-up. Data suggest pregabalin spares morphine use.

						hours for each group, 2 times pre- and post-surgery.		pregabalin group vs. placebo. (p <0.003). At 12th and 24th hour, gabapentin group (p <0.013 and p <0.005) and pregabalin group (p <0.001 and p <0.001) had significantly lower levels of morphine consumption vs. placebo. VAS pain scores recorded 1st, 2nd, 3rd and 6th post-op hours significantly lower in gabapentin (p <0.003, p < 0.001, p <0.001, and p <0.001 respectively) and pregabalin group (p <0.001, p <0.001, p <0.001, p <0.001) vs. placebo group.	effects, higher patient satisfaction and are more effective for preventing postoperative shivering than the placebo following lumbar laminectomy and discectomy. The findings revealed that pregabalin 300 mg day−1 had equivalent analgesic, adverse and opioid sparing effects and patient satisfaction as gabapentin 1,200 mg day−1."	
Gabapentin vs. Placebo: Radicular Pain										
McCleane 2001 (score= 6.5)	Gabapentin	RCT	No mention of COI or industry sponsorship.	N = 80 with LBP and associated referred leg pain (neuropathic pain excluded)	Mean age: 44.7 years; 29 males, 36 females	Gabapentin (300mg, n = 31) vs. placebo (n = 34).	Follow-up for 8 weeks.	Gabapentin showed a significant difference from baseline to week 8 in back pain movement, and leg pain: p <0.05.	"Gabapentin in a dose increasing to 1,200mg a day was found to have no effect on background pain and only a marginal effect on referred pain and pain on movement."	Unclear if double counting. Hospital-based pain clinic patients. Baseline characteristics sparse. Co-interventions not well described. Gabapentin did not have significant effect on non-neuropathic chronic low back and leg pain.
Yildirim 2003 (score= 4.0)	Gabapentin/ Radiculopathy	RCT	No mention of COI or industry sponsorship.	N = 50* with chronic L5 or S1 radiculopathy mean duration 68.5 months. *50 patients	39 years; 18 males, 32 females.	Gabapentin (dosage titrated from 900mg a day to 3,600mg a day, n = 23) vs. placebo (n = 20). Follow-up for 8 weeks. Run-in phase: Gabapentin administration initiated gradually	No mention of follow-up.	Gabapentin significant improvement at first control in pain at rest, muscle strength, limitation of spinal flexion, straight-leg raise test, sensory function: p <0.001, p <0.01, p <0.001, p	"Gabapentin was particularly effective on parameters such as, intensity of pain, muscle strength, limitation of spinal flexion, straight leg raising test, and sensory function.	Radiculopathy definition likely included both true radiculopathy patients and patients with non-specific LBP with referred pain. Intergroup statistics not well defined. Data suggests modest efficacy.

				started the trial (7 dropped during the trial)		starting with 900mg for first days, then dosage usually increased every 3 days up to 3600mg per day, but when side effects observed, dosage reduced to tolerable levels. Seven female patients dropped out (2 from treatment group with adverse effects and 5 from placebo group due to inefficacy).		<0.001, p <0.001. Placebo significant improvement at first control for sensory function, p <0.05.	Gabapentin, moreover, works significantly better than placebo."	
Gabapentin vs. Placebo: Spinal Stenosis										
Yaksi 2007 (score= 4.0)	Gabapentin	RCT	No funds received in support of this work. No mention of COI.	N = 55 with claudication from lumbar spinal stenosis	Mean age: 50.8 years; 18 males, 37 females.	Gabapentin adjuvant treatment (dose titrated from 900 to 2,400mg/ day, n = 28) vs. control (n = 27) for 4 months. All received PT exercises, lumbosacral corset, steel bracing, NSAIDs. Follow-up for 4 months. All patients analyzed in study. Run-in period above. No mention of wash-out period. "All patients continued the treatment to completion, and none of the patients experienced side effects severe enough to stop the drug."	Follow-up at baseline, 4 months.	Gabapentin vs. placebo mean±SD for changes in VAS score Months 3 and 4: 3.6±2.2/4.8±2.2, p = 0.039, 2.9±2.6/4.7±2.2, p = 0.006.	"[E]xtensive clinical studies are warranted to investigate the role of gabapentin in the management of symptomatic LSS."	No blinding, no placebo control. Data suggest no significant differences.
Pregabalin vs. Placebo: Radicular Pain or Spinal Stenosis										
Baron 2010 (score= 8.5)	Pregabalin	RCT - Single and double blind	No mention of COI or industry	N = 217 with chronic lumbosacral radiculop	Mean age: 52.6 years; 107 males,	1-week single-blind placebo run-in phase (ID placebo responders, ≥50% pain	Follow-up at baseline, 43 days.	Percent of days with severe/mild-no pain: pregabalin (7.1/61.8%) vs. 6.4/62.4%), NS.	"[A]lthough a satisfactory response for pain, sleep disturbance and quantity, and	Single blind run-in, 35 day RCT. Adverse effects in 32/363 (8/8%). Lack of efficacy in single-blind

			sponsorship.	athy from spinal stenosis or disc herniation; pain required in calf or foot in L5 or S1 with sensory change or muscle weakness; if LBP, required calf/foot pain;	110 females.	reduction). 4-week single-blind pregabalin (150-600mg a day) to identify responders (≥30% pain reduction with pregabalin), continued double-blind phase (pregabalin, n = 110) vs. placebo) 5 weeks with optimal dose from prior phase; then tapered off (n = 107). Wash-out 1-week period; 151 withdrew from single blind part of study before double-blind randomization; 31 withdrew from double blind part of study.		Mean pain score change -0.16 (pregabalin) vs. -0.05 (placebo), p = 0.332. After single-blind run-in, pain score decreased: mean 2.3 from 6.4 baseline. Most (57.9%) had ≥30% pain reduction and 34% ≥50% pain reduction.	anxiety parameters was observed during the pregabalin single-blind phase, there was no significant difference in time to LOR (increase in pain, use of rescue medication, or discontinuation from study) between patients who discontinued pregabalin treatment and patients who continued to take pregabalin for 5 weeks, although 57.9% of patients who received one or more doses of single-blind pregabalin were responders."	run-in 82/363 (22.6%). Data suggest minimal to no efficacy. Data also suggest diminished to no effect by 1 month.
Mathieson, 2017 (score=8.5)	Pregabalin	RCT	Sponsored by a grant from the National Health and Medical Research Council of Australia. No COI	N = 209 patients with sciatica	Mean age: 53.8 years; 92 males, 115 females	Pregabalin group, given pregabalin 150mg per day and up to 600mg at 8 weeks (n=106) VS placebo group, given same dosing as pregabalin group of placebo for 8 weeks	Follow-up at 2 , 4, 8, 12, 26, and 52 weeks	The leg intensity score at 8 wks was 3.7 in the pregabalin group and 3.1 in the placebo group, respectively; at 52 wks the score was 3.4 and 3.0, respectively. The adjusted mean difference (95% CI) for leg pain intensity at 8 wks was 0.5 (-0.2 to 1.2), P=0.19; at wk it was 0.3 (-0.5 to 1.0), P= 0.46.	"Treatment with pregabalin did not significantly reduce the intensity of leg pain associated with sciatica and did not significantly improve other outcomes, as compared with placebo, over the course of 8 weeks. The incidence of adverse events was significantly higher in the pregabalin group than in the placebo group."	Data suggest lack of efficacy but twice as many adverse events occurred in pregabalin group
Prevention of Neuropathic Pain after Spinal Cord Injury										
Salinas 2012 (score=7.0)	Neuropathic pain/ Carbamazepine	RCT	Funded by Colciencias and the Universidad de	N = 46 with a spinal cord injury sustained <2	Mean age: 36 years; 42 males, 4 females.	Carbamazepine (up to 600mg/day) (n = 24) vs. placebo (n = 22). Follow-up at 1, 3, and 6 months.	Follow-up at baseline, 1, 3, and 6 months.	At 1 month, 8 patients in placebo and 2 in carbamazepine group reported moderate-intense pain	"Early intervention with carbamazepine decreased NP incidence at the 1 month but not	Study to evaluate efficacy to prevent neuropathic pain in spinal cord injury population, with small sample

			Antioquia. No COI declared.	weeks before enrollment and without evidence of neuropathic pain (NP)				(VAS, ≥40, p = 0.024); not seen at 3 or 6 months. No differences between groups in numbers receiving some treatment for NP or occurrence or intensity of depression. No differences in any SF-36 subscales or in bodily pain.	at the 3 and 6 month follow-ups in the group of patients with acquired spinal cord injury."	size. Data suggest no intermediate to long term prevention of neuropathic pain.
Other										
Harke 2001 (score= 6.0)	Carbamazepine / Morphine	RCT	No mention of COI or industry sponsorship.	N = 43 with peripheral neuropathic pain, including pain reduced by spinal cord stimulation	Mean age: 55.1 years; 21 males; 22 females.	Phase I: carbamazepine (600 mg a day, n = 19) vs. placebo (n = 19) for 7 days. Phase II: Sustained-release morphine (90mg a day, n = 20) vs. placebo (n = 15) for 8 days.	Follow-up at baseline, 37 days.	Differences between groups (sustained release morphine vs. placebo) for partial responders vs. non-responders at pain regeneration time without SCS (hour), and maximum pain (NAS): p = 0.32/p = 0.52, p = 0.41/p = 0.83. (CMZ) vs. placebo differences: p = 0.03/p = 0.65, p = 0.04/p = 0.06.	"[C]MZ is effective in peripheral neuropathic pain. Morphine obviously requires larger individually titrated dosages than those used in this study for results to be adequately interpreted."	Data suggest carbamazepine effective and appears more effective than morphine.
Romanò 2009 (score= 5.5)	Pregabalin, NSAIDs	RCT	No mention of COI or industry sponsorship	N = 36 with chronic LBP due to disc prolapse, lumbar spondylosis and/or spinal stenosis, and VAS >40	Mean age: 53±16 years; 16 males, 20 females	Celecoxib (3-6 mg/kg/d) plus placebo (n = 12) vs. pregabalin (1mg/kg/d) for 1week followed by placebo vs. celecoxib (3-6mg/kg/d) plus pregabalin (1mg/kg/d) for 4 weeks.	Follow-up at baseline, 12 weeks	Drug combination group (celecoxib plus pregabalin) showed statistically significant improvement compared to pregabalin plus placebo (p = 0.0001) and celecoxib plus placebo (p = 0.001).	"[C]elecoxib and pregabalin proved to be superior to either single agent, with comparable side-effects and reduced mean consumption of any single drug (calculated as mean administered dosage per patient weight)."	Quasi-randomized by order of enrollment. Enrollment criteria pre-supposed etiology of CLBP use of LANSS tool described as possible predictor of efficacy. Data suggest no benefit from celecoxib or pregabalin alone, with clinical improvement with combination. Small sample and heterogeneous patients (spinal stenosis/LBP) limit conclusions.

BISPHOSPHONATES

Bisphosphonates reduce osteoclastic activity, resulting in net gain of bone mass. While more popularly used for treating and preventing osteoporosis, bisphosphonates have been used to treat CRPS.(933) (See Chronic Pain Guideline). They have been postulated to have analgesic properties.(934)

Recommendation: Bisphosphonates for Chronic Low Back Pain

Bisphosphonates are not recommended for patients with chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation

There are no quality studies evaluating the use of bisphosphonates for chronic LBP. Bisphosphonates are either not invasive in oral formulations or are minimally invasive in parenteral administrations. They are moderate to high cost and have adverse effects that include gastritis, reflux esophagitis (can be severe and erosive causing stricture and achalasia), subtrochanteric hip fracture, and osteonecrosis of the jaw (uncommon). Based on the literature, their use is recommended for consideration as an option for CRPS in patients who have remained symptomatic despite other interventions (see Chronic Pain Guideline). However, since there is no evidence for LBP, they are not recommended.

Evidence for the Use of Bisphosphonates

There are no quality studies incorporated into this analysis.

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates. The search terms used included Bisphosphonates, chronic low back pain, Clinical trial, randomized controlled trial, random. Of those, we included none of the RCTs and reviews.

CALCITONIN

Calcitonin, the lesser known of the thyroid's two main hormones, is secreted by parafollicular cells, and is involved in increasing calcium uptake from the GI tract while also decreasing bone resorption. It is also thought to have anti-nociceptive effects that have not been well elucidated.(935)

Recommendation: Calcitonin for Chronic Low Back Pain

Calcitonin is not recommended for the treatment of chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation

There is no evidence of efficacy. Calcitonin is minimally invasive, has relatively few adverse effects, and is moderately costly (see Chronic Pain Guideline). Adverse effects are relatively rare and include nausea, vomiting, decreased appetite, abdominal pain, injection site reactions, nasal symptoms, rhinitis, sinusitis, anaphylaxis, bronchospasm, hypersensitivity reactions, osteogenic sarcoma, and hypocalcemic tetany.

Evidence for the Use of Calcitonin

There are no quality studies incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: Calcitonin, chronic, low, back, and pain to find 32,668 articles. Of the 32,668 articles, we reviewed zero articles and included zero articles.

COLCHICINE

Colchicine inhibits microtubule formation. Its primary use is to treat acute gout attacks. Because of its anti-inflammatory properties, it has been used to treat LBP. Thiocolchicoside is a muscle relaxant derived from colchicoside.

1. *Recommendation: Oral and IV Colchicine for Acute, Subacute, or Chronic Low Back Pain*
   Oral and IV colchicine are not recommended for treatment of acute, subacute, or chronic low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Thiocolchicoside for Acute, Subacute, or Chronic Low Back Pain*
   There is no recommendation for or against the use of thiocolchicoside for the treatment of acute, subacute, or chronic low back pain.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendations

The results from studies of colchicine are conflicting and there is no clear evidence of lasting benefit.(936-938) Newer results with thiocolchicoside are more impressive,(939, 940) but need to be replicated by a different group. Intravenous or intramuscular colchicine is invasive, moderately expensive, has potentially serious adverse effects, and has not been shown to be superior to placebo. Oral colchicine is not invasive, has adverse effects, is not costly, but has not been shown to be superior to placebo.

Evidence for Use of Colchicine

There are 5 moderate-quality RCTs incorporated into this analysis.(936-940)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: Oral colchicine, colchicine, Thiocolchicoside, IV placebo, Oral TCC, tizanidine, subacute, low, back, pain, and chronic to find 20,676 articles. Of the 20,676 articles, we reviewed and included 5 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Thiocolchicoside vs. Placebo						
Tüzün 2003 RCT No mention of COI or industry sponsorship.	7.5	N = 149 with acute LBP <72 hours >5 days in Turkey	Thiocolchicoside 4mg BID IM for 5 days (n = 74) vs. placebo IM injections (n = 69).	VAS scores fell from 71±18 to 25±21 vs. 73±16 to 47±20 (p <0.0005). ROM measured by distance from fingers to floor decreased 33±16cm to 14±14cm vs. 34±18cm to 22±13cm; p <0.001 on Day 3 for treatment group; p <0.0005 Day 5.	"[T]wice daily administration of 4 mg thiocolchicoside group for 5 days provides an efficient and safe treatment for patients with acute LBP accompanied by muscle spasm."	Data suggest thiocolchicoside provides more benefits than placebo for acute LBP associated with paravertebral muscle spasm (inspection, palpation), over 5-day treatment course.
Colchicines vs. Placebo						
Simmons 1990 RCT No mention of COI or industry sponsorship.	4.5	N = 48 with LBP <6 months	Intravenous colchicine (1mg colchicines in 50ml solution, n = 30) vs. placebo (n = 18) for 3 weeks.	Minimal partial relief or good significant relief of pain 19% vs. 54% for colchicine, but duration usually 1-3 hours, occasionally up to 1 or 2 days.	"This treatment may be discouraging in light of the short duration of a symptomatic improvement, the risk of complications, and the cost."	Sparse details. Differences in treatment group size (18 vs. 30) and other baseline differences (gender and duration of symptoms) concerning.
Schnebel 1988 RCT No mention of COI or industry sponsorship.	4.5	N = 27 with LBP <3 months	Oral colchicines (0.6 mg, n = 12) vs. placebo (n = 15) for 12 weeks.	VAS pain ratings decreased from 7.3 to 5.6 in placebo group vs. 7.1 to 5.9 (not significant).	"[T]reatment of low-back pain with oral colchicine with the dosage regimen described above provided no advantage over placebo treatment."	Small sample size. Conclusions limited by concomitant co-interventions, as all groups received ibuprofen, cyclobenzaprine, and PT. Data suggest no benefit from addition of colchicine.
Thiocolchicoside vs. Other medications vs. Placebo						
Ketenci 2005 RCT No mention of COI or industry sponsorship.	5.5	N = 97 with acute LBP associated with muscle spasm	Three arms compared thiocolchicoside (8mg AM and PM, n = 38) vs. tizanidine (placebo AM and 6mg PM, n = 32) vs. placebo (AM and PM, n = 27) in Turkey, 5-7 days.	Thiocolchicoside found superior for relief of back pain without sedative effects of tizanidine.	"[O]ral TCC is at least as effective as TZ in acute LBP patients, but showing a more pronounced effect on pain at rest with a significant reduction observed in its effects on the psychomotor performances of the patients."	Unsuccessful randomization, which is not well described. There are differences in baseline measures of tiredness, dizziness, and alertness. Somewhat variable follow-up length.
Colchicines vs. Other Medications vs. Placebo						
Meek 1985 RCT No mention of COI or industry sponsorship.	4.0	N = 39 with disc disorders	IV colchicines or IV placebo, followed by colchicines; 0.6mg BID (n = 18) vs. placebo BID (n = 21) for 14 days.	Frequency distribution of double-blind efficacy in disc disease comparing colchicine vs. placebo: not improved 3 vs. 14. Marginally better 2 vs. 3. Improved 2 vs. 2. Much improved 10 vs. 2; p = 0.01 difference between both groups.	"[E]very one of the twelve parameters of measurement of patient clinical response, marked and immediate improvement occurred following the administration of Colchicine. Conversely, the "placebo" patients either failed to respond, or did so much more gradually and generally incompletely."	Randomization not described, uncertain if truly an RCT. Lack of study details such as baseline characteristics and co-interventions make interpretation problematic. Small numbers.

KETAMINE

Ketamine is a strong NMDA receptor antagonist that is also a general anesthetic and has been used orally and intravenously to treat CRPS(941-943) and other neuropathic pain conditions (see Chronic Pain Guideline). Ketamine affects a number of receptors and inhibits serotonin and dopamine reuptake and has also been used as an adjunct to psychotherapy in alcohol and heroin addiction.(944)

Recommendation: Ketamine for Chronic Low Back Pain

Ketamine infusion is not recommended for treatment of chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

High-quality experimental studies show intravenous ketamine can lead to pain reductions in patients with chronic neuropathic pain; however, the pain reduction paralleled the length of the infusion with follow-up periods of 160 minutes or less. Adverse effects were considerable.(945, 946) Lower, oral doses have been associated with lightheadedness, dizziness, tiredness, headache, bad dreams, and sensory changes. Ketamine has high abuse potential and when used as a general anesthetic leads to direct myocardial and respiratory depression. Ketamine is invasive, has adverse effects (e.g., respiratory depression and hallucinations), and is moderate to high in cost. Other treatments have evidence of efficacy. Ketamine is not recommended for diagnostic or therapeutic use until clinical studies demonstrate efficacy.

Evidence for the Use of Ketamine

There are 2 high-(945, 946) and 3 moderate-quality(947-949) RCTs/ crossover trials incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates. We used the following terms: ketamine infusion, ketalar infusion, intravenous ketamine, intravenous ketalar, chronic low back pain and low back pain. This search found 1,100 articles, we reviewed 557 and included 4 article.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Kvarnström 2003 RCT/Crossover Trial Industry sponsored (the Swedish Medical Research Council grant no. 9077 (TG) and from Astra Zeneca R&D, So¨derta¨lje, Sweden) and no mention of COI.	8.0	N = 12 with neuropathic pain	Ketamine 0.4mg/kg vs. lidocaine 2.5mg/kg vs. saline. Follow-up 160 minutes.	Patients had post-op pain (n = 9), trauma operations (n = 2), disc hernia (n = 1). Mean reductions in VAS scores: ketamine 55%, 34% lidocaine, 22% placebo; 50% or greater response rates for 58.3% ketamine vs. 33.3% lidocaine vs. 16.7% placebo. Adverse effects (ketamine/lidocaine/placebo): somnolence (100/75/33%), light-headedness (75/42/8%), out-of-body sensation (67/34/0%), nausea (33/25/8%), paraesthesia (83/17/0%), unpleasant experience (50/8/17%).	"Ketamine showed a significant analgesic effect. The clinical usefulness is, however, limited by disturbing side-effects."	Small sample size. Short-term follow-up of IV medication trial demonstrated no difference between placebo and lidocaine and rapid benefit with ketamine, but rapid return to baseline after administration. Response rate low.
Kvarnström 2004 RCT/Crossover Trial No mention of COI or industry sponsorship.	8.0	N = 10 with chronic pain after spinal cord injury (SCI) that averaged 9 years duration	Ketamine 0.4mg/kg vs. lidocaine 2.5mg/kg vs. saline placebo.	At least 50% reductions in VAS scores during infusions found during 50% of ketamine, 10% of lidocaine, 0% of placebo infusions.	"Ketamine but not lidocaine showed a significant analgesic effect in patients with neuropathic pain after spinal cord injury. The pain relief was not associated with altered temperature thresholds or other changes of sensory function."	Short-term experiment with IV medication. Spinal cord injury patients. Requires longer term follow-up to determine if significant efficacy.
Amr 2011 RCT No mention of COI or industry sponsorship.	7.5	N=200, with lumber radiculopathic LBP	Group 1 triamcinolone 80mg and 0.25% bupivacaine (3mL)+ ketamine 30mg (n = 100) vs. Group 2: triamcinolone 80mg and 0.25% bupivacaine (3mL)+ 2 mL NS (n = 100). Dropouts (n = 26).	Pain scores in Group I vs. Group II at 1 week/month, 3, 6, 9, 12 months after treatment (p <0.0001); ODI scale decreased significantly in Group I versus Group II, (p <0.0001). At all time, pain scores were significantly lower in both groups compared to pre-injection scores, p <0.05).	"Epidurally administrated ketamine seems to be a safe and useful adjunct to epidural corticosteroid therapy in chronic radiculopathic pain."	Data suggest bupivacaine plus triamcinolone plus ketamine superior to triamcinolone plus bupivacaine from 1 week to 12 months of follow-up. No placebo group.

Loftus 2010 RCT No mention of COI or industry sponsorship.	6.5	N = 102 with chronic back pain	0.5mg/kg intravenous ketamine on induction of anesthesia and continuous infusion of 10μg/(kg*min) begun on induction and terminated at wound closure (n = 52) vs. saline of equivalent volume (n = 50). Follow-up at 6 weeks.	Ketamine group 37% and 30% less morphine during 48-hour post-op period (309±341mg, placebo; 195±111mg, treatment: p = 0.029) and during 24-hour post-op period (202±176mg, placebo; 142±82mg, treatment; p = 0.032). Ketamine group 26.2% pain intensity reduction at 6 weeks (4.2±2.4cm, placebo: 3.1±2.4cm, treatment; p = 0.026).	"[L]ow-dose ketamine should be considered as part of multimodal therapy for all patients with chronic pain who are undergoing painful surgery."	Data suggest lower MEQs used and better pain control with induction ketamine.
Subramaniam 2011 RCT - Double-blind No mention of COI or industry sponsorship.	6.0	N = 30 who underwent lumbar or thoracolumbar laminectomy and fusion for back pain	Treatment group had ketamine IV 0.15mg/kg at induction then 2μg/kg/min IV intraoperatively and postop. for 24 hours (n = 15) vs. controls IV NS bolus at induction and IV infusion for 24 hours (n = 15). Pain monitored via VAS scale at 0, 1, 2, 4, 8, 12, 18, 24, 36, 48 hours after surgery.	After operation, VAS scores recorded for both groups at rest and while moving. NS at rest VAS scores: 0 hours – 7.5±3.3, 12 hours – 5.3±2.8, 24 hours – 4.7± 2.8, 36 hours – 4.5±2.8, and 48 hours – 4.3±2.2. Ketamine at rest VAS scores: 0 hours – 7.7±2.6, 12 hours – 5.9±3.0, 24 hours – 5.3± 3.0, 36 hours – 4.9±3.0, and 48 hours – 4.8± .6. NS while moving VAS scores: 0 hours – 8.3±3.2, 12 hours – 7.3±2.7, 24 hours – 6.5± 2.3, 36 hours – 6.4±2.4, and 48 hours – 6.3±2.1. Ketamine while moving VAS scores: 0 hours – 8.4±2.3, 12 hours – 7.1±3.2, 24 hours – 6.9±3.2, 36 hours – 6.7± 3.4, and 48 hours – 7.0±3.3.	"The addition of IV very low dose ketamine infusion regimen did not improve postoperative analgesia. Side effects were not increased with low dose ketamine."	Small sample size. No differences in post-op hydromorphone use. Data suggest lack of efficacy.

KETANSERIN

Ketanserin is a selective S2 serotonergic antagonist that has been used to treat patients with CRPS (see Chronic Pain Guideline).

Recommendation: Ketanserin for Chronic Low Back Pain
Ketanserin is not recommended for treatment of chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no quality studies evaluating ketanserin for treatment of chronic LBP (see Chronic Pain Guideline).

Evidence for the Use of Ketanserin
There are no quality studies incorporated into this analysis.

We search PubMed, EBSCO, Cochrane Review, Google scholar with no limits on publication dates. The search terms used were following chronic low back pain and ketanserin to find 1075 articles. Of 1075 articles, we reviewed none and included none.

LIDOCAINE PATCHES

Topical lidocaine patches have been increasingly used to treat numerous pain conditions ranging from LBP to carpal tunnel syndrome (CTS) to postherpetic neuralgia.(950, 951)

1. *Recommendation: Lidocaine Patches for Chronic Low Back Pain*
   Lidocaine patches are not recommended for treatment of chronic low back pain.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

2. *Recommendation: Lidocaine Patches for Acute, Subacute, Radicular, or Post-operative Low Back Pain*
   There is no recommendation for or against the use of lidocaine patches for treatment of acute, subacute, radicular, or post-operative low back pain.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendations
There is one placebo-controlled quality trial for treatment of chronic LBP that failed to show superiority of the lidocaine patch.(952) For other potential indications, there are no quality studies. Lidocaine patches are not invasive and have a low adverse effect profile, although some patients may experience local reactions such as skin irritation, redness, pain, or sores. Lidocaine patches have moderate to high cost over time. Without quality evidence, there is no recommendation for indications. They are not recommended for treatment of chronic LBP.

Evidence for the Use of Lidocaine Patches
There is 1 high-(950) and 1 moderate-quality(952) RCT or crossover trial incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: lidocaine patch, chronic low back pain, and postoperative to find 1,564 articles. Of the 1,564 articles, we reviewed 8 articles and included 8 (2 RCT).

Author/ Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Galer 1999 Crossover Trial Study supported by a grant from the Hind Health Care, INC. No mention of COI.	9.0	N = 33 with post-herpetic neuralgia (PHN)	Lidocaine patch (5%) vs. placebo patch for 28 days.	Most used patches 3x a day, one wore 4 and 5 patches a day. Required to be responsive to lidocaine patches in open-label phase. Main outcome measure time to efficacy of decrease in pain score of "2" for 2 consecutive days (stated in abstract to be >14 days for lidocaine patch and 3.8 days for vehicle patch, thus data appear switched in abstract). Most preferred lidocaine patch (78.1% vs. 9.4%). More moderate or greater pain relief for at least 5 days using lidocaine patch.	"[T]opical lidocaine patch is a novel therapy for PHN that is effective, does not cause systemic side effects, and is simple to use."	Open-label phase may somewhat limit generalizability of study.
Hashmi 2012 RCT Assistance from Abkanan lab personnel. Study funded by Endo Pharmaceuticals and in part by National Institutes of Health R01 NS35115. Endo Pharmaceuticals provided financial aid, Lidocaine and placebo patches, but had no involvement in other aspects of project. No mention of COI.	6.0	N = 30 with chronic back pain mean age 51.36 years.	Lidocaine patch group (n = 15) received patches containing 5% Lidocaine vs. placebo group (n = 15) received patches containing the vehicle, but not Lidocaine. Both groups instructed to self-administer the patch every 12 hours for 2 weeks. Also assessed with functional MRI.	Both Lidocaine and placebo groups had decreases in sensory and affective MPQ scores for treatment duration (sensory: 11.6, $p < 0.001$; affective: 22.66, $p = 0.0001$). No treatment type effect was observed at 6 hours (sensory $p > 0.5$; affective $p > 0.3$), or at 2 weeks (sensory $p > 0.1$, affective $p > 0.4$). No evidence of differences with functional MRI.	"These findings suggest that although the 5% Lidocaine is not better than placebo in its effectiveness for treating pain, the patch itself induces a potent placebo effect in a significant proportion of CBP patients."	Data suggest lack of efficacy.

NMDA RECEPTOR ANTAGONISTS (MK-801, Amantadine, Dextromethorphan, Memantine)
Numerous new compounds that specifically target mechanisms mediating neuropathic pain such as the N-methyl-D-aspartate (NMDA) receptor complex are currently used in clinical trials. These compounds include dextromethorphan, amantadine, and memantine.(953) Methadone is a mu agonist that also has affinity for the NMDA receptor. NMDA inhibitors purportedly help to prevent acute pain from progressing to chronic pain. These agents theoretically act by blocking receptors of neurotransmitters that are essential to long-term memories. They are thought to potentially help reduce opioid tolerance and may enhance opioid analgesia. Dextromethorphan is the most studied of these agents,(954) having been used to treat malignant,(955, 956) neuropathic,(957, 958) and chronic pain,(959, 960) and as an adjunct for peri-operative pain relief.(961) The utility of these agents has been limited by their significant adverse-effect profile, which includes lightheadedness, dizziness, tiredness, headache, nervous floating sensation, bad dreams, and sensory changes. Dextromethorphan, amantadine, and memantine are better tolerated with lower CNS adverse effects than ketamine possibly due to a lower affinity for the NMDA receptor which plays a role in both normal physiological functions as well as pathological pain processing.

Recommendation: NMDA Receptor/Antagonists for Chronic Low Back Pain
NMDA receptor/antagonists, including dextromethorphan, are not recommended for treatment of chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendations
There are no quality studies evaluating NMDA receptor/antagonists other than dextromethorphan (see Chronic Pain Guideline for these studies).

Evidence for the Use of NMDA Receptor/Antagonists
There are no quality studies incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: NMDA receptor, chronic, low, back, pain, Ketamine, Dextromethorphan, NMDA receptor antagonist, MK-801, Amantadine, and Memantine to find 36,805 articles. Of the 36,805 articles, we reviewed zero articles and included 0 articles

OPIOIDS – Oral, Transdermal, and Parenteral (Includes Tramadol)
Opioids are addressed in a separate guideline. The treatment recommendations are summarized below (see Opioids Guideline for all supporting evidence).

Acute Pain (Up to 4 Weeks)

1. *Recommendation: Routine Use of Opioids for Treatment of Non-Severe Acute Pain*
   Routine opioid use is strongly not recommended for treatment of non-severe acute pain (e.g., low back pain, sprains, or minor injury without signs of tissue damage).

   Harms – May inadequately treat acute, severe pain.
   Benefits – Faster recovery, less debility, reduced accidents risks, risks of dependency or addiction.
   Strength of Evidence – **Strongly Not Recommended, Evidence (A)**
   Level of Confidence – High

2. *Recommendation: Opioids for Treatment of Acute, Severe Pain*
   Opioids are recommended for treatment of acute, severe pain (e.g., crush injuries, large burns, severe fractures, injury with significant tissue damage) uncontrolled by other agents and/or with functional deficits caused by pain. They also may be indicated at the initial visit

for a brief course for anticipated pain accompanying severe injuries (i.e., failure of other treatment is not mandatory). A Schedule IV[v] opioid may be indicated if there is true allergy to NSAIDs and acetaminophen, other contraindication to an alternative medication, or insufficient pain relief with an alternative. Recommend to taper off opioid use in 1 to 2 weeks.

Indications – Patients should meet all of the following:

1) Severe injury with a clear rationale for use (objective functional limitations due to pain resulting from the medical problem, e.g., extensive trauma such as forearm crush injury, large burns, severe radiculopathy).[vi]
2) Other more efficacious treatments should have been instituted,[vii] and either: a) failed; and/or 2b) have reasonable expectations of the immediate need for an opioid to obtain sleep the evening after the injury.
3) Where available, prescription databases (usually referred to as Prescription Drug Monitoring Program (PDMP)) should be checked and not show evidence for conflicting opioid prescriptions from other providers or evidence of misreporting.[viii]
4) Non-opioid prescriptions (e.g., NSAIDs, acetaminophen) absent contraindication(s) should nearly always be the primary treatment and accompany an opioid prescription.
5) Low-dose opioids may be needed in the elderly who have greater susceptibility to the adverse risks of opioids. Those of lower body weight may also require lower opioid doses.
6) Dispensing quantities should be only what is needed to treat the pain. Short-acting opioids are recommended for treatment of acute pain. Long-acting opioids are not recommended.
7) Due to greater than 10-fold elevated risks of adverse effects and death, considerable caution is warranted among those using other sedating medications and substances including: i) benzodiazepines, ii) anti-histamines (H_1-blockers), and/or iii) illicit substances.(244, 962-964) Patients should not receive opioids if they use illicit substances unless there is objective evidence of significant trauma or moderate to severe injuries. Considerable caution is also warranted among those who are unemployed as the reported risks of death are also greater than 10-fold.(244, 963) Due to elevated risk of death and adverse effects, caution is also warranted when considering prescribing an opioid for patients with any of the following characteristics: depression, anxiety, personality disorder, untreated sleep disorders, substance abuse history, current alcohol use or current tobacco use, attention deficit hyperactivity disorder (ADHD), post-traumatic stress disorder (PTSD), suicidal risk, impulse control problems, thought disorders, psychotropic medication use, chronic obstructive pulmonary disease (COPD), asthma, or recurrent pneumonia.(963, 965-986) Considerable caution is also warranted among those with other comorbidities such as chronic hepatitis and/or cirrhosis,(987) as well as coronary artery disease, dysrhythmias, cerebrovascular disease, orthostatic hypotension, asthma, recurrent pneumonia, thermoregulatory problems, advanced age (especially with mentation issues, fall risk, debility), osteopenia, osteoporosis, water retention, renal failure, severe obesity, testosterone deficiency, erectile dysfunction, abdominal pain, gastroparesis, constipation, prostatic hypertrophy, oligomenorrhea, pregnancy, human immunodeficiency virus (HIV), ineffective birth control, herpes, allodynia, dementia, cognitive dysfunction and impairment, gait problems, tremor, concentration problems, insomnia, coordination problems,

[v]USA classifies controlled substances that includes a classification system, ranging from Class 1 to Class V corresponding to lower risks of abuse and dependence. Class I includes substances with a high potential for abuse and without a recognized medical use (e.g., heroin, marijuana, LSD). Class II includes most opiates, amphetamines and cocaine. Class III includes buprenorphine, dihydrocodeiene, hydrocodone/codeiene when compounded with an NSAID, Marinol. Class IV includes tramadol (in some states), carisoprodol, benzodiazepines, and long-activing barbiturates. Class V includes small amounts of codeine (e.g, 30mg, 60mg).

[vi]Other indications beyond the scope of this guideline include acute myocardial infarction or agitation interfering with acute trauma management.

[vii]Treatments to have tried generally include NSAIDs and acetaminophen. For LBP patients, additional considerations include muscle relaxants, progressive aerobic exercise, and directional exercise.

[viii]Exceptions such as acute, severe trauma should be documented.

and slow reaction time. There are considerable drug-drug interactions that have been reported (see Appendices 2-3 of Opioids Guideline).

Frequency/Duration – Generally, opioids should be prescribed at night or while not working.(988) Lowest effective, short-acting opioid doses are preferable as they tend to have the better safety profiles, less risk of escalation,(989) less risk of lost time from work,(990) and faster return to work.(991) Short-acting opioids are recommended for treatment of acute pain and long-acting opioids are not recommended. Recommend opioid use as required by pain, rather than in regularly scheduled dosing.

If parenteral administration is required, ketorolac has demonstrated superior efficacy compared with opioids for acute severe pain,(862, 873) although ketorolac's risk profile may limit use for some patients. Parenteral opioid administration outside of obvious acute trauma or surgical emergency conditions is almost never required, and requests for such treatment are clinically viewed as red flags for potential substance abuse.

Indications for Discontinuation – Resolution of pain, sufficient improvement in pain, intolerance or adverse effects, non-compliance, surreptitious medication use, consumption of medications or substances advised to not take concomitantly (e.g., sedating medications, alcohol, benzodiazepines), or use beyond 2 weeks.
Harms – Adverse effects are many (see section below on "Opioids Benefits and Harms").
Benefits – Improved short-term pain control.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

3. Recommendation: Screening Patients Prior to Initiation of Opioids

Initial screening of patients is recommended with more detailed screening for: i) requiring continuation of opioids beyond 2 weeks for those with an acute severe injury, and ii) at consideration of initiation for severe pain but no objective evidence. Screening should include history(ies) of depression, anxiety, personality disorder, other psychiatric disorder, substance abuse, sedating medication use (e.g., anti-histamine/anti-H_1 blocker(963)), benzodiazepine use, opioid dependence, alcohol abuse, current tobacco use, other substance use history, COPD, PTSD, other psychotropic medications, (severe) obesity, cognitive impairment, balance problems/fall risk, osteoporosis, and renal failure (see Appendix 1 of Opioids Guideline). Those who screen positive, especially to multiple criteria, are recommended to: i) undergo greater scrutiny for appropriateness of opioids (may include psychological evaluation), ii) consideration of consultation and examination(s) for complicating conditions and/or appropriateness of opioids, and iii) if opioids are prescribed, more frequent assessments for compliance, achievement of functional gains,(244, 992, 993) adverse effects, and symptoms and signs of aberrancy.

Harms – Negligible. If a consultation is needed, there are additional costs that are incurred.
Benefits – Improved identification of more appropriate candidates for opioids. Identification of patients at increased risk of adverse effects. In cases where a patient has an elevated, but potentially acceptable risk, the provider may be alerted to improve surveillance for complications and aberrant behaviors.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

4. Recommendation: Opioid Dose Limits in Acute Pain

Dispense only that which is required. The maximum daily oral dose recommended for opioid-naïve, acute pain patients based on risk of overdose/death is 50mg morphine equivalent dose (MED) (994).[ix] In rare cases with documented functional improvement (see Appendix 1 of Opioids Guideline), higher doses may be considered, however, risks are substantially higher and greater

[ix]Statistical significance present for acute and chronic pain at and above 50mg per day of oral morphine equivalent dose.

monitoring is also recommended (see Subacute/Chronic Opioid recommendations below). Lower doses should be used for patients at higher risk of dependency, addiction and other adverse effects. Monitoring is also recommended and consultation may be considered for those patients on higher doses.
Harms – Theoretical potential to undertreat pain in some patients with increased pain sensitivity.
Benefits – Reduced risk for adverse physical and cognitive effects, dependency, addiction and opioid-related overdoses and deaths.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

Post-Operative Pain (Up to 4 Weeks) (After 4 weeks, see Subacute Pain)
Oral opioids are commonly prescribed after sinus surgery,(995) major noncardiac surgical procedures,(996) mastectomy and immediate breast reconstruction (IBR),(997, 998) coronary artery bypass graft surgery,(999) major abdominal surgery (abdominal laparoscopic, abdominal hysterectomy, bowel resection or radical hysterectomy),(1000-1003) orthopedic surgery,(1004) and molar extraction.(1005)

1. *Recommendation: Limited Use of Opioids for Post-operative Pain*
   Limited use of opioids is recommended for post-operative pain management as adjunctive therapy to more effective treatments.

   Indications – For post-operative pain management, a brief prescription of short-acting opioids as adjunct to more efficacious treatments (especially Cox-2 NSAIDs such as celecoxib, non-selective NSAIDs after risk of bleeding is no longer a concern).[x] A brief course of opioids is often needed for minor surgical procedures. However, minor wound laceration repairs often require no opioids. Evidence suggests perioperative pregabalin for 14 days and/or continuous femoral nerve catheter analgesia instead of solely using oral opioids results in superior knee arthroplasty functional outcomes with less venous thromboses.(1006) Additional considerations include:

   1) Non-opioid prescriptions (e.g., NSAIDs, acetaminophen) should nearly always be the primary treatment and accompany an opioid prescription. Computerized programs may also assist in optimal management.(1007)
   2) The lowest effective dose of a short-acting opioid should be used,(989) as well as weaker opioids if possible.(990, 991)
   3) Short-acting opioids are recommended for treatment of acute pain.
   4) Dispensing should be only what is needed to treat the pain.[xi]
   5) Long-acting opioids are not recommended.
   6) Low-dose opioids may be needed in the elderly who have greater susceptibility to the adverse risks of opioids. Those of lower body weight may also require lower opioid doses.
   7) Where available, prescription databases (usually referred to as Prescription Drug Monitoring Program (PDMP)) should be checked for other opioid prescriptions. Due to greater than 10-fold elevated risks of adverse effects and death, considerable caution is warranted among those using other sedating medications and substances including: i) benzodiazepines, ii) anti-histamines (H_1-blockers), and/or iii) illicit substances.(244, 962-964) Patients should not receive opioids if they use illicit substances unless there is objective evidence of significant trauma or moderate to severe injuries. Considerable caution is also warranted among those who are unemployed as the reported risks of death are also greater than 10-fold.(244, 963)

[x]More efficaciouos treatments also include therapeutic exercises, e.g., progressive ambulation especially for moderate to extensive procedures (e.g., arthroplasty, fusion).
[xi]Generally, this should be sufficient to cover two weeks of treatment. Prescriptions of 90-day supplies in the post-operative setting are not recommended.

Due to elevated risk of death and adverse effects, caution is also warranted when considering prescribing an opioid for patients with any of the following characteristics: depression, anxiety, personality disorder, ADHD, PTSD, suicidal risk, impulse control problems, thought disorders, psychotropic medication use, substance abuse history, current alcohol use or current tobacco use, untreated sleep disorders, COPD, asthma, or recurrent pneumonia.(963, 965-986) Considerable caution is also warranted among those with other comorbidities such as chronic hepatitis and/or cirrhosis,(987) as well as coronary artery disease, dysrhythmias, cerebrovascular disease, orthostatic hypotension, thermoregulatory problems, advanced age (especially with mentation issues, fall risk, debility), osteopenia, osteoporosis, water retention, renal failure, severe obesity, testosterone deficiency, erectile dysfunction, abdominal pain, gastroparesis, constipation, prostatic hypertrophy, oligomenorrhea, pregnancy, HIV, ineffective birth control, herpes, allodynia, dementia, cognitive dysfunction and impairment, gait problems, tremor, concentration problems, insomnia, coordination problems, and slow reaction time. There are considerable drug-drug interactions that have been reported (see Appendices 2-3 of Opioids Guideline).

Inpatient management may moderate these recommendations provided there is careful monitoring, although these same management issues then apply post-discharge.

8) For patients taking opioids chronically prior to surgery, consultations with anesthesiology and/or pain management are generally needed as post-operative dosing may be very high and management is often quite challenging.
9) Ongoing prescriptions of opioids after the immediate post-operative period should generally be for patients who have undergone a major surgery or have other condition(s) necessitating opioids. Most patients should be making progress towards functional restoration, pain reduction and weaning off the opioids. Patients who have not progressed should be carefully evaluated for physical complications or psychiatric comorbidity, adherence to active treatments, and pending development of addiction or dependency.

Frequency/Duration – For moderate and major surgeries, opioids are generally needed on a scheduled basis in the immediate post-operative period. Other post-operative situations may be sufficiently managed with an as needed opioid prescription schedule. Provision of opioids sufficient to participate in therapeutic exercise (e.g., progressive ambulation) and allow sleep may be needed. However, high dose use at night is not recommended due to respiratory depression and disruption of sleep architecture. Weaning should begin as soon as function is recovering and pain is subsiding. Subsequent weaning to as needed opioid use is recommended.

Indications for Discontinuation – Physician should discontinue the use of opioids based on sufficient recovery, expected resolution of pain, lack of efficacy, intolerance or adverse effects, non-compliance, surreptitious medication use, self-escalation of dose, or use beyond 3 to 5 days for minor procedures, and 2 to 3 weeks for moderate or less extensive procedures. Use for up to 3 months may occasionally be necessary during recovery from more extensive surgical procedures (e.g., spine fusion surgery). However, with rare exceptions, only nocturnal use is recommended in months 2 to 3 plus institution of management as discussed in the subacute/chronic guidelines below. For those requiring opioid use beyond 1 month, the subacute/chronic opioid use recommendations below apply.
Harms – Adverse effects are many (see section on "Opioids Benefits and Harms").
Benefits – Improved short-term, post-operative pain control. Some studies suggest this may modestly improve functional outcomes in the post-operative population.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

2. Recommendation: Screening Patients Prior to Continuation of Opioids
Screening of patients is recommended for patients requiring continuation of opioids beyond the second post-operative week. Screening should include history(ies) of: depression, anxiety, personality disorder, pain disorder, other psychiatric disorder, substance abuse history, sedating medication use (e.g., anti-histamine/anti-H_1 blocker), benzodiazepine use, opioid dependence, alcohol abuse, current

tobacco use, and other substance use history, COPD, PTSD, other psychotropic medications, (severe) obesity, cognitive impairment, balance problems/fall risk, osteoporosis, and renal failure (see Appendix 1 of Opioids Guideline). Those who screen positive, especially to multiple criteria, are recommended to: i) undergo greater scrutiny for appropriateness of opioids (e.g., may include psychological and/or pain evaluation), ii) compliance with active therapies (e.g., ambulation and other exercise after arthroplasty), iii) consider consultation examination(s) for complicating conditions and/or appropriateness of opioids, and iv) if ongoing opioids are prescribed, ensure more frequent assessments for treatment compliance, achievement of functional gains,(244, 992, 993) and symptoms and signs of aberrancy.

Harms – Negligible. If a consultation is needed, there are additional costs that are incurred.
Benefits – Identification of patients at increased risk of adverse effects. Improved identification of more appropriate and safe candidates for opioids compared with attempting post-operative pain control with non-opioids. This should reduce adverse effects. In cases where someone has elevated, but potentially acceptable risk, this may alert the provider to improve surveillance for complications and aberrant behaviors.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

3. Recommendation: Opioid Dose Limits in Post-operative Pain
The maximum daily oral dose recommended for opioid-naïve, acute pain patients based on risk of overdose/death is 50mg morphine equivalent dose (MED) (994).[xii] Post-operative patients particularly require individualization due to factors such as the severity of the operative procedure, response to treatment(s) and variability in response. Higher doses beyond 50mg MED may be particularly needed for major surgeries in the first 2 post-operative weeks to achieve sufficient pain relief, however, greater caution and monitoring are warranted and reductions below 50mg MED at the earliest opportunity should be sought. Lower doses should be used for patients at higher risk of dependency, addiction and other adverse effects. In rare cases with documented functional improvement, ongoing use of higher doses may be considered, however, risks are substantially higher and greater monitoring is also recommended (see Subacute/Chronic Opioid recommendations below).

Harms – Theoretical potential to undertreat pain, which could modestly delay functional recovery.
Benefits – Reduced risk for adverse effects, dependency, addiction and opioid-related deaths.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Subacute (1-3 Months) and Chronic Pain (>3 Months)

1. *Recommendation: Routine Use of Opioids for Subacute and Chronic Non-malignant Pain*
   Opioid use is moderately not recommended for treatment of subacute and chronic non-malignant pain. Opioid prescription should be patient specific and limited to cases in which other treatments are insufficient and criteria for opioid use are met (see below).

   Harms – May inadequately treat severe subacute or chronic pain.
   Benefits – Less debility, fewer adverse effects, reduced accident risks, lower risks of dependency, addiction, overdoses, and deaths.

   Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
   Level of Confidence – High

2. *Recommendation: Opioids for Treatment of Subacute or Chronic Severe Pain*
   The use of an opioid trial is recommended if other evidence-based approaches for functional restorative pain therapy have been used with inadequate improvement in function.(1008,

[xii] Statistical significance present for acute and chronic pain at and above 50mg per day of morphine equivalent dose.

1009) **Opioids are then recommended for treatment of function impaired by subacute or chronic severe pain (e.g., inability to work due to any of the following: chronic severe radiculopathy, chronic severe peripheral neuropathies, complex regional pain syndrome (CRPS), and severe arthroses)**(992) **(See Appendix 1 of Opioids Guideline).**

Indications – Patients should meet all of the following criteria:

1) Reduced function is attributable to the pain. Pain or pain scales alone are insufficient reasons.(238, 239, 241-244, 992, 1010-1016)
2) A severe disorder warranting potential opioid treatment is present [e.g., CRPS, severe radiculopathy, advanced degenerative joint disease (DJD)].(1011)
3) Other more efficacious treatments have been documented to have failed.(1011) Other approaches that should have been first utilized include physical restorative approaches, behavioral interventions, self-applied modalities, non-opioid medications (including NSAIDs, acetaminophen, topical agents, norepinephrine adrenergic reuptake blocking antidepressants or dual reuptake inhibitors; also antiepileptic medications particularly for neuropathic pain) and functional restoration. For LBP patients, this also includes[xiii] fear avoidant belief training and ongoing progressive aerobic exercise, and strengthening exercises. For CRPS patients, this includes progressive strengthening exercise. For DJD, this includes NSAIDs, weight loss, aerobic and strengthening exercises.
4) An ongoing active exercise program is prescribed and complied with.
5) Non-opioid prescriptions (e.g., NSAIDs, acetaminophen) absent a contraindication should nearly always be the primary pain medication and accompany an opioid prescription. Other medications to consider include topical agents, norepinephrine adrenergic reuptake blocking antidepressants or dual reuptake inhibitors; also antiepileptic medications particularly for neuropathic pain).
6) The lowest effective dose should be used.(989) Weaker opioids should be used whenever possible.(990, 991) Meperidine is not recommended for chronic pain due to bioaccumulation and adverse effects.
7) Low-dose opioids may be needed in the elderly who have greater susceptibility to the adverse risks of opioids. Those of lower body weight may also require lower opioid doses.
8) Dispensing should be only what is needed to treat the pain.[xiv]
9) Extended-release/long-acting opioids are recommended to be used on a scheduled basis, rather than as needed.(1011) As needed opioids should generally be avoided for treatment of chronic pain, although limited use for an acute painful event (e.g., fracture, sprain) is reasonable. Sublingual fentanyl is not recommended for treatment of subacute or chronic pain. Caution is warranted with fentanyl patches due to unpredictable absorption.
10) Where available, prescription databases (usually referred to as Prescription Drug Monitoring Program (PDMP)) should be checked for conflicting opioid prescriptions from other providers or evidence of misreporting.
11) Due to greater than 10-fold elevated risks of adverse effects and death, considerable caution is warranted among those using other sedating medications and substances including: i) benzodiazepines, ii) anti-histamines (H_1-blockers), and/or iii) illicit substances.(244, 962-964) Patients should not receive opioids if they use illicit substances unless there is objective evidence of significant trauma or moderate to severe injuries. Considerable caution is also warranted among those who are unemployed as the reported risks of death are also greater than 10-fold.(244, 963)

    Due to elevated risk of death and adverse effects, caution is also warranted when considering prescribing an opioid for patients with any of the following characteristics: depression, anxiety, personality disorder, untreated sleep disorders, substance abuse history, current alcohol use or current tobacco use, ADHD, PTSD, suicidal risk, impulse control problems, thought disorders, psychotropic medication use, COPD, asthma, recurrent pneumonia.(963, 965-986)

[xiii] A previous trial of a muscle relaxant is generally recommended. However, if an opioid trial is contemplated, cessation of all depressant medications including muscle relaxants is advisable.

[xiv] Generally, this should be sufficient to cover one week of treatment at a time during the trial phase. If a trial is successful at improving function, prescriptions for up to 90-day supplies are recommended.

Considerable caution is also warranted among those with other comorbidities such as chronic hepatitis and/or cirrhosis,(987) as well as coronary artery disease, dysrhythmias, cerebrovascular disease, orthostatic hypotension, asthma, recurrent pneumonia, thermoregulatory problems, advanced age (especially with mentation issues, fall risk, debility), osteopenia, osteoporosis, water retention, renal failure, severe obesity, testosterone deficiency, erectile dysfunction, abdominal pain, gastroparesis, constipation, prostatic hypertrophy, oligomenorrhea, pregnancy, HIV, ineffective birth control, herpes, allodynia, dementia, cognitive dysfunction and impairment, gait problems, tremor, concentration problems, insomnia, coordination problems, and slow reaction time. There are considerable drug-drug interactions that have been reported (see Appendices 2-3 of the Opioids Guideline).

Frequency/Duration – Opioids use is generally initiated as a "trial" to ascertain whether the selected opioid produces functional improvement (see Appendix 1 of Opioids Guideline). Opioid use is generally prescribed on a regular basis,(1017) at night or when not at work.(988) Only one opioid is recommended to be prescribed in a trial. More than one opioid should rarely be used. Lower opioid doses are preferable as they tend to have the better safety profiles, less risk of dose escalation,(989) less work loss,(990) and faster return to work.(991) Patients should have ongoing visits to monitor efficacy, adverse effects, compliance and surreptitious medication use. Opioid prescriptions should be shorter rather than longer duration.(1018)

Indications for Discontinuation – Opioids should be discontinued based on lack of functional benefit(1009) (see Appendix 1), resolution of pain, improvement to the point of not requiring opioids, intolerance or adverse effects, non-compliance, surreptitious medication use, medication misuse (including self-escalation and sharing medication), aberrant drug screening results, diversion, consumption of medications or substances advised to not take concomitantly (e.g., sedating medications, alcohol, benzodiazepines).

Harms – Adverse effects are many (see section on "Opioids Benefits and Harms"). May initiate path to opioid dependency.
Benefits – Improved short-term pain ratings. Theoretical potential to improve short-term function impaired by a painful condition.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

3. Recommendation: Screening Patients Prior to Initiation of Opioids

Screening of patients is recommended prior to consideration of initiating a trial of opioids for treatment of subacute or chronic pain. Screening should include history(ies) of depression, anxiety, personality disorder and personality profile,(991, 1019, 1020) other psychiatric disorder, substance abuse history, sedating medication use (e.g., anti-histamine/anti-H_1 blocker),(983) benzodiazepine use, opioid dependence, alcohol abuse, current tobacco use, and other substance use history, COPD, PTSD, other psychotropic medications, (severe) obesity, cognitive impairment, balance problems/fall risk, osteoporosis, and renal failure (see Appendix 1 of Opioids Guideline). Those who screen positive, especially to multiple criteria, are recommended to: i) undergo greater scrutiny for appropriateness of opioids (may include psychological and/or psychiatric evaluation(s) to help assure opioids are not being used instead of appropriate mental health care); ii) consideration of consultation and examination(s) for complicating conditions and/or appropriateness of opioids; and iii) if opioids are prescribed, more frequent assessments for compliance, achievement of functional gains and symptoms and signs of aberrant use.

Harms – Negligible. If a consultation is needed, there are additional costs that are incurred.
Benefits – Identification of patients at increased risk of adverse effects. Improved identification of more appropriate and safe candidates for treatment with opioids. This should reduce adverse effects. In cases where someone has elevated, but potentially acceptable risk, this may alert the provider to improve surveillance for complications and aberrant behaviors.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – High

4. Recommendation: Opioid Dose Limits in Subacute and Chronic Pain

The maximum daily oral dose recommended for subacute or chronic pain patients based on risk of overdose/death is 50 mg Morphine Equivalent Dose (MED).(969, 994) In rare cases with documented functional improvements occurring with use above 50 mg MED, subsequent doses up to 100 mg may be considered, however, risks of death are much greater and more intensive monitoring is then also recommended. Lower doses should be considered in high risk patients. Caution appears warranted in all patients as there is evidence the risk of dose escalation is present even among patients enrolled in a "hold the line (Stable Dose) prescribing strategy" treatment arm.(1021)

For those whose daily consumption is more than 50 mg MED, greater monitoring is recommended to include: 1) at least monthly to not more than quarterly appointments with greater frequencies during trial, dose adjustments and with greater co-morbid risk factors and conditions; 2) at least semiannual attempts to wean below 50mg MED if not off the opioid; 3) at least semiannual documentation of persistence of functional benefit; 4) at least quarterly urine drug screening (see drug screening section); and 5) at least semiannual review of medications, particularly to assure no sedating medication use (e.g., benzodiazepine, sedating anti-histamines).

Harms – None in a short-term trial. For chronic pain patients, theoretical potential to undertreat pain and thus impair function. However, there is no quality literature currently available to support that position.

Benefits – Reduced risk for adverse effects, dependency, addiction, and opioid-related deaths.

Strength of Evidence – **Recommended, Evidence (C)**

Level of Confidence – High

5. Recommendation: Use of an Opioid Treatment Agreement (Opioid Contract, Doctor/Patient Agreement, Informed Consent)

The use of an opioid treatment agreement (opioid contract, doctor/patient agreement, or informed consent) is recommended to document patient understanding, acknowledgement of potential adverse effects, and agreement with the expectations of opioid use (see Appendix 1 of Opioids Guideline).(1008, 1022-1033) **If consent obtained, it is recommended appropriate family members be involved in this agreement.**

Harms – Negligible.

Benefits – Educates the patient and significant others that these medications are high risk, with numerous adverse effects. It allows for a more informed choice. It provides a framework for initiation of a trial, monitoring, treatment goals, compliance requirement, treatment expectations, and conditions for opioid cessation. It should reduce risk of adverse events and opioid-related deaths, although that remains unproven to date.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**

Level of Confidence – Moderate

6. Recommendation: Urine Drug Screening

Baseline and random urine drug screening, qualitative and quantitative, is recommended for patients prescribed opioids for the treatment of subacute or chronic pain to evaluate presence or absence of the drug, its metabolites, and other substance(s) use. In certain situations, other screenings (e.g., hair particularly for information regarding remote use(1034-1039) **or blood (for acute toxicity) may be appropriate.**

Indications – All patients on opioids for subacute or chronic pain.

Frequency – Screening is recommended at baseline, randomly at least twice and up to 4 times a year and at termination. More intensive screening is recommended for those consuming more than 50mg MED (see above). Federal guidelines recommend at least 8 tests a year among those utilizing opioid

treatment programs.(1040) Screening should also be performed "for cause" (e.g., provider suspicion of substance misuse including over-sedating, drug intoxication, motor vehicle crash, other accidents and injuries, driving while intoxicated, premature prescription renewals, self-directed dose changes, lost or stolen prescriptions, using more than one provider for prescriptions, non-pain use of medication, using alcohol for pain treatment or excessive alcohol use, missed appointments, hoarding of medications, and selling medications). Standard urine drug/toxicology screening processes should be followed (consult a qualified medical review officer).(1040-1043) If there is an aberrant drug screen result (either positive for unexpected drugs or unexpected metabolites or unexpectedly negative results), there should be a careful evaluation of whether there is a plausible explanation (e.g., drug not tested, drug metabolite not tested, laboratory cutpoint and dosing interval would not capture the drug/metabolite, laboratory error). In the absence of a plausible explanation, those patients with aberrant test results should have the opioid discontinued or weaned.(1009)

Harms – No adverse clinical effects if properly interpreted.
Benefits – Identifies aberrant medication(s) and substance(s) use. Such uses are high-risk for opioid events including fatalities (see tables below). It provides objective evidence to cease an opioid trial or ongoing treatment. Identifies patients who may be diverting medication (those screening negative for prescribed medication).

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – High

Evidence for the Use of Opioids
See Opioids Guideline.

SKELETAL MUSCLE RELAXANTS
Skeletal muscle relaxants comprise a diverse set of pharmaceuticals designed to produce "muscle relaxation" through different mechanisms of action – generally considered to be effects on the central nervous system (CNS) and not directly on skeletal muscle.(1044, 1045) These medications are widely used to treat painful conditions, most prominently LBP.(651, 1046-1051)

1. *Recommendation: Muscle Relaxants for Mild to Moderate Acute, Subacute, or Chronic Low Back Pain*

   Muscle relaxants are not recommended for mild to moderate acute low back pain due to problems with adverse effects, or for chronic use in subacute or chronic low back pain (other than acute exacerbations).

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Muscle Relaxants for Moderate to Severe Acute Low Back Pain*
   Muscle relaxants (not including carisoprodol) are moderately recommended as a second-line treatment in moderate to severe acute low back pain that has not been adequately controlled by NSAIDs.

   Indications – Recommended for select cases of moderate to severe acute LBP. For most cases, these agents are not recommended as NSAIDs, progressive walking, and other exercises will be sufficient to control the symptoms. Generally, it is recommended that these agents be prescribed nocturnally initially and not during workdays or when patients plan to operate motor vehicles. Diazapam should generally be avoided. Caution should be used in prescribing skeletal muscle relaxants for those with a history of depression, personality disorder, and/or substance addiction/abuse, including alcohol or tobacco. If a muscle relaxant is felt to be necessary in patients with those problems, cyclobenzaprine has a chemical structure resembling a tricyclic anti-

depressant, and so addiction and abuse of this drug typically do not occur but may occur with other muscle relaxants.

Frequency/Dose – The initial dose should generally be in the evening, and not prior to starting a work shift, operating a motor vehicle, machinery or performing safety-sensitive work. Daytime use is acceptable in circumstances where there are minimal CNS-sedating effects and little concern about sedation compromising function or safety. There is no evidence of benefit from higher doses (e.g., cyclobenzaprine 10mg over 5mg).(1052) If significant daytime somnolence results, the medication may need to be discontinued, particularly if it interferes with performance of the aerobic exercise and other components of the rehabilitation plan. Another option is to decrease a dose of cyclobenzaprine by 50% to as little as 2.5mg.(1052)

Indications for Discontinuation – Resolution of pain, non-tolerance, significant sedating effects that carry over into the daytime, or other adverse effects.
Benefits – Modest reduction in acute LBP compared with placebo.
Harms – Sedation, daytime fatigue. Modest potential for abuse. Risk for safety including motor vehicle crash and other injuries.

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – Moderate

3. *Recommendation: Carisoprodol for Moderate to Severe Low Back Pain*
Carisoprodol is not recommendended for moderate to severe acute low back pain that has not been adequately controlled by NSAIDs or for acute exacerbations of chronic pain, or acute post-surgical situations.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

4. *Recommendation: Muscle Relaxants for Acute Radicular Pain, Acute Exacerbations of Chronic Pain, or Post-surgical Use*
Muscle relaxants are recommended as second- or third-line agents for selective use to treat acute exacerbations of chronic pain, or acute post-surgical situations. However, other agents may be more efficacious for relieving radicular pain, e.g., NSAIDs.

Indications – Moderate to severe acute worsening of pain and/or functional loss associated with worsening of LBP, radicular pain syndromes or post-surgical pain thought to be musculoskeletal in nature. Generally, muscle relaxants should be prescribed nocturnally initially and not during workdays or when patients plan on operating motor vehicles.

Frequency/Dose – The initial dose should be in the evening. Daytime use is acceptable in circumstances where there are minimal CNS-sedating effects. If significant daytime somnolence results, then the medication may need to be discontinued, particularly if it interferes with the patient's performance of aerobic exercise or other components of the rehabilitation plan.

Indications for Discontinuation – Resolution of pain, non-tolerance, significant sedating effects that carry over into the daytime, or other adverse effects.
Benefits – Modest reduction in acute low back pain compared with placebo.
Harms – Sedation, daytime fatigue. Modest potential for abuse. Risk for safety including motor vehicle crash and other injuries.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

4. *Recommendation: Muscle Relaxants for Chronic Low Back Pain*
Muscle relaxants are not recommended for ongoing use for treatment of chronic low back pain, particularly without documented functional benefit.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations
Skeletal muscle relaxants have been evaluated in quality studies although the outcomes comparing these agents to placebo may be overstated due to the unblinding that would be inherent in taking a drug with substantial CNS-sedating effects.(1046) Nevertheless, there is quality evidence that skeletal muscle relaxants modestly improve acute LBP, particularly for the first several days.(834, 1052-1056) The mechanism of action is unclear. However, the adverse-effect profile is concerning,(1057) and there are many adverse effects from these agents. Most concerning is the significant potential for CNS sedation which has typically ranged between 25 to 50%. There are some studies indicating that more than 50% of patients are affected by CNS sedation. Thus, prescriptions for skeletal muscle relaxants for daytime use should be carefully weighed against the need to drive vehicles, operate machinery, perform at heights, direct others, perform safety-sensitive work, or otherwise engage in occupations where mistakes in judgment may have serious consequences. Skeletal muscle relaxants also have a modest but significant potential for abuse(1051, 1058, 1059) and caution should be used when prescribing them for patients with a history of any substance abuse or dependence.(801, 1060) Some caution should be exerted with all of these agents when a patient has a history of substance abuse or requests specific medications.

Carisoprodol is more commonly abused because one of its active metabolites is meprobamate. There also is no evidence it is superior to any other muscle relaxant. Thus, it is not recommended as a first, second or third choice muscle relaxant. Use of this agent is recommended to be only under highly selective circumstances that would include having tried the other available muscle relaxants, as well as more effective and usual treatments such as progressive active exercise and NSAIDs.

There is little evidence of muscle relaxant efficacy for treatment of chronic LBP as the few available studies appear to have mostly evaluated acute exacerbations of chronic pain.(1054, 1061, 1062) Skeletal muscle relaxants have demonstrated efficacy in acute LBP, have significant adverse effects, and are low cost, especially if generic medications are prescribed. Thus, skeletal muscle relaxants are recommended for select management of moderate to severe acute LBP. They are not recommended for continuous management of subacute or chronic LBP although they may be recommended for brief management of acute exacerbations in the setting of chronic LBP.(1061-1063)

Diazepam appears inferior to skeletal muscle relaxants,(1064) has a higher incidence rate of adverse effects, and is addictive. Diazepam is not recommended for use as a skeletal muscle relaxant. Evidence suggests that carisoprodol is comparable to cyclobenzaprine in efficacy. However, cyclobenzaprine may have advantages of lower abuse potential and some chemical analogy to tricyclic anti-depressants. Chlorzoxazone has been associated with hepatocellular toxicity. Chlormezanone has been implicated in Stevens-Johnson syndrome and toxic epidermal necrolysis.

Evidence for the Use of Skeletal Muscle Relaxants
There are 3 high-(1053, 1062, 1065) and 33 moderate-quality(834, 835, 840, 859, 878, 1054-1056, 1061, 1063, 1064, 1066-1087) RCTs or crossover trials incorporated into this analysis. There are 5 low-quality RCTs in Appendix 1.(836, 1088-1091)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: muscle relaxants, low back pain, and chronic low back pain radicular pain syndrome, carisoprodol cyclobenzaprine, diazepam, metaxalone methocarbamol, baclofen, chlorzoxazone, dantrolene, orphenadrine, tizanadine, clinical trial or randomized controlled trail or random, systematic reviews or reviews, population study or epidemiological study or prospective cohort to find 7,086 articles. Of those we reviewed 54 articles and included 34 articles (32 RCTs and 2 reviews).

Author/Title Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Central-acting Muscle Relaxants						
Salzmann 1992 RCT (In German) No mention of COI or industry.	9.0	N = 152 with chronic LBP not responding to physiotherapy; no placebo responders in single blind run-in phase	Tetrazepam 150mg a day (1 tablet in morning and 2 in evening, n = 79) vs. placebo (n = 73) for 2 weeks.	Tetrazepam superior at Day 7, p = 0.011. Reductions in daytime pain present Day 3 (7.3% vs. 2.1%), Day 7 (29.1% vs. 8.3%), Day 14 (45.5% vs. 27.1%). Days 3 to 7, modest differences favoring treatment to reduce night pain, but gone Day 14. Day 7, response rate 10 times higher in active group vs. placebo, p = 0.002.	"The results of this double-blind placebo-controlled study are in accordance with those of earlier studies with an open design in similar indications. They confirm that tetrazepam is an appropriate therapy for chronic low-back syndrome, leading to markedly accelerated improvement in pain and in the patient's clinical condition."	Despite being a study of chronic LBP, trial of short duration and used a benzodiazepine (that class of medication has long-term safety questions), thus conclusions not readily supportable.
Bajaj 2003 RCT Crossover Trial Study supported by grant from Danish National Research Foundation. No mention of COI.	8.5	N = 20 male volunteers, aged 25.2 +/-0.82 years (mean +/- SEM) participated in 10 sessions	Tolperisone hydrochloride (150mg, n = 10) vs. placebo (n = 10) 3 times daily for 8 days.	Tolperisone did not reduce pain, but reduced maximum force capabilities by approximately 25% in non-exercised hand. Trends in data suggest medication may produce sedation effects.	"[T]he prophylactic administration of tolperisone (150 mg thrice daily) results in reduced isometric force without having a pain relieving effect on PEMS[post-exercise muscle soreness]."	Study suggests no benefit from prophylaxis of muscle soreness with tolperisone.
Baratta 1976 RCT No mention of COI or industry sponsorship.	8.0	N = 105 previously described (see Opioids) apparently mix of LBP, neck pain, SI sprain, and thoracolumbar pain problems (variously labeled as "sprains")	Carisoprodol 350mg (n = 33) vs. propoxyphene 65mg (n = 32) vs. placebo (n = 29) TID plus QHS for 14 days.	Statistically significant changes in ROMs, but no clear pattern that all ROMs better with 1 medication compared to other.	"Carisoprodol was significantly better than either propoxyphene or placebo in relieving stiffness, as demonstrated by the significant greater improvement observed with carisoprodol versus propoxyphene in five of six evaluated objective measures of range of movement, and with carisoprodol versus placebo in all six of these measures."	Global ratings in favor of carisoprodol (satisfactory improvement 59.4% vs. 21.9% for propoxyphene vs. 12.5% for placebo).
Preston 1984 RCT A.H. Robins Company provided grant and study materials to those participating in study. No mention of COI.	7.5	N = 227 with muscle spasm, local pain, and tenderness, limitation of normal motion, and interference with daily activities	Methocarbamol (1.5g QID, n = 82) vs. cyclobenzaprine (10mg TID, n = 75) vs. placebo (n = 40) for 7 days.	At interim appointment, percentage with absent/mild muscle spasm: 35.0% placebo vs. 33.3% cyclobenzaprine vs. 40.2% methocarbamol. CNS side effects: 1% placebo vs. 29% cyclobenzaprine vs. 15% methocarbamol.	"Although the differences between Robaxin-750 (methocarbamol) and Flexeril (cyclobenzaprine) were not statistically significant for the four parameters measured, trend was definitely in favor of Robaxin-750."	Twice as many active treatment patients in both arms excluded from analyses for reasons of adverse effects than placebo patients. Data suggest trend towards modest efficacy.
Boyles 1983 RCT	7.0	N = 80 with acute painful thoracolumbar	Carisoprodol tablets (350mg QID, n = 36) vs. diazepam tablets (5mg QID, n = 35) for 8 days.	Percentage of subjects with very good to excellent responses: 70% for carisoprodol compared to 45 to 60% for diazepam, with diazepam	"[W]hile carisoprodol (350 mg) and diazepam (5 mg) are both effective adjunctive therapeutic agents, carisoprodol provides a	Short-term follow-up of 8 days. Adverse events up to 35% of all patients.

No mention of COI or industry sponsorship.		strain or sprain up to 7 days duration		inferior for multiple measures (e.g., pain, stiffness, sleep impairment). Overall improvement scores favored carisoprodol. Percentage of patients reporting CNS side effects worse for diazepam (42.5% vs. 25.0%).	consistent pattern of numerical improvement with statistically significant clinical superiority over diazepam in the management of the symptom-complex associated with acute musculoskeletal conditions represented by lumbar strain or sprain."	
Rollings 1983 RCT No mention of COI or industry sponsorship.	6.5	N = 58 with acute painful thoracolumbar "strain" or "sprain" of up to 7 days duration	Carisoprodol (350mg QID, n = 28) vs. cyclobenzaprine (10mg QID, n = 30) for 7 days.	No significant differences between groups in numerous metrics over 1-week intervention period (e.g., pain, stiffness, sleep impairment). Significantly higher incidence of dry mouth with cyclobenzaprine. Percentage of patients reporting CNS side effects 51.3% vs. 56.8%.	"Soma (carisoprodol and Flexeril (cyclobenzaprine) were effective ($p<0.025$) as adjunctive therapy in the management of acute musculoskeletal conditions, as represented by the acute symptom-complex of thoracolumbar sprain or strain; however, none of the efficacy evaluations showed any statistically significant differences between the treatments ($p>0.05$)."	Large rate of adverse events; 61-64% to all patients. Baseline differences in gender. No placebo group. Data suggest equal efficacy.
McGuinness 1983 RCT No mention of COI or industry sponsorship.	6.5	N = 28 with painful musculoskeletal disorders	Orphenadrine citrate and paracetamol (450mg paracetamol plus 35mg orphenadrine, n = 14) vs. paracetamol alone (450mg paracetamol, n = 14) for 10 days.	Pain scores at Days 0, 5, and 10: 2.3, 0.9, and 0.2 vs. 2.1, 1.4, and 1.3 for placebo. Stiffness worse in paracetamol group.	"All three symptomatic parameters which were measured: pain, spasm and impaired activity, showed a significant quicker recovery when the combination product was used. Further studies are necessary to evaluate the combination product against orphenadrine citrate alone."	Study population mixed disorders with probable baseline differences. Data suggest 'Norgesic' provides benefit over paracetamol in pain, spasm, function over 10-day course, but no dosage information provided, limiting strength of conclusion.
Basmajian 1978 RCT (2 studies) Supported by grant from Merck Sharp and Dohme. No mention of COI.	6.5	N = 120 in Study 1; N = 55 in Study 2; all with chronic pain in neck and/or lumbar region	Cyclobenzaprine hydrochloride (10mg, n = 17) vs. diazepam (5mg, n = 16) vs. placebo TID (n = 19) with increase gradually allowed to 5 a day. Study lasted 14 days.	End of week 1, EMG mean values: Cyclobenzaprine % change 140%, $p<0.05$. Placebo -4.8% NS, Diazepam 45.5% NS. End of Week 2, EMG mean values: Cyclobenzaprine % change 178.4%, $p<0.01$, placebo -5.5% NS, Diazepam 81.0% NS.	"Clinical improvement over two weeks was statistically significant in all treatment groups with a statistically significant preference for Cyclobenzaprine hydrochloride."	By combining 2 studies in 1 report, neither is well described.
Brizzi 2004 RCT Placebo-controlled study No mention of COI or industry sponsorship.	6.5	N = 18 adults with chronic LBP outpatients, under 50 years	Group A: 3 Hydrofor applications of mixture containing both NSAIDs and muscle relaxants (n = 9) vs. Group B: 3 Hydrofor applications of drug-free solutions (n = 9). Follow-up for 2 months.	Pain intensity at baseline; mean VAS scores decreased from 6 to 0 in Group A and from 5 to 1 in group B, $F = 26.4$ $p < 0.0001$. At week 1; time effect $F = 7.4$, $p < 0.01$, median VAS score 1.5 in group A vs. VAS score in Group B. At 2 months, no differences time x group effect, 2.1, $p = 0.08$. Pain-related disability or ODI score	"Hydrofor treatment relieves relapsing LBP and could be recommended to active adults as a safe-technique shortening the time needed to achieve functional restoration."	Small sample size. Patients not well described. Data largely consistent with placebo effect and no significant differences at 2 months.

				decreased from 23 to 7.5 in Group A vs. 22 to 14 in Group B, F = 3.9 p <0.05.		
Meng 2003 RCT Study supported by New York Chapter of Arthritis Foundation. Authors have declared no conflict of interest.	6.5	N = 55 with chronic, non-specific LBP in older patients.	Acupuncture group received usual care plus biweekly acupuncture with electrical stimulation for 5 weeks (n = 31) vs. control group received usual care, i.e. NSAIDs, muscle relaxants, paracetamol and back exercise (n = 24). 8 drop outs. Follow-up time for 9 weeks.	At week 6, pain and disability or RDQ score of 4 or more in clinical significance. Acupuncture group RDQ score of 4.1±3.9 vs. mean decrease of 0.7±2.8 in control, intergroup difference 3.6±6.6 p = 0.001. No differences in pain score in acupuncture group week 6 (0±1.1) vs. increase in pain score week 6 of 0.6±1.2 in control, p = 0.1. Mean transition global score higher in acupuncture group, 3.7±1.2, greater improvement in acupuncture, 2.5±0.9 p <0.001.	"Acupuncture is an effective, safe adjunctive treatment for chronic LBP in older patients."	Bias in usual care and non-care limits conclusions.
Borenstein 2003 RCT Studies supported by grant from Merck & Co., Inc., Whitehouse Station, NJ. No mention of COI.	6.0	N = 668 with LBP (1/3 having neck pain)	Cyclobenzaprine hydrochloride (5mg, n = 242/10mg, n = 249 TID) vs. placebo (n = 246) Study 1. Study 2, cyclobenzaprine (2.5, n = 223/5mg, n = 222 TID) vs. placebo (n = 223). Study lasted 7 days.	Dropouts (372) in Study 1: 27.3% placebo, 28.6% 5mg, and 44.2% 10mg. In Study 2, dropouts 37.5% placebo, 35.7% 5mg, and 26.8% 10mg.	"The results of these trials demonstrated the efficacy and tolerability of the 5-and 10-mg doses of cyclobenzaprine in the management of acute musculoskeletal spasm of the back or neck, whereas cyclobenzaprine 2.5 mg TID was not significantly different from placebo."	Authors conclude 2.5mg dose not efficacious, but data and graphs suggest clinical results for that dosing regimen likely intermediate between placebo and 5mg dosing regimens and they lacked power to detect differences.
Tervo 1976 RCT No mention of COI or industry sponsorship.	6.0	N = 50 with acute LBP	Orphenadrine injection followed by Norgesic tablets (orphenadrine 35mg and paracetamol 450mg, n = 25) vs. placebo injection followed by paracetamol (n = 25). Follow-up done on Days 7-10, and again 14-21 days after first follow-up.	Significantly better walking distances in orphenadrine group. Orphenadrine significant improvement Days 7-10 for walking and sitting ability vs. placebo/paracetamol (p <0.01). Orphenadrine vs. placebo mean±SEM for duration of disability (days): 8.6±0.6, 12.9±1.2, p <0.01.	"[O]rphenadrine citrate significantly shortens the duration of disability from acute lumbago when given by intramuscular injection and orally as a combination preparation with paracetamol."	Lack of details for co-interventions. Statistical analyses inappropriate as excluded those unable to work >25 days (5/6 in paracetamol group). Data suggest single IM dose of Norgesic with oral treatment for additional 2 weeks provides modest benefit in functional measures vs. placebo. Lack of details in statistical analysis limits conclusions.
Hingorani 1971 RCT No mention of COI or industry sponsorship.	6.0	N = 99 with acute or chronic LBP of sufficient severity to require hospitalization	Orphenadrine/paracetamol (Norgesic, n = 49) vs. aspirin (n = 50) for duration of 7 days.	No significant differences found.	"Both drugs produced equal, statistically significant improvement in SLR (p<0.001) but in the forward flexion test the result for Norgesic was significantly better (p<0.05) then that for aspirin."	Data suggest no clinically significant improvement in Norgesic compared to aspirin.

Klinger 1988 RCT No mention of COI or industry sponsorship.	5.5	N = 80 with low back strain accompanied by pain with short-term follow-up	Intravenous dose of orphenadrine citrate (60mg, n = 40) vs. matching placebo (n = 40).	Post-treatment scores ROM: 100% normal: 20% (treatment) vs. 5% (placebo. 75-100% normal: 75% vs. 42.5%. Patient assessment of post-treatment pain 87.5% vs. 10.0% for none or slight pain.	"Intravenous orphenadrine safely and effectively reduced lumbar paravertebral muscle pain and spasm in this group of 80 patients."	Study may be applicable to first health care provider evaluation in an ER. Very brief treatment duration.
Brown 1978 RCT No mention of COI or industry sponsorship.	5.5	N = 49 with long-term intractable pain of cervical and lumbar origin	Cyclobenzaprine hydrochloride (10mg 3 times a day, n = 16) vs. diazepam (5 mg 3 times a day, n = 16) vs. placebo (n = 17) for 2 weeks.	Global improvements (f: 11/16 (68.8%) cyclobenzaprine vs. 8/16 (50%) diazepam vs. 5/17 (29.4%) placebo.	"Cyclobenzaprine (Figure) has been demonstrated to be an effective skeletal muscle relaxant in animals and in man."	All study measures subjective. Chronic pain patients referred to pain clinic. Half of placebo had at least slight improvement in pain. All had PT.
McGuinness 1969 RCT No mention of COI or industry sponsorship.	5.5	N = 110 with acute painful conditions of locomotor system such as lumbago, shoulder pain, fibrositis, OA, and sprains	Parazolidin (phenylbutazone 50mg plus paracetamol 500mg, n = 59) vs. paracetamol alone (500mg, n = 51) for 14 days.	Percent improvements: 38.3% (parazolidin) vs. 32.4% (placebo) at Day 3 and 74.6% vs. 66.6% at Day 14.	"A double-blind trial of Parazolidin and paracetamol confirms the earlier impression of usefulness of the combined preparation containing butazolidin and validates statistically the superiority of Parazolidin in respect of relief of tenderness."	Multiple diagnostic categories used. Follow-up for 14 days. Parazolidin not currently a treatment option.
Arbus 1990 RCT No mention of COI or industry sponsorship.	5.0	N = 50 with lesion-induced LBP and electromyographic abnormalities	Tetrazepam (50mg increased to 150mg on Day 10, n = 25) vs. placebo (n = 25) for 14 days.	More tetrazepam patients improved compared with placebo. EMG parameters also favored active treatment group.	"Tetrazepam was statistically more effective than placebo after four days of treatment."	Some study design features may be problematic including exclusions of "placebo responders" who improved 1st 3 days. Not clear if surface or needle EMG.
Childers 2005 RCT Study supported by Mcneil Consumer & Specialty Pharmaceuticals. No mention of COI.	5.0	N = 772 with acute neck or back pain with muscle spasm for <14 days	Low dose cyclobenzaprine (5mg TID, n = 334) vs. cyclobenzaprine and low dose ibuprofen (5mg/400mg TID, n = 330) vs. cyclobenzaprine and high dose (5mg/800mg TID, n = 336) for 7 days.	No difference among treatments in 7 days PGIC with neck pain only (CYC5, 3.0±1.0; CYC5/IBU400, 3.1±0.9; CYC5/IBU800, 3.0±0.9) or back pain only (3.0±1.0, 3.1±0.9, and 2.9±1.0).	"[C]ombination therapy with low dose cyclobenzaprine (5mg TID) and ibuprofen (400mg TID or 800mg TID) is not superior to low dose cyclobenzaprine alone in adult patients with acute neck and back pain with muscle spasm, and combination therapy was well tolerated."	Open-label trial. Large study population. No physician follow-up visits after baseline. No discussion of some baseline characteristics. Data suggest comparable efficacy, which suggests ibuprofen was not of additive benefit for those patients.
Bouchier-Hayes 1984 RCT No mention of industry sponsorship or COIs.	5.0	N = 49 with acute LBP or wry neck associated with muscle spasm	Chlormezanone 3 times a day (20 tablets total 200mg each, n = 25) vs. an identical appearing placebo (n = 24) for 6 days.	Throughout 6-day treatment course, chlormezanone group reported less pain (graphic form). Percent of soldiers returning to full duty within 4 days: placebo 0% vs. chlormezanone 30.4%.	"The results of this study suggest that further work should be done on a combination of chlormezanone with paracetamol or other analgesic in painful conditions associated with muscle spasm."	5-day treatment. Healthy soldiers with acute low back and neck pain. Chlormezanone widely discontinued in 1996 due to adverse effect of toxic epidermal necrolysis; not viable treatment option today. Data suggest efficacy.

Gold 1978 RCT Study supported by grant from Riker Laboratories, Inc., Northridge, CA. No mention of COI.	4.5	N = 60 with moderate to severe LBP	Orphenadrine (n = 20) vs. phenobarbital (n = 20) vs. placebo (n = 20) for 1 week.	Evaluations showed more pain reductions in orphenadrine group vs. phenobarbital vs. placebo.	"[O]rphenadrine and phenobarbital were statistically superior to placebo in terms of overall symptom relief."	Noted to be double-blind study, but how that was achieved with different tablets is unclear as does not clearly describe placebo pills.
Bercel 1977 RCT No mention of COI or industry sponsorship.	4.5	N = 54 with signs and symptoms of moderate to severe chronic muscle spasm secondary to OA of cervical or lumbar spine	Cyclobenzaprine (10mg TID, n = 27) vs. placebo (n = 27) for 3 weeks.	More patients in marked or moderate improvement categories taking cyclobenzaprine (13/27 vs. 8/27). More central nervous system (CNS) side effects present in active treatment group (drowsiness, dizziness, and ataxia/weakness combined).	"Cyclobenzaprine was superior to placebo in providing relief for the primary symptom of muscle spasm and the concomitant symptoms of pain, limitation of motion, and limitation of activities of daily living."	Lack of study details including no baseline characteristics of participants makes indications for treatment difficult. After 1 week of no medication no differences between groups. Data suggest minimal efficacy.
Hoiriis 2004 RCT Study supported by Life University in funding and clinical facilities. No mention of COI.	4.5	N=192 patients experiencing low back pain for 2-6 weeks duration	Chiropractic adjustment group with placebo medicine, adjustments tailored to needs (n = 48) vs. sham chiropractic adjustment with muscle relaxant group, cyclobenzaprine HCl 5mg (A), carisoprodol 350mg (B), and methocarbamol 750mg (C), starting at 2 tabs QHS from A and 2 TID from bottle B, if adverse effects took B and C instead, could also take acetaminophen (500mg) maximum dose 2 caps, TID (n = 50) vs. sham chiropractic and sham medications (n = 49). Follow-up at 2 and 4 weeks.	For VAS, chiropractic group improved more than controls with scores from 4.52-2.44 in chiropractic group and 3.84-3.18 in placebo. All groups showed decline in disability ($p < 0.0001$). Depression scores improved in all groups ($p < 0.0001$). No differences in Schober's test. No differences in acetaminophen used. Chiropractic group improved over other 2 groups for global impression of severity 13.02-7.58 for chiropractic, 11.32-8.57 in medication and 12.68-9.78 for placebo group.	"The chiropractic group responded significantly better than the control group with respect to a decrease in pain scores."	Attempted chiropractic sham, but data indicate blinding unsuccessful (real chiropractic belief 87.5 vs. 40.0 vs. 20.4%, $p < 0.001$). Medication blinding also unsuccessful ($p = 0.008$). Individualized chiropractic and variable medications used. All improved. Medical control suboptimal treatment. Weaknesses and unblinding limit conclusions.
Cabitza 2008 RCT No mention of COI or industry sponsorship.	4.5	N = 160 with LBP and no severe spinal disease. Possibly mostly chronic.	Oral eperisone 100 mg TID (n = 80) vs. thiocolchicoside 8mg PO BID (n = 80), for 12 days. Follow-ups at 0, 3,7, and 12 days.	No significant differences between groups, though both improved.	"[E]perisone is an effective muscle relaxant agent with potency similar to that of other compounds, such as Thiocolchicoside."	Very short trial. Blinding not well described. Dropouts unclear. No placebo. Control of somewhat unclear efficacy, thus results difficult to interpret.
Waagen 1986 RCT	4.0	N = 29 college students with subacute and	Chiropractic adjustments (n = 18) vs. manual interventions (n = 11). Patients required to be	Average pain duration 2.5 to 2.8 years upon entering trial, but 3.6 to 3.8 years upon completion. Mean pain levels among control group -	"[B]ased on analysis of the data in this study, we conclude that: 1) both subjectively and objectively, chiropractic therapy	Utilization of college students and high dropout rates (10/29) warrant caution in extrapolation to other adults.

Study supported by Palmer College of Chiropractical Research Grant to senior author. No mention of COI.		chronic LBP (19 completed trial)	naïve to chiropractic treatment; 9 in experimental group received chiropractic adjustments; controls received manual interventions. Treatments 2-3 times a week for 2 weeks.	3.7 at baseline and 3.6 among completers. Pain levels in intervention group - 4.6 and 3.5, respectively. Active straight-leg rise on right leg: control 13.5± 10.3 vs. experimental 6±8.65, p = 0.004. Global index: -2.08 vs. 1.71, p = 0.02.	is more effective at relieving low back pain than a manual placebo treatment; and 2) the design and procedures used in this present study are sufficient for a large-scale trial."	Concerns in this population about misdiagnosis, such as ankylosing spondylitis. While authors labeled this a double-blind trial, this is not likely based on available description which is better considered to have an attempted sham.
Basmajian 1989 RCT No mention of COI or industry sponsorship.	4.0	N = 175 with acute musculoskeletal pain and associated spasm of neck or low back	Flexeril plus Dolobid (5/500mg BID, n = 43) vs. Flexeril (5mg BID, n = 43) vs. Dolobid (500mg BID, n = 44) vs. placebo (n = 45) over 7 to 10 days.	At Visit 2, those with marked/moderate improvements: 20/43 vs. 19/44 vs. 13/43 vs. 15/45. Visit 4, statistics: 37/48 vs. 31/39 vs. 37/44 vs. 30/41. Visit 3, statistically significant findings favored combination treatment vs. placebo.	"A combination therapy with an effective safe analgesic and a true muscle relaxant for less than a week appears to be an excellent relief measure for acute back problems."	Lack of randomization, allocation, baseline comparability details. Study suggests short-term benefit of combination NSAID/ muscle relaxant, although clinical significance of findings uncertain.
Vernon 1972 RCT No mention of COI or industry sponsorship.	4.0	N = 183 males with musculoskeletal syndromes most commonly LBP	3 studies: Study 1: combination drug (2 tablets 250mg chlorzoxazone plus 300mg acetaminophen, n = 19) vs. chlorzoxazone (250mg, n = 20) vs. placebo (n = 19). Study 2: chlorzoxazone (3 250mg tablets, n = 31) vs. placebo (n = 28). Study 3: chlorzoxazone (375mg QID, n = 22) vs. acetaminophen (2 tablets 300mg QID, n = 22) vs. combination drug (2 tablets 550mg QID, n = 22) for 6 days.	Improvements occurred rapidly in all 3 groups. Acetaminophen group appeared ineffective relative to other groups, e.g., at end of Study 3, all treated with combination and 82% treated with chlorzoxazone had complete remission vs. 40 to 50% of acetaminophen group who still had pain or spasm.	"Although physical therapy is the superior course of treatment, the combination drug was clinically effective in relieving pain and spasm both as adjunctive treatment or in the lieu of physical therapy."	Many study details not reported. Report consists of multiple studies, none of which are well described.
Sweetman 1987 RCT No mention of COI or industry sponsorship.	4.0	N = 122 with acute LBP of 1-28 days duration	Mefenamic acid (500mg TID, n = 40) vs. chlormezanone-paracetamol (100mg chlormezanone plus 450mg paracetamol TID, n = 44) vs. ethoheptazine aspirin-meprobamate (75mg ethoheptazine plus 150mg meprobamate plus 250mg aspirin, n = 40) for 7 days.	Patient overall assessment of pain on Day 7 showed rate of marked improvement with mefenamic acid was 9/32 = 28.1% vs. chlormezanone-paracetamol 14/31 = 45.2% vs. ethoheptazine/aspirin/ meprobamate 12/32 = 37.5%.	"Mefenamic acid, chlormezanone-paracetamol, and ethoheptazine-aspirin-meprobamate were all effective in the management of acute low back pain as shown by both the clinician's assessments and the patient's diary cards."	Study medications either not widely used or not available. May be underpowered for superiority analysis.
Muscle-acting Muscle Relaxants						
Casale 1988 RCT	6.5	N = 20 with uncomplicated acute LBP	Dantrolene sodium (25mg a day, n = 10) vs. placebo (n = 10) for 4 days.	Dantrolene (only drug in this category that probably works in skeletal muscle and not in CNS) superior to placebo for "muscle contracture." Also superior for	"Data show the possibility of treating uncomplicated acute low back pain with a pure muscle relaxant."	Small numbers. Study of hospitalized patients over 4 days. Dantrolene decreased muscle activity (spasm) subjectively and on EMG.

No mention of COI or industry sponsorship.				pain: 100% vs. 40% improvement in 4 days.		
Spinal-acting Muscle Relaxants						
Bragstad 1979 RCT No mention of COI or industry sponsorship.	7.0	N = 27 with acute muscle spasms due to episodic degenerative disorders of intervertebral discs in lumbar spine	DS 103-282/Tizanidine (2mg TID, n = 14) vs. chlorzoxazone (500mg TID, n = 13) for 7 days.	Muscle pain scores baseline 2.9 vs. 2.3 decrease to 2.33 vs. 2.15 (Day 2) to 1.76 vs. 1.22 (Day 5).	"[D]S 103-282 is a safe and effective muscle relaxant in acute conditions."	Reportedly "no side effects" with tizanidine. No placebo group to verify this was not placebo response. Data suggest modest efficacy.
Hennies 1981 RCT No mention of COI or industry sponsorship.	6.5	N = 30 ambulatory patients with acute painful spasm of paravertebral musculature in cervical or lumbar segments of spine	Tizanidine DS 103-282 (4mg TID, n = 15) vs. diazepam (5mg TID, n = 15) for 7 days.	Statistically significant improvements in muscle pain at Day 3 (but not Day 7), and in Lasègue test at Day 7 and forward flexion present.	"[D]S 103-282 may be considered a more powerful and faster-acting myotonolytic agent than diazepam with which it was compared in similar clinical indication."	Small numbers. Minimal baseline characteristics reported. Co-interventions not well described.
Berry 1988 RCT No mention of COI or industry sponsorship.	6.5	N = 105 with acute LBP	Tizanidine (4mg TID) vs. placebo where all patients in both treatment arms received ibuprofen (400mg TID) for 7 days.	Tizanidine/ibuprofen better Day 3 for pain with walking (-23±-25.4 vs. -13±-22.6). No differences in pain at Day 7, but trends favored tizanidine. Day 3, those with moderate/severe sciatica decreased 18 to 6 with tizanidine vs. 14 to 11 with placebo/ibuprofen; by Day 7, no differences.	"This study shows that tizanidine/ibuprofen is more effective in the treatment of moderate or severe acute low-back pain than placebo and ibuprofen alone."	Drowsiness occurred in 22 taking tizanidine No mention of co-interventions such as activity level. Data suggest that at Day 7 no benefit of tizanidine over ibuprofen.
Pareek 2009 RCT Study sponsored by Ipca Laboratories Limited. First two authors employees of Ipca Laboratories Limited.	6.5	N = 197 (120 male, 77 female) age 18-70 with localized, uncomplicated acute lumbosacral pain, associated with degenerative spinal disorders (confirmed by x-ray) of recent onset (1-30 days).	Patients received either aceclofenac (100mg), tizanidine (2mg) BID or aceclofenac (100mg) alone BID for 7 days.	Day 3, difference in CG vs. MG in Pain on Movement (-2.94 ±1.59 vs. -1.81±1.04, p <0.01), Pain at Rest (-3.01±1.51 vs. -1.90±1.13, p <0.01) and Pain at Night (-3.02± 1.51 vs. -1.92± 1.26, p <0.01). Day 7, differences presenting Pain on Movement (-6.09±2.34 vs. -3.98±1.86, p <0.01), Pain at Rest (-5.88 ± 2.14 vs. -4.35±2.06, p <0.01), and Pain at Night (-5.76± 2.12 vs. -4.40±2.15, p <0.01).	"[T]izanidine is a useful adjunct to the aceclofenac in the treatment of acute LBP in general practice. The combination was found to be superior to aceclofenac monotherapy with respect to efficacy."	Very short trial of 7 days. Data suggest tizanidine of additive benefit to aceclofenac.
Sirdalud Ternelin Asia-Pacific Study Group 1998 RCT Study supported by Novartis Pharma AG, Basel. No mention of COI.	6.0	N = 361 with acute local pain syndromes of low back (50-53%), neck, shoulder girdle; not over 7 days duration	Diclofenac (50mg BID, n = 185) with placebo vs. tizanidine (2mg BID, n = 176) for 8 days.	Moderate/severe pain (baseline/Day 4/Day 8): diclofenac/tizanidine 79/26/11% vs. diclofenac/placebo 77/53/36%. Differences at Day 4 and 8 for muscle tension, restriction of movement, disability due to pain, and bed rest significant.	"[C]ombined treatment with tizanidine with diclofenac provides significantly better efficacy and tolerability than placebo with diclofenac."	Data suggest combination of tizanidine with diclofenac provided statistically significant reduction in pain vs. diclofenac alone. Clinical significance uncertain for analgesic effects.

Fryda-Kaurimsky 1981 RCT No mention of COI or industry sponsorship.	5.0	N = 20 with acute paravertebral muscle spasm	Tizanidine (4 to 8mg TID, n = 10) vs. diazepam (5 to 10 TID, n = 10) for 7 days.	Trial found significant and clinically relevant improvements in mobility in both treatment groups.	"A centrally mediated blood-pressure-lowering effect was observed with both drugs. Tizanidine was generally better tolerated, only two patients reporting transient side-effects compared with five patients in the diazepam group."	Very small numbers. Baseline characteristics not well defined. Co-interventions not well described. Both medications appeared to decrease symptoms and increase somnolence.
Zaringhalam 2010 RCT No mention of COI or industry sponsorship.	5.0	N = 80 males with LBP at least 6 months and no radiation of LBP, age 50-60	Control group (n = 20) vs. baclofen (n = 20) 30mg/day for 5 weeks vs. acupuncture (n = 20) using 10-12 needles for 20-25 minutes. Using neurohumoral mechanism theory of acupuncture vs. acupuncture + baclofen (n = 20). All groups received treatment for 5 weeks.	VAS mean (SD) Week 1: BA vs. AC 52.8 (19.4) p <0.05. Week 2: AC vs. BA: 50.5 (20.1) p <0.05. Week 4,5,10 AC vs. BA; 49.1 (19.3), 47.3 (18.9), 47 (19.1), 50.1 (20.3) p <0.001. Week 3,4,5,10; BA+AC vs. BA: 45.6 (14.7), 42.3 (13.9), 40.1 (13.3), 47.3 (14.1) p <0.05. RDQ: AC vs. BC, week 5 and 10 mean (SD): 6.4 (2.9), 7.2 (3.1) p <0.05. BA+AC vs. with BA: 5.7 (1.4) and 58 p <0.001.	"[T]he present study indicates that the combined treatment of acupuncture and baclofen is more effective than baclofen treatment alone to reduce pain in patients with non specific chronic LBP."	Study compares baclofen with acupuncture for chronic LBP. Data suggest acupuncture plus baclofen superior to baclofen, raising questions regarding whether baclofen is efficacious for chronic LBP.
Dapas 1985 RCT No mention of COI or industry sponsorship.	4.0	N = 200 with acute low back syndrome <2 weeks	Baclofen (n = 100) vs. placebo (n = 100) for 14 days.	Metrics represented in graphic form; all favored baclofen over placebo. Side effects greater in baclofen group (68% vs. 30%) (86 events patients among 98 vs. 19 events among 97 patients).	"[B]aclofen was shown to be an effective and safe drug for the treatment of patients with acute low-back syndrome."	Sparse study details. Suggests statistical benefit of baclofen at Days 4 and 10 vs. placebo. Clinical significance uncertain. No differences in perceived muscle spasms.

SYSTEMIC GLUCOCORTICOSTEROIDS (AKA "Steroids")

Glucocorticosteroids are used to treat symptomatic herniated discs both through local injections (e.g., epidural glucocorticosteroid injections) and oral agents to attempt to reduce localized inflammation and swelling.(13, 1092-1118)

1. Recommendation: Systemic Glucocorticosteroids for Acute or Subacute Radicular Pain Syndromes

Systemic glucocorticosteroids are recommended for treatment of acute and subacute radicular pain syndromes. (56% panel agreement. 44% felt oral steroids should be Not Recommended.)

Strength of Evidence – **Recommended, Evidence (C)**

Level of Confidence – Moderate

Indications – Moderate to severe acute and subacute radicular pain syndromes where the goal is to improve function with the understanding there are no demonstrable impacts on the necessity for surgery. One study suggested that the patient should have an ODI >30.(1119) Recommend as part of an overall active care strategy that includes pregressive increases in activity designed to promote early activity, self-care, and self-efficacy.

Frequency/Dose – One 15-day course of oral prednisone (5 days at 60mg, then 5 days at 40mg, then 5 days at 20mg).(1119)

Indications for Discontinuation – Intolerable adverse effects, e.g., agitation, non-tolerance or other adverse effects.

Benefits – Modestly improved function compared with placebo.(1119)

Harms – Short term worsening of glucose control in diabetics is likely. Anxiety and insomnia are frequent. May exacerbate hypertension. Longer term and higher dose use has been particularly associated with adverse effects such as osteonecrosis, glaucoma, mood swings, infection, osteoporosis, and weight gain.

2. *Recommendation: Systemic Glucocorticosteroids for Chronic Radicular Pain Syndromes*

There is no recommendation for or against systemic glucocorticosteroids for treatment of chronic radicular pain syndromes.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Level of Confidence – Moderate

3. Recommendation: Systemic Glucocorticosteroids for Acute, Subacute, or Chronic Low Back Pain

Systemic glucocorticosteroids are not recommended for treatment of acute, subacute, or chronic low back pain.

Strength of Evidence – **Moderately Not Recommended, Evidence (B) –** Acute LBP
Not Recommended, Insufficient Evidence (I) – Subacute or chronic LBP

Level of Confidence – High

Rationale for Recommendations

Glucocorticosteroids to treat radicular pain syndromes and LBP have been assessed in quality studies.(1119-1122) The single blinded trial for treatment of radicular pain that included long-term follow-up suggested long-lasting benefits compared with placebo suggesting apparent efficacy.(1119) Other trials had followed subjects inadequately or used less steroid, although still suggesting benfit. However, trials uniformly have shown no benefit for treatment of LBP. One moderate-quality trial found comparable (in)efficacy for treatment of LBP with intramuscular compared with intraarticular steroids (2408).

Systemic glucocorticosteroids are either minimally invasive or not invasive depending on the chosen administration route, have adverse effects, but are low cost. Glucocorticosteroids are not recommended

for management of LBP, but are recommended for acute and subacute radicular pain syndromes where their efficacy has been documented.

Evidence for the Use of Systemic Glucocorticosteroids (aka "Steroids")
There are 3 high-(1119, 1120, 1123) and 3 moderate-quality(1121, 1122, 1124) RCTs incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: acute low back pain, subacute low back pain, chronic low back pain, radicular pain syndrome, sciatica, spinal stenosis, Epidural Glucocorticosteroid Injection, Dexamethasone, Glucocorticosteroid injection, Methylprednisolone, Triamcinolone, Steroid injection, Corticosteroid injection, betamethasone, Peridural Injection, Extradural Injection, Epidural Injection, clinical trial, randomized controlled trial, random, systematic review, review, population study, epidemiological study, and prospective cohort as well as reviewed references to find 44,715 articles (24 articles from reference lists). Of the 44.691 articles, we reviewed 190 articles and included 105 articles (all RCTs).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Finckh 2006 RCT Authors report no industry sponsorship and no COI.	9.0	N = 60 hospitalized with acute sciatica with pain radiating below knee, positive SLR or neurologic deficit, positive corroborative MRI or CT	IV bolus of 500mg methylprednisolone (n = 31) vs. placebo (n = 29) as an adjuvant to standard care for 15 days (including NSAIDs and physical therapy).	Significantly less pain on Days 1 to 2. At Day 30, statistics not presented, but appear to show significant benefit from glucocorticosteroid.	"[A] single IV pulse of glucocorticoids provides a small and transient improvement in sciatic leg pain, and no effect on functioning or objective signs of radicular irritation."	Trend towards more neurologic deficits in glucocorticosteroid (52% vs. 34%). IV steroids appeared to impact function at 30 days.
Goldberg 2015 RCT COI: Dr. Carragee reports travel support from US Army, grants from Orthopaedic Research and Education Foundation and AOSpine, and options from Simpirica and Intrinsic Orthopedics. Sponsorship: supported by grant R01 AR053960 from National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) of US National Institutes of Health to Drs. Goldberg and Avins.	8.5	N = 269 with radicular pain for 3 months or less, leg pain extending below knee in nerve root distribution, herniated disk confirmed by MRI, ≥30 points on Oswestry Disability Index. Mean±SD age 46.0±12.1 years.	A tapering 15-day course of oral prednisone (5 days each of 60mg, 40mg, and 20mg; total cumulative dose = 600mg; n = 181) vs. matching placebo (n = 88). Follow-up for 52 weeks.	Mean ODI scores at 3 weeks: prednisone group: 6.4 point (95%CI, 1.9-10.9; p = 0.006). ODI scores at 52 weeks: placebo group: 7.4 point (95%CI, 2.2-12.5; p = 0.005).	"Among patients with acute radiculopathy due to a herniated lumbar disk, a short course of oral steroids, compared with placebo, resulted in modestly improved function and no improvement in pain."	In patients with acute and subactute radiculopathy due to lumbar disc herniation. A 15 day course of steroids showed superiority over placebo for improved function both at 3 weeks and one year. However, use of oral steroids did not prevent the need for more invasive treatment such as surgery and there were more AE's in oral steroid group.
Friedman 2006 RCT No mention of COI or industry sponsorship.	8.0	N = 86 with LBP	Intramuscular (IM) injection of methylprednisolone acetate (160mg, n = 44) vs. placebo (n = 43) for duration of 1 month.	Pain scores decreased from 7.6±2.4 to 2.4±3.3 at 1 month (methylprednisolone) vs. 8.1±1.8 to 2.3±3.4 (placebo).	"Corticosteroids do not seem to benefit patients with acute non-radicular low back pain."	Study suggests no benefit at 1 month from steroid injection IM for acute LBP.
Haimovic 1986 RCT No mention of COI or industry sponsorship.	7.0	N = 33 with lumbosacral radicular pain kept at bed rest for 7 days	Oral dexamethasone (Day 1 = 64mg, Day 2 = 32mg, Day 3 = 16mg, Day 4 = 12mg, and Days 5-7 = 8mg, n = 21) vs. identical appearing	Early improvements between groups identical. Among those with positive straight-leg raise, non-statistically significant trend toward improvement in	"[D]examethasone was not better than placebo for short or long-term relief of lumbosacral radicular pain."	Mixing patients with clear radiculopathy with those who might have had just radiating pain may have produced a Type II error.

			placebo (n = 12) for duration of 7 days. Subjects evaluated at 1 and 4 years.	dexamethasone group. No overall differences at 1 year.		
Holve 2008 RCT Supported by grant from Kaiser Foundation Research Institute. No mention of COI.	7.0	N = 27 with acute sciatica, within 1 week of onset of symptoms, aged between 20 and 60 years	Tapering course of prednisone: 60mg for 3 days, 40mg for 3 days, and 20mg for 3 days (n = 13) vs. placebo capsules (n = 14). Follow-ups Q week for first month, then monthly for 5 months.	Both groups improved at follow-up. No significant differences between groups. Results similar for mental and physical health scores, disability, return to work. No differences in use of narcotics, NSAIDs, epidural injection, surgical intervention.	"The impact of oral steroids on other outcomes is suggested by this study, but its small sample size limited its statistical power."	Small sample size (N=27). Data suggest no efficacy compared with placebo.
Porsman 1979 RCT No mention of COI or industry sponsorship.	5.5	N = 49 with acute, subacute, and chronic symptoms and signs of prolapsed lumbar disc	Intramuscular administration of dexamethasone phosphate (Day 1, 64mg; Day 2, 32mg; Day 3, 24mg; Day 4, 12mg; Day 5-7, 8mg, n = 25) vs. placebo (n = 24) for 7 days.	Rate of success 52% (dexamethasone) vs. 58.3% (controls).	"The results of the present study do not support the use of dexamethasone phosphate administered intramuscularly to patients with a clinically diagnosed prolapsed disc."	Lack of study details. Variation in duration of symptoms (few days to 6 months). Diagnosis based on symptoms rather than diagnostic imaging. Suggests no difference between placebo and IM dexamethasone phosphate at 9 days.

THALIDOMIDE

Thalidomide is a sedative-hypnotic and multiple myeloma medication. Case reports have found it efficacious in treating CRPS (1125-1127); thus, thalidomide is under investigation as an agent with possible wider benefit for this condition. However, severe birth defects (phocomelia) have resulted when the drug has been taken during pregnancy.

Recommendation: Thalidomide for Chronic Low Back Pain

Thalidomide is not recommended for treatment of chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation

There are no quality studies evaluating thalidomide for treatment of chronic pain syndromes. This medication has severe adverse effects and should never be used by patients who are pregnant or have the potential to become pregnant. Peripheral neuropathy (apparently dose dependent)(1128) is another potentially severe adverse effect and occurs in as many as 80% of patients. Risk of thrombosis has also been reported. Therefore, thalidomide cannot be recommended for the treatment of LBP.

Evidence for the Use of Thalidomide

There are no quality studies incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: thalidomide, and chronic low back pain to find 13,020 articles. Of the 13,020 articles we reviewed zero articles.

TUMOR NECROSIS FACTOR-ALPHA INHIBITORS

Tumor necrosis factor alpha is thought to have a role in resorption of herniated intervertebral discs and also in producing the pain associated with herniated discs. Adalimumab and infliximab are monoclonal antibodies against tumor necrosis factor alpha. Etanercept is a tumor necrosis factor receptor inhibitor. They have been used for a number of rheumatological conditions, as well as in uncontrolled trials of sciatica.(1129-1131)

1. *Recommendation: Tumor Necrosis Factor Alpha for Radicular Pain*
   Tumor necrosis factor-α inhibitors are moderately not recommended for treatment of radicular pain syndromes.
   Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
   Level of Confidence – Moderate

2. *Recommendation: Tumor Necrosis Factor Alpha for Acute, Subacute, or Chronic Low Back Pain*
   Tumor necrosis factor-α inhibitors are not recommended for treatment of acute, subacute, or chronic low back pain.
   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations

Most RCT data including over 1 year of follow-up failed to find beneficial effects of infliximab for lumbar radicular pain syndromes (1132-1134), although one study reported benefits (2409). Thus, there is no consistent quality evidence that tumor necrosis factor-α inhibitors have beneficial effects on the treatment of radicular pain syndromes. These agents are invasive and have significant adverse effects, including leucopenia, thrombocytopenia, pancytopenia, predisposition to serious infection, and a lupus-like autoantibody syndrome. Since potential adverse effects can be severe, proof of efficacy is essential

before these inhibitors could be recommended. They are costly and also have not been assessed in acute, subacute, or chronic LBP syndromes.

Evidence for the Use of Tumor Necrosis Factor Alpha Inhibitors

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates and an updated search was conducted using PubMed for publications between 1/1/2013 and 11/15/2017. We used the following search terms: tumor necrosis factors, tumor, necrosis, factor-α, inhibitors, radicular, syndromes, sciatica, subacute, low, back, pain, chronic, and random to find 22,806 articles. Of the 22,806 articles we considered for inclusion 61. Of the 61 articles considered for inclusion, 4 are randomized controlled trials and 57 systematic reviews.*

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Freeman 2013 (score= 8.5)	Tumor Necrosis Factors	RCT	Sponsored by BioAssets Development Corporation, a subsidiary of Teva Pharmaceuticals Industries Ltd. COI, one or more of the authors have received or will receive benefits for personal or professional use.	N = 49 patients with a current diagnosis of lumbosacral radicular pain of 6 to 26 weeks secondary to lumbar disc herniation confirmed by radiological means with a mean pain score of 5/10 or more for average leg pain.	Mean age: 47.2 years. 24 male, 13 female.	0.5 mg Etanercept group (n = 8) vs 2.5 mg Etanercept group (n = 10) vs 12.5 mg Etanercept group (n = 9) vs Placebo (n = 10). All patients received 2 transforaminal epidural injections, 2 weeks apart and were assessed after the second injection	Follow up at 2, 4, 6, 8, 12, 16 and 28 after first injection.	Decrease from baseline of mean daily WLP score was 4.4(ITT) and 5.1 (PP) for the etanercept 0.5 mg group vs 1.8 (ITT) and 1.9 (PP) in the placebo group (p=0.058 and p=0.066)	"Two transforaminal injections of etanercept provided clinically significant reductions in mean daily WLP and worst back pain compared with placebo for subjects with symptomatic LDH. Epidural etanercept may offer patients with sciatica a safe and effective nonoperative treatment."	Should be placebo controlled. 2 injections given 2 weeks apart and follow-up at 26 weeks post second injection. Data suggest Etanercept, a TNF at 0.5 mg for 2 injections 2 weeks apart may provide clinically significant reductions in both worst leg and back pain in LDH patients.
Korhonen 2005 (score= 8.0)	Tumor Necrosis Factors	RCT	Sponsored by Centocor, Inc, Malvern, PA. COI, One or more authors received or will receive benefits for personal or professional use from commercial party related directly or indirectly to subject of this manuscript.	N = 40 with sciatic pain	Mean age: 40.7 years; 24 male, 16 female.	Infliximab (5mg/kg, n = 21) vs. placebo (n = 19) over 2-hour period.	Follow up at 1 and 2 weeks and 1 and 3 months.	Median reduction in leg pain at week 12: 43mm infliximab group vs. 50mm in placebo group. No significant difference between groups. No further differences found.	"[T]he results of the present trial do not support the use of a single infusion of infliximab 5 mg/kg to treat moderate to severe disc herniation-induced sciatica."	Follow-up report with 1-year observation data reported that 67% in infliximab group pain free vs. 63% in placebo (Korhonen 06). Data suggest no benefit over placebo at 3 months or 1 year.
Autio 2006 (score= 6.5	Tumor Necrosis Factors	RCT	Sponsored by Centocor, Inc, Malvern, PA. COI, One or more authors received or will receive benefits for	N = 21 patients who were candidates for discectomy because of unilateral sciatica.	Mean age: 41.2 years; 11 male, 10 female.	Infliximab (5mg/kg, n = 11) vs. placebo (n = 10) over 2-hour period.	Follow up at 1 and 2 weeks and 1, 3, and 6 months.	Mean HNP volume decrease at 6 months compared to baseline was 431 mm^3 for the infliximab group vs 381 mm^3 for the	"Infliximab did not appear to interfere with disc herniation resorption over a 6-month period."	Small sample. MRI data suggest at 6 months, Infliximab did not interfere with disc herniation reabsorption.

			personal or professional use from commercial party related directly or indirectly to subject of this manuscript.					placebo group.		
Korhonen 2006 (score= 7.0)	Tumor Necrosis Factors	RCT	Sponsored by Centocor, Inc, Malvern, PA. COI, One or more authors received or will receive benefits for personal or professional use from commercial party related directly or indirectly to subject of this manuscript.	N = 40 with sciatic pain	Mean age: 40.7 years; 24 male, 16 female	Infliximab (5mg/kg, n = 21) vs. placebo (n = 19) over 2-hour period.	Follow up at 1 and 2 weeks and 1, 3, and 6 months, and 1 year.	Median back pain reduction was 13 mm for the infliximab group vs 17 mm for the placebo group (p=0.48),	"Although the long-term results of this randomized trial do not support the use of infliximab compared with placebo for lumbar radicular pain in patients with disc herniation-induced sciatica, further study in a subgroup of patients with L4–L5 or L3–L4 herniations, especially in the presence of Modic changes, appears to be warranted."	Data suggest a lack of efficacy of Infliximab compared to placebo at all time points up to one year post injection for treatment of pain related to disc-herniation-induced sciatica.

COMPLEMENTARY OR ALTERNATIVE METHODS OR DIETARY SUPPLEMENTS, ETC.
Some interventions for LBP are classified as dietary supplements or as complementary or alternative treatments. A few of these interventions include homeopathic treatments, naturopathic treatments, vitamins, herbal remedies, spiritual healing, touch for healing, craniosacral therapy, aromatherapy, energy healing, and neural therapy.(1135-1144) Tuina-focused integrative Chinese medical therapies emphasize anatomy and physiology when used for the treatment of LBP.(1145) Most of these interventions (certain exceptions discussed below) do not have quality evidence of efficacy for low back pain. As there are many interventions shown to be efficacious for the treatment of acute, subacute, chronic, radicular and post-operative LBP, it is strongly recommended that patients be treated with therapies proven to be efficacious for these conditions, whether or not the intervention is considered complementary, alternative, or a dietary supplement, etc.

Recommendation: Complementary or Alternative Treatments or Dietary Supplements, etc., for Acute, Subacute, or Chronic Low Back Pain
Complementary or alternative treatments or dietary supplements, etc. (other than those specifically described below) are not recommended for treatment of acute, subacute, or chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
Except where described elsewhere, quality studies regarding complementary or alternative interventions or dietary supplements have not been identified or do not exist. Available trials frequently have significant methodological weaknesses. These interventions are not proven efficacious for the treatment of acute, subacute, or chronic LBP or for radicular pain syndromes or other back-related problems. There are other interventions shown to be efficacious.

Evidence for the Use of Complementary or Alternative Treatments or Dietary Supplements
There are 7 moderate-quality RCTs incorporated into this analysis.(1146-1152) There is 1 low-quality RCT in Appendix 1.(1153)

We searched PubMed, EBSCO, Cochrane Review, and Google scholar without limits on publication dates. We used the following search terms: Complementary alternative medicine, homeopathic treatments, naturopathic treatments, spiritual healing, touch for healing, craniosacral therapy, aromatherapy, energy healing, and neural therapy, subacute low back pain, chronic low back pain, low back pain, clinical trial, randomized controlled trial, random, systematic review, population study, epidemiological study, and prospective cohort to find 4,436 articles. Of the 4,436 articles, we reviewed 13 articles and included 9 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Naturopathic						
Szczurko 2007 RCT Funded by Canada Post Corporation and Canadian Union of Postal Workers. No COI.	5.5	N = 75 with non specific LBP at least 6 weeks	Naturopathic care, n = 39 (acupuncture treatment 2x a week for 12 weeks; deep breathing exercises and diet high in omega 3 fatty acids, Mg and Ca; aerobic exercise 30 minutes 3x a week) vs. educational booklet and advice for back stretching and strengthening and relaxation exercises, n = 36.	Oswestry (baseline/week 12): naturopathic 10/4 vs. control 9/12, p <0.0001. Roland-Morris: 7/2 vs. 5/8, p <0.0001. Pain scale: 2/1 vs. 2/2, p <0.0001. Spinal flexion (cm): 30/34 vs. 31/30.5, p <0.0001. SF-36 outcomes: aggregate physical component (38.96±8.56/48.21±8.10 vs. 39.75±8.39/40.57±8.58, p <0.0001), aggregate mental component (47.30±11.46/ 51.57± 8.05 vs. 49.15±11.18/ 47.57± 10.03, p = 0.0045).	"Naturopathic care provided significantly greater improvement than physiotherapy advice for patients with chronic low back pain."	High dropouts in controls. Some baseline differences. Intervention was complex (acupuncture, deep breathing, exercises, diet), therefore, unclear what is effective. PT is not aerobically-based, appears primarily stretching (?type) and thus control may be equivalent to non-interventional control due to lack of effective treatment arm.
Meditation						
Morone 2009 RCT Funded by NIH Roadmap Multi-disciplinary Clinical Research Career Development Award Grant (1KL2RR024154-04) from National Institutes of Health (NIH). Publication also made possible by Grant Number UL1RR024153 from National Center for Research Resources (NCRR), a component of NIH and NIH Roadmap for Medical Research. No COI.	6.0	N = 40 community dwelling older adults aged 65 and older with chronic LBP for at least 3 months	8 weekly 90 minute mindful meditation sessions (n = 20) vs. control group who received 8 weekly 90 minute sessions of a health education program (n = 20). Follow-up at 8 weeks and 4 months.	No significant differences between groups.	"Both the intervention group and the education control group improved on outcome measures suggesting both programs had a benefit effect."	Pilot study. Small sample size and much data variability. Data suggest meditation not superior.
Morone 2008 RCT Supported by AG23641 K07 of Dr. Stephanie	5.0	N = 37 community-dwelling adults aged 65+ years with chronic LBP at least 3 months	8 weekly 90 minute mindful meditation sessions and meditation homework assignments (n = 19) vs. wait-listed control who did not receive any intervention (n =	SF 36 physical function scale (baseline/8 week): meditation 42.0±10.9/45.7±9.2 vs. 45.1±9.5/44.5±10.1, p = 0.03. Chronic pain acceptance questionnaire total score:	"[A]n 8-week mindfulness meditation program is feasible among community dwelling older adults with CLBP. Three-month	Pilot study. Wait-listed controls, thus biased in favor of intervention. High dropouts and non-compliance limit ability to draw conclusions.

Studenski from National Institutes of Health. During time of this work, Dr. Morone supported by primary care faculty development training grant (HRSA D55 HP05156) and by NIH Roadmap Multi-disciplinary Clinical Research Career Development Award Grant (1KL2RR024154-01) from NIH. No mention of COI.			18). After 8 weeks, control could crossover to 8 week program. Follow-up at 8 weeks and 3 months.	72.2±13.4/75.5±16.0 vs. 68.1±20.3/64.8±23.0, p = 0.008. Chronic pain acceptance questionnaire activities engagement: 47.7±8.9/50.3±12.3 vs. 47.9±12.3/43.4±13.5, p = 0.004. NS between groups for all other outcomes and all outcomes at 3 months.	follow-up suggested sustained benefit from the program as measured by continued meditation by program participants and sustained improvement in physical function and pain acceptance."	
Breath Therapy						
Mehling 2005 RCT Supported by Mount Zion Health Fund; HRSA Fellowship, US Department of Health and Human Services. No mention of COI.	5.0	N = 36 age 20-70 with continuous chronic LBP of 3-24 months duration	Breath therapy, n = 18 (particular attention to breath; touch and stretching of patient by therapist) vs. physical therapy, n = 18 (soft tissue mobilization, joint mobilization, and exercise for postural righting, flexibility, pain relief, stabilization, strengthening, functional task performance, and back related education) 12 sessions 45 minutes each 6-8 weeks. Daily exercises at home 20-30 minutes. Follow-up post and 6 months.	No significant differences between groups.	"Patients suffering from cLBP improved significantly with breath therapy. Changes in standard low back pain measures of pain and disability were comparable to those resulting from high-quality, extended physical therapy."	Nearly all had had prior PT (75% vs. 92%). Exercise appears heterogenous. Protocol suggests breath therapy had exercise too. PT control is more of same and trial likely biased in favor of intervention.
Alternative Treatment-Subacute LBP						
Kulisch 2009 Double-blind RCT No mention of COI or industry sponsorship.	6.5	N = 71 with chronic lumbar pain >12 weeks	Thermal water (n = 36) vs. tap water (n = 35), both groups underwent 20-min QD balneotherapy sessions, for 3 weeks, water temperature 34˚C.	At 3 weeks, between group differences in VAS IV, Schober, Oswestry, and SF-36. After 15 weeks, Physical Functioning, for patients who completed full treatment (p <0.05/p <0.05) greater in thermal water group.	"[T]reatment with hot water is an effective treatment modality for the management of chronic lumbar pain."	Attempted blind. Data suggest equal (in)efficacy.

Lauche 2012 RCT Supported by grant from Karl and Veronica Carstens Foundation. No COI.	6.0	N = 40 with chronic neck or low back pain (≥3 months pain), 18-75 years old	Treatment group (TG): Gua Sha treatments administered to sitting patients by study physician (n = 10 with LBP) vs. waiting list control group (WLC) (n = 8 with LBP). Follow-up 7 days after treatment.	Effects with levels of pain at rest (VAS) at follow-up (Δ -1.1; 95% CI -2.0 to -0.2, p = 0.03) favoring TG. TG favored in general health outcome as well (mean ranks TG 6.9; WLC 12.75; U = 14.0; p = 0.02). No differences for pressure pain threshold.	"Gua Sha therapy may be effective in treating patients with chronic neck and chronic low back pain. Further study of Gua Sha is warranted."	Small groups. No adverse events found. Wait list control group bias. 7-day trial.
Yuan 2013 RCT Supported by Key Discipline of TCM Orthopaedic and Traumatic of Ministry of Education of the People's Republic of China (100508); Medical Key Project of Shanghai Science and Technology Commission (09411953400); project of Shanghai Medical leading talent (041); National Natural Science Foundation of China (81073114, 81001528); National Key New Drugs Creation Project, innovative drug research and development technology platform (no. 2012ZX09303009-001); Shanghai University Innovation Team Construction Project of Spine Disease of Traditional Chinese Medicine (2009-26). No COI.	6.0	N = 408 with LBP due to lumbar disc herniation	Experimental Group (n = 306): 2-week integrative TCM treatment. Further divided into 3 subgroups according to duration from initial LBP to receive treatment: acute stage (0-14 days) = electro-acupuncture + Chinese herbal injection (Salvia miltiorrhiza injection) + external plaster (compound redbud injury-healing cataplasms), subacute stage (15-30 days) = Chinese Tuina (massage) + hot compress using Chinese medicine + external plaster, and chronic stage (>30 days) = TCM functional exercise + external plaster vs. control group (n = 102): 2-week normal conservative treatment (health education, rest, pain medication or physical therapy). Follow-up at 6 months.	Primary outcomes: immediately after treatment, VAS score decreased in experimental group vs. control (−16.62 points [95% CI: −20.25 to −12.98]; p<0.001). At 1-month, experiment group had lower VAS score vs. controls (−6.37 points [95% CI: −10.20 to −2.54]; p = 0.001). At 6-months, no significant differences between-groups in VAS scores. Secondary outcomes: immediately after treatment, experimental group had greater improvement in C-SFODI vs. controls (−15.55 points [95% CI: −18.92 to −12.18]; p<0.001). At 6-months, experimental group had greater improvement vs. controls (−7.68 points [95% CI: −11.42 to −3.94]; p <0.001).	"This randomized controlled clinical trial provides reliable evidence regarding the effectiveness of integrative TCM conservative treatment for patients with low back pain due to lumbar disc herniation."	Mix of acute, subacute and chronic pain. Pragmatic trial with heterogenous mix of interventions prevents assessment of efficacy of any one of them.

MEDICAL FOODS

Theramine, an amino acid formulation (AAF), has been used as a prescription medical food to theoretically reduce pain and inflammatory processes through dietary management.(1154) Theramine purportedly may increase the production of serotonin, nitric oxide, histamine, and gamma-aminobutyric acid by providing precursors to these neurotransmitters.(1154)

Recommendation: Medical Foods for Acute, Subacute, Chronic, Radicular and Post-operative Low Back Pain

There is no recommendation for or against use of medical foods, including theramine, for treatment of acute, subacute, chronic, radicular and post-operative low back pain.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendation

There are no placebo-controlled trials identified. There is one moderate-quality trial comparing theramine with low dose naproxen.(1154) This may have biases similar to a non-treatment or wait-listed control group. Theramine is not invasive, has low adverse effects but cost quickly becomes high. In the absence of trials demonstrating efficacy, there is no recommendation for or against theramine.

Evidence for the Use of Medical Foods

There is 1 moderate-quality RCT incorporated into this analysis.(1154)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates. We used the following terms: medical food theramine, theramine, subacute low back pain, chronic low back pain and low back pain. This search found 8 articles and we included 1 article.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Shell 2012 RCT Industry Sponsored (Physician Therapeutics, Los Angeles, CA and UCLA School of Medicine) and no mention of other COI.	5.0	N = 129 with LBP lasting >6 weeks and VAS score of 0.40 of 100mm	Naproxen 250mg QD (n = 42) vs. theramine amino acid food (AAF) (n = 43) vs. AAF plus naproxen (n = 44) for 28 days.	Combination group showed greatest improvement in both Oswestry Disability Index (60.47%) and Roland-Morris Pain Index (65%). Naproxen alone did not show significant changes in back pain over 28 days (3.4% and 2.95%).	"[A]ddressing the dietary management of pain syndromes could allow for the dose reduction of NSAIDs without affecting therapeutic efficacy."	Many details sparse. Unblinded study, no placebo group. Trends toward higher ODI and RMPS at baseline in OTC naproxen group. Limited results provided. Naproxen 250mg QAM, thus very low dose, NSAID low dose may be equivalent to no-treatment control bias. Data suggest combination superior but potential biases mitigate against reliability.

HERBAL AND OTHER PREPARATIONS

Herbal treatments have been utilized to treat LBP, including Camphora molmol, Salix alba, Melaleuca alternifolia, Angelica sinensis, Aloe vera, Thymus officinalis, Menthe piperita, Arnica montana, Curcuma longa, Tanacetum parthenium, Harpagophytum procumbens, and Zingiber officinale. Evidence of efficacy varies across these compounds. (Creams and ointments, including capsicum, are reviewed separately.)

1. *Recommendation: Herbal Treatments for Acute, Subacute, or Chronic Low Back Pain*
   There is no recommendation for or against the use of Harpagoside, Camphora molmol, Melaleuca alternifolia, Angelica sinensis, Aloe vera, Thymus officinalis, Menthe piperita, Arnica montana, Curcuma longa, Tanacetum parthenium, or Zingiber officinale,(1155) for treatment of acute, subacute, or chronic low back pain.

   Strength of Evidence **– No Recommendation, Insufficient Evidence (I)**
2. *Recommendation: Willow Bark for Acute, Subacute, or Chronic Low Back Pain*
   Willow bark (salix) is not recommended for treatment of acute, subacute, or chronic low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations

Treatments are diverse with limited comparability between treatment regimens. Herbal treatments/supplements for any condition are not well regulated in the U.S. and research regarding therapeutic and biologically available dosage is limited or non-existent. There is a potential for a placebo effect to be misinterpreted as a sign of efficacy.

There is evidence suggesting that harpagoside is effective in the treatment of LBP.(1156, 1157) There is one trial comparing harpagoside with a low dose (12.5mg) of Vioxx (see below).(1157) As this was a low dose of Vioxx, it may be reasonable to infer that harpagoside is somewhat less efficacious than NSAIDs. Safety of this agent also needs to be addressed in larger trials over longer durations. However, in patients who do not tolerate a NSAID or who have contraindications, this may be a reasonable medication for treating chronic LBP. Providers should be cautioned that there are no quality long-term safety data. However, there is little, if any, control over the quality and dosing of these compounds in contrast with pharmaceuticals and thus, there is no recommendation.

There is evidence that salicin is effective in the treatment of LBP,(1158, 1159) as this is the plant from which salicylates were derived. There also is evidence that Salix (willow bark) inhibits platelet aggregation, though less strongly than aspirin or other salicylates.(1160) While willow bark appears mildly effective in short-term trials, when compared to a low dose of rofecoxib there is no difference, but this also suggests that willow bark is inferior to NSAIDs for the treatment of LBP. A rationale basis for using this agent is not apparent when, as it is directly related to salicylates, it may contain other compounds with potential adverse effects and is more expensive than most generic NSAIDs. **If salicylates are used as treatment, generic aspirin is preferable to Willow bark or salicin.**

Harpagoside and salicin are taken orally. Neither have long-term demonstrated efficacy and safety. Adverse effects appear low. They are not costly. Both appear likely to be substantially inferior to prescription dose NSAIDs.

There is no quality evidence to support the use of most of these agents including Camphora molmol, Melaleuca alternifolia, Angelica sinensis, Aloe vera, Thymus officinalis, Menthe piperita, Arnica montana, Curcuma longa, Tanacetum parthenium, and Zingiber officinale,(1155) for LBP or post-operative patients.

Evidence for the Use of Herbal Treatments
There are 2 high-(1156, 1157) and 4 moderate-quality(1158, 1159, 1161, 1162) RCTs incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google scholar without limits on publication dates. We used the following search terms: herbal preparations, herbal remedies, herbal medicine, herbalism, Harpagoside, Camphora molmol, Melaleuca Alternifolia, Angelica Sinensis, Aloe Vera, Thymus Officinalis, Menthe Peperita, Arnica Montana, Curcuma Longa, Tancaetum Parthenium, Zingiber Officinale, Harpagophytum, Willow Bark Extract, chronic low back pain, low back pain, clinical trial, randomized controlled trial, random, systematic review, population study, epidemiological study, and prospective cohort to find 5,197 articles. Of the 5,197 articles, we reviewed 10 articles and included 8 articles (6 original articles, 2 reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Harpagophytum vs. Rofecoxib						
Chrubasik 2003 RCT Funded by Ardeypharm GmbH, Herdecke, Germany. No mention of COI.	9.0	N = 79 with acute exacerbation of chronic LBP, most (59-66%) with pain radiation into legs	Doloteffin 60mg a day (Harpago-phytum, n=44) vs. rofecoxib (Vioxx, n = 44) 12.5mg a day for 6 weeks.	Nearly all exacerbations (91%) >90 days duration. Adverse effects in 14 in each group (31.8% of all), with 8 GI effects with Vioxx vs. 2. >50% improvement at Weeks 1 to 6: 41% Harpagophytum vs. 25% Vioxx. Percent requiring tramadol: 48% vs. 30%, respectively (230mg vs. 133mg).	"Though no significant intergroup differences were demonstrable, large numbers will be needed to show equivalence."	No placebo control. Low dose of Vioxx used may bias in favor of harpagoside. Lack-of co-intervention controlling. Differences in tramadol suggest Harpagophytum may be inferior. Data suggest equal efficacy. Data suggest no significant improvements.
Harpagophytum vs. Placebo						
Chrubasik 1999 RCT No mention of COI or industry sponsorship.	8.5	N = 197 with chronic LBP median 15 years duration	Harpagophytum extract Ws 1531 600mg (n = 65) vs. Harpagophytum extract Ws 1531 1200mg (n = 66) vs. placebo (n = 66) for 4 weeks.	Percentages of patients pain-free for 5 days in prior week at end of trial: 9% placebo vs. 15% (600mg) vs. 15% (1,200mg). Similar trends present whether initial pain score milder (5% vs. 11% vs. 13%) or greater than 7 (4% vs. 5% vs. 21%).	"[H]arpagophytum can probably help many patients who might also be helped by bed rest, paracetamol or NSAIDs or manipulation and back school."	High dose in one arm to detect adverse effects, but numbers treated and short treatment precludes robust conclusions on safety. No mention of co-interventions other than medications. Data suggest Harpagophytum modestly superior to placebo.
Willow Bark Extract vs. Placebo						
Chrubasik 2000 RCT Funded in part by European Academy of Natural Medicine/ Bad Schwalbach and by Plantina GmbH/ Munich. No mention of COI.	6.0	N = 210 with chronic LBP	240mg of oral willow bark extract (containing salicylates, n = 70) vs. 120mg of oral willow bark extract (n = 70) vs. placebo (n = 70) for 4 weeks.	Number (%) pain free at Week four: placebo 4(7); low dose 15(22); high dose 27(42); p <0.001.	"Willow bark extract may be useful and safe treatment for low back pain."	Baseline data concerning for randomization failure with trends across two major variables (duration of LBP over 6 years of 56% vs. 66% vs. 76%, p = 0.05 and Beck depression inventory 6 vs. 7 vs. 8, p = 0.02). Dropout rates high. Study problems preclude conclusions.
Chrubasik 2001 RCT No mention of COI or industry sponsorship.	4.5	N = 228 with acute exacerbations of chronic LBP	Extract of willow bark (240mg of Assalix®, n = 114) vs. selective inhibitor (12.5mg rofecoxib) of enzyme cyclo-oxygenase-2 (COX-2, n = 114) for 4 weeks.	Percentage changes in VAS scores identical at 44%.	"There was no significant difference in effectiveness between the two treatments at the doses chosen. Treatment with Assalix® was less expensive."	Baseline differences in radiation of pain into legs present (31% among Salix vs. 46% of Vioxx). Low dose rofecoxib used and baseline demographics favor Assalix®, suggesting willow bark may be inferior to NSAIDs.
Root Extract vs. Placebo						
Giannetti 2010 RCT	4.5	N = 120 with acute upper or lower back pain (either one but not combination)	Root extract ointment (n = 60) vs. placebo ointment (n = 60). Treatments 3x/day (4 g per application). Follow-up at	Pain intensity decreased ~95.2% in root extract group (mean VAS sum: 104.8 to 12.7 mm) vs. 37.8% in placebo (100.0 to 56.5 mm), (p<0.001). In secondary variables, back pain at rest	"The results of this clinical trial were clear-cut and consistent across all primary and secondary efficacy variables. Comfrey root extract	Many details sparse. Success of blinding unclear. Short, 5-day trial. Data suggest efficacy. Weaknesses limit strength of conclusion.

No mention of COI or industry sponsorship.			day 1, 2, 3, 4, and 5 (4 visits).	decreased ~97.4% in root extract (mean VAS: 33.1 to 3.5 mm) vs. 39.6% in placebo (31.8 to 18.9mm), (p <0.001).	showed a remarkably potent and clinically relevant effect in reducing acute back pain. For the first time a fast-acting effect of the ointment (1 h) was also witnessed."	
Root Extract vs. Methyl Nicotinate vs. Placebo						
Pabst 2013 RCT Sponsored by Merck Selbstmedikation GmbH. Conducted by CRO CRM clinical trials GmbH, Rheinbach, Germany. Industry COIs: Helmut Pabst and Axel Schaefer were investigators, Hans-Georg Predel was PI, Marc Junker-Samek and Christiane Staiger are employees of Merck.	5.5	N = 379 with acute upper or LBP (either one but not combination)	Topical combination of 35% comfrey root extract plus 1.2% methyl nicotinate (n = 163) vs. Methyl nicotinate (n = 164) vs. placebo cream (n = 52). All 3x/day (4 g per application) for 5 days.	In primary outcomes, combination group 27% lower VAS on active standardized movement values at visits 1-4 vs. methyl nicotinate (6548.65 vs. 8975.32 mm × h, mean treatment effect: -2426.7 mm × h), combination group 50% lower values vs. placebo (6548.65 vs. 13052.40 mm × h, mean treatment effect -6503.8 mm × h) (ANOVA: p <0.0001). In secondary outcomes, combination group 27% lower VAS values on pain vs. methyl nicotinate (1782.60 vs. 2457.32 mm × h, mean treatment effect -674.7 mm × h), combination group 54% lower values vs. placebo (1782.60 vs. 3910.66 mm × h, mean treatment effect -2128.1 mm × h), (t-test: p = 0.0005, p <0.0001).	"The combination of comfrey root extract plus methyl nicotinate was consistently more effective in the treatment of acute upper or low back pain than both comparators, while methyl nicotinate displayed an effect as well. The clinical trial at hand confirms the topical combination is an effective and well-tolerated treatment option for acute back pain."	Many details sparse, with no description of patients by group to assure randomization success; no description of randomization, concealment or blinding success. Baseline pain scores comparable. Data suggest efficacy for lower pain and other measures with combination superior to nicotinate to placebo.

CAPSAICIN, "SPORTS CREAMS," AND OTHER CREAMS; OINTMENTS AND TOPICAL AGENTS

Capsaicin is applied to the skin as a cream or ointment and is thought to reduce pain by stimulating other nerve endings, thus it is thought to be potentially effective through distraction. Rado-Salil ointment is a proprietary formulation of 14 agents, the two most common of which are menthol (55.1%) and methylsalicylate (26.5%). There are many other commercial products that similarly cause either a warm or cool feeling in the skin. All of these agents are thought to work through a counter-irritant mechanism (i.e., feeling the dermal sensation rather than the LBP). There is evidence that capsaicin compounds should not be used chronically due to reported adverse effects on neurons.(1163) Other topical medications include dimethyl sulfoxide (DMSO), and N-Acetylcysteine (NAC) in addition to those previously reviewed. DMSO, a free radical scavenger, has been used for years. CRPS is one of the few indications for its use (see Chronic Pain Guideline).

1. *Recommendation: Capsaicin for Acute or Subacute Low Back Pain or Temporary Flares of Chronic Low Back Pain*
   Capsaicin (capsicum) is moderately recommended for treatment of acute or subacute low back pain or temporary flare-ups of chronic low back pain. Long-term use is not recommended. Capsaicin appears superior to Spiroflor. Other creams and ointments may be useful, although there is no quality evidence to guide recommendations.

   Indications – For acute, subacute, or temporary flare-ups of chronic LBP. However, other treatments appear to likely have greater efficacy (e.g., NSAIDs, progressive exercise program, etc.). Yet, capsaicin may be a useful adjunct. These compounds may also be used in those patients who prefer topical treatments over oral treatments and other more efficacious treatments, but have only mild LBP.

   Indications for Discontinuation – Resolution of LBP, lack of efficacy, or development of adverse effects that necessitate discontinuation. Recommended not to be used more than 1 month due to concerns about adverse effects, aggregate costs, and acknowledgement that the patient should be transitioning to an active treatment program.

   Benefits –Modest reductions in pain through distraction.

   Harms – Local irritation and theoretical neuronal death with longer term use.(1164)

   Strength of Evidence **– Moderately Recommended, Evidence (B)**

   Level of Confidence – Moderate

2. *Recommendation: Spiroflor for Acute, Subacute, or Chronic Low Back Pain*
   Spiroflor is not recommended for treatment of acute, subacute, or chronic low back pain as it appears less efficacious then capsaicin and there are other treatments that are efficacious.

   Strength of Evidence **– Not Recommended, Insufficient Evidence (I)**

   Level of Confidence – Low

3. *Recommendation: Topical NSAIDs or Other Creams and Ointments for Acute, Subacute, or Chronic Low Back Pain*
   There is no recommendation for or against the use of topical NSAIDs or other creams and ointments for treatment of acute, subacute, or chronic low back pain.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

   Level of Confidence – Low

4. *Recommendation: DMSO for Chronic Low Back Pain*
   DMSO is not recommended for treatment of chronic low back pain.

   Strength of Evidence –**Not Recommended, Insufficient Evidence (I)**

   Level of Confidence – Low

5. *Recommendation: N-Acetylcysteine for Chronic Low Back Pain*
   N-Acetylcysteine is not recommended for treatment of chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

6. *Recommendation: EMLA Cream for Chronic Low Back Pain*
   EMLA cream is not recommended for treatment of chronic low back pain.
   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

7. *Recommendation: Wheatgrass Cream for Chronic Low Back Pain*
   Wheatgrass cream is not recommended for treatment of chronic low back pain.
   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
Capsicum compounds have evidence of efficacy in quality studies, although they do not appear particularly potent. There is evidence that capsicum is superior to Spiroflor. There are many other commercially available creams and ointments, but no quality studies for the purposes of treating LBP. These agents are topical, thus not invasive, and have low adverse effects. Over an extended period of time they are not inexpensive, but they are not expensive for short-term use. There are no studies of long-term chronic use, so there is no information about long-term efficacy or dermal or other toxicity. Capsaicin is moderately recommended for treatment of LBP. It may be reasonable to combine capsicum with NSAIDs for additional reductions in LBP through different mechanisms, although that has not been tested in a trial. For other topical agents, see the Chronic Pain Guideline.

Evidence for the Use of Capsaicin, "Sports Creams," or Other Creams and Ointments
There are 2 high-(1165, 1166) and 3 moderate-quality(1159, 1167, 1168) RCTs incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: topical NSAIDs, creams, ointments, NAC, DMSO, ELMA, cream, wheatgrass cream, capsaicin, capsicum, subacute, low back pain, and chronic low back pain to find 22,850 articles. Of the 22,850 articles we reviewed 5 articles and all were included.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Stam 2001 RCT No mention of COI or industry sponsorship.	8.0	N = 161 with acute LBP who did not have sciatica	SRL® gel (n = 83) 3g 3x a day vs. Cremor Capsici Compositus (n = 78) 3g 3x a day for 1 week.	Compliance low (56.4% vs. 61.5% capsicum). Proportions using rescue paracetamol 79% vs. 75%. Percentages of good and excellent results favored capsicum (52.1% vs. 41.6%), although neither result spectacular.	"[S]piroflor SRL® gel and Cremor Capsici Compositus FNA are equally effective in the treatment of acute low back pain. However, Spiroflor SRL® gel is better tolerated. Therefore, it appears that Spiroflor SRL® gel and comparable products are preferable to capsicum-based products for the topical treatment of low back pain, due to the lower chance of adverse effects."	Spiroflor SRL® gel had reportedly lower adverse effects than capsicum. But, conclusion not well supported by data. Low compliance rates suggest lack of efficacy or cumbersomeness of both.
Frerick 2003 RCT No mention of COI or industry sponsorship.	8.0	N = 320 with chronic LBP at least 3 months duration	Capsicum plaster (n = 159) vs. placebo (n = 160) for 3 weeks.	Response rates in capsicum group 67% vs. 49% in placebo with minimum 30% reduction in pain. Patients with at least 50% pain reduction: 45.3% capsicum vs. 24.4% placebo.	"The superiority of the treatment of chronic non-specific low back pain with capsicum plaster compared to placebo was clinically relevant and highly statistically significant. The capsicum plaster offers a genuine alternative in the treatment of non specific low back pain."	No systemic adverse events noted. Co-interventions not well described. Blinding questionable because of treatment symptoms. Data suggest capsicum may have some efficacy in chronic LBP patients.
Chrubasik 2010 RCT T. Weiser is an employee of Boehringer Ingelheim, manufacturer of "Finalgon CPD™ Wärmecreme."	7.0	N = 281 with chronic soft tissue pain (MSDs and LBP)	"Finalgon CPD Wärmecreme" of which 100g contain 2.2-2.6 g soft extract of capsici fructus acer (DER 5.5:1 (4-7:1) corresponding to 53mg capsaicin (0.05%)) (n = 140) vs. placebo (cream with same color and fragrance n = 141). All patients to apply cream onto painful area 3 times a day for 3 weeks. Last follow-up 14 days after treatment.	At 3 weeks pain sum score improved significantly more in capsicum group vs. placebo, 40.5% vs. 21.1% (p <0.001). Capsicum group had more responders in pain sum score improvement ≥30 and 50% at 2 weeks (65.6% vs. 42.4%, p <0.01) and 3 weeks (75% vs. 40.9%, p <0.001). Capsicum rated good to excellent in 59% of cases vs. 24.3% for placebo; 21.9% and 51.5% rated as unchanged or worsened for capsicum and placebo. On more than half of treatment days, capsicum group reported pain relief within 1 hour of application vs. 19-23% under placebo.	"[C]apsicum cream is useful in patients with chronic soft tissue pain and is also efficacious in patients with chronic back pain for which effectiveness was already demonstrated in earlier clinical trials."	Study sample size variously 272 vs. 281. Claim of double blind dubious. Mostly mixed MSDs and LBP in the report, which may be questionable. Some LBP subset data provided and suggest efficacy.
Keitel 2001 RCT No mention of COI or industry sponsorship.	6.0	N = 154 with chronic non-specific back pain at rest and during exercise	Capsicum pain plaster (n = 74) vs. placebo (n = 76) for 3 weeks.	Responder rate (pain reduction greater than 30%) significantly better in Capsicum group than placebo (p = 0.0219).	"The tolerance ratings by the investigators and patients were superior to the placebo product."	Co-intervention not well described. Blinding questionable because of symptoms. Over 7-day treatment period, capsicum cream appears more effective than placebo.

Ginsberg 1987 RCT No mention of COI or industry sponsorship.	5.0	N = 40 with acute LBP	Rado-Salil® (n = 20) vs. placebo (n = 20) for 14 days.	Improvements in pain scores at Day 3: 0.15 placebo vs. 1.90 Rado-Salil®. At Day 14, improvements were 0.4 vs. 3.79.	"[A]s an adjuvant therapy in the treatment of low-back pain, topical applications of irritant ointments such as Rado-Salil® might be an effective alternative to certain physical treatments particularly in patients unable to follow regular courses of physical treatment or when physiotherapeutic facilities are unavailable."	No discussion of randomization and no baseline data given. Many details sparse. Success of blinding seems dubious due to both olfactory and dermal stimuli.

VITAMINS

Vitamins have been used to treat essentially all disorders. There has been particular interest in anti-oxidants. However, all anti-oxidants are simultaneously pro-oxidants,(1169, 1170) thus evidence of potential harm from vitamins, particularly vitamin E, is accumulating.(1171-1173) There is poor evidence that vitamins or minerals have beneficial therapeutic effects in normal or over-nourished societies.

Recommendation: Vitamins for Treatment of Acute, Subacute, Chronic, or Post-operative Low Back Pain, or Radicular Pain

In the absence of documented deficiencies or other nutritional deficit states, the use of vitamins is not recommended for treatment of patients with acute, subacute, chronic, or post-operative low back pain or with radiculopathy.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**

Level of Confidence – Low

Rationale for Recommendation

There are few trials of vitamins. There is no consistent evidence of efficacy. Various types of vitamins have been suggested for musculoskeletal conditions such as chronic low back pain because of their anti-inflammatory and antinociceptive properties. These vitamins, minerals, and supplements include glucosamine, bromelain, variations of B vitamins, vitamin C, zinc and manganese.(1136) Studies have suggested a correlation between non-specific musculoskeletal pain and vitamin D deficiency, but no significant correlation has been demonstrated in patients with low back pain and vitamin D deficiency.(1174, 1175) This has been complicated by the difficulty of diagnosing vitamin D deficiency.(1176) Randomized controlled trials are needed for better understanding vitamin D repletion in patients with chronic low back pain.(1177)

Evidence for the Use of Vitamins

There is 1 moderate-quality RCT incorporated into this analysis.(1178) There is 1 low-quality RCT in Appendix 1.(1153) (In addition, there are two RCTs that appear to be high quality published in German that are reviewed in Appendix 1.(1179, 1180) However, these were not considered for the development of guidance as the ACOEM methodology requires publications in English.(9))

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: vitamins and low back pain to find 79,341 articles. Of the 79,341 articles, we reviewed 10 articles and included 10 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Mibielli 2009 RCT Study funded by research grant from Centro Universitario Serra dos Orgaos. Merck SA donated drugs. No COI.	6.0	N = 372 age 18-65 with acute, non-traumatic LBP lasting >3 days	Diclofenac 50mg with vs. without vitamin B complex (thiamine 50mg, pyridoxine 50mg, cyanocobalamin 1mg). Evaluations at 0, 3, 5, 7 days.	Mean VAS scores after 3 days treatment group DB 24.5±20 vs. group D 31.9±20, p = 0.0003. Mean reduction in VAS after 3 days: DB 24.5±18 vs. 20.7±18, p = 0.044. VAS after 5 days: 72 in DB scored <20mm VAS vs. 53 in D, p <0.001. Finger to floor distance favored DB (p = 0.0001).	"The combination of diclofenac with B vitamins was superior to diclofenac monotherapy in lumbago relief after 3 days of treatment."	Short trial of 7 days. Daily IM injections. Very high dropouts over time. Unclear impact although available data suggest vitamin B complex may be of modest additional benefit.

Allied Health Professionals, Physical and Occupational Therapy, and Other Physical Methods (Devices, Therapies, Electrical Therapies, Acupuncture, and Neuroreflexotherapy) . . . . . .

This section discusses devices, physical methods, and other modalities that have been used to treat LBP. As many of the physical methods described in this section can be administered by other health professionals including physical and occupational therapists and chiropractors, referrals and components of physical and occupational therapy are addressed.

Studies of Referrals to Allied Health Professionals

There are many RCTs that have compared the results of LBP treatments between different health care providers in an attempt to provide evidence for efficacy of one array of treatments over another. However, there are numerous, major methodological weaknesses to this approach that limits the value of these studies including: 1) employment of multiple active, often diverse treatments, 2) lack of a systematic, controlled method to employ the treatments (e.g., not knowing what interventions were employed in what sequence under what circumstances), 3) inability to determine how any one patient was (typically) treated, and 4) lack of control for these potentially confounding variables. Perhaps the single greatest weakness with those studies is that in large part, due to the progress of science, the comparison groups are often no longer treated in the manner that most of these studies utilized (e.g., using bed rest for the general treatment arm). Thus, these studies are largely unusable for purposes of specific evidence-based decision making and guideline development. Throughout this Guideline, these studies are reviewed, but they are nearly always excluded from the decision-making process due to the aforementioned insurmountable problems. However, guidance on the number of visits for these interventions with allied health professionals (e.g., physical therapists, occupational therapists, chiropractors) may be helpful for treatment of LBP, including guiding a conditioning program, as well as other modalities as indicated elsewhere.

- It should be expected that most patients with more severe acute and subacute LBP conditions receive 8 to 12 visits with allied health professionals over 6 to 8 weeks, as long as functional improvement and program progression are documented. Patients with mild symptoms may require either no therapy appointments or few appointments. Those with moderate problems may require 5 to 6 visits. (The number of recommended visits is the consensus of the Evidence-based Practice Spine Panel.)
- During an episode of therapy, the use of physical agents and manual procedures should be weaned and treatment frequency should decrease. This promotes the patient's active participation in the program and allows transition to an independent self-management program.
- Patients with chronic LBP who have not had prior treatment should follow similar guidance as those with acute LBP. Other chronic LBP patients may need more treatment. Factors influencing the number of visits needed include the content of prior treatment, patient response to prior treatment, their retention of information, and the exercises they were taught.

PHYSICAL AND OCCUPATIONAL THERAPY

The term "physical therapy" is used here in the generic sense to include physical medicine and therapeutic and rehabilitative evaluations and procedures. Physical therapists are major health care providers who render many of these services through multiple, specific interventions (e.g., exercise, ultrasound, manipulation, iontophoresis, etc.).(692, 699, 1181-1193) The majority, if not all, of these interventions are also employed by other health care practitioners. Most occupational therapists are trained to recognize both psychological and physical issues that may influence the treatment of back pain. Each of these specific interventions is discussed in individual topical sections within these Guidelines. However, there are a few RCTs of "physical therapy." The studies in this section include numerous interventions and lack structuring of treatments within the arms of these trials. Thus, there

are no strong conclusions that may be drawn from this body of evidence with respect to the value of individual modalities and comparisons between generic treatment programs are weak. These studies of "physical therapy" are reviewed here for completeness. More recent physical therapy literature has explored treatment based on identifying subgroups. The three most commonly seen classification systems are McKenzie, Delitto, et al., and O'Sullivan. There is also research exploring the impact of fear-avoidance beliefs on low back pain, with treatment approaches based on the presence or absence of fear avoidant beliefs.

Recommendation: Physical Therapy, Occupational Therapy, or Other Professionals for Mild to Moderate Acute, Subacute, or Chronic Low Back Pain

A course of 4 to 6 appointments is typically recommended to initiate a directed therapeutic exercise program for mild to moderate acute, subacute, or chronic low back pain. In self-motivated patients or in rapidly resolving cases, one or two visits may suffice.

Indications – Mild to moderate LBP that is felt to be mostly manageable by self-care.

Frequency – Four to six visits to initiate and then reinforce an exercise program is typically helpful. In self-motivated patients and rapidly resolving cases, one or two visits may suffice. More appointments may be indicated for cases where there is incomplete resolution, lack of a plateau and/or ongoing functional improvements after reaching six visits (see Exercise Section).

Benefits – Increased probability of engaging in an exercise program. Potential reinforcement with provider recommendations.

Harms – Medicalization, prolongation and increased risk of chronicity.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**

Level of Confidence – Low

(See Exercise Section regarding recommendations and education for moderate to severe LBP which may require more prolonged services.)

Evidence for the Use of Physical and Occupational Therapy

There are 4 high-(1194-1197), 49 moderate-quality RCTs (one with 3 reports),(611, 623, 650, 669, 672, 675, 691, 696, 701, 703, 716, 721, 725, 1182, 1198-1233) and 4 secondary analyses(1234-1237) incorporated into this analysis. These studies are heterogeneous with numerous simultaneous interventions, thus sound conclusions cannot be drawn from them (see individual treatment modalities to ascertain the available evidence on specific treatment interventions). There are 2 low-quality RCTs (one targeting unrelated conditions)(1238, 1239) and 4 other studies(753, 1240-1242) in Appendix 1.

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates. The following search terms were used "(Physical OR occupational) AND therapy AND (subacute low back pain OR chronic low back pain)" to find 5498 articles. Of those 5498 articles, we reviewed 68 articles, included 68 articles (68 RCTs, and zero reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Ostelo 2003a RCT Research was supported by "Profilcringsfonds" (PF-57) of the Maastricht University Hospital and "Stichting Annofonds Loiden." No mention of COI.	8.0	N = 105 undergoing first-time lumbar disc surgery. Follow-up at 6 and 12 months.	Behavioral graded activity (BGA, n= 52) vs. usual care (UC, n = 53).	In UC group, 67% described themselves as "recovered" on dichotomized Global Perceived Effect compared to 48% of BGA patients (95% CI: 0.1 to 38.5). However, difference no longer significant after adjustment.	"[A]ctivity after first-time lumbar disc surgery is safe, as the re-operation rate was very low, and therefore it is not necessary for patients to remain passive after surgery."	Usual care bias. However, it still outperformed the intervention.
Ostelo 2003b RCT Research supported by "Profileringsfonds" (PF-57; B96.1.996) of University Hospital Maastricht and "Stichting Annafonds Leiden." No mention of COI.	8.0	N = 105 undergoing first-time lumbar disc surgery. Follow-up at 6 and 12 months.	Behavioral graded activity (BGA, n = 52) vs. usual care (UC, n = 53).	No significant difference between groups at one year follow-up.	"Both fear of movement and pain catastrophizing seem to be unaffected by either treatment in these patients. It is concluded that treatment principles derived from theories within the field of chronic low back pain might not apply to these patients. After 1 year of follow-up, there were no statistically significant or clinically relevant differences between the BGA program and UC as provided by physiotherapist for patients following first-time lumbar disc surgery."	Same population as Ostelo 2003a.
Erdogmus 2007 RCT Supported by Austrian Social Insurance for Occupational Risks AUVA (to G.R.E.) and other funds. No COI has been declared.	7.5	N = 120 who underwent a first uncomplicated disc surgery for lumbar vertebral disc herniation with a preoperative history of symptoms of less than 6 months. Follow-up at 6 and 12 weeks and 1.5 years.	Physiotherapy group (n = 40) received 20 treatment sessions over 12 weeks with custom-tailored instructions vs. sham treatment (n = 40) of 'sham' neck massage vs. no treatment (n = 40) asked to 'wait and see' for 3 months after operation.	LBP rating baseline (mean±SD)/baseline to 6-weeks (mean, 95% CI)/baseline to end of therapy (mean 95% CI)/baseline to 1.5 year follow-up (mean 95% CI) no therapy vs. sham vs. physiotherapy: 53.4 ±10.9/-11.4 (-9.3 to -19.5)/-20.3 (-14.2 to -26.4)/-19.4 (-11.5 to -27.3) vs. 56.1± 10.8/-20.7 (-14.7 to -26.8)/-27.4 (-21.3 to -33.5)/-29.4 (22.0 to -33.5) vs. 57.5 ± 10.8/-20.2 (-15.3 to -25.0)/-31.6 (-26.4 to -36.7)/-28.0 (-20.4 to -35.5), physiotherapy vs. no therapy at 6 weeks p = 0.102, 12 weeks p = 0.005, 1.5 years p = 0.118. Other groups not statistically significantly. LBP rating scale subscores for pain (max. 60 points worst): 12.95± 8.05/1.35 (-1.55 to 4.24)/0.82 (-2.8 to 4.43)/1.2 (-3.29 to 5.68) vs. 13.92±8.27/-	"As compared with no therapy, physiotherapy following first-time disc herniation operation is effective in the short-term. Because of the limited benefits of physiotherapy relative to 'sham' therapy, it is open to question whether this treatment acts primarily physiologically in patients following first-time lumbar disc surgery, but psychological factors may contribute substantially to the benefits observed."	Data suggest no difference between intervention and sham, although modest difference of small clinical significance between intervention and no-treatment group in pain, ADL, activity. No differences in return to work.

				1.00 (-4.70 to 2.69)/-2.91 (-6.53 to 0.7)/-3.81 (-8.18 to 0.56) vs. 14.68±8.07/0.20 (-2.76 to 3.16)/-4.1 (-6.59 to -1.61)/-2.05 (-6.27 to 2.17), physiotherapy vs. no therapy at 12 weeks p = 0.026. Other comparisons not statistically significant. LBP rating scale subscores for activity of daily living (max=30 points worst): 17.4± 3.86/-6.93 (-8.58 to -5.27)/-8.8 (-10.69 to -6.91)/-9.8 (-12.12 to -9.86) vs. 18.6± 3.63/-9.2 (-10.98 to -7.42)/-11.33 (-13.42 to -9.23)/-12.42 (-14.6 to -10.25) vs. 18.13 ± 3.6/-7.65 (-9.51 to -5.79)/-11.48 (-13.39 to -9.56)/-12.8 (-14.19 to -9.96), physiotherapy vs. no therapy at 12 weeks p = 0.047. LBP rating scale subscores for physical function (max. = 40 points worst): 23.1 ± 3.9/-8.85 (10.88 to -6.82)/-12.15 (-14.59 to -9.71)/-11.37 (-14.16 to -8.58) vs. 23.6 ± 4.5/-10.48 (-12.54 to -8.41)/-13.23 (-15.35 to -11.1)/-13.2 (-15.66 to 10.74) vs. 24.4 ± 4.0/-12.7 (-14.53 to -10.87)/-15.98 (-18.02 to -13.9)/-13.83(-16.71 to -10.94), physiotherapy vs. no therapy at 6 weeks p = 0.006, at 12 weeks p = 0.017.		
Thackeray 2010 RCT Funding provided by seed grant from Research Foundation, University of Utah (project no.: 51003142). No US federal agencies provided funding for this grant. No COI.	7.5	N = 44 with lumbar disk herniation	Selected nerve root block (SNRB) alone (n = 23) vs. SNRB followed with physical therapy (n = 21).	Both groups improved over time, p <0.001.	"The results of this pilot study failed to show that physical therapy interventions intended to centralize symptoms after SNRBs were more beneficial than SNRBs alone."	Pilot study. Up to 3 injections. Data suggest lack of efficacy.
Lau 2008 RCT No mention of COI or industry sponsorship.	7.5	N = 110 with acute LBP.	Experimental group (n = 55) with education, reassurance, pain management, mobility training, interferential therapy, walking training, and walking aid vs. control group (n = 55) with walking training and walking aids. Follow-up 6 months.	Experimental group had less pain (97.5% CI 0.9 to 2.3) than control group on discharge and on admission to Physiotherapy Outpatient Department (97.5% CI 0.1 to 1.6) but difference not significant at 1 month.	"Early physiotherapy intervention was effective in reducing pain and increasing satisfaction for patients with acute low back pain in an Accident and Emergency Department but the effect tailed off."	Study to determine effectiveness of single PT session in ED. Patients in Chinese medical system included admissions for acute LBP, non-standard practice in US. Thus, applicability uncertain. Data suggest no clinical significance (-1.5 of 10

						VAS), a short-term improvement.
Sertpoyraz 2009 RCT No mention of COI or industry sponsorship.	7.0	N = 40 with LBP at least 6 months.	Isokinetic exercise group (n = 20) 5 days a week for 3 weeks vs. standard exercise group (n = 20) for 3 weeks under physiotherapist. Follow-up at 3 and 4 weeks.	Pre/post/follow up mean±SD for isokinetic exercise vs. standard exercise for VAS: 4.85±0.93/1.30± 1.45/0.55±0.99 vs. 5.40±1.27/1.20± 1.43/0.75±1.58; fingertip-to-floor 9.65±11.34/2.40±4.67/1.70±3.75 vs. 13.75±14.45/3.60±6.43/2.70±4.56; Modified Oswestry Low Back Disability Questionnaire 16.60±8.12/ 9.40±6.81/7.0±5.21 vs. 18.80±7.79/ 10.45±5.78/8.55±7.55; Beck Depression Inventory 8.30±6.46/6.45± 5.81/5.11± 4.90 vs. 10.40±7.97/6.0± 5.94/5.95±7.37. All post/follow-up scores for both groups significant.	"Isokinetic and standard exercise programmes have an equal effect in the treatment of low back pain, with no statistically significant difference found between the two programmes. The standard exercise programme was easily performed and had a low cost, making it the preferred option for exercise."	All participants were supervised for 3 week programs. Data suggest both groups improved, with no differences between groups (pain, range of motion). Small sample size. Narrow inclusion criteria (age 20-45).
Nordeman 2006 RCT Financial support obtained from Medical Care Executive Board of Vastra Gotaland Region. No mention of COI.	6.5	N = 60 consecutive patients with subacute LBP (3 to 12 weeks duration) in Sweden	Early access to PT: physical exam and PT within 2 days of inclusion, treatment individualized based on history and exam (EA to PT, n = 32) vs. waiting list; same treatment after 4 weeks (n = 28). Follow-up at 6 months.	Significant baseline differences favored early intervention (e.g., duration "scores" of 3.0 vs. 5.0). Pain intensity from baseline to 6 months: EA (-3.0/ 1.7) vs. controls (-2.0±2.2), p = 0003). Risk for long-term disability: not significant. Sick leave: not significant.	"[E]A to physical therapy resulted in greater improvement in perceived pain at 6 months compared to later access."	Intervention not well described. Likely heterogeneous. Wait-listed controls biased in favor of treatment. This bias likely severely limits ability to generalize results.
Carr 2005 RCT No mention of COI or industry sponsorship.	6.5	N = 237 with chronic LBP (59% >6 months duration) and some had subacute LBP (at least 6 weeks duration)	Group exercise program (n = 118) vs. individual physiotherapy in materially deprived area of U.K. (n= 119).	No differences in baseline scores between those who did/not attend for treatment, except for age. Non-participants tended to be younger (mean difference = 8.08 years, CI = 711.54 to 74.49). Those in exercise program improved slightly more than individual physiotherapy (mean difference = 71.07, CI = 72.50 to 0.36).	"[N]o differences in clinical outcomes were found between the group receiving the Back to Fitness programme and those receiving individual physiotherapy in this study. Importantly, neither therapy was very effective in reducing disability scores in this study of a socially deprived back pain sample. However, group therapy was less costly and therefore more cost effective."	Heterogeneous group of interventions significantly limit the strength of the conclusions. Some baseline differences in duration of pain. Individual physiotherapy different with each participant. About 50% in both groups attended 5 plus sessions. Outcomes were similar

						but group programs less costly.
McGregor 2011 RCT No industry sponsorship. No mention of COI.	6.5	N = 338 with lateral nerve root compression, neurogenic claudication, or lumbar disc prolapse.	Rehab programs with booklet (n = 91) vs. rehab program with no booklet (n = 86) vs. usual care with booklet (n = 70) vs. usual care with no booklet (n = 91). Rehab program comprised 12 standardized 1 hour classes run 2x a week by physiotherapist. 1 year follow-up.	No significant difference between groups.	"This study found that neither intervention had a significant impact on long term outcome."	Low compliance limits utility. Data suggest rehab group superior but under powered.
Marshall 2008b RCT No industry sponsorship. No mention of COI.	6.5	N = 120 with chronic LBP at least 12 weeks	Specific exercise group with swiss ball (n = 60) vs. control exercise group with advice to stay active and exercise (n = 54). Randomization after first 4 weeks. Treatment period 12 weeks. Follow-up at 4, 8, and 16 weeks and 9 months.	Pain intensity reduced significantly from baseline to 4 weeks and from 4 to 8 weeks ($p < 0.001$) but no difference between groups. Swiss ball group significantly improved for both physical and mental components from SF-12 compared to control group ($p < 0.05$).	"Supervised exercise is a more successful subsequent to manual treatment compared with exercise advice. The improvements associated with this type of program were primarily manifested in the psychologic self-report measures rather than physical measurements."	Multiple differences between groups at baseline.
Marshall 2008 RCT No industry sponsorship. No mention of COI.	6.5	N = 50 with LBP at least 12 weeks duration	After 4 weeks of Manipulative control or MC, (n = 13) vs. non-manipulative Swiss Ball or M-SB, (n = 12), individuals assigned to non-manipulative control (n = 13) vs. non-manipulative Swiss ball (n = 12).	SF-12 physical (PCS)/SF-12 mental (MCS) component, time effect and time exercise (0-8 weeks); $F = 4.9$, $p < 0.003$, and $F = 3.4$, $p = 0.02$/ $F = 3.2$, $p = 0.026$ and $F = 0.61$, $p = 0.66$; time treatment and time exercise treatment (16-56); $F = 1.2$, $p = 0.34$, $F = 1.9$, $p = 0.14$/$F = 1.9$, $p = 0.14$ and $F = 32$, $p = 0.03$.	"Supervised exercise is a more successful subsequent to manual treatment compared with exercise advice."	Multiple differences between groups at baseline.
Critchley 2007 RCT Supported by the Arthritis Research Campaign. No mention of COI.	6.0	N = 212 with chronic LBP >12 weeks duration	Outpatient physiotherapy: joint mobilizations, joint manipulations, massage, exercises at home, back care advice (n = 71) vs. spinal stabilization classes: individual exercises for spinal stability (n = 72) vs. physiotherapist pain management classes: structured back pain group education general strengthening, stretching, light aerobic exercises, (n = 69). Follow-up at 18 months.	Mean (CI) Roland disability score from baseline to end of study: individual physiotherapy 11.1 (9.6-12.6) to 6.9 (5.3-8.4), spinal stabilization group 12.8 (11.4-14.2) to 6.8 (4.9-8.6) and pain management group 11.5 (9.8-13.1) to 6.5 (4.5-8.6), $p < 0.001$.	"For chronic low back pain, all three physiotherapy regimens improved disability and other relevant health outcomes, regardless of their content. Physiotherapist-led pain management classes offer a cost-effective alternative to usual outpatient physiotherapy and are associated with less healthcare use."	Heterogeneous interventions. While pain management classes were less costly, they had higher dropout rates.
Vong 2011	6.0	N = 88 with diagnosis of	Motivational enhancement therapy and physical	Mean±SD motivational-enhancing factors at session1, 5, and 10, for	"[I]ntegrated MET-plus-PT treatment produced	Baseline difference in secondary outcome.

RCT No COI or industry sponsorship.		LBP at least 3 months.	therapy group (MET-PT, n = 45) vs. physical therapy alone (PT, n = 43). Outcomes assessed after treatment session 1, 5, 10, and 1 month cessation of treatment.	MET-PT vs. PT for proxy efficacy: 3.25± 0.36/3.35±0.38/3.37±0.38 vs. 2.91±0.44/3.01±0.41/3.08± 0.47, 95% CI 0.15 to 0.50 p <0.001; work alliance: 3.49± 0.38/3.50±0.39/ 3.53±0.40 vs. 3.17±0.37/3.14±0.40/ 3.29± 0.47, p <0.001; treatment: 3.36±0.32/3.38±0.32/3.38±0.34 vs. 3.20±0.32/3.24±0.26/ 3.19±0.28, p = 0.011; pain self-efficacy: 39.45±9.71/ 41.58±8.70/44.42±9.86/ 45.37±8.77 vs. 40.47±10.24/ 43.92±8.68/45.50± 8.70/45.61±10.18, p = 0.490.	significantly higher motivational status during the study period than PT-alone for patients with chronic LBP. This integrated intervention also produced significantly greater improvements in lifting capacity, self-perceived CH, and compliance with exercise up to 1-month follow-up."	Compliance data unclear. Data suggest intervention improves motivation but clinical significance related to pain, disability was not significant.
Rasmussen-Barr 2009 RCT No COI or industry sponsorship.	6.0	N = 71 with recurrent LBP >8 weeks but at least 1 pain-free period during previous year.	Exercise group with physical therapy individually supervised and used clinical judgment in progression of the graded stabilizing exercises (n = 36) vs. reference group informed of benefits of daily walks as physical activity (n = 35). Follow-up at 6, 12 and 36 months. Treatment period 8 weeks.	Pain reduction by 50% or more by 12 months for 55% of exercise group and 26% of the reference group, p=0.01. Minimal clinically important change regarding perceived disability for 53% of exercise group and 26% of reference group at 12 months, p = 0.02. Long term adherence with training at 12- and 36-months was 78% and 61% for exercise group vs. 57% and 71% for reference group, p = 0.01 and p = 0.41. Recurrent need for new treatment periods at 12- and 36-months was 22% and 46% for exercise group vs. 36% and 40% for reference group, p = 0.03 and p = 0.73.	"A graded-exercise intervention emphasizing stabilizing exercises for working patients with nonspecific recurrent LBP seems to improve disability and health parameters such as self-efficacy and physical health, more than do instructions to take daily walks. However, no such positive results emerged for pain over a longer term, or for fear-avoidance beliefs. Although the graded stabilizing exercises seem beneficial in LBP, there is still no clear evidence as to how they affect disability and pain levels."	Data suggests graded exercises (stabilization) improve perceived disability up to 1-year and perceived health up to three years over walking alone. Neither intervention resulted in long term pain improvement.
Helmhout 2008 RCT No COI or industry sponsorship.	6.0	N = 127 with moderate chronic back complaints from Royal Netherlands Army	Regular physical therapy program (PT, n = 56) for 10 weeks of passive mobilizing and pain-cushioning technique, manual therapy, exercise therapy, individual education, instruction on back function vs. lumbar extensor strength training program (n = 71) for 14 sessions (2x a week over 10 weeks). Follow-up at 5 and 10 weeks, 6 and 12 months.	No significant difference between groups by RMDQ, PSFS or GPE at any time point.	"Consistent with prior evidence, specific back strengthening does not seem to offer incremental benefits in LBP management compared with regular PT care that mainly consists of general exercise therapy."	Data suggest no differences in interventions, both groups improved.
Albaladejo 2010 RCT	6.0	N = 348 with chronic LBP. Primary care physicians	Control group (n = 109) vs. education (n = 139) vs. education and physiotherapy (n = 100).	Improvement in control group negligible. Additional improvement in education and education + physiotherapy groups found for	"The addition of a short education program on active management to usual care in primary care leads to small but	Differing contact time between 3 groups, unclear if randomization

No mention of COI. No industry sponsorship.		randomized and then recruited patients.	Follow-up at 3 and 6 months.	disability (2.0 and 2.2 Roland Morris Questionnaire points, respectively), LBP (1.8 and 2.10 VAS points), referred pain (1.3 and 1.6 VAS points), catastrophizing (1.6 and 1.8 Coping Strategies Questionnaire points), physical quality of life (2.9 and 2.9 SF-12 points), and mental quality of life (3.7 and 5.1 SF-12 points).	consistent improvements in disability, pain, and quality of life. The addition of a short physiotherapy program composed of education on postural hygiene and exercise intended to be continued at home, increases those improvements, although the magnitude of that increase is clinically irrelevant."	on physician level was successful.
Cecchi 2010 RCT Study financed by current research funds from Fondazione Don Gnocchi Foundation, Scientific Institute. No COI.	6.0	N = 210 with nonspecific LBP	Back school for 15 one hour sessions (n = 70) vs. individual physiotherapy for 15 one hour sessions (n = 70) vs. spinal manipulation (n = 70) 4-6 (as needed) weekly sessions of 20 minutes for total of 4-6 weeks. Follow-up at discharge, 3, 6 and 12 months.	Mean±SD Roland-Morris disability score at discharge, 3, 6, 12 months for back school vs. individual physiotherapy vs. spinal manipulation: 5.9±4.8/5.3±4.7/5.4±4.7/5.3±4.6 vs. 5.3±5.2/5.4±4.7/5.8±5.0/ 5.7±5.0 vs. 1.6±2.6/2.2±3.3/ 2.7±3.4/2.5±3.6, difference across groups at discharge p <0.001, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001; back school vs. spinal manipulation at discharge p <0.001, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001; individual physiotherapy vs. spinal manipulation discharge p <0.001, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001. Mean±SD pain rating scale score at discharge, 3, 6, 12 months for back school vs. individual physiotherapy vs. spinal manipulation: 1.0±0.8/14±1.2/ 1.4±1.0/1.3±0.9 vs. 0.9±0.8/1.5±1.2/ 1.4±1.1/1.6±0.9 vs. 1.2±1.2/0.5±0.7/ 0.8±0.7/ 0.7±0.8, difference across groups at discharge p = 0.401, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001; back school vs. spinal manipulation at discharge p = 0.747, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001; individual therapy vs. spinal mobilisation at discharge p = 0.259, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001.	"Spinal manipulation provided better short and long-term functional improvement, and more pain relief in the follow-up than either back school or individual physiotherapy."	Study design a bit unclear as aspects may be retrospective analysis of RCT. 1 year follow-up. Baseline difference in working (36 vs. 44 vs. 57%) outcome measures not provided at baseline. Result interpretation assumes no differences and suggest Manipulation superior.
Van der Roer 2008a RCT	5.5	N = 114 with new episode LBP lasting	Intensive group training with exercise therapy and back school for 10 individual and 20 group	Mean scores for pain intensity (PI-NRS) at baseline, 6, 13, 26, 52 weeks for protocol group vs. guideline groups: 6.2/5.3/4.4/4.1/3.9 vs.	"[O]ur study did not find that an intensive group training protocol based on principles of graded activity was more	Data suggest no differences in the interventions for chronic LBP. No differences in

Study funded by The Netherlands Organization for Health Research and Development (ZONMW) grant no: 945-03-023. Authors have no COI.		more than 12 weeks	sessions (protocol, n = 55) vs. guideline physiotherapy treated according to Low Back Pain Guidelines of Royal Dutch College of Physiotherapy (guideline, n = 47). Follow-up 1 year.	5.9/5.4/4.9/4.8/4.6, p <0.05 at 26 weeks, other time points nonsignificant; passive coping (PCI-P): 6.1/5.8/5.3/5.4/5.5 vs. 6.4/6.3/6.1/5.9/5.9, p<0.05 at 13 weeks, other time points nonsignificant.	effective than usual physiotherapy guideline care. The reduction in sick leave seen in occupational populations was not confirmed in a primary care population. Therefore, we conclude that the intensive group training protocol was not more effective than usual care and need not to be implemented in primary care physiotherapy."	costs after 1-year between groups.
Schenkman 2009 RCT Study supported by funding from The Foundation for Physical Therapy. No mention of COI.	5.5	N = 61 with at least 1 episode of LBP requiring treatment provider and current LBP for 6 weeks or longer	Group 1 (n = 20) single educational session vs. Group 2 (n = 21) conventional physical therapy vs. Group 3 (n = 20) functional movement training. Follow-up at 2, 6, and 12 months.	No significant difference between groups.	"This pilot study suggests that a functional movement training program may be effective in improving and retaining functional capacity in individuals with recurrent LBP. Results of this study support the need for a definitive investigation with greater power and one that allows for attrition."	Pilot study. No significant differences.
Moseley 2002 RCT No mention of COI or industry sponsorship.	5.0	N = 57 with mostly chronic LBP	Physiotherapy (2x a week using manual therapy) and education (1 hour session 1x a week on neurophysiology) (n = 29) vs. GP care (n = 28) for 4 weeks. Controls received non-described exercises (n = 18), manipulation (n = 6), medications (n = 9) and non-described injections (n = 2).	Average number of health care visits for LBP lower in treatment group at 1 year. At final assessment, mean reduction in NRS for pain 2.9/10 for physiotherapy vs. 1.4/10 controls and mean reduction on RMDQ 8.2/18 and 4.3/18, respectively. NRS and RMDQ significant between groups, p <0.01 for both.	"The findings support the efficacy of combined physiotherapy treatment in producing symptomatic and functional change in moderately disabled chronic low back pain patients."	Mild baseline differences likely favored physiotherapy group. Heterogenous and unstructured interventions. High number of health care visits suggests major issues that are not elsewhere described and suggest potential confounding.
Hurwitz 2002 RCT Federal and Institutional funds received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to subject of this manuscript.	5.0	N = 681 with LBP workers' comp excluded	Four treatment arms: 1) chiropractic care with physical modalities (DCPm, n = 172); 2) chiropractic care without physical modalities (DC, n = 169); 3) medical care with PT (MDPt, n = 170); or 4) medical care without PT (MD, n = 170). Follow-up at 6 and 18 months.	Six-month follow-up: improvements in all categories, similar results for medical and chiropractic groups; slightly better pain reduction in PT groups. Those performing more physical activity had less back disability. Borderline results with less psychological distress (no test for trend). Risks for severe pain not significant, though psychological distress and average pain trended lower across categories of METS. Results for back exercises more difficult to interpret. Risks for subsequent severe LBP higher among those performing	"Differences in outcomes between medical and chiropractic care without physical therapy or modalities are not clinically meaningful, although chiropractic may result in a greater likelihood of perceived improvement, perhaps reflecting satisfaction or lack of blinding. Physical therapy may be more effective than medical care alone for some patients, while physical	Lack of control for numerous co-interventions which limits conclusions about any one intervention.

				back exercises, but risks for subsequent psychological distress borderline lower.	modalities appear to have no benefit in chiropractic care."	
Göhner 2006 RCT No mention of COI. No industry sponsorship.	5.0	N = 47, with subacute back pain duration 7 days to 7 weeks	Control group or partly standardized physiotherapy treatment (n = 25) vs. training group or partly standardized physiotherapy treatment + cognitive-behavioral training (n = 22). All received physiotherapy treatment for 6-8 weeks.	Self-efficacy group and time and interaction effect of time by group/Barriers group+time and interaction effect/Severity interaction effect/Intention group and time and interaction effect/Behavior time and interaction effect/Pain intensity for time; F (1,45) = 19.08, p <0.001) and F (3,43) = 10.57, p <0.001), and F (3, 43) = 10.36, p< 0.001)/F (3, 43) = 3.76, p <0.01), and F (3, 43) = 4.96, p = 0.005/F (3, 43) = 6.63, p < 0.001/F (1,45) = 5.17, p = 0.028, and F (3,43) = 14.38, p <0.001, and F (3, 43) = 2.88, p <0.047/F (3, 43) = 17.46, p <0.001) and F (3, 43) = 4.62, p <0.007/F (3, 43) = 14.86, p <0.001.	"Results indicated that short and inexpensive cognitive behavioural training programme was able to enhance patients' self-efficacy and severity perceptions and to reduce their perceived barriers compared to a standard physiotherapy treatment control group."	Lack of study details for allocation, control of cointerventions, compliance of home regimens. Data suggest benefit from CBT in acute/subacute LBP is limited to self-efficacy and behavior outcomes. There was no demonstrated clinical benefit on pain or disability in this group.
Overman 1988 RCT Study supported by grants from Division of Hospitals and Clinics, Bureau of Medical Services, US Public Health Service Hospital, and Foundation for Physical Therapy. No mention of COI.	5.0	N = 174 with LBP	Physical therapists provider care (n = 107) vs. physician management (n = 67).	Percentage of patients very satisfied overall with care was 42% for physical therapist and 32% for physician group, p <0.05.	"[S]tudy demonstrates that physical therapists can provide safe, effective, and efficient first-contact care in an organized outpatient setting. Patients were more satisfied with several aspects of first-contact physical therapist care and demonstrated greater functional improvement with such care than when physician-referred."	Non-interventional RCT. Data suggest practice differences based on provider. Clinical outcomes similar in both groups despite practice differences. Some baseline differences.
Chiradejnant 2003 RCT No mention of COI or industry sponsorship.	5.0	N = 140 with non-specific LBP	Preferred mobilisation technique (n = 70) vs. randomly assigned mobilisation group (n = 70).	No significant difference between groups.	"The results of this study confirm that lumbar mobilisation treatment has an immediate effect in relieving low back pain, however, the specific technique used seems unimportant.	Study of single manipulation/effect; compliance, follow-up, timing at assessment implied not stated. Possible baseline difference in average duration of pain. Data suggest no differences. No comparison with non-manipulation group limits conclusion of efficacy of manipulation.
Sorensen 2010 RCT	5.0	N = 207 with LBP at least 4 out of previous 12 months and	Educational programme (n = 105) participants attended 1-3 30-60 minute sessions, at 1-3 week intervals vs. symptom-based physical	Mean (SD) for fear avoidance belief questionnaire at baseline, 2, 6, 12 months educational approach vs. physical training: 13.0 (10.9)/10.3 (5.9)/10.8 (6.2)/10.5 (6.1) vs. 13.0	"An educational approach to treatment for chronic LBP resulted in at least as good outcomes as a symptom-based physical training method,	Data suggest no differences in major clinical outcomes between educational model and symptom

Funding granted by IMK Foundation, Health Insurance Foundation (Sygekassernes Helsefond), Tryg Foundationen, Funen County Research Foundation, and Danish Rheumatism Association. Authors declare no competing interests.		mean LBP score over last 14 days of ≥4 (scale 0-10). Follow-up at 2, 6, and 12 months.	training programme (n = 102).	(6.3)/13.3 (6.4)/13.3 (6.0)/13.1 (6.5), p <0.001 2 months, p = 0.007 6 months p = 0.01 12 months; back belief questionnaire: 26.6 (10.9)/23.1 (10.6)/24.3 (12.7)/23.9 (12.2) vs. 27.1 (10.2)/25.7 (13.0)/28.5 (11.4)/27.2 (11.8), p = 0.01 at 6 months.	despite fewer treatment sessions."	based physical exercises (training).
Hurwitz 2005	See Hurwitz et al, 2002 (Spine)					
Hurwitz 2006	See Hurwitz et al, 2002 (Spine)					
Kääpä 2006 RCT Foundation funds received in support of this work. No industry sponsorship.	4.5	N = 120 females with chronic LBP	Group rehab program (n = 59) vs. individual physiotherapy lasting 10 hours total (n = 61).	Baseline data suggest that more in multidisciplinary group felt a greater physical work burden (40.7% vs. 31.6%) and more in individual group felt greater mental work burden (39.4% vs. 47.5%). Back pain scores not different between the groups and there were no differences in sick leave or other measures.	"[O]utpatient multidisciplinary rehabilitation program for female chronic low back pain patients does not offer incremental benefits when compared with rehabilitation carried out by a physiotherapist having a cognitive-behavioral way of administering the treatment."	Primary reliance on passive methods in the individualized physiotherapy group may have resulted in these findings.
Gudavalli 2006 RCT Study supported by grant from National Chiropractic Mutual Insurance Company (Grant # R18 AH 10001). No mention of COI.	4.5	N = 235 with chronic LBP	Flexion-distraction by chiropractor (FD, n = 123) vs. active exercise: flexion/ extension exercises, weight training, flexibility and cardio exercises to strengthen muscles surrounding spine, increase flexibility (ATEP, n = 112) 2-4 times a week for 4 weeks.	VAS ratings 20.57±2.00 for flexion distraction vs. 12.34±1.80, p = 0.00. Roland-Morris 2.81±0.38 vs. 2.30±0.33, p = 0.17; also favored flexion distraction. No other significant differences between groups.	"[P]atients perceived significantly less pain after intervention, regardless of group allocation. Subjects randomly allocated to FD had significantly greater relief from perceived pain, as defined by VAS scores, than those in ATEP."	Heterogenous interventions in pragmatic trial. Many sparse details. Follow-up 4-weeks in person, thereafter by mail. Data suggest distraction and stabilization exercises had equivalent functional improvements. Post hoc analyses with flexion-distraction worked better among those with radiculopathy.
Hay 2005 RCT Study funded by grants from UK National Lottery Charities Board and North Staffordshire Primary Care Research Consortium, UK. No mention of COI.	4.5	N = 402 with acute LBP	Physiotherapy including manual therapy techniques program: one 40 minute assessment and treatment session and up to 6 subsequent 20 minute treatment sessions (n = 201) vs. a brief pain management program (n = 201) with follow-up at 3 and 12 months.	No differences in Roland-Morris scoring at 3 or 12 months. Over 1 year: 18.3±42.4 GP visits in pain management group vs. 15.1±35.2 in PT group. No difference in health care costs between two programs, but PT "had marginally greater effectiveness at 12 months, albeit with greater health care costs."	"Brief pain management techniques delivered by appropriately trained clinicians offer an alternative to physiotherapy incorporating manual therapy and could provide a more efficient first-line approach for management of non-specific subacute low back pain in primary care."	Heterogeneous, numerous interventions. Included psychological measures at baseline. Co-interventions not well described. Psychological measures and exercise is as effective as manual therapy but also results in fewer GP and therapist visits.

Roche 2007 RCT No mention of COI. No industry sponsorship.	4.5	N = 132 with LBP at least 3 months on sick leave or at risk of work disability and not in temporary employment.	Functional restoration program (FRP, n = 68): 6 hours treatment a day, 5 days a week in groups of 6-8 patients vs. active individual therapy (AIT, n = 64): individual rehab with private practice physiotherapist 1 hour 3 x a week and individual home exercise 50 minutes 2x a week. Treatment 5 weeks. Follow-up at 5 weeks.	Fingertip to toe difference (cm) for AIT vs. FRP -11.9 vs. -16.3, p <0.05; Sorensen test (sec) 61.2 vs. 100.7, p <0.001; Ito test (sec) 71.2 vs. 121.3, p <0.001; endurance (kJ) 4.2 vs. 32.5, p <0.001; Dallas Pain Questionnaire (DPQ) anxiety and depression (%) -7.4 vs. -17.4, p <0.01; DPQ social interaction (%) -4.1 vs. -13.6, p<0.01.	"Low-cost ambulatory AIT is effective. The main advantage of FRP is improved endurance. We speculate that this may be linked to better self-reported work ability and more frequent resumption of sports and leisure activities."	Allocation unclear, baseline differences. Lack of data for compliance and control for cointerventions. Data suggests both groups improved with no significant difference in VAS or daily activity of living. FRP demonstrated significant differences in secondary outcomes, although clinical significance is uncertain.
Cambron 2006a RCT Study supported by Health Resources and Services Administration (HRSA) for (Grant # R18 AH 10001), National Chiropractic Mutual Insurance Company, and many chiropractic physicians for their generous donations. Author(s) declare that they have no competing interests.	4.0	N = 191 with primary complaint of LBP, >3 months, with no contra-indications to manual therapy	Chiropractic care (FD) with series of flaxation distractive procedures, administrated by chiropractors (n = 107) vs. formal physical therapy (EP) active trunk exercise, administrated by physical therapist (n = 84). For 4 weeks, 2-4 times a week.	Percent seeking care/Average number of visits/Self-medical treatments/Self-care/Changes in daily living; 38% vs. 54%/ lower number of visits by FD group, p = 0.06/77% vs. 87% and 14% vs. 11%, over counter and prescription medications, respectively/99% vs. 100%/66% vs. 73%.	"Based on one-year follow-up data imputed for complete analysis, participants who received physical therapy (exercise program) during a clinical trial attended a higher number of visits to any health care provider and to general practitioners during the year after care when compared to participants who received chiropractic care (flexion distraction) within the trial."	Comparison study of chiropractic care and physical therapy. Interventions not well described.
Reme 2009 RCT Secondary analysis of Hagen 2000 Study financed with aid of EXTRA funds from Norwegian Foundation for Health and Rehabilitation. No COI.	4.0	N = 246 sick listed 8-12 weeks diagnosed with either back pain, LBP, back pain without sciatica, or sciatica. Follow-up at 3, 12, and 24 months.	Brief intervention (BI, n = 122) vs. BI and physical exercise program (BI/PE, n = 124) for 1 hour, 3x a week for 8 weeks.	Predictors (OR, 95% CI) for non-RTW work at 3 months for all participants pain intensity (5.6, 1.7-19.0), perception of constant back strain while working (4.1, 1.5-11.5), negative expectation of RTW (4.2, 1.7-10.2), and saw physiotherapist (PT) prior to participation (3.3, 1.3-8.3). Predictors for non-RTW at 1 year perceived reduced ability to walk far due to complaints (2.6, 1.3-5.4), pain during activities (2.4, 1.1-5.1), and having been to PT prior to participation (2.1, 1.1-4.3). Predictor for non-RTW at 2-years was age (2.9, 1.4-6.0).	"It appears that return to work is highly dependent on individual and cognitive factors. Patients not returning to work after the interventions were characterized by negative expectations, perceptions about pain and disability, and previous physiotherapy treatment."	Data suggests detailed return to work influenced by patient perception about pain and disability, negative expectations, and previous PT prior to trial.
Wand 2004 RCT No COI or industry sponsorship.	4.0	N = 102 with acute LBP.	Physiotherapy treatment (n = 50) immediately vs. wait control (n = 52) who waited 6 weeks to begin treatment. Follow-up at 3 and 6 months.	Roland-Morris Disability questionnaire mean (SD) at 6 weeks for treatment group vs. wait group, 4.5 (4.5) vs. 6.3 (5.9), p = 0.02, non-significant at 3 and 6 month follow-up. State-Trait anxiety inventory at six weeks 10.8 (4.2) vs.	"At short-term, intervention is more effective than advice on staying active, leading to more rapid improvement in function, mood, quality of life, and general health. The timing of	Lack of details for compliance, duration of treatment, compliance, control of cointerventions. Author stated single blind but

				13.6 (4.5), p = 0.01, at 3/6 months 9.7(3.8)/10.3 (3.4) vs. 14.2 (5.5)/12.6 (4.9), p = 0.01. Modified Zung self-rated depression score at 6 weeks 14.2 (10.4) vs. 22.8 (12.2), p = 0.01, at 3/6 months 14.2 (10.4)/12.6 (8.6) vs. 25.2 (14.9)/20.5 (13.9), p = 0.001.	intervention affects the development of psychosocial features. If treatment is provided later, the same psychosocial benefits are not achieved. Therefore, an assess/advice/treat model of care seems to offer better outcomes than an assess/advice/ wait model of care."	not clear what type of blinding exercised. Dropouts/loss to follow-up: 35-40%. Data suggest no benefit to early PT for pain, disability outcomes although some benefits may be measured in other subjective categories.
Cambron 2006b RCT Study supported by Health Resources and Services Administration (HRSA) (Grant #R18 AH 10001), National Chiropractic Mutual Insurance Company, and many chiropractic physicians for their generous donations. Author(s) declare no competing interests.	4.0	N = 235 patients with chronic LBP	Flexion distraction (FD, n = 123) administered by chiropractors vs. active truck exercise program (EP, n = 112) administered by physical therapists. Follow-up at 5, 13, 25 or 53 weeks.	Mean VAS at baseline/week 5/week 13/week 25/week 53 for FD group: 38.0±2.0/14.6±1.7/19.3±2.1/19.2± 2.0/20.6±1.9, p <0.001 for all time points compared to baseline; for EP group: 35.7±2.0/19.7±2.0/22.1±2.2/ 23.8±2.4/21.6±2.0, p <0.001 for week 5, 13, and 53 vs. baseline and p = 0.002 at week 25. Oswestry Disability Index for FD group: 6.6±0.4/3.6±0.4/ 2.7±0.4/2.6±0.4/2.9±0.4, p <0.001 for all time points compared to baseline; for EP group: 6.8±0.4/3.8±0.4/2.9± 0.4/3.4±0.5/3.2±0.4, p <0.001 for all time points vs. baseline.	"Subjects with chronic low-back pain who were treated with 4 weeks of either FD therapy or an exercise program and followed for 1 year demonstrated a decrease in low-back pain and disability, with the FD group demonstrating significantly greater pain reduction."	Author suggests at 1-year chiropractic group had significantly lower pain than PT group. Results based on pain scores at end of study rather than baseline. No significant differences found based on baseline data comparisons.
Whitman 2004 RCT Study supported by grant from Foundation for Physical Therapy, Inc. and Wilford Hall Medical Center Commander's Intramural Research Funding Program. No mention of COI.	See Childs 2004	N = 131 with primary complaint of LBP.	Manipulation group (n = 70) vs. stabilization exercise group (n = 61). Follow-up at 1 and 4 weeks.	Patients in manipulation group had significant interaction between time and specialty certification status of physical therapist (n = 0.04).	"With the standardized protocols utilized in this study, it appears that the therapist-related factors of increased experience and specialty certification status do not improve patient outcomes. These results have immediate implications on the incorporation of manipulation techniques into first-professional education."	Secondary analysis of Childs 2004.

Van der Roer 2008b RCT No mention of COI. No industry sponsorship.	5.5	N = 114 with new episode of LBP lasting more than 12 weeks.	Intensive group training with exercise therapy and back school for 10 individual and 20 group sessions (protocol, n = 55) vs. guideline physio-therapy treated according to Low Back Pain Guidelines of Royal Dutch College of Physiotherapy (guideline, n = 47). Follow-up 1 year.	Mean cost (SD) in Euros per patients for direct health care costs for protocol group 1003 (595) compared to guideline group 527 (447), mean difference (95% CI) 475 (211 to 681).	"The results of this economic evaluation showed no difference in total costs between the protocol group and the guideline group. The differences in effects were small and not statistically significant. At present, national implementation of the protocol is not recommended."	Cost analysis of prior study. Exercise plus back school vs. physiotherapy. Heterogenous and relatively unstructured interventions not well described. Cost analysis of prior study.
Morris 2011 RCT Foundation funds received to support this work. No benefits in any form have been or will be received from commercial party related directly or indirectly to subject of manuscript.	N/A	N= 338 patients with low back pain	Rehabilitation only (n=79) vs. Booklet Only (n= 64) vs. Rehabilitation plus booklet (n= 89) vs. Usual care only (n= 84).	Interactions between booklet and rehabilitation were nonsignificant. Booklet vs. no booklet were – £87 (95% CI: – £1221 to £1047) and –0.023 (95% CI: –0.068 to 0.023).	"Cost-effectiveness evidence does not support use of booklet over no booklet or rehabilitation over no rehabilitation for the postoperative management of patients after spinal surgery."	Second report of McGregor. Cost effectiveness largely negative. Likely due to low compliance.
Underwood 2006 RCT UK BEAM funded by Medical Research Council and NHS Research and Development. No mention of COI.	N/A	N = 1,334 with simple LBP	Manipulation package (n = not specified) vs. exercise program (n = not specified).	"Participants randomized to usual general practice care reported dissatisfaction with receiving only 'usual care', which consisted of providing analgesic medication without providing an explanation for their pain. Those randomized to a manipulation package felt the intervention was appropriate to their needs and explanation for their pain. Those randomized to a manipulation package felt the intervention was appropriate to their needs and commonly reported striking benefits. Participants assigned to the exercise programme developed a sense of self-reliance in managing back pain, although some failed to be sufficiently motivated to continue their exercise regimen outside the classes."	"This qualitative analysis has found much clearer differences between the groups than the main quantitative analysis. This suggests that some of the added value from being allocated to additional physical treatment for low back pain is not being captured by existing methods of measurement. Improved methods of assessment that consider a wider range of domains may be needed when interpreting the added value of such treatments to individual patients."	Secondary analysis to UK Beam 2004.
Bekkering 2005 RCT No mention of COI. No industry sponsorship.	N/A	N = 500 with non-specific LBP	Physiotherapists randomly assigned to maximum of 10 patients with non-specific LBP allocated to receive guidelines by mail only (control n = NA) vs.	After 12 months, 77.4% of patients showed clinically significant improvement in pain, 57.5% improvement in physical functioning, and 72.9% had no disabling LBP. At	"A substantial proportion of patients still experienced some pain and disability at 12 months follow-up. The most stable predictor of prognosis in low back pain was the duration	Secondary analysis Bekkering 2004.

			receiving additional active strategy (intervention n = NA). Total of 500 included in study. Outcomes measured 3 and 12 months.	both 3 and 12 months, 75% of patients perceived recovery.	of the current episode. The choice of statistical method influenced the final model; however, changes in the explained variance were small."	
Rivero-Arias 2006 RCT No mention of COI. No industry sponsorship.	N/A	N = 286 with back pain >6 weeks.	Physiotherapy (n = 144) vs. advice only (n = 142). 12 month follow-up period.	Cost of physiotherapy intervention to treat LBP pain an average of £52 (95% CI £41-63) more expensive per patients.	"We found no significant differences between the total NHS cost of physiotherapy intervention and advice given by a physio-therapist for patients with mild-to-moderate low back pain, and no significant differences in quality of life. The significantly higher out-of-pocket expenses incurred by patients receiving routine physiotherapy suggests that advice given by a physiotherapist should be considered as the first-line treatment for patients with this level of severity of back pain."	Secondary analysis Frost 2004.
Physical Therapy vs. Cognitive-behavioral Therapy						
Apeldoorn 2012a RCT No mention of COI. No industry sponsorship.	8.0	N = 156 with subacute or chronic LBP	Classification based treatment group: treated according to primary classification category for 4 weeks then PT could change treatment strategy according to Dutch LBP guidelines (n = 74) vs. Usual Physical Therapy Group: treated with individually tailored treatment according to Dutch LBP guidelines (n = 82). Follow-up 8, 26, 52 weeks.	At all follow-ups, both groups had improved pain and functional ($p < 0.001$). Global perceived effect dropped in usual care group between 26 and 52 weeks (overall effect: Wald = 6.03, df = 2 [P = 0.05]), which did not happen to classification group (overall effect: Wald = 3.66, df = 2 [P = 0.16]). Those in classification group attended fewer treatment sessions than other group after 1 year (mean difference, 4.6; 9.5 % CI, 0.7-8.5; P = 0.02), but was not seen during first 8 weeks (mean difference, 1.3 95% CI, -0.2 to 2.8; p =0.08).	"The classification-based treatment approach used in this study did not improve outcome in a population of patients with subacute and chronic LBP."	Data do not support Delitto classification system; they were unable to validate it.
Apeldoorn 2012 b RCT See also Apeldoorn 2012a Study received grant from Netherlands Organization for Health Research and	8.0	N = 156 with subacute or chronic LBP	Classification based treatment group: treated according to primary classification category for 4 weeks then PT could change treatment strategy according to Dutch LBP guidelines (n = 74) vs. Usual Physical Therapy Group: individually	Patients in classification-based treatment group recovered more often than patients in usual physical therapy group. No differences in other outcomes. Costs between groupsnot significant for primary care costs or societal costs.	"The classification-based treatment approach as used in this study was not cost-effective in comparison with usual physical therapy care in a population of patients with sub-acute and chronic LBP."	Data suggest classification system not cost-effective.

Development (ZonMw, project no: 170882401). No mention of COI.			tailored treatment according to Dutch LBP guidelines (n = 82). Follow-up at 8, 26, and 52 weeks.			
Bronfort 2011 RCT Grants: National Institute on Aging. No mention of COI.	7.5	N = 301 with mechanical LBP at least 6 weeks with or without radiating pain to lower extremity	Supervised exercise therapy group (SET): 20 1-hour sessions performed exercises with 15-30 reps for each exercise (n = 100) vs. spinal manipulative therapy group (SMT): 1-2 sessions per week for 15-30 minutes with short-lever, low-amplitude, high-velocity spinal manipulative therapy (n = 100) vs. home exercise and advice (HEA): instructions for home exercise given in 2 1-hour appointments and follow-up 1-2 weeks later; instructed to do exercises for length of study (n = 101). Follow-up at 4, 12, 26, 52 weeks.	At 12 weeks, only difference was satisfaction ($p < 0.01$) with highest satisfaction in SET group, and HEA least satisfied and in middle was SMT group. At 52 weeks, only differences were for satisfaction ($p < 0.0001$). In all groups, treatment effects at $p < 0.05$ were observed for endurance and strength but not for range of motion.	"For CLBP, supervised exercise was significantly better than chiropractic spinal manipulation and home exercise in terms of satisfaction with treatment and trunk muscle endurance, and strength."	Data suggest supervised exercise and spinal manipulation not superior to minimal home exercise group. Home exercise did not include intensive aerobic and strengthening exercises.
Wand 2012 Randomized crossover experiment No mention of COI. No industry sponsorship.	7.0	N = 25 with chronic non-specific back pain	Visual feedback group used mirrors to visualize their back as it moved (n = 25) vs. control group (no mirrors to visualize movements. n = 25). Participants rested 5 minutes before cross-over.	Average pain after movement less with visual feedback (35.5±22.8mm) than when without visual feedback (44.7±26.0mm, MD = 9.3, 95 % CI: 2.8-15.7 F 91,22) = 8.82, $p = 0.007$). Time to ease was shorter in the visual feedback group (44.5 s ± 53.8) than control group (94.4 s ± 80.7, $p = 0.003$). Wilcox in matched-pairs test also significant ($p = 0.008$).	"[P]atients reported significantly less increase in pain and recovered significantly faster when they were able to visualize their back during the performance of repeated spinal movements, than when they were not able to visualize their back."	Experimental study. Needs to be RCT or crossover with health outcomes assessed over time to ascertain effects on health outcomes.
Iles 2011 RCT No mention of COI or industry sponsorship.	6.5	N = 30 with non-chronic LBP	Physiotherapy with 5 sessions of phone coaching by physiotherapist trained in health coaching techniques (n = 15) vs. physiotherapy alone (n = 15). Follow-up at week 4 and 12.	At 12 weeks, coaching group had significantly better scores on Patient Specific Functional Scale vs. other group (mean difference 3.0 points, 95% CI 0.7-5.4). At 12 weeks, no difference between groups on primary non-leisure activity item from Patient Specific Functional Scale, but 2/13 participants (15%) in coaching group and 7/13 participants (54%) did not return to primary non-leisure activity. No difference between groups in Oswestry Disability Index or Pain Self Efficacy Questionnaire. At 12 weeks, coaching group had significantly	"Trend in different leisure activity at baseline. Individualized PT. Data suggest efficacy of health coaching as an additive intervention."	Trend in different leisure activity at baseline. Individualized PT. Data suggest efficacy of health coaching as an additive intervention.

				higher recovery expectation (mean difference 3.4 points, 95% CI 1.1-5.7).		
Cecchi 2012 RCT See also Cecchi 2010 No mention of COI or industry sponsorship.	6.0	N = 210 with chronic LBP	Back school: 5 sessions of information and group discussions then 10 sessions of relaxation techniques postural, respiratory group exercises (n = 68) vs. individual physiotherapy included therapeutic exercise, patient education, manual therapy, mobilization, massage (n = 68) vs. spinal manipulation of 4-6 weekly 20-minute sessions 4-6 weeks of treatment (n = 69). Follow-up 3, 6, and 12 months.	All groups improved significantly in disability score (mean reduction 3.7+ 4.1 for back school, 4.4+3.7 for individual physiotherapy, and 6.7+3.9 for spinal manipulation, p <0.001). Spinal manipulation had lowest rate of non-responders and back school with highest (p <0.001).	"In our patients with cLBP lower baseline pain-related disability predicted non-response to physiotherapy, but not to spinal manipulation."	Described as retrospective analysis of RCT. See Cecchi 2010.
O'Sullivan 1997 RCT No mention of COI or industry sponsorship.	6.0	N = 44 with chronic LBP	Specific stabilizing exercise program (n = 22, 10-week treatment program on contracting deep abdominal muscles) vs. non-directed treatment by provider (n = 22, regular weekly general exercise). Outcome assessments at 3, 6, 30 months.	Pain intensity before/after control group vs. specific exercise group: 53/48 vs. 59/19, p <0.0001. Pain descriptors: 15/12 vs. 15/7, p = 0.0088. Oswestry disability: 26/25 vs. 29/15, p <0.0001.	"A 'specific exercise' treatment approach appears more effective than other commonly prescribed conservative treatment programs in patients with chronically symptomatic spondylolysis or spondylolisthesis."	Design of usual treatment for controls biases in favor of intervention. Conclusion that 22 control patients can adequately represent "conservative treatment programs" seems questionable. Data suggest specific exercises superior.
Smeets 2008 RCT Supported by Zorgonderzoek Nederland/Medische Wetenschappen (ZonMw) grant no. 014-32-007. No mention of COI.	6.0	N = 172 with nonspecific LBP of more than 3 months resulting in Roland Disability Questionnaire score >3	Active physical therapy (APT, n = 51): 30 minutes aerobic training on bicycle and 75 minutes strength and endurance training 3 times a week vs. cognitive-behavioral therapy (n = 57) with 3 group sessions followed by maximum of 17 individual sessions of 30 minutes vs. combined therapy (n = 59) offered as described together.	Characteristics associated with treatment-credibility: female patients (p <0.05), patients who reported less pain-related fear (p <0.01), patients who were less catastrophizing (p <0.05), patients who experienced more internal control of pain (p <0.01), work status (p <0.05). Characteristics associated with treatment expectancy: patients with a lower level of pain-related fear (p <0.01), patients who reported more internal control of pain (p <0.01), patients who experienced less depression (p <0.05).	"Although the associations found were low to modest, these results underscore the importance of expectancy and credibility for the outcome of different active interventions for [chronic low back pain] and might contribute to the development of more effective treatments."	Subanalysis of larger original study (Smeets 2008 in aerobic).
França 2012 RCT	5.5	N = 30 with chronic low back pain	Segmental stabilization group (SS) exercises focused on TrA and lumbar multifidus muscles (n = 15) vs. stretching group (ST)	SS group significantly favored in all variables when compared with ST group. Variables measured were Pain-VAS (cm), Pain-McGill, Oswestry, PBU (mmHg); (p <0.001).	"[S]S was superior to muscular stretching for the measured variables associated with chronic low back pain."	Suggests segmental stabilization is better than stretching.

Study received Public Financial Support of: State of São Paulo Research Foundation (FAPESP). No mention of COI.			exercises focused on stretching erector spinae, hamstrings, triceps surae (n = 30). Exercises 6 weeks, 2x a week. 30 minutes. Follow-up at end of treatment.			
Niemistö 2003 RCT Institutional and Professional Organization funds received in support of this work. No mention of COI.	5.5	N = 204 with chronic LBP	Manipulation, stabilizing exercise andphysician consultation (n = 102, 60 minute evaluation, treatment, exercise sessions plus educational booklet) vs. physician consultation alone (n = 102, educational booklet). Physician consultation group received individual instructions regarding posture and 3-4 exercises to increase spinal mobility, muscle stretch, and/or trunk muscle stability based on clinical evaluation. Treatment sessions each group 4 times over 4 weeks.	Baseline differences modestly favored manipulation group. Visual analogue pain score mean (SD) in mm at baseline, 5 months, 12 months for manipulative-treatment vs. consultation group: 59.5 (21.2)/25.2 (23.3)/25.7 (23.3) vs. 53.3 (21.2)/36.1 (23.3)/ 32.2 (23.3), p<0.001. Oswestry Disability Index: 29.5 (9.7)/14.7 (11.6)/13.7 (11.6) vs. 28.8 (9.7)/18.6 (11.6)/16.5 (11.6), p = 0.002.	"The manipulation treatment with stabilizing exercises was more effective in reducing pain intensity and disability than the physician consultation alone. The present study showed that short, specific treatment programs with proper patient information may alter the course of chronic low back pain."	Lack of significant content of physician consultations. If usual care, trial likely biased against that group. Manipulation treatment combined with exercise, precluding assessment of which is responsible for results and impairs the ability to draw strong conclusions.
Del Pozo-Cruz 2012 RCT Study supported by University of Extremadura (Quality of Life Research Group and Occupational Preventive Medicine) and Government of Extremadura and European Union Regional Development Funds for research groups (GR10127). No COI.	5.5	N = 100 with subacute non-specific LBP	On-line occupational postural and exercises (n = 44) vs. control group (n = 46) of standard preventive medicine care.	Scores on STarT Back Screening Tool (SBST) improved in treatment group vs. controls (95% CI -1.01 [-1.79 to 0.118] p = 0.019).	"…[T]his intervention was effective to reduce the risk of progression to chronicity among office workers with subacute non-specific LBP."	Studied office workers. Non-interventional control bias precludes strong conclusions.
Diab 2012 RCT No mention of COI or industry sponsorship.	5.0	N = 80 with chronic mechanical LBP	Traction group attended sessions 3x a week 10 weeks with traction beginning at 3 minutes and increasing by 1 minute per session to 20 minutes (n = 40) vs. comparison group told to do a stretching program 3x a week and infrared radiation 15 minutes per session (n = 4	Variation among mean values significantly greater than chance (p <0.0001) for traction and comparison groups and stable at follow-up (P <0.05) in pain, but no differences between groups in pain. Only difference in absolute rotatory angle was for traction group (p = 0.00), but was lost from 10 week to 3 month follow-up (p = 0.6). For traction, difference among 3 measurement	"Lumbar extension traction with stretching exercises and infrared radiation was superior to stretching exercises and infrared radiation alone for improving the sagittal lumbar curve, pain, and intervertebral movement in CMLBP."	Assessment of traction as additive treatment biases in favor of traction. Outcomes not blinded, susceptible to data errors. Conclusions on intervention efficacy used in both groups unwarranted. Despite design bias in favor of traction, no differences

			0). Follow-up after 10 weeks and at 3 months.	intervals for all measured levels, but for comparison group only seen for L3-L4 and L5-S1 (p = 0.000 and 0.005) levels in translational displacement.		in pain, ODI at 10 weeks suggesting no significant benefit. Later modest differences at 6 months present is not well explained.
Casserley-Feeney 2012 RCT No mention of COI. No industry sponsorship.	5.0	N = 161 with acute and chronic LBP referred to physical therapy (PT)	Public PT (n = 80) vs. Private PT (n = 80). Follow-up at 3, 6, and 12 months.	Wait for private PT 13.3 days vs. 53.1 days for public PT [95% CI = 39.79 days (26.88-52.69); t = 6.12; p <0.001]. Private PT more treatment visits [5.05 (3.46) vs. 5.73 (3.23): mean difference, 95% CI = − 1.06 (− 2.13 to 0.003); p = 0.050], in shorter time [73.92 days (59.39) vs. 50.44 days (26.88); mean difference, 95% CI = 23.48 days (7.43 to 39.52); p = 0.005]. Participants received more manual therapy ($\chi 2$ = 6.941; p = 0.008) and home exercise ($\chi 2$ = 4.701; p = 0.030) in private PT group and group exercise classes in public PT group ($\chi 2$ = 7.062; p = 0.008).	"Despite differences between public and private PT regarding waiting times for treatment and therapist experience, there were no significant differences between groups in the majority of clinical outcome measure scores at follow-up, apart from SF-36 Role Physical and satisfaction with treatment outcome in favor of the private PT group."	Socialized medicine (Ireland) with much longer wait times for public PT than private. Shorter pain duration in private group at baseline (226 vs. 457 days). Despite issues, data suggest comparable outcomes. As interventions (e.g., manual therapy, exercises used) differed, conclusions are consequently limited.
Balthazard 2012 RCT Study financed by DO-RE Funds of Swiss National Science Foundation (13DPD3-109903). No mention of COI.	5.0	N = 42 with chronic non-specific LBP	MT group: Spinal manipulation/ mobilization plus active exercises (AE) (n = 22) vs. ST group: Detuned ultrasound plus AE (n = 20). Eight sessions delivered in 4-8 weeks. Follow-up before treatments, after 8th therapeutic session, and at 3 and 6 months.	MT group with greater decrease in mean pain level vs. ST (-0.76 VAS units; 95% CI -1.22 to -0.3). For MT + AE/ST+AE treatment larger decrease in pain and reduced disability favored in MT group over ST group (VAS-pain mean group difference: -1.24; 95%; CI: -2.37 to -0.30; p = 0.032) and (ODI mean group difference: -7.14; 95% CI: -12.8 to -1.52; p = 0.013). No other significant effects.	"The present study confirms the immediate analgesic effect of manual therapy for CNSLBP."	Pilot study. Higher baseline VAS in ST (6.5 vs. 5.3). Data suggest manual therapy of additive benefit, however, exercise did not emphasize strengthening and aerobic.
Kamioka 2011 RCT Study supported by research grant of Akaeda Medical Research Foundation in 2009. No COI.	4.5	N = 8 female caregivers at 4 different nursing homes	Intervention group guided by orthopedist and exercise instructor to perform 6 minutes of exercise/day (n = 44) vs. control group given no education on how to prevent back pain (n = 44). Last follow-up after 12 weeks.	No differences between groups for any variable. Rate of adherence to stretching exercise was 2.7±1.3 times per week.	"Even with the conduct of one OJT [on-the-job training], and exercises of only 6 min every day, the adherence of caregivers was low, and there appeared to be few effects of the OJT."	Pilot cluster randomized by nursing home. High dropouts and low compliance limit conclusions.

Kell 2011 RCT University of Alberta, Augustana Campus Research and Travel grant. No mention of COI.	4.5	N = 240 with chronic non-specific LBP >3 months	4 days/week (4D) of periodized musculoskeletal rehabilitation (PMR) (n = 60) vs. 3 days/ week (3D) of PMR (n = 60) vs. 2 days/ week (2D) of PMR (n = 60) vs. control (C) who did not perform any PMR (n = 60). Follow-up at 9 and 13 weeks.	3D and 4D groups both had increase in body mass (kg, $p \leq 0.05$) and reduction in % body fat from baseline to week 13. All groups except C, showed increases in strength ($p \leq 0.05$) from baseline to week 9 and baseline to week 13. 2D, 3D, and 4D groups improved in pain, disability, and quality of life from baseline to week 9 and baseline to week 13 ($p \leq 0.05$). Group 4D only group with improvement in pain and disability from 9 to 13 week ($p \leq 0.05$). Group 4D had less improvements in pain, disability, and quality of life ($p \leq 0.05$). Groups 2D and 3D had improved quality of life, pain and disability vs. C group ($p \leq 0.05$).	"The 4D training volume is most effective at treating CLBP. Periodization cannot only be applied to athlete training but also to the rehabilitation setting."	Randomization not well described. Controls without exercises, but pragmatic and thus unstructured. Data suggest dose-response relationships with strengthening exercise.
Roche-Leboucher 2011 RCT No mention of COI. No industry sponsorship.	4.0	N = 132 with LBP	Functional Restoration Program group (FRP) including intensive physical training and multi-disciplinary approach 6 hours/day, 5 days/week x 5 weeks (n = 68) vs. Outpatient active physiotherapy (AIT) (n = 64). Last follow-up at 1 year.	Both groups had reduced sick days, but FRP group had greater reduction (-101.2±126.5 days vs. -79±143.9 days; $p < 0.001$). No differences in rate of employment $p = 0.72$) or in physical outcome measures. Better results in FRP for trunk flexibility with fingertip-to-floor distance. More said they had increased their physical fitness in FRP group (84% vs. 66%; $p = 0.02$).	"Both programs are efficient in reducing disability and sick-leave days. The FRP is significantly more effective in reducing sick-leave days. Further analysis is required to determine if this overweighs the difference in costs of both programs."	Data suggest FRP effective with less sick leave, increased fitness and trends towards greater return to work and full time work (latter 2 likely underpowered).
Hemmilä 2002 RCT Study funded by Finnish Slot Machine Association (RAY) and completed with personnel and facilities of Folk Medicine Centre of Kaustinen, Finland. No mention of COI.	4.0	N = 132 with back pain	Physiotherapy (n = 34) vs. bone-setting (n = 45) vs. exercise (n = 35). A maximum of 10 one-hour treatment sessions of each therapy offered over 6-week period. Follow-up 6 weeks, 3, 6 and 12 months.	Improvement of Oswestry Disability scores at baseline mean (SD)/6 weeks mean (95%CI)/3 months/6 months/12 months for physiotherapy vs. bone-setting vs. exercise: 18.1 (7.7)/2.0 (-1.1 to 5.1)/4.0 (1.3 to 6.7)/4.7 (1.5 to 7.9)/4.4 (1.2 to 7.6) vs. 23.7 (11.6)/7.0 (3.4 to 10.2)/5.1 (1.8 to 8.4)/9.4 (6.7 to 12.1)/8.4 (5.2 to 11.6) vs. 19.4 (9.5)/3.2 (0.4 to 6.1)/2.9 (-0.2 to 5.9)/3.5 (0.2 to 6.8)/2.2 (-1.2 to 5.7), $p = 0.06$ /0.09/ 0.6/ 0.01/0.4.	"Traditional bone-setting seemed more effective than exercise or physiotherapy on back pain and disability, even 1 year after therapy."	Many details sparse. Interventions not well described.

Devices

Many devices have been used to treat LBP, including shoe insoles and lifts, taping, lumbar supports and braces, magnets, bedding/mattresses, and hyperbaric oxygen.

SHOE INSOLES AND SHOE LIFTS

1. *Recommendation: Shoe Insoles and Lifts for Treatment of Acute Low Back Pain*
   Shoe insoles and lifts are not recommended for treatment of acute low back pain as there other treatments that have been shown to be beneficial. Patients with a significant leg length discrepancy found in the context of treatment for acute LBP may be reasonable candidates for a shoe insole.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Shoe Insoles and Lifts for Treatment of Subacute or Chronic Low Back Pain, Radicular Pain, or Other Back-related Conditions*
   Shoe insoles and lifts are not recommended for treatment of subacute or chronic low back pain or radicular pain syndromes or other back-related conditions other than in circumstances of leg length discrepancy over 2cm. In the absence of significant leg length discrepancy, shoe insoles and lifts are not recommended as there are other treatments shown to have demonstrable benefits and minor leg length discrepancies appear unlikely to result in meaningful adverse health effects.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

3. *Recommendation: Shoe Insoles and Lifts for Significant Leg Length Discrepancy*
   Shoe lifts are recommended for treatment of chronic or recurrent low back pain among individuals with significant leg length discrepancy of more than 2cm.

   Indications – Leg length discrepancies that are confirmed on repeated measurements as over 2cm.

   Frequency/Duration – Daily use of shoe lifts.

   Indications for Discontinuation – Patient exhibits lift intolerance. There are substantial numbers of subjects (35%) who do not tolerate shoe insoles as the shoes become too tight.(1243)
   Benefits – Theoretical reduction in LBP.
   Harms – Discomfort associated with accommodation, especially short-term.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

4. *Recommendation: Shoe Insoles and Lifts for Prevention of Low Back Pain*
   Shoe insoles and lifts are not recommended for prevention of low back pain.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

5. *Recommendation: Shoe Insoles for Patients with Prolonged Walking Requirements*
   There is no recommendation for or against the use of shoe insoles for patients with chronic low back pain who have prolonged walking requirements.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations

Some individuals have lower extremities that are substantially different in length, referred to as "leg length discrepancies" which are generally defined as over 2 to 3cm. These discrepancies are

theoretically linked to increased risk of LBP. However, robust prospective cohort studies to substantiate this purported risk factor have not been reported. In theory, shoe lifts may ameliorate this leg length discrepancy and thereby reduce LBP. A nonsystematic review noted that the "role of leg length discrepancy (LLD) both as a biomechanical impediment and a predisposing factor for associated musculoskeletal disorders has been a source of controversy for some time." Shoe insoles or orthotics are sometimes used for primary prevention purposes to theoretically reduce risk of LBP through the reduction in the force generated from heel strike.

There is one quality study reported comparing shoe insoles in patients with LBP which is likely mostly chronic. All of these studies, even those attempting blinding, suffer from probable unblinding of participants and placebo effects. The length of trials ranged from a few weeks to a few months. Shoe insoles are relatively low cost, not invasive, and have little potential for adverse effects. However, there is no recommendation for or against the use of shoe insoles for chronic LBP patients with prolonged walking requirements. For all other spinal pain patients, including those without prolonged walking requirements, there is no quality evidence of efficacy. Shoe insoles and lifts are not recommended for the primary prevention of low back pain as there is no quality evidence of their efficacy. There are other interventions with greater likelihood of efficacy in preventing spinal pain. Shoe insoles and inserts are moderate cost, particularly when considering frequency of replacements. They are not invasive, but problems with discomfort are relatively common, and non-compliance rates of more than 50% have been reported.

Evidence for the Use of Shoe Insoles and Lifts
There are 3 moderate-quality RCTs or crossover trials incorporated into this analysis.(1243-1245)
There are 3 low-quality RCTs in Appendix 1.(1246-1248)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: shoe insoles and lifts, subacute, chronic, radicular and sciatica to find 347 articles. Of the 347 articles, we reviewed 9 and included 4 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Shabat 2005 RCT/Crossover Trial No COI mentioned.	6.0	N = 60 with chronic LBP	Insoles (FSAP – Foot Support Anterior Posterior, n = 41) vs. placebo insole (n = 19) for 5 weeks then crossover for another 5 weeks.	LBP rating 5.46±1.8 at baseline and both placebo (5.11±1.85) and interventional insoles (3.96 ±1.74) reduced LBP, but reductions greater in true insoles, p <0.05.	"[T]he low back pain decreased significantly after the use of real insoles compared to placebo ones."	Randomization not described; 2/3 received custom orthotics first. Patients enrolled with symptoms, not clinically seeking care. No washout described between crossover treatments. Results of uncertain clinical significance.
Larsen 2001 RCT No COI mentioned.	6.0	N = 145 consecutive military conscripts in an intention-to-treat analysis	Biomechanic semi-rigid shoe orthoses (n = 77) vs. placebo (n = 69) for 3 months.	No differences in LBP and lower extremity (LE) problems with orthoses. Actual-use analyses: any problems in back or LE (controls 56% vs. intervention 36%, p = 0.045); shin splint (24% vs. 5%, p = 0.005; not significant between groups all other areas. ITT: not significant between groups for LBP, LE pain and number of off-duty days; shin splints (24% vs. 6%, p = 0.005.	"[I]t may be possible to prevent certain musculoskeletal problems in the back or lower extremities among military conscripts by using custom-made biomechanic show orthoses."	Generalizability of these results to a working population is somewhat unclear. Data suggest differences favoring shoe orthotics for LBP prevention in military population, but not significant in ITT analyses. However, data suggest they may lower shin splints.
Basford 1988 RCT/Crossover Trial No COI mentioned.	4.0	N = 90 females spending at least 75% of day standing and not under medical treatment	Viscoelastic polyurethane insoles (n = 50) vs. usual footwear (n = 46) for 5 weeks to reduce back, leg, and foot pain.	17 reported reduced pain, 20 reported no effect, and 1 reported increased pain with insoles, p <0.02. Remainder found insoles very comfortable (p <0.002) and had reductions in back pain (p <0.02), foot pain (p <0.03), and leg pain (p <0.007).	"[V]iscoelastic insoles can effectively improve comfort and reduce back, leg, and foot pain in individuals who must stand throughout the day."	Overall dropout rate high at 35%. Subjects preferred insoles.

KINESIOTAPING (including KT Tape and RockTape) AND TAPING
Taping and kinesiotaping (including KT tape and Rocktape) are used on the extremities and the spine particularly in sports settings.

Recommendation: Kinesiotaping and Taping for Treatment of Acute, Subacute, Chronic Low Back Pain, Radicular Pain, or Other Back-related Conditions
Kinesiotaping and taping are not recommended for treatment of acute, subacute, or chronic low back pain or radicular pain syndromes or other back-related conditions.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendation
There are no consistent quality studies demonstrating kinesiotaping and taping are efficacious for the treatment of acute, subacute, or chronic LBP or radicular pain syndromes or other back-related problems. One moderate-quality study suggested it may be effective, however, three found it ineffective.(1249-1252) The theory is that taping supports the muscles, although most of the spine muscles are small and deep, thus the rationale for taping the back seems limited. Taping has occasionally been used as a technique to teach posture. However, there are concerns about the value of this technique as there also is some controversy regarding appropriate postures for work and lifting. These interventions are not invasive, but there are generally minor adverse effects among patients who do not tolerate tape or the adhesives. However, tape is expensive and there are other interventions shown to be efficacious.

Evidence for Use of Kinesiotaping and Taping
There are 4 moderate-quality RCTs incorporated into this analysis.(1249-1252) There are 2 low-quality RCT in Appendix 1.(1253, 1254)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates. The following search terms were used "(kinesiotaping AND taping) AND (subacute low back pain chronic low back pain radicular pain syndromes (including 'sciatica') spinal stenosis, sacroiliitis spondylolisthesis)" to find 13,533 articles. Of those 13,533, we reviewed 5 articles, and included 5 articles (5 RCTs and zero reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Castro-Sanchez 2012 RCT No mention of COI or industry sponsorship.	7.5	N = 60 with chronic non-specific LBP	Kinesiotaping over lumbar spine for 1-week vs. control of sham taping. Outcome measures at baseline, immediately after week of taping and 4 weeks.	At 1-week, experimental group greater improvement in ODI by 4 points (95% CI 2-6) and 1.2 points (95% CI 0.4-0.2) on Roland-Morris; effects not significant 4-weeks later. Experimental group greater decrease in pain vs. controls immediately after treatment (mean between-group difference 1.1cm, 95% CI 0.3- 1.9), maintained 4-weeks later (1.0cm, 95% CI 0.2-1.7). Trunk muscle endurance better at 1-week (by 23 sec, 95% CI 14-32) and 4-weeks later (by 18 sec, 95% CI 0.2-1.7). Other outcomes not significant.	"[I]ndividuals with chronic nonspecific low back pain experienced statistically significant improvements immediately after the application of Kinesiotaping in disability, pain, isomeric endurance of the trunk muscles, and perhaps trunk flexion range of motion. However, the effects were generally small and only the improvements in pain and trunk muscle endurance were observed four weeks after the week with the tape *in situ*."	Kinesiotaping with more taping vs. less taping may bias in favor of kinesiotaping. Data suggest mildly better data at 1 week for kinesiotaping. Yet, 1 of 5-week data favored control (RMDQ KT baseline/1 week/5 weeks.
Álvarez-Álvarez 2014 RCT	7.0	N = 99 healthy subjects (≥18 years)	Kinesio® Tape (KT) using 2 5cm strips on either side of lumbar spine vs. placebo (P) using same strips but placed on paravertebral muscles fibers vs. control (C) no tape	Post- hoc: KT subjects able to hold test positions significantly longer vs. C subjects (between group effect size: 0.650 (0.157-1.143); p = 0.03).	"KT appears to improve the time to failure of the extensor muscle of the trunk obtained using the Biering-Sorensen test. These findings suggest that KT influences processes that lead to muscle fatigue and that KT could be effective in the management of LBP."	Short duration. No statistical difference between active and placebo tape treatments.
Chen 2012 Pilot RCT Study supported by Australian Centre for Research into Sports Injury and Its Prevention, an International Research Centres for Prevention of Injury and Protection of Athlete Health supported by International Olympic Committee. No mention of COI.	6.5	N = 43 with non-specific LBP more than 6 weeks	Functional Fascial Taping (n = 21) vs. placebo (n = 22). Follow up at 2, 6, and 12 weeks.	Primary outcomes: 1) Low back average pain intensity was not significant at 2 week (p = 0.226), 6 week (p = 0.903) or 12 week (p = 0.605) follow-up; 2) Low back worst pain intensity only significant at 2 week follow-up (p = 0.020); and 3) Oswestry Disability Index not significant at 2 week (p = 0.054), 6 week (p = 0.278) or 12 week (p = 0.329) follow-up.	"[F]unctional Fascial Taping reduced worst pain in patients with non-acute low back pain during the treatment phase."	Data suggest some difference only at week 2. Mostly chronic LPB 18-65 years.

Paoloni 2011 RCT No mention of COI or industry sponsorship.	4.0	N = 39 with chronic LBP >12 weeks failed to gain flexion-relation in lumbar muscle, age 30-80	Kinesio taping group(KT-G), (n = 13) vs. Exercise group (EX-G), (n = 13) vs Kinesio tape and Exercise group (KTEx-G), (n = 13). Therapeutic exercise 30 minutes, 3x a week. Study lasts 4 weeks.	No significant difference between 3 groups for pain reduction. Pain duration mean and (SD); KTEx-G: 6 (46.1), KT-G: 4 (30.8), Ex-G: 5 (38.5).	"When applied to CLBP patients, KT leads to pain relief and lumbar muscle function normalization shortly after its application; these effects persist over a short follow-up period."	Report of 2 studies with sparse details. Some baseline differences with lower duration in KT-exercise. Small sample size, short follow-up. Suggests kinesiotaping not effective.

LUMBAR SUPPORTS

Lumbar supports range from soft wrap-around appliances to reinforced braces to rigid braces and have been used to treat various phases of lumbar pain(837, 1255-1259) and post-surgical rehabilitation. They have also been used for prevention of low back pain.(193, 1260-1263) The rigid devices have been used particularly in post-operative lumbar fusion with a goal to facilitate boney union.

1. *Recommendation: Lumbar Supports for Prevention of Low Back Pain*
   Lumbar supports are not recommended for prevention of low back pain.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

2. *Recommendation: Lumbar Supports for Treatment of Acute, Subacute and Chronic Low Back Pain*
   Lumbar supports are not recommended for treatment of low back pain.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

3. *Recommendation: Lumbar Supports after fusion surgery for Low Back Disorders*
   Rigid lumbar supports are recommended for post-operative fusion patients.

   Benefits – Facilitate fusion.
   Harms – Discomfort, dermal irritation.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

Rationale for Recommendations

The overall quality of the available evidence is relatively limited and there is no clear evidence of efficacy for the use of lumbar supports for short- or long-term treatment or prevention of low back pain. Lumbar supports also attempt to enforce reduced mobility in contrast to evidence that increasing activity levels reduces LBP (see Bed Rest and Aerobic Exercises). Thus, the theoretical construct for a beneficial use of lumbar supports for either treatment or prevention of LBP appears tenuous, although they may be useful for specific treatment of spondylolisthesis, documented instability, or post-operative treatment.

Soft braces have been used to prevent LBP and studied in workers in high risk industries (warehousing, airline baggage handling). Theoretical mechanisms for the prevention of LBP include provision of trunk support and prevention of pain-producing events, reminders of "proper lifting technique," and an increase in intra-abdominal pressure and a decrease in intradiscal pressure.(1264) However, limiting movement to avoid pain is contrary to the cognitive behavioral approaches to LBP shown to be helpful. Proper lifting technique is problematic and reviewed elsewhere, and there is no quality evidence that such devices reduce intradiscal pressure. Reported compliance rates are poor (about 40%)(136, 1265) and complaints include excessive heat, restrictive movements, discomfort with sitting, rubbing or pinching of skin, and feelings of bruised ribs.(136, 1265)

Lumbar supports are low to moderate cost. They are not invasive, but they have minor and widely prevalent adverse effects resulting in low compliance rates. There are other interventions with evidence of efficacy especially for treatment (NSAIDs, exercise, cognitive-behavioral, etc.), and also for prevention (exercise).

Evidence for the Use of Lumbar Supports

There are 10 moderate-quality RCTs incorporated into this analysis.(136, 208, 837, 1258, 1263, 1265-1269) There are 4 low-quality RCTs in Appendix 1.(1270-1273)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: lumbar supports, subacute low back pain and chronic low back pain to find 31,235 articles. Of the 31,235 articles we reviewed eleven articles and included all eleven articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Doran 1975 RCT No mention of COI or industry sponsorship.	5.0	N = 456 with acute, subacute, or chronic LBP	Manipulation (individualized, 2x a week) (n = 98) vs. physiotherapy (individualized twice a week) (n = 104) vs. corset (not standardized) (n = 93) vs. paracetamol 2 tablets Q 4 hour (n = 100) for 3 weeks.	Percentage who reported improvement or complete relief respectively, 74%, 65%, 83%, and 76%. Never any important differences among 4 patient groups.	"[N]one of the methods of treating low back pain compared in this trial showed any great superiority. Patients treated with analgesics alone fared marginally worse than those on the other three treatments."	Study not well described. Study included many interventions that are not well standardized.
van Poppel 1998 RCT Supported by grant from Fraeventiefonds, the Hague, The Netherlands. No COI mentioned.	4.0	N = 312 airline cargo workers in The Netherlands	Lifting instructions (3 sessions for groups of 10-15; first session 2 hours, other sessions 1.5 hours at 6 weeks and 12 weeks) and lumbar support (n = 70) vs. lifting instruction (n = 82) vs. lumbar support (n = 83) vs. no intervention (n = 77) for 6 months.	Compliance with supports at least half the time was low (43%). No differences in LBP incidence or lost-time injuries. In workers who never had LBP, incidence was higher among those using a support. Among workers compliant with supports, LBP reporting was non-significantly increased.	"[L]umbar supports or education did not lead to a reduction in low back pain incidence or sick leave."	If objects large, a "lift with your knees not with your back" directive would be infeasible due to human strength considerations and increased intradiscal pressures (potentially substantiated by statement that 11% stated they lifted as they were taught all the time, 73% some of the time, and 11% never).
Reddell 1992 RCT No mention of COI or industry sponsorship.	4.0	N = 642 airline baggage handling workers	Weightlifting belt (n = 57) vs. video training, booklet, and hands on training (n = 122) vs. belt and training (n = 57) vs. control (n = 88) for 8 months.	Compliance with belt use poor with 58% discontinuing use before end of 8-month observation time. Lowest injury rates occurred in training only and control groups. Difference present for lost work day case incident rate, p <0.0181. Control group had most lost work days.	"As industries are experimenting with the use of belts, it is recommended that great care be taken in any further evaluation and close attention directed towards injuries which occur when not wearing the belt following a period of wearing the belt (i.e., off-the-job injuries)."	Data suggest no significant benefit from back-belt use, with trend that use may result in unintended harm.
Walsh 1990 RCT Supported by Institutional Biomedical Research Grant. No mention of COI.	4.0	N = 90 for prevention of LBP in grocery warehouse	Back school single 1 hour session (Group 2, n = 27) vs. back school and lumbosacral orthosis (Group 3, n = 27) vs. control (Group 1, n = 27) for 6 months.	Abdominal muscle strength increased in all groups, but increased most in back school plus orthosis group. Lost days in controls changed from 0.4±0.2 to 0.8±0.5 (6 months previously vs. 6 months during study). In back school, lost days changed from 3.2±1.9 to 2.6±1.6 vs. 2.9±1.2 to 0.5±0.4 for combination group.	"It appears that the use of intermittent prophylactic bracing has no adverse effects on abdominal muscle strength and may contribute to decreased lost time."	Baseline differences in lost days in prior 6 months, suggesting randomization failure. No brace only group. Abdominal muscle strength was measured, but not back muscle strength.
Hsieh 1992 RCT	4.0	N = 85 with subacute or chronic LBP	Manipulation 3 times a week, hot pack 10 minutes (n = 26) vs.	Both revised Oswestry Low Back Pain Questionnaire (ROLBPQ) and Roland-Morris Activity Scale	"[B]oth ROLBPQ and RMAS are reliable instruments for assessing low back pain	Study results comparing subjective assessment tools. Baseline differences in

Supported by grant from Foundation for Chiropractic Education and Research and National Institute of Disability and Rehabilitation Research. No mention of COI.			massage 3 times a week, no deep soft tissue manipulation and hot pack (n = 15) vs. corset worn 8 hours a day (n = 12) vs. TENS (n = 10) for 3 weeks.	(RMAS) showed significant difference between chiropractic manipulation and massage groups (p <0.05).	disability. We support the use of RMAS in the subacute nonspecific low back pain population because it is more sensitive to detect changes than ROLBPQ."	outcomes. Sparse study details. Clinical significance of comparisons is uncertain (mean percentage of scale) is reported statistic.
Coxhead 1981 RCT No mention of COI or industry sponsorship.	4.0	N = 322 outpatients with pain radiating at least as far as buttock crease, with or without back pain	Traction with motor-driven "Tru-Trac" apparatus giving traction at pre-set forces and time intervals vs. exercises all ROMs and muscle groups vs. manipulation vs. corset: ready-made fabric lumbar support 4 weeks; 16 treatment groups.	At 4 weeks, mean improvement scores: traction 50.1, manipulation 52.6, exercises 49.0, and corset 49.8. Authors concluded no beneficial effects of treatment detectable at 4 or 16 months. At 4 weeks, pain scores improved more in manipulation group, p <0.05.	"There were no beneficial effects of treatment detectable at four or sixteen months. In the short-term, active physiotherapy with several treatments appears to be of value in the outpatient management of patients with sciatic symptoms, but it does not seem to confer any longer-term benefit."	Entry criteria included those with pain "at least as far as the buttock crease," thus diagnosis of sciatica appears to not follow typical medical practice and the breakdown between LBP and true sciatica patients is unclear.
Subacute Low Back Pain						
Lumbar Support vs. Control Group						
Calmels 2009 RCT No mention of COI or industry sponsorship.	4.0	N = 197 age 20-60 with subacute LBP lasting 1-3 months	Lumbar support belt worn whole day (n = 102) vs. control group: no lumbar support belts (n = 95) with follow up 3 months.	EIFEL change between groups day 0-30: reduction in average EIFEL lumbar belt 5.4±4.1 vs. control 4.0±4.3, p = 0.022; day 0-90 7.6±4.4 vs. 6.1±4.73, p = 0.023. Change in VAS pain intensity: day 0-30 26.8±18.2 vs. 21.3±18.7, p = 0.038; day 0-90 41.5±21.49 vs. 32.0±20.0, p = 0.002. Medication consumption at day 90: patients that did not use any medication 60.8% vs. 40%, p = 0.029.	"Lumbar belt wearing is consequent in subacute low back pain to improve significantly the functional status, the pain level, and the pharmacologic consumption."	Control group poorly described, may have been usual care thus biased in favor of intervention. Many methods details sparse. Data suggest poor compliance.
Acute Low Back Pain						
Back Support and Education vs. Education Alone						
Oleske 2007 RCT Corporate/Industry funds received in support of this work: UAW-GM National Joint Committee on Health and Safety (International Union,	5.0	N = 433 with work-related low back disorder claim (WR-LBD). 9 plants in 3 states from 3 automotive divisions.	Back support, n = 222 (fittedErgodyne Proflex support) and education (health education program by videos and brochures on self-care activities during acute episodes of back pain and weight control, body fat, physical activity) vs. education alone (n = 211).	No significant differences between groups. LBP recurrence of 23.1% vs. 45.2%, p = 0.059.	"Although there was no overall effect on self-reported recovery or administrative measures or lost work time between the study groups, a back support plus health education may have some value in preventing recurrent WR-LBD… "	Large sample size. Co-interventions unclear. High non-compliance (49% at 1 year) and dropouts. Data borderline reductions in recurrences (p=0.059), although recall bias possible and most results statistically negative.

UAW, General Motors Corporation). No mention of COI.			Follow up at 1, 2, 6, and 12 months			
Lumbar Support vs. Usual Care						
Roelofs 2007 RCT No mention of COI or industry sponsorship.	5.0	N = 360 home care workers with self-reported history of LBP	Control group, n = 177 (short refresher course on healthy working methods and primary and secondary care for low back pain management) vs. intervention group, n=183 (1 of 4 types lumbar support on working days when they might develop low back pain plus usual care). Follow up for 12 months after enrollment.	Mean calendar days with LBP: lumbar support 71.7 vs. control 124.4, p <0.001. Mean calendar days of sick leave: 38.5 vs. 43.5, p = 0.45. Mean severity of LBP in previous week: 4.0 vs. 4.6, p = 0.020. Mean function status in previous week: 26.2 vs. 30.3, p = 0.017. Mean calendar days of self-reported LBP-related sick leave: 3.2 vs. 8.0, p = 0.003.	"Adding patient-directed use of lumbar supports to a short course on healthy working methods may reduce the number of days when low back pain occurs, but not overall work absenteeism, among home care workers with previous low back pain."	Control group consisting of "refresher" suggests more of the same treatment and may be biased in favor of intervention. Used multiple types of supports.
Roelofs 2010 RCT No mention of COI or industry sponsorship.	5.0	N = 360 home care workers with self-reported history of LBP	See Roelofs 2007.	Mean direct costs in intervention group significantly lower than control group, -$266 95% CI -437 to -89. Indirect costs nonsignificant between groups. No other significant differences between groups.	"Lumbar support seems to be a cost-effective addition to usual care for home care workers with recurrent LBP."	Economic report of Roelofs 2007.

MAGNETS

Proponents believe that magnetic fields have therapeutic value in the treatment of musculoskeletal disorders.

Recommendation: Magnets for Treatment of Acute, Subacute, or Chronic Low Back Pain

Magnets are moderately not recommended for treatment of acute, subacute, or chronic low back pain.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – High

Rationale for Recommendation

Two moderate-quality RCTs suggest a lack of efficacy and none support efficacy.(1274, 1275) Magnets are not invasive, have no adverse effects, and are low cost. However, other treatments have proven efficacy.

Evidence for the Use of Magnets

There are 2 moderate-quality RCT/crossover trial incorporated into this analysis.(1274, 1275)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: magnets, subacute low back pain, chronic low back pain, radicular pain syndromes (including 'sciatica'), Spinal stenosis, spinal fractures, sacroiliitis, and spondylolisthesis to find 437 articles. Of the 437 articles we reviewed 2 articles and included 2 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Collacott 2000 RCT/Crossover Trial No mention of COI or industry sponsorship.	7.5	N = 20 with stable LBP (mean 19 years duration, with no past use of magnet therapy)	Magnets vs. sham magnets each for 1 week before crossing over with 1 week washout period between trials. Each group applied devices 6 hours a day, 3 days a week (Monday, Wednesday, Friday) total 18 hours of treatment.	Average 300G magnets did not lead to pain reductions. Mean VAS scores declined by 0.49±0.96 points for real magnet treatment vs. 0.44±1.4 points for sham, p = 0.90. No significant differences for other outcome measures (ROM, p = 0.66, PRI p = 0.55).	"Application of 1 variety of permanent magnet had no effect on our small group of subjects with chronic low back pain."	Pilot study. Data suggest lack of efficacy.
Khoromi 2007 RCT No mention of COI or industry sponsorship.	5.0	N = 40 age18-75; average leg pain at least 4/10 on verbal numerical scale of 0-10, with 0 representing no pain and 10 representing worst possible pain, present 5 days per week or more for at least 3 months; evidence of lumbar radiculopathy, based on presence of pain in one or both buttocks, thighs, or legs)	Phase I included 4 random periods of 2-week duration: 2 periods with 200 G, 1 period with 50 G, and 1period of "no treatment." Phase II consisted of two 5-week periods with most effective magnet from Phase I and its corresponding 50 or 200 G device.	Primary outcome, average daily leg pain score (0-10 scale) in each period of Phase II, was 3.2 ±2.1 for 200 G magnets (mean ±SD) as compared with 3.9±2.2 for 50 G magnets (p=0.08). Difference corresponds to an 18% pain reduction produced by the 200 G compared to the 50 G treatment. In Phase II, global pain relief scores better for patients receiving 200 vs. 50 G magnets ($p < 0.0002$, Wilcoxon Signed Rank test for comparison across 6 category scale; t=3.88, P=0.0007 using parametric t-test).	"[T]his randomized, controlled, double-blind study showed a nonsignificant trend toward leg pain reduction in patients with chronic sciatica exposed to magnets of 200 vs. 50 G strength. The use of 50 G magnets achieved the goal of proper blinding, which is an important issue in magnet studies, but may have partially masked the true effect of the 200 G magnets on radicular pain. A longer duration of treatment may have increased the effect of 200 vs. 50 G magnets...Studies of larger size and longer duration should be considered to explore the effects of 200 G or stronger magnets compared with novel sham magnet devices that offer superior blinding without deep tissue effects."	Phase trial, 1st phase to determine patient preference, 2nd phase crossover trial at weak vs. strong magnets. Lack of study details for randomization, allocations, control of cointerventions, compliance. Dropouts high. Data not analyzed in ITT. Data suggest strong placebo effects in all groups, and no significant effect from use of magnets.

HYPERBARIC OXYGEN

Hyperbaric oxygen (HBO) involves the administration of oxygen in a pressurized chamber to increase the oxygen delivery to the tissues of the body. It has been used to treat a number of conditions with problematic microvascular blood supply, including diabetic foot ulcers and decubitus ulcers. Oxygen may be titrated to higher concentrations up to 100%. Small individual patient chambers or a large walk-in multi-patient chamber may be used. There also are "topical" hyperbaric oxygen treatments that do not involve the use of chambers.

1. *Recommendation: Hyperbaric Oxygen for Treatment of Chronic Low Back Pain*
   Hyperbaric oxygen is not recommended for treatment of chronic low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Topical Hyperbaric Oxygen for Treatment of Chronic Low Back Pain*
   Topical hyperbaric oxygen is not recommended for treatment of chronic low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
There are no quality trials identified. Hyperbaric oxygen is costly, and in the absence of evidence of efficacy, is not recommended (see Chronic Pain Guideline for other conditions).

Evidence for the Use of Hyperbaric Oxygen
There are no quality studies incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without any limits on publication dates. We used the following search terms: Topica Hyperbaric Oxygen, Hyperbaric Oxygen, HBO and Chronic Low back pain to find 4, 600 articles. Of the 4, 600 articles, we reviewed 0 articles and included 0 articles.

IONTOPHORESIS

Iontophoresis is a drug delivery system utilizing electrical current to transdermally deliver either glucocorticosteroids or NSAIDs and that has apparent efficacy in the extremities where the dermis and adipose tissue overlying the target tissue is thin and penetration of the medicine to the target tissue is possible, which does not describe the spine.

Recommendation: Iontophoresis for Treatment of Low Back Pain
There is no recommendation for or against iontophoresis for treatment of acute, subacute, or chronic low back pain or radicular pain syndromes or other back-related conditions.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendation
Iontophoresis is not shown to be efficacious for the treatment of acute, subacute, or chronic LBP or radicular pain syndromes or other back-related problems. It is not invasive and is not low cost. There are other interventions shown to be efficacious.

Evidence for Use of Iontophoresis
There are no quality studies evaluating the use of iontophoresis for the treatment of LBP.

We searched PubMed, EBSCO, Google Scholar, Cochrane review with no limits on publication dates. We used following search terms chronic low back pain radicular pain syndromes (including 'sciatica') spinal stenosis, sacroiliitis, spondylolisthesis to find 54 articles. Of 54 articles, we reviewed zero articles and included zero articles.

Allied Health Therapies

MASSAGE

Massage is a commonly used treatment for LBP.(801, 804, 1276-1283) Massage is theorized to aid muscle and mental relaxation which could hypothetically result in increased pain tolerance through endorphin release.(1284-1286) Other theories are that massage may enhance local blood flow that could increase clearance of chemical pain mediators or stimulate large diameter nerve fibers that have an inhibitory input on T-cells in the spinal cord, resulting in decreased pain.(1284, 1287, 1288)

1. *Recommendation: Massage for Select Subacute or Chronic Low Back Pain*
   Massage is recommended for select use in subacute or chronic low back pain as an adjunct to more efficacious treatments consisting primarily of a graded aerobic and strengthening exercise program.

   Indication – For time-limited use in subacute and chronic LBP patients without underlying serious pathology such as fracture, tumor, osteoporosis, or infection as an adjunct to a conditioning program that has both graded aerobic exercise and strengthening exercises. Massage is recommended to assist in increasing the patient's functional activity levels and comfort more rapidly although the primary treatment focus should remain on the conditioning program. In patients not involved in a conditioning program or who are non-compliant with graded increases in activity levels, this intervention is not recommended.

   Frequency/Duration – Six to 10 sessions of 30 to 35 minutes each, 1 or 2 times a week for 4 to 10 weeks. Objective improvements should be shown approximately half way through the regimen to continue this treatment course.

   Indications for Discontinuation – Resolution, intolerance, lack of benefit, or non-compliance with aerobic and strengthening exercises.
   Benefits – Modest reduction in pain.
   Harms – Short term discomfort during massage, and potentially longer term afterwards with more vigorous massage.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Massage for Treatment of Acute Low Back Pain or Chronic Radicular Pain Syndromes*

   Massage is recommended for select use in acute low back pain or chronic radicular pain syndromes in which low back pain is a substantial symptom component.

   Indications – Patients with acute LBP or chronic radicular pain syndromes. For acute LBP, patients should have already had NSAIDs/acetaminophen, aerobic exercise, directional exercises, cold/heat instituted with insufficient results as they typically resolve acute LBP. Massage is recommended as an adjunct to more efficacious treatments to assist in increasing functional activity levels more rapidly although it is recommended that the primary treatment focus remain on the conditioning program. In patients not involved in a conditioning program or who are non-compliant with graded increases in activity levels, this intervention is not recommended.

   Frequency/Duration – Objective benefit (functional improvement along with symptom reduction and opioid reduction) should be demonstrated after a trial of 5 sessions in order for further treatment to continue, for up to 10 visits during which a transition to a conditioning program is accomplished.

   Indications for Discontinuation – Resolution, intolerance, or lack of benefit.

   Benefits – Modest reduction in pain

Harms – Short term discomfort during massage, and potentially longer term afterwards with more vigorous massage.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

3. *Recommendation: Mechanical Devices for Administering Massage*
Mechanical devices for administering massage are not recommended.(1289, 1290)
Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendations
Massage is a commonly used treatment for LBP. Relatively few higher quality trials of massage have been reported, varying massage methods have been used, methods and patient populations differed substantially between trials, and long-term followup is largely lacking in most trials(1291) resulting in heterogeneous results. Many trials have utilized massage as a control treatment for other interventions.(1258) Trials suggest modest benefits.

Two studies used mechanical massage devices – one was negative,(1289) and the other showed no differences with modest overall reductions in pain similar to two other interventions demonstrating that mechanical massage devices have not been shown to be beneficial.(1290)

The two highest quality studies involving manual massage techniques suggest benefits of massage compared to other modalities for treatment of subacute and chronic LBP.(1292, 1293) Higher quality studies utilized massage therapists to administer the treatments, suggesting that the experience of the massage provider and quality of the massage may be important factors.

Massage is not invasive, has low risk of adverse effects aside from short-term pain, (1292) and is moderately costly in aggregate. It is recommended for treatment of subacute and chronic LBP, but only as an adjunct to a conditioning program. It is also recommended for select use in acute LBP or radicular pain syndromes. Mechanical devices are not recommended.(1289, 1290)

Evidence for the Use of Massage
There are 14 moderate-quality RCTs incorporated into this analysis.(555, 645, 866, 1258, 1289, 1290, 1292-1299) There are 5 low-quality RCTs in Appendix 1.(1282, 1300-1303)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: massage, subacute low back pain, low back pain, radicular low back pain, massage, clinical trial, randomized controlled trial, random, systematic review, review, population study, epidemiological study, and prospective cohort to find 11,944 articles. Of those 11,944 articles, we reviewed 26 articles and included 25 articles (18 RCTs and 7 reviews). We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: Mechanical devices for administering massage subacute low back pain, chronic low back pain, radicular pain syndromes, and sciatica to find 2,084 articles. Of the 2,084 articles, we reviewed zero articles and included zero articles.

Author/Title Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cherkin 2001 RCT Study supported by grants from Group Health Cooperative, The Group Health Foundation, Seattle, WA, and John E. Fetzer Institute, Kalamazoo, MI, and grant HS09351 from Agency for Healthcare Research and Quality. No mention of COI.	7.0	N = 262 with subacute and chronic LBP	Traditional Chinese acupuncture (n = 94) vs. massage (n = 78) vs. self-care education (n = 90) for 10 weeks. Follow-up at 4, 10 and 52 weeks.	At 10 weeks, massage superior to self-care on symptom scale, (3.41 vs. 4.71; p = 0.01) and disability scale (5.89 vs. 8.25; p = 0.01). Massage superior to acupuncture on disability scale (3.08 vs. 4.74; p = 0.002). After 1 year, massage not superior to self-care but superior to acupuncture on symptom scale (3.08 vs. 4.74, p = 0.002), dysfunction scale (6.29 vs. 8.21, p = 0.05).	"Traditional Chinese Medical acupuncture was relatively ineffective. Massage might be an effective alternative to conventional medical care for persistent back pain."	Lack of control group limits conclusions. Study results suggest all groups improved, with additional benefit in therapeutic massage group compared with acupuncture. However, outcome is of uncertain clinical significance. Massage not well described.
Preyde 2000 RCT No mention of COI or industry sponsorship.	7.0	N = 107 with subacute LBP or LBP	Comprehensive massage therapy (n = 25) vs. soft-tissue manipulation only (n = 25) vs. remedial exercise with posture education only (n = 22) vs. placebo-sham laser therapy (n = 26) 6 treatments in 1 month.	At treatment end, comprehensive massage had more improvement in function and pain than remedial exercise and sham laser, more improvement in pain than soft-tissue manipulation, better anxiety scores than sham laser. Post-treatment RDQ score (comprehensive massage/soft tissue/remedial exercise and posture education/placebo): 2.36±2.8/3.44±2.8/6.82±5.6/6.85±3.5, p <0.001. PPI score: 0.44±0.6/1.04±0.7/ 1.64±0.8/1.65±0.8.	"Patients with subacute low-back pain were shown to benefit from massage therapy, as regulated by the College of Massage Therapists of Ontario and delivered by experienced massage therapists."	Author states study of "subacute" LBP, but inclusion criteria included pain of 2 weeks to 8 months, with the average > 12 weeks, making this a mixed result more applicable to chronic pain. Data suggest massage therapy and soft tissue mobilization may provide benefit post treatment and may have effect for 1 month. Longer duration of effect not studied.
Cherkin 2011 RCT Study funded by grant from National Center for Complementary and Alternative Medicine. Link to disclosure information not able to be accessed (June 2014).	7.0	N = 401 with diagnoses indicative of non-specific back pain of at least≥3 months without 2 or more pain-free weeks and pain bothersomeness rated at least 3 on scale of 0 to 10	Relaxation massage (RM) (n = 136), 10 weekly treatments aimed at relaxation. Treatment comprised of effleurage, petrissage, circular friction, vibration, rocking, jostling, and holding for time limits at each body region including 7-20 minutes on back or buttocks vs. Focused Structural Massage (FSM) (n = 132), 10 massages intended to	Roland Disability Questionnaire, structural massage, relaxation massage, and usual care groups means and CI. 10 Weeks: (6.5 (5.80-7.2) 6.0 (5.3-6.8) 9.0 (8.2-9.8); p <0.001)). 26 Weeks: 6.7(6.0-7.5) 6.4 (5.5-7.2) 8.2 (7.3-9.0); p = 0.007). 52 weeks: 7.2 (6.4-7.9) 6.0 (5.2-6.9) 7.4 (6.6-8.3); p = 0.049. Symptom Bothersomeness Score structural massage, relaxation massage, and usual care groups	"[M]assage therapy may be effective for treatment of chronic back pain, with benefits lasting at least 6 months. No clinically meaningful difference between relaxation and structural massage was observed in terms of relieving disability or symptoms."	Does not give details about treatments used by usual care. More pain below knee in usual care and more unemployed in relaxation groups. Usual care group likely in/attention and more-of-the-same biases in favor of intervention. Allowed semi-structured exercises. Data suggest equal (in)efficacy of massage types.

			identify and alleviate musculoskeletal contributors to LBP. Interventions included therapeutic massage, myofascial and neuromuscular techniques. Both massage protocols 10x 50-60 minutes visits over 10 weeks. Therapists could recommend home exercise consisting of psoas stretch to enhance and prolong any benefits of structural massage. Continued Usual Care, (n = 133). Follow-up at 10, 26, and 52 weeks.	means and CI. 10 weeks: 3.8 (3.5-4.2) 3.5 (3.2-3.9) 5.2 (4.8-5.6); p< 0.001. 26 Weeks: 4.2 (3.9-4.5) 4.3 (3.9-4.7) 4.6 (4.2-5.0); p=.31. 52 Weeks: 4.6 (4.2-5.0) 3.9 (3.5-4.3) 4.2 (3.8- 4.6); p= .097. Difference between groups and CI. Structural Massage vs. Relaxation Massage. 10 weeks: .5 (-0.5 - 1.5) 26 weeks: .04 (-0.8-1.5) 52 weeks: 1.1 (0.02-2.2)		
Chatchawan 2005 RCT Study supported by study grant from Office of the Higher Education Commission, Ministry of Education, Thailand. No mention of COI.	7.0	N = 180 recruited through flyer posted around city of Khon Kaen with sub-acute (4-12 weeks) or chronic (lasting over 12 weeks) back pain associated with myofascial trigger points (MTrPs)	Traditional Thai Massage (TTM) with applied theory of 10 Sens. First line of massage starting point 2cm above posterior superior iliac spin (PSIS), ending at thoraco-cervical junction. Pressing technique utilized and pressure applied until patient feels pain then pressure maintained 5-10 seconds (n = 90) vs. Swedish Massage (SM) using body-oil and pressure applied on back between PSIS and C7. Pain not induced with procedure and techniques included: stroking, effleurage, petrissage (n = 90).	VAS, mean (SD), Baseline and 1 month follow-up: TTM: 5.5 (1.5) to 2.4 (1.9) p <0.05. SM: 5.2 (1.7) to 2.5 (1.7) p <0.05. Difference between groups at baseline adjusted mean: TTM: 4.0 SM: 3.6 CI (difference): .04 p = 0.05. 3 weeks: TTM: 2.2 SM: 2.0 CI (difference): .2 p = 0.56. 1 month: TTM: 2.4 SM 2.6 CI (difference) -.2 p = 0.51.	"[W]e therefore suggest that massage therapy, and in particular Thai massage, be considered as an alternative primary health care treatment for this disorder."	Short follow-up only. Active control. Data suggest equal (in)efficacy.
Giles 2003 RCT Study supported by Queensland State Government Health Department and partly by Townsville Hospital. No COI.	6.5	N = 115 with mostly chronic LBP or neck pain	Post-randomization individualized treatment in all three arms: acupuncture (near and far technique), (n = 36); manipulation; high velocity, low amplitude thrust spinal manipulation to a joint 2 times a week, (n = 36) and medication (63% celecoxib, 26% rofecoxib and 11% paracetamol;	Manipulation with best overall results with improvements of 50% (p = 0.01) on ODI, 38% (p = 0.08) on NDI, 47% (p <0.001) on the SF-36, and 50% (p <0.01) on VAS for back pain, 38% (p <0.001) for lumbar standing flexion, 20% (p <0.001) for lumbar sitting flexion, 25% (p = 0.1) for cervical sitting flexion, and 18% (p = 0.02) for cervical sitting	"In summary, the significance of the study is that for chronic spinal pain syndromes, it appears that spinal manipulation provided the best overall short-term results, despite the fact that the spinal manipulation group had experienced the longest pretreatment duration of pain."	Individualization of treatments results in lack of standardization and substantially precludes drawing robust conclusions. Post-randomized individualized treatment in all three arms. Ill-defined mixture of diagnoses, combined with non-randomization

			apparently unblinded), (n = 43) for 9 weeks.	extension. Acupuncture better results than manipulation on VAS neck pain (50% and 42%). Asymptomatic status: manipulation (9 patients) vs. acupuncture (3) vs. medication (2 patients), p = 0.05. Manipulation greater results for all main outcomes except NDI.		arguably relegates study to a non-RCT.
Manniche 1988 RCT Study supported by grants from Danish Research Council and Danish Health Foundation. No mention of COI.	6.5	N = 105 with chronic LBP median 15 years duration	Group A: hot compresses, massage and isometric lumbar exercises vs. Group C: intensive back strengthening group vs. Group B: placebo.	Pain scores (disability scores) reduced in Group A from median 11.7 (disability score 10.2) to 9.2 (8.5) after treatment to 11.5 (7.8) at follow-up. Group B median pain scores were 14.0 (11.4) to 10.3 (8.8) to 11.1 (8.3). Group C scores: 13.3 (10.3) to 5.7 (9.0) to 5.0 (5.9).	"The results consistently favored intensive exercise, which had no adverse effects."	Authors felt differences in treatment length may have influenced results. At 1-year, those who continued to exercise were significantly better. Data support intensive strengthening exercise.
Kalauokalani 2001 RCT Study supported by grants from Group Health Cooperative of Puget Sound, Group Health Foundation, Agency for Health Care Policy and Research, and John E. Fetzer Institute and Robert Wood Johnson Clinical Scholars Program. COI category: 12.	6.0	N = 177 with chronic LBP	Acupuncture (Chinese medical body needling) vs. Massage (Swedish technique) vs. sham laser acupuncture, 10 treatments for 10 weeks. (Number of patients per group not clearly stated.)	Mean±SD change from baseline Roland score all patients: -5.3±5.3. Higher baseline expectations for benefit for treatment received: -6.8±5.9. Lower baseline expectations -4.9±4.3; p = 0.00.	"[P]atient expectations may influence clinical outcome independently of the treatment itself. In contrast, general optimism about treatment, divorced from a specific treatment, is not strongly associated with outcome."	Study suggests patient expectations regarding treatment play an important role in outcomes.
Gam 1998 RCT Kebo Care A/S, Denmark provided apparatus and sound-head and technical control of apparatus. No mention of COI or industry sponsorship.	6.0	N = 67 with MTrP in neck and shoulder (at least 3 months duration)	Ultrasound plus exercise plus massage applied to 5 most tender trigger points; exercises were handouts for at home program focused on strength and mobility of neck and shoulders (Group A, n = 18) vs. sham ultrasound plus exercise plus massage (Group B, n = 22) vs. control group (Group C, n = 18) for 6 weeks.	No significant differences found in analgesic usage and VAS scores at rest and on function between groups.	"[M]assage and exercise reduces the number of intensity of MTrP, but this reduction had little impact on the patients' neck and shoulder complaints."	Compliance with exercise 68% at 6 months. Control group's worse ratings week after randomization and treatment initiation, and higher medication use suggest bias problem from using wait-listing controls. Baseline differences considerable, controls had longer symptom duration (12 vs. 7.5 months for placebo ultrasound vs. 4 months active ultrasound).

						Massage in first 2 groups co-intervention and limits conclusions.
Browder 2007 RCT Study funded by research grant from the Foundation for Physical Therapy. No mention of COI.	6.0	N = 48 with primary complaint of LBP already receiving PT. Six month follow up.	Extension-oriented treatment approach (EOTA, n = 26) vs. strengthening group (n = 22). Both groups attended PT 2x week for first 2 weeks, then 1x a week next 2 weeks.	1 week/4 week/6 month change (95% CI) for Oswestry LBP disability questionnaire for strengthening group vs. EOTA group: 4.2 (-0.70 to 11.1)/5.8 (-3.5 to 15.2)/8.2 (-1.7 to 18.0) vs. 13.1 (6.9 to 19.4)/20.2 (11.6 to 28.8)/22.7 (13.7 to 31.7); for numeric pain rating scale: 0.30 (-0.70 to 1.3)/1.0 (-0.30 to 2.3)/1.4 (-0.10 to 2.9) vs. 1.7 (0.80 to 2.7)/2.3 (1.0 to 3.6)/2.5 (1.1 to 3.9).	"In a subgroup of subjects identified a priori as expecting to benefit from an EOTA, subjects who received an EOTA experienced significantly greater improvements in disability than subjects who received an alternative trunk strengthening program that also has evidence for its effectiveness in a different subgroup of patients. No differences were found between the groups for reductions in pain beyond 1 week."	Study to test extension exercise approach for select patients. No compliance data. Baseline differences present of surgical vs. non-surgical histories. Study conducted in higher select population (centralization of pain distal to buttocks). Data suggest extension exercise approach modestly superior for patients whose pain centralizes with those exercises.
Little 2008 Factorial RCT Study funded by grant from Medical Research Council. No COI.	5.5	N = 579 with chronic or recurrent LBP. Patients with sciatica excluded.	Normal care or control (n = 144) vs. massage (n = 147) vs. 6 Alexander technique lessons (n = 144) vs. 24 Alexander technique lessons (n = 144). Exercise factor: control (n = 293) vs. exercise (n = 286). Follow-up at baseline, 3 months, and 1 year.	At 3 months and 1 year; 24 lessons in Alexander technique greater at 1 year vs. 3 months with 42% reduction in Roland disability score and 86% reduction in days in pain vs. control group. Six lessons maintained at 17% reduction in disability score but not days in pain. Six lessons combined with exercise on disability score and most other factors almost as good as 24 lessons. No adverse events reported for exercise or Alexander technique.	"One to one lessons in the Alexander technique from registered teachers have long term benefits for patients with chronic low back pain. Six lessons followed by exercise prescription were nearly as effective as 24 lessons."	Low compliance. Usual care and wait listed control bias. Exercise and massage intervention not well described which limits conclusions.
Werners 1999 RCT No mention of COI or industry sponsorship.	5.0	N = 152 with mostly chronic LBP	Traction and mechanical massage (n = 73) vs. interferential therapy for 6 sessions over 2-3 week period (n = 74).	No significant differences between groups for ODI questionnaire and VAS scores throughout study.	"This study shows a progressive fall in Oswestry Disability Index and pain visual analog scale scores in patients with low back pain treated with either interferential therapy or motorized lumbar traction and massage."	Entry criteria unclear. Most experienced years of back pain, although unclear if new episode. Data suggest no treatment differences. No conclusion about effectiveness as no control group.

Buselli 2011 Double-blind RCT Study associated with Engineering Department of Themesys Srl, company that designed and manufactured SMATH® system. Authors declare no competing interests.	4.5	N = 72, with non-specific, sub-acute, and chronic LBP, age 18-70	SMATH system (medical device that combines basic principles of mechanical massage, thermotherapy, acupressure, infrared therapy, and moxibustion) (n = 36) vs. sham therapy (medical device without active principles) (n = 36).	RMDQ average score of 10.96 (sd = 3.04; p <0.05) at baseline and 3.21 (sd = 2.99; p <0.05); at 3 months, and average quality adjusted life year (QALY) was 0.46 (sd = 0.13; p <0.05) at baseline and 0.81 (sd = 0.12; p <0.05) after 3 months.	"These data have not been published because they were not suitable for publication and represented the results obtained by one clinical study in which the primary outcome was the demonstration of clinical safety."	Only a study protocol, no results.
Melzack 1983 RCT Study supported by Natural Sciences and Engineering Research Council of Canada. No mention of COI.	4.5	N = 41 with acute or chronic LBP	TENS (n = 20) vs. massage (n = 21) twice a week for 30 minutes for total of 10 treatments.	Mean percentage decreases in Pain Rating Index for TENS 69.5 vs. massage 37.2, p = 0.01; for decrease in present pain intensity 80.8 vs. 40.9, p = 0.001; for change in back flexion -2.5 vs. -4.7, p=NS; for change in straight left leg raising -9.6 vs. +3.4, p = 0.02; for change in straight right leg raising -16.1 vs. +1.7, p = 0.03.	"The results show clearly that TENS is an effective modality for the treatment of low back pain. Because of the double-blind, randomized design of the study, the significant effectiveness of TENS cannot be attributed to other factors such as placebo efficiency or other psychological effects. The significant correlations between pain-relief scores and range-of-motion scores highlight the usefulness of pain evaluation. The [present pain intensity] score of the [McGill pain questionnaire] can be obtained in less than a minute and provides valuable information about subjective pain relief that can complement range-of-motion scores."	Gentle massage used could conceivably be viewed as a placebo control procedure for evaluating effectiveness of TENS.
Hsieh 1992 RCT Study supported by grant from Foundation for Chiropractic Education and Research and National Institute of Disability and Rehabilitation Research. No mention of COI.	4.0	N = 85 with subacute and chronic LBP	Manipulation 3x week plus hot pack to low back 10 minutes (n = 26) vs. massage 3x week, no deep soft tissue manipulation and hot pack (n = 15) vs. corset 8 hours a day (n = 12) vs. 3 weeks transcutaneous muscle stimulation (n = 10).	Both ROLBPQ and RMAS showed good internal consistency with alpha co-efficients ranging from 0.77 to 0.93. Both instruments showed a significant difference between the chiropractic manipulation and massage groups (p <0.05).	"[B]oth ROLBPQ and RMAS are reliable instruments for assessing low back pain disability. We support the use of RMAS in the subacute nonspecific low back pain population because it is more sensitive to detect changes than ROLBPQ."	Massage not well described. Data suggest massage inferior.

REFLEXOLOGY

Reflexology is a treatment that focuses on massage of reflex points which are believed to be linked to physiological responses and healing of other tissues including those in the back.(1304)

1. *Recommendation: Reflexology for Treatment of Chronic Low Back Pain*
   Reflexology is not recommended for treatment of chronic low back pain.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

2. *Recommendation: Reflexology for Treatment of Acute, Subacute, Radicular, Post-operative Low Back Pain or Other Low Back Conditions*
   Reflexology is not recommended for treatment of acute or subacute low back pain or other low back conditions.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations

Reflexology has not been shown to be clearly efficacious for the treatment of chronic LBP in either of two moderate-quality studies.(1305, 1306) There is no evidence of efficacy for the use of reflexology for other LBP conditions. Other treatments have been shown to be efficacious.

Evidence for the Use of Reflexology

There are 2 moderate-quality RCTs incorporated into this analysis.(1305, 1306) There is 1 low-quality RCT in Appendix 1.(1307)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with limits on publication dates from 2011-2012. We used the following terms: reflexology, subacute low back pain, chronic low back pain, radicular pain syndromes (including 'sciatica'), Spinal stenosis, spinal fractures, and spondylolisthesis to find 116 articles. Of the 116 articles we reviewed 3 articles and included 3 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Quinn 2008 RCT No mention of COI or industry sponsorship.	5.5	N = 15 with non-specific LBP and naïve to reflexology	Reflexology: pressure massage on specific reflex points in feet associated with organs throughout and points representative of vertebrae of spine and surrounding musculature (n = 7) vs. sham reflexology: foot massage with vertebrae of spine and surrounding musculature points avoided (n = 8). Both 40-minute treatments weekly for 6 weeks. Follow up 6, 12, 18 weeks.	VAS score: baseline, weeks 6, 12, 18: reflexology 4.7, 3.1, 2.1, 2.2 vs. sham 3.4, 3.9, 4.1, 3.2. Roland-Morris: 5, 6, 4, 4 vs. 7.5/5/4.5/3.5. McGill pain: 24/12/11/6 vs. 19/11.5/6.5/7.5.	"Reflexology appears to offer promise as a treatment in the management of LBP; however, an adequately powered trial is required before any more definitive pronouncements are possible."	Pilot study. Small sample size. Baseline difference with lower VAS in sham. No clear benefits.
Poole 2007 RCT No mention of COI or industry sponsorship.	5.0	N = 243 with chronic LBP	Reflexology 6 1-hour treatments over 6-8 weeks (n = 77) vs. relaxation therapy 6 1-hour treatments over 6 weeks (n = 82) vs. no treatment (n = 75).	No differences in treatment groups at any point during or after treatment.	"[T]he current study does not indicate that adding reflexology to usual GP care for the management of CLBP is any more effective than usual GP care."	Use of no-treatment arm potentially biased study design. While suggesting reflexology is not effective, study unable to address utility of GP care.

CHIROPRACTIC CARE

There are RCTs of "chiropractic care" which are reviewed here for completeness. Because of the broad realm of chiropractic care, including different manipulation techniques,(1340) the lack of structuring of treatment arms within these particular trials of chiropractic care, inclusions of multiple co-interventions, and questions about the adequacy of control group treatments, no strong conclusions can be drawn from this particular body of evidence with respect to the value of individual modalities or even comparisons between generic programs. Sound conclusions cannot be drawn from these RCTs of multiple modalities. (See individual treatment modalities to ascertain the available evidence on specific treatment interventions.)

Evidence for the Use of Chiropractic Care

There are 11 moderate-quality RCTs incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: chiropractic care, chiropractor, and low back pain to find articles. Of the articles we reviewed, 9 articles and all were included.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Cherkin 1998 RCT No mention of COI or industry sponsorship.	7.0	N = 323 who saw primary care physician and still had LBP 7 days later	McKenzie approach physical therapy (9 sessions, n = 133) vs. chiropractic manipulation (short-lever, high-velocity thrust/9 sessions, n = 122) vs. educational booklet (n = 66) for 4 weeks. Final follow-up at 2 years.	Booklet (n = 65) vs. chiropractic (n = 119) vs. PT (n = 129) bothersome of symptoms mean (95% CI), and Roland disability mean (95% CI) measured at baseline: 5.3 (4.9-5.7)/5.5 (5.1-5.8)/6.0 (5.6-6.5)/p unadjusted = 0.04, 11.7 (10.4-13.0)/12.1 (11.2-13.1)/12.2 (11.2-13.1)/p unadjusted = 0.83. Booklet (n = 63) vs. chiropractic (n = 118) vs. PT (n = 117) 12 weeks: 3.2 (2.4-4.0)/2.0 (1.6-2.4)/2.7 (2.2-3.2)/p unadjusted = 0.02/p adjusted = 0.06, 4.3 (3.1-5.5)/3.1 (2.4-3.9)/4.1(3.2-5.0)/p unadjusted = 0.15/p adjusted = 0.28.	"[T]he McKenzie method of physical therapy and chiropractic manipulation had similar effects and costs, and patients receiving these treatments had only marginally better outcomes than those receiving the minimal intervention of an educational booklet."	Considerable exercise in chiropractic group, thus assessment of manipulation value not possible. Data suggest PT and manipulation/exercise superior to booklet, but magnitudes of benefits modest. Baseline differences with less pain in chiropractic group. No significant differences in outcomes other than costs reported between chiropractic cone booklet, and McKenzie exercise protocol.
Blomberg 1992 RCT Study supported by grants from Kopparberg County Council, National Health Insurance Company, The Save Our Backs Association, and The Swedish Association for Orthopaedic Medicine. No mention of COI.	7.0	N = 101 with acute and subacute LBP thought to have herniated disc, but not surgical candidates	Standard care: medication, LBP school, back exercises, corsets, taping, short wave, ultrasonic wave, TENS, TEMS, heat, cold, postural exercises, plunge-bath training, massage (n = 53) vs. complex manual treatments: Swedish manual therapy; thrust techniques or specific mobilization, muscle stretching, taught muscle stretching exercises, auto-traction, steroid injections (n = 48).	After 8 months, sick leave proportion 2.3 times larger in conventional group vs. treated group, p = 0.015.	"In the early phase as well as at the 90 days follow-up, the group receiving manual therapy had significantly less pain, less disability, a faster rate of recovery, and lower drug consumption, indicating that this type of treatment is superior to conventional treatment."	Due to study design, not possible to determine role of injections, needling, manipulation, mobilization, and traction on outcomes.
Skargren 1997 RCT Supported by County Council of Ostergotland and Federation of County Councils. No mention of COI.	6.0	N = 411 with acute, subacute, and chronic back or neck problems	Chiropractic management (n = 219) vs. physiotherapy management (n = 192). Treatments at discretion of chiropractor or physiotherapist.	Baseline Oswestry scores DC: 35±17 vs. PT: 37±16. After treatment, these modestly favored DC [-1.49, (-5.51 to 2.54)] and after 6 months modestly favored PT [0.36, (-4.01-4.76)]. Pain intensity scores same pattern. 12-month follow-up data showed same pattern of non-statistically significant findings favoring	"The effectiveness and total costs of chiropractic or physiotherapy as primary treatment were similar to reach the same result after treatment and after 6 months."	Individualization and use of multiple treatments substantially weakens or eliminates ability to draw conclusions regarding utility of manipulation. Baseline data dissimilar and somewhat favor chiropractic treatment group. Five poor prognostic factors at baseline identified – duration of current

				physiotherapy over chiropractic adjustment (Skargren 98).		episode, Oswestry score at baseline, expectations of treatment, number of localizations, and well-being.
Parkin-Smith 2012 RCT No mention of COI or industry sponsorship.	6.0	N = 118 with acute non-specific LBP with pain score of 35/100 on VAS	Usual care (n=53) treatments chosen by chiropractor vs. conservative care (n=49) that included patient advice and education, spinal manipulation, soft tissue work.	Both groups had significant improvements in disability and VAS scores from baseline to week 2 ($p < 0.001$). At week 4, chiropractor group had significantly improved VAS scores ($p < 0.001$). Both groups improved from week 2 to week 4 in disability scores.	"… [T]he 2 treatment groups were similar based on primary or secondary outcome measure scores for the full treatment period (4 weeks, with up to 7 treatments). However, there were statistically significant and clinically meaningful differences in both disability and pain scores at week 2 (midpoint) with 4 treatments, suggesting that the protocol of care had a more rapid effect than usual care."	Both groups manipulated.
Doran 1975 RCT No mention of COI or industry sponsorship.	5.0	N = 456 with acute, subacute, or chronic LBP	Manipulation (individualized, 2 times a week) (n = 98) vs. physiotherapy (individualized 2 times a week) (n = 104) vs. corset (not standardized) (n = 93) vs. paracetamol 2 tablets every 4 hours (n = 100) for 3 weeks.	Percent of patients reporting improvement or complete relief, respectively, 74%, 65%, 83%, and 76%. Never any important differences among the 4 groups.	"[N]one of the methods of treating low back pain compared in this trial showed any great superiority. Patients treated with analgesics alone fared marginally worse than those on the other three treatments."	Study not well described. Study included many interventions that were not well standardized.
Koes 1992 RCT Supported by grants from Dutch Ministry of Welfare, Health and Cultural Affairs and Dutch National Health Insurance Council. No mention of COI.	5.0	N = 256 with subacute and chronic LBP (≥6 weeks duration); herniated discs excluded	Manual therapy, n = 65 (manipulation and mobilization, Dutch Society for Manual Therapy) vs. physiotherapy, n = 66 (exercises, massage, heat, electrotherapy, ultrasound, diathermy) vs. placebo therapy, n = 64 (physical exam, placebo ultrasound, placebo diathermy) vs. general practice, n = 61 (analgesics, NSAIDs, posture advice, home exercises, participation in sports, bedrest, etc.) for 3 months.	Manipulative group showed better results in physical functioning compared to physiotherapy group at 12 month follow-up, 0.9 (95% CI 0.1-1.7). Manipulative group had largest improvement at 12 month follow-up (4.5 SD 2.2).	"Manipulative therapy and physiotherapy are better than general practitioner and placebo treatment. Furthermore, manipulative therapy is slightly better than physiotherapy after 12 months."	Value of this type of trial diminished today when therapies may have been heavily relied upon that have been subsequently shown to be ineffective. The heterogeneous nature of these largely unstructured interventions prevents strong conclusions regarding efficacy of any given intervention, including manipulation compared with other treatments.

Brealey 2003 RCT No mention of COI or industry sponsorship.	5.0	N = 1,287 with subacute and chronic LBP in UK (at least 4 weeks duration)	Best care alone (n = 326): trained practice teams and provided *The Back Book* for patients vs. best care plus exercise classes (n = 297): exercise program 9 classes in community settings vs. best care plus spinal manipulation (n = 342): spinal manipulation 8 sessions vs. best care plus manipulation then exercise (n = 322) for maximum 8 sessions over 12 weeks, 6 weeks of each for those in manipulation and exercise group.	Exercise group had significant improvements in other disability ratings and back beliefs questionnaire. Spinal manipulation group had improvements in Roland-Morris, back beliefs questionnaire, and SF-36 physical. Manipulation plus exercise had more improvements. Difference in mean quality adjusted life year relative to best care: best care plus exercise 0.017 (-0.017 to 0.051); best care plus manipulation 0.041 (0.016 to 0.066); best care plus manipulation and exercise 0.033 (-0.001 to 0.067).	"Spinal manipulation is a cost effective addition to 'best care' for back pain general practice. Manipulation alone probably gives better value for money than manipulation followed by exercise."	Heterogeneous mix of interventions prevents strong conclusions.
UK BEAM Trial Team 2004 Study funded by Medical Research Council (MRC), NHS in England, Northern Ireland, Scotland, Wales. COI: LL, JM, MU, MV, KW received salaries from MRC; MU received speaking fees from Menarini Pharmaceuticals and Pfizer.	5.0	See Brealey 2003				
Meade 1990 RCT Supported by Medical Research Council, National Back Pain Association, European Chiropractors Union, and King Edward's Hospital Fund for London. No mention of COI.	5.0	N = 741 with acute, subacute, and chronic LBP in UK (59 to 60% had current episode >1 month)	Chiropractic (n = 357) for maximum of 10 treatments within 3 months but could be spread over a year vs. outpatient treatment (n = 384). Patients were followed up for 2 years.	44% more chiropractic appointments than hospital treatments. At 6 weeks, patients treated by chiropractor more satisfied (91% vs. 81%), Oswestry scores lower. Oswestry score differences (6 weeks/6 months/1 year/2 years): hospital treatment vs. chiropractic (1.69, NS/3.31, p ≤0.05/2.09, NS/7.16, p ≤0.01.	"For patients with low back pain in whom manipulation is not contraindicated chiropractic almost certainly confers worthwhile, long term benefit in comparison with hospital outpatient management."	Adequacy of treatment in control group seems questionable. The 3-year follow-up data are somewhat similar, though showing "smaller benefits."
Wright 2005 RCT	5.0	N = 111 with new	Group 1 given *The Back Book* designed to change beliefs about behavior in	Median number of days to return to work 20 for Group 1 vs. 13 for Group 2 (p = 0.034). On	"[T]he study demonstrated that an intervention including	Missing the number/ information of participants who received each

Federal/institutional funds received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.		episode of back and off work or on light duties ("new" defined as onset within past 12 months)	relation to back pain, and verbal advice, also received advice on how to modify physical activities specific to individuals work situation while maintaining current care (n = 37) vs. Group 2 received *The Back Book* plus treatment depending on senior physiotherapist assessment (n = 43). Treatment offered; manipulate/joint/ soft tissue mobility/steroid injection/ specific exercise. Subsequently patients attended group exercise sessions for 1 hour 3 times a week in gym. Exercise comprised of circuit stations, aerobic exercise and focus on proprioception, spinal ability, and strengthening exercises. Patients scheduled to attend 3 times a week for 2 weeks.	average, Group 2 patients return to work 7 days earlier than Group 1. Those who had achieved a change in their work status: 50% in Group 1 vs. 72% in Group 2.	information, advice, and simple back program that offered manipulation, steroid injection, and group exercise therapy resulted in a speediest return to work than intervention than proved information, advice, and the normal route of care as directed by the general practitioner."	specialized treatment. High dropout rate.
Pope 1994 RCT See Hsieh 1992 Study supported by Foundation for Chiropractic Research and Education. No mention of COI.	4.0	N = 85 with subacute and chronic LBP 3 weeks to 6 months duration	Manipulation 3 times a week and hot pack to low back for 10 minutes (n = 26) vs. massage 3 times a week, no deep soft tissue manipulation and hot pack (n = 15) vs. corset worn 8 hours a day (n = 12) vs. transcutaneous muscle stimulation (TMS, n = 10) for 3 weeks.	Both ROLBPQ and RMAS showed good internal consistency with alpha co-efficients ranging from 0.77 to 0.93. Both instruments showed a significant difference between chiropractic manipulation and massage groups ($p < 0.05$).	"[B]oth ROLBPQ and RMAS are reliable instruments for assessing low back pain disability. We support the use of RMAS in the subacute nonspecific low back pain population because it is more sensitive to detect changes than ROLBPQ."	Heterogeneous mixture of interventions.

MYOFASCIAL RELEASE

Myofascial release is a manual soft tissue technique to attempt to stretch and apply traction on target tissue(s). It is most commonly used in the periscapular area to treat non-specific muscle soreness.

Recommendation: Myofascial Release for Treatment of Low Back Pain

There is no recommendation for or against the use of myofascial release for treatment of acute, subacute, chronic, post-operative low back pain, radicular pain syndromes or other back-related conditions.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendation
There are no placebo or sham trials. There is one comparative trial and it does not show clear efficacy.(1308) Thus, myofascial release is not shown to be efficacious for LBP, although there are other techniques to be investigated. Myofascial release is not invasive and is not low cost and there is no recommendation for or against its use. However, there are other interventions shown to be efficacious.

Evidence for Use of Myofascial Release
There is 1 moderate-quality RCT incorporated into this analysis.(1308)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates. The search terms used were "(sub-acute low back pain OR chronic low back pain OR radicular pain syndrome OR sciatica OR Spinal stenosis OR spinal fractures OR sacroiliitis OR spondylolisthesis) AND myofascial release" to find 1357 articles. Of those 1357 articles, we reviewed one and included (1 RCT and zero review).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Hsieh 2002 RCT Project supported by Human Resources and Service Administration, Public Health Service, Department of Health and Human Services (Grant 1 R18 AH10004), Foundation for Chiropractic Education and Research, Leander Health Technologies, and Lloyd Table Company.	6.5	N = 200, age ≥18 years, diagnosed with LBP duration ≥3 weeks and <6 months for current episode or pain-free period of ≥2 months in prior 8 months for recurrent LBP. Excluded those with BMI >33.	Joint manipulations, high velocity and short-amplitude specific thrusting manipulations ("Diversified" technique), to lumbar and/or sacroiliac regions. Therapy 3x a week 3 weeks (n = 49) vs. myofascial therapy: included intermittent Fluoro-Methane sprays and 5-10 stretches after 3-5 seconds of each isometric contraction at 50-70% of maximal effort, ischemic compressions using massage finger, stripping massage along taut bands orientation by 2 thumbs for 3-5 strokes, and hot packs x 10 minute at therapy completion. Group received therapy 3x a week for 3 weeks (n = 51) vs. combined group, treated with combination 3x a week for 3 weeks (n = 52) vs. back school (3 videos on spine anatomy, common LBP causes, body mechanics for daily activities, sitting and standing neutral postures, body mechanics, and home exercises (lumbar flexion, extension, stretching, and stabilization), 3 x a week for 3 weeks (n = 48).	No significant between-group differences at 3-week or 6-month reassessments, p value not reported. All groups had pain reductions and activity scores after 3 weeks, but no further significant changes at 6-months. Complications: n = 23 reported adverse treatment effects: 7 combined group, 6 joint manipulation group, 4 myofascial therapy group, and 6 back school group.	"[F]or subacute LBP, joint manipulation, myofascial therapy, and back school appeared to be as effective as combined joint manipulation and myofascial therapy for reducing pain and functional disability."	Lower compliance in back school. Data suggest equal (in)efficacy, although trend to less efficacy with myofascial.

TRACTION

Traction is the distraction of structures within the lumbar spine by application of tension along the axis of the spinal column that is most frequently used to treat radicular syndromes.(593, 1291, 1309-1317) Duration and magnitude of force is adjustable and sometimes varied. Types of traction include motorized, manual, bed rest, pulley-weight, gravitational, suspension, and inverted, with manual and motorized being most commonly used. Trials with subgroups of patients have appeared promising for a minority of patients, but full validation studies are yet to be reported.(575, 1309)

Recommendation: Traction for Treatment of Low Back Pain

Traction is not recommended for treatment of acute, subacute, or chronic low back pain or radicular pain syndromes.

Strength of Evidence – **Strongly Not Recommended, Evidence (A)** (Subacute, Chronic)
Moderately Not Recommended, Evidence (B) (Radicular)
Not Recommended, Insufficient Evidence (I) (Acute, Post-operative LBP)

Level of Confidence – Moderate

Rationale for Recommendation

There are quality studies that have evaluated the value of traction in treating LBP, although most of the literature has significant limitations. The higher quality studies appear to have successfully blinded participants in contrast with many other studies. Nearly all of the highest quality studies failed to show meaningful benefits from traction.(575, 1318-1323)

Traction has long been used to treat sciatica with a belief that this therapy produces negative intradiscal pressures that result in improved rates of disc resorption. However, this has not been borne out and more studies show a lack of efficacy (1314, 1318, 1324-1326) than show efficacy for those patients.(1323, 1327, 1328) Traction is non-invasive, does not have adverse effects, but is moderately costly. There are interventions that are effective that should be employed. Traction is not recommended for treatment of low back conditions or radicular pain syndromes.

Evidence for the Use of Traction

There is 1 high- (with 2 reports)(1318, 1320) and 19 moderate-quality(575, 704, 1067, 1266, 1290, 1313, 1321-1333) RCTs incorporated into this analysis. There are 4 low-quality RCTs in Appendix 1.(1314, 1334-1336)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: traction, subacute low back pain, chronic low back pain, and radicular pain syndromes (including sciatica) to find 6,348 articles. Of the 6,348 articles, we included 19 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Beurskens 1995 RCT No mention of COI or industry sponsorship.	10.0	N = 151 with subacute and chronic LBP, 1/3 of which radiated below knee	High-dose traction (intervention, n = 77) vs. low-dose traction (sham, n = 74) 20 minute sessions, 12 times in 5 weeks.	Global perceived effect: 34 (44%) vs. 37 (51%). Roland-Morris scores: 3.5 vs. 4.8. Work absences: 21 and 22.8 days. No significant differences between groups for any outcome measures.	"Our data do not support the claim that traction is effective for patients with low back pain."	Assessment of blinding showed that 74% and 71% of patients felt that they were given real treatment. Data suggest lack of efficacy.
Beurskens 1995 RCT	10.0	See Beurskens 1995 (Lancet) above.				
Letchuman 1993 RCT No mention of COI or industry sponsorship.	7.0	N = 30 with clinical sciatica	Intermittent traction for 6 minutes (n = 13) vs. static traction for 6 minutes (n = 13) vs. controls: 6 minutes of sham traction (each person served as own control).	No difference myoelectric activity between 2 types of traction: >50% in both groups had decreased pain after traction; 30% of static patients vs. 15.4% intermittent traction had increased pain. 53.9% vs. 61.5% decreased pain.	"[I]ntermittent traction appears to be associated less with posttraction discomfort than does static traction and likely produces intervertebral joint distraction equivalent to that of static traction."	No placebo arm. Study assessed these patients apparently on a 1-time basis after this single set of interventions, thus limits development of treatment guidance.
Fritz 2007 RCT Supported by Saunders Company, Inc.	6.5	N = 64 with LBP plus leg pain and nerve root compression signs	Extension exercises (exercise, mobilization, education to centralize pain; emphasis on increased extension ROM while not peripheralizing pain) up to 9 sessions over 6 weeks plus HEP of 3x10 reps every 4-5 hours vs. extension exercises plus mechanical traction (ActiveTrac table by Saunders Group) up to 12 sessions over 6 weeks. Follow-up at 2, 6 weeks.	ODI (baseline/2/6 weeks): extension (41.5/32.4/25.6) vs. traction/extension (46.1/30.0/28.3). Pain ratings: extension (5.3/4.1/3.0) vs. combined (5.0/3.6/3.2).	"A subgroup of patients likely to benefit from mechanical traction may exist."	More medication use (93 vs. 72%) belief in traction benefits (48 vs. 37%) and higher FABQ-work subscale (13.3 v. 10.6) are in the traction + exercise group at baseline. More treatments in traction group provides additional contact bias potential beyond study design of additive benefit. No differences at 6 weeks. Study interpreted as only 2 weeks traction but article states traction over 6 weeks. Data do not support meaningful benefits.
van der Heijden 1995 RCT	6.5	N = 25 with chronic LBP and/or sciatica	High-dose continuous lumbar traction (n = 13) vs. low-dose continuous lumbar traction (n = 12) 10-12 treatments during 4 consecutive weeks 3 times a week.	Differences at baseline (9% traction vs. 17% sham on sick leave, 18% vs. 58% white collar, 73% vs. 58% radiating pain). At 5 weeks, 64%	"[T]raction did not appear to be more effective than sham traction, both in the short term and long term."	Data suggest lack of efficacy. Small sample size, high withdrawal rates in traction group (3/14). No differences

No mention of COI or industry sponsorship.				complete or very much improved vs. 34%. Results for most outcome measures favored high-dose traction, but not significant.		between sham and active traction for chronic non-specific LBP, although likely under-powered.
Schimmel 2009 RCT Supported by grant from the Steadfast Corporation Ltd.	6.5	N = 60 with LBP more than 3 months	Intervertebral differential dynamics (IDD) therapy 20 traction sessions of approximately 25 minutes during 6 weeks in Accu-SPINA device (n = 31) vs. same procedure with sham traction weight (n = 29). Follow-up 0, 2, 6, and 14 weeks.	No significant differences between the two groups.	"[M]echanical traction of IDD therapy to a standard graded activity program has been shown not to be effective."	Success of blinding unclear. Data suggest traction of no additive benefit to graded activity.
Sweetman 1993 RCT Supported by grant from Arthritis and Rheumatism Council.	6.0	N = 400 with LBP or pain down a leg with approximately half having pain in knee or lower	Extension exercises: leg/arm raises, bridging, head and shoulder raises (n = 100) vs. diathermy 3 times a week for 20 minutes (n = 100) vs. traction: constant pull for 10 minutes (n = 100) vs. control sham diathermy (n = 100).	No significant differences between groups.	"[A] randomized trial of different forms of physiotherapy showed no obvious differences between the treatment and control groups."	Control was sham diathermy. No control for co-interventions detailed. Withdrawal of 25%. Data suggest no differences in treatment groups although conclusions limited by study weaknesses.
Mathews 1975 RCT No mention of COI or industry sponsorship.	5.0	N = 27 with sciatica for at least 3 weeks with or without back pain	Traction using force of at least 80lbs (n = 13) vs. sham traction (n = 14) 30 minutes a day, 5 days a week for 3 consecutive weeks.	Determined that more traction patients than controls improved (28.8% vs. 18.9%). No significant differences between groups.	"[A]large trial using more discriminating criteria might delineate a group of patients susceptible to help by traction."	Study details not well reported. Data suggest lack of efficacy, but trends were towards benefit.
Pal 1986 RCT No mention of COI or industry sponsorship.	5.0	N = 41 with back pain and sciatica	Continuous lumbar traction, Group A, n = 25 (5.5 to 8.2kg according to body weight) vs. continuous traction, Group B, n = 16 (1.4-1.8kg according to body weight).	Similar improvements in both treated group (weighted traction) and the control group (simulated traction). No significant differences between groups.	"The findings of this study question the justification of admitting patients with back pain into hospitals for purposes of traction alone."	Not clear if amount of traction blinded. Data suggest lack of efficacy.
Werners 1999 RCT No mention of COI or industry sponsorship.	5.0	N = 152 with mostly chronic LBP	Traction and mechanical massage (n = 73) vs. interferential therapy (n = 74) for 6 sessions over a 2-3 week period.	No significant differences between groups for ODI questionnaire and VAS scores throughout study.	"This study shows a progressive fall in Oswestry Disability Index and pain visual analog scale scores in patients with low back pain treated with either-interferential therapy or motorized lumbar traction and massage."	Entry criteria unclear. Most experienced years of back pain, but unclear if a new episode. Data suggest no differences in treatments. No control group.
Mathews 1988 RCT Supported by grant from Department of	4.5	N = 434 with lumbago and sciatica	Manipulation treated on alternate days as required vs. continuous traction 30 minutes each weekday until pain relieved or 3 weeks vs. controls receiving infrared heat with comparable frequency 3 times	Treated patients had greater improvement compared to controls, p between 0.05 and 0.1. Trial B2. 98 treated patients and 56 controls recovered, p = 0.05. Trial C.	"[M]anipulation for patients with low back pain and restriction of movement hastens relief of pain by an amount whose significance	Study methods not well described.

Health and Social Security and Special Trustees of St Thomas' Hospital.			a week for 2-3 weeks. Patients assessed at least 4 times at 8 days, 2 weeks, and 1, 3, 6, 12 months.	On 8th day, more than twice as many treated patients than control patients recovered, p between 0.05 and 0.1	compared with controls varies with the group studied. The traction trial also shows that treatment hastens recovery by an amount of borderline statistical significance compared with controls."	
Güvenol 2000 RCT No mention of COI or industry sponsorship.	4.5	N = 29 with lumbar disc herniation and chronic pain	Inverted spinal traction for 5 minutes 1st day, 8 minutes second day, 10 minutes 3rd, onward through 7 days (n = 15) vs. conventional spinal traction for 20 minutes (n = 14) both administered for 10 days and 15 minutes of infrared radiation.	Both groups improved. Decreases in disc protrusion favored conventional traction (69.2% vs. 35.7%, p = 0.0185). No significant differences between groups for pain scores.	"[T]here was significant clinical improvement after the treatment in both traction groups and this improvement continued until after follow-up examination. There were no significant differences between efficacies of two different traction techniques clinically."	No descriptions of type of CT findings or blinding procedures. Interpretation could also be that both equally inefficacious.
Larsson 1980 RCT Supported by grant from Swedish Work Environment Fund.	4.5	N = 82 with acute and subacute sciatica	Autotraction for up to 3 1-hour sessions within 1 week (n = 41) vs. use of corset and bed rest advice (n = 41) with follow-up at 1 and 3 weeks after start of treatment and 3 months after treatment.	No difference in efficacy of traction for pain radiation below knee. Percent completely recovered: 15% vs. 0% at 1 week. At 3 weeks, groups different for completely recovered or free from pain in leg (p <0.05) and completely recovered or free from leg or back pain (p <0.01).	"The difference between the two treatment groups was statistically significant. The immediate difference noted between the treatment groups had decreased slightly at 3 weeks but was still statistically significant at this time."	Utility of corset is suboptimal as it is now thought to be equivalent to no treatment.
Weber 1973 RCT No mention of COI or industry sponsorship.	4.5	N = 86 with radiating pain and neurological signs and positive myelography	Traction (n = 37) vs. sham traction (n = 35) for 20 minutes once a day for 5-7 days; 72 patients used for evaluation.	Six dropouts due to aggravation of symptoms. No differences found between groups.	"[I]t appears that the treatment has had no effect. A comparison with the results from the control group did not show any difference."	Data suggest lack of efficacy.
Ljunggren 1984 RCT Supported by grant from The Norwegian Research Council for Science and Humanites, The Fund for Post-graduate Education of Physiotherapists, and Norsk Hydro.	4.5	N = 49 with chronic pain thought from prolapsed lumbar intervertebral discs	Autotraction (n = 26) vs. manual traction (n = 23) for 1-hour treatment sessions for 1 week.	Pain intensity significantly reduced in all body parts. About 1/4 avoided operation.	"After two years there was no recurrence of symptoms."	Randomization process not described; degree of differences in baseline variables stark suggesting total failure of randomization, potentially rendering results uninterpretable.

Weber 1984 RCT No mention of COI or industry sponsorship.	4.5	N = 215 admitted with sciatica and positive myelogram	TruTrac, n = 72 (intermittent traction applied with motor) for 20 minutes once a day vs. Spina-Trac, n = 44 (intermittent traction by apparatus) for 20 minutes 1x a day vs. auto-traction, n = 49 (multiplane table) for 1 hour vs. manual traction, n = 50 (therapist applied) for 5-7 days. Each group had control group and different study.	Tru-Trac method: no significant differences between treatment group and control group. Spina-Trac method: no significant differences between treatment group and control group. Auto-traction method: no significant differences between treatment and control groups. Manual traction method: no differences between groups.	"Traction therapy does not alter the course of the disease in patients with radicular symptoms and signs due to a herniated intervertebral lumbar disc."	Sparse study details for randomization, allocation, baseline comparability, co-interventions and compliance. Data suggest limited benefit from automatic and manual traction therapy compared with sham traction. Treatment failure in active groups 60-75%.
Diab 2013 RCT No mention of COI or industry sponsorship.	4.5	N = 80 chronic mechanical LPB with symptoms lasting 3+ months. Exclusion criteria: spinal canal stenosis, rheumatoid arthritis, osteoporosis, inability to tolerate the lumbar extension position, scoliotic deformity and any lower extremity deformity.	Traction Group (n = 40): Lumbar extension traction using Harrison protocol 3x a week for 10 weeks starting with 3 minutes a session, increasing to 1 minute a session to 20 minutes vs. Control Group (n =40). Both groups received stretching exercises (stretched erector spinae muscles and hamstring muscles held each for 30 seconds repeated 3 times, 3x a week for 10 weeks) and infrared radiation (15 minutes per session 3 times a week for 10 weeks), instructed to avoid other exercise programs. Follow up at 6 months.	Mean±SD, pre-treatment/10 weeks post treatment/6 months follow up. Lumbar lordosis: traction (13.9±3.1) vs. control (13.7±2.9)/ traction (20.1±3.8) vs. control (15.2±3.6), p = 0.000/traction (18.3±3.6) vs. control (14.7±3), p = 0.000. Thoracic kyphosis: traction (31.4±4.1) vs. control (30 ±4.8), traction (34.3±4.2) vs. control (29.7±5.4), p = 0.013/ traction (33.9±3.9) vs. control (29.9±4.8), p = 0.0001. Plumb line: traction (39.8±6.7) vs. control (38.7±6.6), traction (36.3±7.1) vs. control (37.9±6), p = 0.001/traction (36.7±6.9) vs. control (38.1±6.1), p = 0.001. Sacral slope: traction (23.5±3.4) vs. control (24.3±2.5), traction (25.5±3.3) vs. control (24.7±2.3), p = 0.001/traction (25.2±3.2) vs. control (24.5±2.6), p = 0.001. Pain: traction (6±1) vs. control (5.5±1.7), traction (3.2±1.4) vs. control (3.5±1.2), p = 0.29/traction (2.6±1.1) vs. control (3.5±1.2), p = 0.004. ODI: traction (32.4 ±3.1) vs. control (31.1± 4.8), traction (21.8±3.1) vs. control (23.4±3.4), p = 0.1/ traction	"The results of the present study show that the lumbar extension traction in addition to stretching exercises and infrared radiation have positive impact on lumbar lordotic curve, pain intensity, disability, and whole spine sagittal balance parameters in CMLBP."	No effect on pain or ODI until after treatment at 6 months is not readily explainable.

				(23.8±2.7) vs. control (27.1±3), p = 0.001.		
Coxhead 1981 RCT No mention of COI or industry sponsorship.	4.0	N = 322 outpatients with pain radiating at least as far as buttock crease, with or without back pain	Traction with motor-driven "Tru-Trac" apparatus giving traction at pre-set forces and time intervals vs. exercises for all ROMs and muscle groups vs. manipulation vs. corset: readymade fabric lumbar support for 4 weeks; 16 treatment groups.	At 4 weeks, mean improvement scores: traction 50.1, manipulation 52.6, exercises 49.0, and corset 49.8. No beneficial effects of treatment detectable at 4 or 16 months. At 4 weeks, pain scores improved greater in manipulation group, p <0.05.	"There were no beneficial effects of treatment detectable at four or sixteen months. In the short-term, active physiotherapy with several treatments appears to be of value in the outpatient management of patients with sciatic symptoms, but it does not seem to confer any longer-term benefit."	Entry criteria included those with pain "at least as far as the buttock crease," thus diagnosis of sciatica appears to not follow typical medical practice and breakdown between LBP and true sciatica patients is unclear.
Borman 2003 RCT No mention of COI or industry sponsorship.	4.0	N = 42 with LBP	Group receiving standard PT (hot pack, ultrasound, active exercise program) with (n = 21) and without traction (n = 21) for 10 sessions in 2 weeks.	No differences in pain ratings or global improvements after therapy or after 3 months and no specific effect of traction on standard PT observed.	"Our results do not provide evidence for the additional effects of traction on traditional physical therapy in patients with persistent, nonspecific LBP."	Randomization, allocation, baseline comparability, compliance, co-intervention details sparse. Data suggest no short- or long-term benefit of traction therapy.
Mathews 1987 RCT Supported by grant from Department of Health and Social Security and Special Trustees of St. Thomas' Hospital.	4.0	N = 895 back pain and sciatica, and sclerosant patients for local tenderness	Manipulation up to 2 weeks daily (n = 58, trial B1, trial B2, n = 233) vs. traction 1 session QD of at least 45kg for 30 minutes (n = 143, trial C) vs. epidural injection of 20 ml 0.125% plain bupivacaine and 2ml methylprednisolone acetate Q14 days up to 3 times (n = 57, trial D) vs. sclerosant injection (n = 22, trial A) of phenol 2.5%, dextrose 25%, and glycerine 30% in distilled water 3 times at 2 week intervals.	At 1 month, 67% of epidural vs. 56% controls had recovered. At 3 months, data favored epidural injections. No differences at 1 year for further pain. Trial A: No differences between groups. Trial BI: No differences between groups. Trial B2: Treatment group recovered better (80%) vs. controls (67%), p <0.05. Trial C: No between-group differences. Trial D: At 3 months, treated group more pain free, p <0.05.	"It might be supposed that mechanical or injection forms of treatment involve a hazard of unwanted side-effects which could detract from the value of short-term pain relief. None was seen."	Traction patients more likely to require surgery. Study population does not clearly distinguish clinical sciatica; rather it may include those with thigh pain. Five multiple trials. Substantially unequal groups occurred for unclear reasons. Sparse details for any one trial thus, of limited use for evidence-based medicine.
Konrad 1992 RCT No mention of COI or industry sponsorship.	4.0	N = 158 with LBP	Balneotherapy with warm water, heat and buoyancy (Group A, n = 35) vs. underwater traction bath (Group C, n = 26) vs. underwater massage (Group B, n = 44) vs. a control (Group D, n = 53) 15 minutes 3 times a week for 4 weeks.	No differences between groups. Analgesics consumed after 4 weeks: 2.3±1.3 vs. 2.2±0.9 vs. 1.8±0.7 vs. 3.9±2.7. Analgesic consumption less in treated groups vs. control, p <0.01. All treated groups had better pain scores compared to control group, p <0.01.	"The prescription of the analgesics and the pain score were significantly reduced in all three treated groups, but there was no difference between the three groups."	Randomization, allocation, baseline comparability, compliance, co intervention details sparse. Data suggest no short or long term benefit of balneotherapy or underwater traction, massage for subacute LBP.

DECOMPRESSION AND DECOMPRESSIVE DEVICES

Decompression through traction is a treatment that utilizes a therapeutic table and traction mechanism. Its intent is to reduce intradiscal pressure, thus allowing for disc decompression. The theory is that decompression will externally decompress the nerve root and help relieve pain and other symptoms.

Recommendation: Decompression through Traction and Spinal Decompressive Devices for Treatment of Acute, Subacute, or Chronic Low Back Pain or Radicular Pain Syndromes

Decompression through traction and spinal decompressive devices is not recommended for treatment of acute, subacute, chronic, post-operative low back pain, or radicular pain syndromes.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation

There is no clear evidence for efficacy of this treatment.(1315, 1337) Decompression through traction and spinal decompressive devices are not recommended for the treatment of acute, subacute, chronic, or radicular pain syndromes. There is insufficient evidence to recommend this treatment which is moderately costly, though not invasive.

Evidence for the Use of Decompression through Traction and Decompressive Devices

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates and an updated search was conducted using PubMed for publication between 1/1/2013 and 11/15/2017 using the following terms: Decompression through traction, spinal decompressive devices, subacute low back pain, chronic low back pain, radicular pain syndromes, sciatica, and random)" to find 1828 articles. Of the 1828 articles, we considered 23 for inclusion. Of the 23 considered for inclusion, 2 are randomized controlled trials and 1 is a systematic review.*

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Decompression Devices										
Brown 2012 (score=7.5)	Decompression	RCT	Sponsored by Vertos Medical. Data entered and maintained by PharmaPros Corporation. COI: Dr. Brown is a paid consultant to Vertos Medical and member of company's Scientific Advisory Board.	N = 38 lumbar spinal stenosis (LSS) with painful lower limb neurogenic claudication and hypertrophic ligamentum flavum.	Mean age: 76.2±9.3 years; 21 male, 17 female	Mild® lumbar decompression device (n = 21) vs. Epidural steroid treatment 80mg triamcinolone acetate (n = 17).	Follow-up at 6 and 12 weeks.	Mild group average baseline VAS pain score 6.3 (95% CI +/- 0.7) improved to mean of 3.8 (95% CI +/- 1.3) at 6 weeks. ESI group mean VAS baseline scores: 6.4 (95% CI +/- 1.0), at 6 weeks 6.3 (95% CI +/- 1.4). Mild group significant improvement in mobility with decrease in mean ODI scores from 38.8 (95% CI +/- 4.2) at baseline to 6-weeks 27.4 (95% CI +/- 7.0; p <0.05). ESI group no significant change form baseline to 6 weeks (p >0.05).	"While ESIs may provide pain relief for patients experiencing inflammation because of radiculopathy, the results of this randomized study indicate that LSS patients with symptomatic neurogenic claudication do not demonstrate a sustained decrease in pain or improved function. Conversely, treatment with mild statistically significantly improved mobility and reduced pain associated with symptomatic LSS."	Data suggest no significant difference in comparisons between groups at 6 weeks in the primary outcome measure of VAS, ODI.
Sherry 2001 (score=5.0)	Decompression	RCT	No mention of sponsorship. COI: Dr. Smart contracted to and shareholder in VAX-D Australaisa PTY, Ltd.	N = 44 with chronic LBP	Mean age: 42.0; 23 male, 21 female.	Vertebral axial decompression (VAX-D, n = 22) 30 minutes 5x a week for 4 weeks and then 1x a week for 4 weeks vs. TENS (n = 22) 30 minutes/day for 20 days then 1x a week for 4 weeks.	Follow up at 6 months.	Efficacy rate 68.4% for VAX-D group compared with 0% for TENS, p <0.001. Results reported by TENS group may have come under negative placebo effect and highlights difficulties in studying medical devices where it is not possible to blind patients to treatment.	"[V]AX-D can achieve a statistically significant improvement in pain and functional outcome for patients suffering from disc-related chronic low back pain."	Small sample. Lack of details for randomization, allocation, baseline comparability. Suggests VAX-D more beneficial than TENS, but patient bias likely as TENS group treated in clinic for VAX-D, resulting in potential negative placebo effect.

MANIPULATION AND MOBILIZATION

Manipulation and mobilization are two types of manual therapy that include wide arrays of different techniques and schools of thought.(103, 1348-1352) Some consider these two interventions to be on a spectrum of velocity and applied force. In general, mobilization involves assisted, low-force, low-velocity movement. Manipulation involves high-force, high-velocity, and low-amplitude action with a focus on moving a target joint. As commonly used, "adjustment" is generally a synonym for manipulation.

From the standpoint of evidence-based practice guidelines development, there are numerous types of manipulation utilized in different studies. It seems unlikely that if there is an effect of manipulation, that it should be the same regardless of diagnosis, technique, or any other factors. This results in difficulties with comparing methods, techniques, or results across the available literature. These differences appear to be largely unstated in the available systematic reviews, which have aggregated all studies.

1. *Recommendation: Manipulation or Mobilization of the Lumbar Spine for Treatment of Acute or Subacute Low Back Pain or Radicular Pain Syndromes without Neurological Deficit*
   Manipulation or mobilization of the lumbar spine is recommended for select treatment of acute or subacute low back pain, or radicular pain syndromes without neurological deficit. Manipulation may also be considered for treatment of *severe*, acute LBP concurrently with directional preference exercises, aerobic exercise, and NSAIDs with the *goal to improve motion* and hopefully to decrease pain and enable more efficient exercise.

   Indications – Acute, subacute LBP, and radicular syndromes without neurological deficits. Patients should generally have had NSAIDs and/or acetaminophen, directional and aerobic exercise instituted and have insufficient results over 1 to 2 weeks. Indications include unresolving acute or sub-acute LBP with: 1) patient preference especially with positive past experience for the same/similar problem; or 2) health conditions with increased risk of harms from NSAIDS/ acetaminophen; or 3) patient aversion to medication use or intolerance to aerobic exercise and directional exercises; and/or 4) persisting activity intolerance or unacceptable pain level after 7 to 10 days and a trial of NSAIDS, acetaminophen or aerobic exercise.

   Frequency/Duration – Most patients with more severe LBP conditions may receive up to 12 visits over 6 to 8 weeks,(600, 717, 1353-1355) as long as functional improvement (and not minor improvements in pain ratings) and progression away from passive modalities to a more active HEP and self-directed activity program are documented when re-evaluated after 3 to 6 visits. There is no quality evidence that more than 12 visits are helpful for an episode of LBP. Compliance, including with conditioning exercises and efficacy should be demonstrated. Patients likely to benefit from manipulation exceeding these ranges may have complicating circumstances associated with slower recovery times or delayed treatment response, though nevertheless should show significant early therapeutic effects.

   Indications for Discontinuation – Increased pain or development of a radicular pain problem is an indication for immediate discontinuation. Failure to progress in functional improvement after 3 to 6 visits should result in reassessment and either a change to an alternative manipulation program or discontinuation. For any episode of acute or subacute pain, or for a treatment trial for chronic back pain, treatment should be discontinued by the 12th manipulation session, except in those cases (noted above) where continued functional improvement is demonstrated.

   Benefits – Potential for faster resolution of pain and improved function.
   Harms – Worsening of LBP, especially immediately after manipulation.

   Strength of Evidence **– Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Regular or Routine Manipulation or Mobilization*
   Regular or routine manipulation or mobilization is not recommended as there is no evidence of efficacy.
   There is no evidence that prophylactic treatment is effective for primary prevention (before the first episode of pain) or for secondary prevention (after recovery from an episode of back pain), and prophylactic treatment is not recommended. There is also no evidence that manipulation on a regular or routine basis is beneficial.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

3. *Recommendation: Manipulation or Mobilization for Chronic Pain*
   Manipulation or mobilization of the lumbar spine is recommended for short-term relief of chronic pain or as a component of an active treatment program focusing on active exercises for acute exacerbations.

   Frequency/Duration – 1 to 3 times a week for 2 weeks;(1356-1358) total treatments dependent on response to therapy with most higher-quality studies suggesting a maximum of 6 appointments.(684, 866, 1201, 1359) Substantial functional progress (e.g., return to work or activities, increasing ability to tolerate exercise, reduced impairing medication use) should be documented at each follow-up visit. Treatment plan should be reassessed after each 2-week interval. Most guidelines suggest that if there is significant response in the above outcomes, it is worth considering another 2 weeks of treatment. If no response to 2 weeks of application of a particular manipulation treatment, it should be discontinued and 2 weeks of a different method of manipulation/mobilization or other treatment should be considered. If there is no response after 4 weeks and two 2-week trials of different manipulation/mobilization techniques, it is unlikely that further manipulation/mobilization will be helpful.

   Indications for Discontinuation **–** Lack of demonstrated continued functional response after 6 manipulation/mobilization sessions (2 trials of 2 or more different methods), resolution of symptoms, or failure to participate in an active rehabilitation program.
   Benefits – Potential for faster resolution of pain and improved function.
   Harms – Worsening of LBP, especially immediately after manipulation.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

4. *Recommendation: Manipulation for Treatment of Radicular Pain Syndromes with Acute Neurological Deficits*
   Manipulation is not recommended for treatment of radicular pain syndromes with progressive motor loss. Patients often have radicular pain in the lower extremity without clear evidence of neurological impingement and these patients do not have demonstrated contraindications for manipulation(1360, 1361) and may be considered in Recommendation #1 above. The available studies attempting to directly address this question provide somewhat contradictory evidence.(1360, 1362) There also are concerns about the use of manipulation in the presence of acute or progressive neurological deficits.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

5. *Recommendation: Manipulation/Mobilization of Non-adjacent Areas for Low Back Pain*
   Manipulation or mobilization of regions outside of/not adjacent to the lumbopelvic area (e.g., cervical spine, lower extremity) is not recommended for treatment of low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – High

Rationale for Recommendations
The highest quality sham-manipulation trial suggested no benefits of manipulation.(1363) There are many additional moderate quality studies evaluating manipulation, although there are problems with quality of the available literature,(1364-1366) use of mixtures of manipulation with exercises and other treatments precluding conclusions on efficacy of spinal manipulation, and suboptimal statistical testing that have been noted.(1367, 1368) There are comparative trials with "usual care" (which often is not "usual" today and/or contain numerous uncontrolled co-interventions) but no quality studies demonstrating superiority of manipulation for LBP patients compared with the other treatment strategies (e.g., NSAIDs, progressive walking program, directional exercises, and heat) contained in this guideline. One comparative trial suggested adjunctive Manual-thrust manipulation was modestly superior to mechanical-assisted manipulation (MAM) at 4 weeks but not longer-term. Both also treated with ibuprofen, with no differences between MAM and largely unstructured "usual medical care."(1351)

The manipulation literature resulted in the publication of a clinical prediction rule (CPR) that appeared quite promising.(600, 1369) Yet, a subsequent attempt to validate this CPR failed.(654, 663) It is also somewhat concerning that of the five highest quality studies, three found no benefit,(817, 1353, 1355) one resulted in the CPR subsequently not validated(600) and only one was positive for comparing manipulation with non-thrust manipulation.(1354) However, most of the evidence continues to suggest manipulation is approximately as efficacious as common physiotherapy interventions such as stretching or strengthening exercises for treatment of acute and chronic LBP. These weaknesses have resulted in a decrease in the strength of evidence rating for manipulation for acute pain to "I" from "B."

Manipulation is not without risks. Reported but rare fatal outcomes have been associated with cervical *not* lumbar manipulation. Adverse effects reported include vertebrobasilar accidents (neck manipulation only) and disc herniation or progression to cauda equina syndrome. One study suggested lower risk among a manipulated group compared to non-manipulated patients but was not randomized and likely had considerable selection and spectrum biases.(1370) The mean age of vertebrobasilar accidents in the case reports is 38 and the risk has been reportedly due to cervical manipulation with a rotary component.(1371) Twenty-nine of the vertebrobasilar accidents resulted in death.

Manipulation is not invasive, is of moderate to high cost in aggregate, but does have rare adverse effects.(1372-1376) However, the adverse effects are primarily from cervical, not lumbar manipulation. If other interventions that have evidence of efficacy have failed, it may be acceptable to use manipulation as a secondary treatment option adjunct to a program of evidence-based functional restoration if tied to signs of objective functional recovery within 2 weeks that is faster than the progress expected with the rate of usual spontaneous recovery. For acute, severe LBP, it may also be reasonable to initially prescribe manipulation in addition to aerobic exercise, directional exercise and NSAID. Minimum and maximum dosage thresholds of manipulation are difficult to extract from these studies. In general, the studies assessed treatment effects early on and with a limited number of encounters. Studies generally suggest that a treatment effect from manipulation would be expected within the first 2 weeks and first few visits. A decision to continue manipulation should be based on establishing a positive early treatment response for functional outcomes (e.g., distance walking, work ability/limitations).

Nearly all studies excluded patients with symptoms consistent with sciatica.(1360) Leg pain was allowed, but the definition of "leg" vs. lower extremity pain was not specified. Essentially all have eliminated those with neurological deficits. Thus, there is lack of demonstrated efficacy on patients with sciatica and concerns exist about reports of increased symptoms of neurological compression after manipulation.

There are no quality studies for adjustments or manipulations of the neck/cervical spine or other areas outside of the lumbopelvic region. High-velocity rotary cervical spine manipulations have reportedly had severe consequences, though these are rare. Adjustments or manipulations are not invasive, are of moderate cost, but have rare severe complications. Therefore, adjustments or manipulations of the cervical spine to treat LBP or other lower back problems are not indicated.

Evidence for the Use of Manipulation and Mobilization
There are 1 high-(817) and 36 moderate-quality RCTs incorporated into this analysis (5 with multiple reports).(554, 600, 623, 644, 684, 696, 837, 857, 866, 1201, 1205, 1266, 1325, 1328, 1345, 1346, 1351-1355, 1359-1363, 1369, 1377-1392) There are 14 low-quality RCTs in Appendix 1.(629, 1393-1405)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: manipulation, mobilization, subacute low back pain, chronic low back pain, and radicular pain syndromes to find 21,394 articles. Of the 21,394 articles we reviewed 39 articles and all were included.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Hancock 2007 RCT R. Day member of advisory board about paracetamol for GlaxoSmithKline. Payments went to audited hospital account for teaching and research purposes.	9.0	N = 240 with acute back pain lasting < 6 weeks with and without leg pain	Diclofenac 50mg BID with manipulation vs. diclofenac with placebo manipulation vs. manipulation with placebo diclofenac vs. placebo; 12 sessions of manipulation for maximum of 4 weeks.	Patients who received active spinal manipulative therapy (SMT) did not recover more quickly than placebo manipulation for both recovery measures (pain score of 0 or 1 for 7 consecutive days) (p = 0.954, p = 0.870). Combination diclofenac and manipulation did not shorten recovery time (CI 0.76-1.60, p = 0.606).	"Neither diclofenac nor spinal manipulative therapy gave clinically useful effects on the primary outcome of time to recovery….no significant effects on pain, disability, or global perceived effect at 1, 2, 4, or 12 weeks."	28 patients had cointerventions during study period. Data suggest no benefit over placebo for spinal manipulation, NSAID, or combination of SMT plus NSAID in outcome of days to recovery.
Cleland 2009 RCT No mention of COI or industry sponsorship.	7.5	N = 112 with LBP.	Spinal thrust manipulation group (n = 37) vs. side-lying thrust manipulation group (n = 38) vs. non-thrust manipulation technique group (n = 37). Follow-up at 1 and 4 weeks, and 6 months.	Success rates after 1 week were 54.1%, 52.6%, and 8.1% for supine thrust, side-lying thrust and non-thrust manipulation groups (p <0.001), and after 4 weeks were 86.5%, 81.6 %, and 18.9% respectively (p <0.001), and after 6 months rates 91.9%, 89.5%, and 67.6% respectively (p = 0.009).	"The results of the study support the generalizability of the CPR [clinical prediction rule] to another thrust manipulation technique, but not to the nonthrust manipulation technique that was used in this study. In general, our results also provided support that the CPR can be generalized to different settings from which it was derived and validated."	Treatments differed in 4 of 5 sessions. Data favored supine thrust manipulation over side-lying thrust manipulation and non-thrust manipulation.
Jüni 2009 RCT PMV, GH, H-RZ and SR are members of Swiss Society for Manual Therapy and RvB is a member of Swiss Federation of Osteopathy.	7.5	N = 104 with acute LBP >4 weeks in ER	Standard care with spinal manipulation therapy (n = 52) vs. standard care alone included general advice on rapid return to normal activities and avoidance of bed rest in acute phase (n = 52). Actual schedule and daily dosage left at discretion of patients, maximum of 5 sessions within 2 weeks.	By day 14, Roland Morris scores 5.8 in SMT group and 5.2 in control (p = 0.49); 95% CI not statistically significant between groups in pain scores.	"We found no evidence for a clinically relevant benefit of SMT in addition to standard care in patients with acute low back pain."	Six month follow-up. Data suggest SMT not of additive benefit. More fit to work at baseline in SMT (53 vs 37%).
Childs 2004 RCT Supported by Foundation for Physical Therapy, Inc., and Wilford Hall Medical	7.0	N = 131 with acute and subacute LBP	Manipulation plus exercise (thrust spinal manipulation and ROM exercise only (n = 70) vs. exercise alone (low stress aerobic and lumbar spine	Modified Oswestry Disability Questionnaire Score change (1 week/4 weeks/6 months): manipulation vs. exercise (9.2, p <0.001/8.3, p = 0.006/10.1, p = 0.001). Responses to questions at 6 month follow-up. Have you	"The spinal manipulation clinical prediction rule can be used to improve decision making for patients with low back pain."	Data suggests clinical prediction rule valid and provides large differentiation in outcomes. Patients who were positive on clinical predictive rule reported benefit from exercise plus 2

Center Commander's Intramural Research Funding Program. No COI mentioned.			strengthening program) for 4 weeks (n = 61)	taken any medications for back pain in past week: manipulation 36.5 vs. exercise 60.0, p <0.05. Are you presently seeking treatment for back pain: 11.5 vs. 42.5, p <0.05. Have you missed any time at work in past 6 weeks because of back pain: 9.6 vs. 25.0, p <0.05.		sessions of manipulation compared to exercises alone.
Childs 2006	7.0	See Childs 2004 above.				
Andersson 1999 RCT No mention of COI or industry sponsorship.	7.0	N = 178 with subacute LBP	Manual therapy, osteopathic treatment individualized (n = 83) vs. standard therapies: analgesics, anti-inflammatory medication, active PT or therapies (ultrasonography, diathermy, hot or cold packs or both, corset or TENS); 10 minute educational video on back pain for 12 weeks; 4 weekly visits initially then 4 more visits at 2 week intervals (n = 72).	NSAID use 54.3% vs. 24.3% (p <0.001). Muscle relaxant use 25.1% vs. 6.3% (p <0.001). Physical therapy use (2.6% vs. 0.2%, p <0.05). VAS pain ratings changed: DO: 49.0±23.6 to 32.0±23.0 and standard care 45.0±20.6 decreased to 26.3±24.1. Oswestry ratings 25.0±12.2 decreasing to 13.6±13.4 and 23.1±11.8 to 12.9±13.4. No significant differences in pain ratings (p = 0.19) or Oswestry ratings (p = 0.97) over duration of observation.	"Osteopathic manual care and standard medical care have similar clinical results in patients with subacute low back pain. However, the use of medication is greater with standard care."	Multiple co-interventions. Outcome measures not statistically significantly different, but pain ratings trended towards improvements in osteopathic manual therapy over "standard medical treatment." Standard treatment group does not appear to have standard treatment as would be performed based on a review of the literature.
Santilli 2006 RCT	7.0	N = 102 with acute LBP of moderate to severe intensity or moderate to severe radiating pain to one leg	Manipulations group (n = 53) vs. Simulated manipulations group (n = 49). Follow-up at 15, 30, 45, 90 and 180 days.	At end of follow-up, significant difference present between manipulation group and simulated manipulations group in percentage of cases becoming pain-free (local pain 28% vs. 6% (p <0.005)) and (radiating pain 55% vs. 20% (p <0.0001)). Differences between groups total days with pain 23.6 vs. 27.4 (p <0.005). total days with moderate or severe pain 13.9 vs. 17.9 (p <0.05).	"Patients receiving active manipulations enjoyed significantly greater relief of local and radiating acute low back pain, spent fewer days with moderate-to-severe pain, and consumed fewer drugs for the control of pain."	Excluded BMI 30+kg/m^2, chronic LBP and Class 4B/4C discs. Adequacy of blinding not assessed. Relatively long follow-up period (180 days). Data suggest manipulation of some benefit for radicular pain.
Giles 2003 RCT Supported by Queensland State Government Health Department and partly supported by The	6.5	N = 115 with mostly chronic LBP or neck pain	Manipulation: high velocity, low amplitude thrust spinal manipulation to joint 2 times a week, n = 36 vs. acupuncture (near and far technique), n = 36 vs. medication (63% celecoxib, 26% rofecoxib	Manipulation with best overall results with improvements of 50% (p = 0.01) on ODI, 38% (p = 0.08) on NDI, 47% (p <0.001) on SF-36, and 50% (p <0.01) on VAS for back pain, 38% (p <0.001) for lumbar standing flexion, 20% (p <0.001) for lumbar sitting flexion, 25% (p =	"In summary, the significance of the study is that for chronic spinal pain syndromes, it appears that spinal manipulation provided the best overall short-term results, despite the fact that the spinal manipulation group had experienced the	Individualization of treatments results in lack of standardization and substantially precludes drawing robust conclusions. Post-randomized individualized treatment in all three arms. Ill-defined mixture of diagnoses, combined with non-

Townsville Hospital. No COI mentioned.			and 11% paracetamol; apparently unblinded, n = 43. Follow-up for 9 weeks and 2 treatments per week for each treatment arm.	0.1) for cervical sitting flexion, and 18% (p = 0.02) for cervical sitting extension. Acupuncture better results than manipulation on VAS neck pain (50% and 42%). Asymptomatic status: manipulation (9 patients) vs. acupuncture (3) vs. medication (2 patients), p = 0.05. Manipulation greater results for all main outcomes except NDI.	longest pretreatment duration of pain."	randomization arguably relegates study to a non-RCT.
Strauss 2002	6.5	See Giles 2003				
Sutlive 2009 RCT No mention of COI or industry sponsorship.	6.5	N = 60 with LBP with or without lower extremity pain for ≤6 days or not radiating pain to knee.	Group I: treated with lumbopelvic manipulation plus an exercise program (n = 30) vs. Group II treated with lumbar neutral gap manipulation plus exercise program (n = 30). Both groups followed-up at 48 hours.	Both groups experienced reduction in pain and disability. Group I 95% CI, 3.6, 12.8 on ODQ different from baseline (p <0.001), and CI, 0.6, 2.0 on NRS (p <0.001) vs. Group II: CI, 0.7, 10.0 on ODQ (p = 0.023), and CI 0.3, 1.8 on NRS (p <0.006). Difference between groups was CI, -6.3, 9.8 on ODQ (p = 0.668), and CI, -0.9, 1.6 on NRS (p = 0.591).	"[B]oth the LP and the NG manipulation groups experienced small but significant reductions in pain and disability, and were equally effective when compared at 48 hours post treatment."	18-65 years old. ODI >30% at least 3 CPR+.
Bialosky 2009 RCT Supported by grant from National Institutes of Health, National Center for Complementary and Alternative Medicine. No COI mentioned.	6.5	N = 36 with LBP with or without lower extremity pain.	Spinal manipulation (n = 12) vs. lumbar extension exercises (n = 12) vs. stationary bicycle (n = 12).	Average duration of back pain in participants was 221 (SD = 365) weeks. AMT showed greatest change in temporal sensitivity compared to the other groups 8.5 (11.8).	"There were no differences in inhibition of Aδ fiber-mediated pain sensitivity for SMT in comparison with lumbar exercises and riding a stationary bike."	Trial to assess short-term effects on hypoalgesia of questionable use for intermediate or longer treatment efficacy. Small sample size. Some baseline differences. No follow-ups.
Von Heymann 2013 RCT Supported by Deutsche Gesellschaft für Manuelle Medizin (DGMM) - Aerzteseminar für Manuelle Wirbelsaeulenund Extremitaetentherapie (MWE). COI: W.v.H. is member of DGMM board.	6.5	N = 101 with acute LBP of up to 2 days duration. Mean age 36.7 years	High-velocity low amplitude spinal manipulation and Placebo-diclofenac (n = 37) vs. Sham manipulation and Diclofenac 50mg TID (n = 38) vs. Sham Manipulation and Placebo-diclofenac (n = 25). Follow-up for 12 weeks.	Mean Roland-Morris Disability Score (RMS) reduction values 7.71 in spinal manipulation group vs. 4.75 in Diclofenac group (p = 0.0134). VAS pain score secondary outcome and lower in spinal manipulation group vs. diclofenac group (p <0.05).	"In a subgroup of patients with acute nonspecifi c LBP, spinal manipulation was significantly better than nonsteroidal antiinflammatory drug diclofenac and clinically superior to placebo."	Two phases of trial, not well described. Sparse baseline and outcomes data. No quantified data in tables. No specific VAS values. Data suggest manipulation modestly superior to diclofenac over 9 days.

Brennan 2006 RCT Supported by a research grant from the Deseret Foundation. No COI mentioned.	6.0	N = 123 with acute and subacute LBP	Manipulation (n = 40): including thrust manipulation or low amplitude mobilization vs. specific exercise (n = 37): instruction in repeated ROM exercises into either lumbar flexion or extension; directional exercises determined by treating therapist vs. stabilization (n = 46): trunk strengthening and stabilization exercises twice a week for 4 weeks, maximum 8 sessions.	Improvements in Oswestry Disability Index (ODI) for those with a matched treatment were 29.9 vs. 23.3 for non-matched. More who were matched advanced to next stage (78% vs. 60%). No significant differences between randomized groups.	"Nonspecific LBP should not be viewed as a homogenous condition and that outcomes can be improved when subgrouping is used to guide treatment decision-making."	Data support the conclusions. Outcomes for those who were "not matched" to the purported proper treatment also realized sizable improvements in ODI scores.
Skargren 1997 RCT	6.0	N = 411 with acute, subacute, and chronic back or neck problems	Chiropractic management (n = 219) vs. physiotherapy management (n = 192). Treatments at discretion of chiropractor or physiotherapist.	Baseline Oswestry scores DC: 35±17 vs. PT: 37±16. After treatment, modestly favored DC [-1.49, (-5.51 to 2.54)] after 6 months modestly favored PT [0.36, (-4.01 to 4.76)]. Pain intensity scores same pattern; 12 month follow-up data same pattern of non-statistically significant findings favoring physiotherapy over chiropractic adjustment (Skargren 98).	"The effectiveness and total costs of chiropractic or physiotherapy as primary treatment were similar to reach the same result after treatment and after 6 months."	Individualization and use of multiple treatments substantially weakens or eliminates ability to draw conclusions regarding utility of manipulation. Baseline data dissimilar and somewhat favor chiropractic treatment group; 5 poor prognostic factors at baseline identified – duration of current episode, Oswestry score at baseline, expectations of treatment, number of localizations, and well being.
Skargren Spine 1998 Study supported by County Council of A-stergAtland and the Federation of County Councils, Sweden. No mention of COI.	6.0	See Skargren 1997				
Skargren Pain 1998 Study supported by County Council of östergötland and Vårdalstiftelsen. No mention of COI.	6.0	See Skargren 1997				
Lewis 2005 RCT No mention of industry sponsorship or COI.	6.0	N = 80 with chronic LBP or LBP	Individualized treatment (n = 40, manual therapy/ spinal mobilization and spinal stabilization exercises) vs. exercise (n = 40, 10-station exercise class treadmill). Most subjects received 6	Exercise group's pain scores decreased pre-to post-treatment. Compliance rates decreased to 70% at 6 months. Exercising had greater improvements. Non-smokers had lower questionnaire scores and greater improvement at 12 months. Exercise group	"The findings of this study suggest that similar results are likely using either an individual treatment or a group exercise approach, with up to 78% of participants	Baseline differences may have favored individual treatment group. Number and heterogeneity of interventions limits ability to draw conclusions on efficacy of any single intervention.

			mobilization sessions over 8-week period.	"40% more cost effective" than individual treatments.	expressing improvement, 12-months after the conclusion of the intervention."	
Cecchi 2010 RCT Supported by current research funds from Fondazione Do Gnocchi Foundation, Scientific Institute. No COI mentioned.	6.0	N = 210 with non-specific LBP	Back school for 15 one hour sessions (n = 70) vs. individual physiotherapy for 15 one hour sessions (n = 70) vs. spinal manipulation (n = 70) 4-6 (as needed) weekly sessions of 20 minutes for 4-6 weeks. Follow up at discharge, 3, 6 and 12 months.	Mean ± SD Roland Morris Disability Score at discharge/3, 6, 12 months for back school vs. individual physiotherapy vs. spinal manipulation: 5.9±4.8/ 5.3±4.7/5.4±4.7/5.3±4.6 vs. 5.3±5.2/5.4±4.7/5.8±5.0/5.7± 5.0 vs. 1.6±2.6/2.2±3.3/2.7± 3.4/2.5±3.6, difference across groups at discharge p <0.001, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001; back school vs. spinal manipulation: discharge p <0.001, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001; individual physiotherapy vs. spinal manipulation: discharge p <0.001, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001. Mean ± SD pain rating scale score at discharge/3, 6, 12 months for back school vs. individual physiotherapy vs. spinal manipulation: 1.0±0.8/ 1.4±1.2/1.4±1.0/1.3±0.9 vs. 0.9 ±0.8/1.5±1.2/1.4±1.1/1.6±0.9 vs. 1.2±1.2/0.5±0.7/0.8±0.7/ 0.7±0.8, difference across groups: discharge p = 0.401, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001; back school vs. spinal manipulation: discharge p = 0.747, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001; individual therapy vs. spinal mobilization: discharge p = 0.259, 3 months p <0.001, 6 months p <0.001, 12 months p <0.001.	"Spinal manipulation provided better short and long-term functional improvement, and more pain relief in the follow-up than either back school or individual physiotherapy."	Study design unclear as aspects may be retrospective analysis of RCT. 1 year follow up. Baseline difference in working (36 vs. 44 vs. 57%) outcome measures not provided at baseline. Results interpretation assumes no differences and suggests manipulation superior.

McMorland 2010 RCT Supported by grant from Foundation for Chiropractic Education and Research. No mention of COI.	6.0	N = 40 with sciatica secondary to lumbar disk herniation (LDH) having radicular symptoms >3 months	Spinal manipulative therapy (n = 20) vs. micro-diskectomy (n = 20); 2-3 treatments per week for first 4 weeks, reduced to 1-2 visits per week for next 3 to 4 weeks.	Both groups improved in quality of life and McGill Pain scores (time x treatment) was not significantly different between groups. After 12 weeks of manipulation, patients could crossover to surgery.	"Most of the patients who were considered surgical candidates for the treatment of radiculopathy from LDH improved with standardized spinal manipulative care to the same degree as those who had undergone surgery."	Pilot study. No placebo or other control. Trend in less employment and greater chronicity in surgery group. Long delay to surgery (6-8 weeks).
Schneider 2015 RCT Sponsored by grant from National Institutes of Health, National Center for Complementary and Alternative Medicine (NIH/NCCAM). COI, consultancy, expert testimony, grants, payment for lecture, royalties, payment for development of educational presentations.	5.5	N = 112 with new LBP episode within previous 3 months for <3 months without chiropractic, medical or physical therapy treatment for current episode. Mean age 41.1±14.3 years.	Manual-thrust manipulation (MTM) high-velocity, low-amplitude thrust manipulation side posture position twice a week for 4 weeks (n = 37) vs. mechanical-assisted manipulation (MAM) prone position using the Activator IV Instrument twice a week for 4 weeks (N=35) vs. usual medical care (UMC) education, OTC analgesics and NSAIDs, given advise to stay active, 3 office visits over 4 weeks (n = 35). Study duration: 4 weeks. Follow-up for 6 months.	Group differences Oswestry LBP Disability Index (disability) at 4 weeks, mean, 95% CI: MTM vs. MAM -8.1, -14.0 to -2.1 ($p<0.05$); MTM vs. UMC -6.5, -12.5 to -0.6 ($p <0.05$). NS between groups at 3 and 6 months. Group differences pain at 4 weeks, mean, 95% CI: MTM vs. MAM -1.4, -2.2 to -0.5 ($p <0.05$); MTM vs. UMC -1.7, -2.5 to -0.8 ($p <0.05$). NS between groups at 3 and 6 months.	"MTM led to greater short-term reductions in self-reported pain and disability than MAM or UMC. These changes were both statistically significant and clinically meaningful."	Usual care not structured and not reported. Manual and mechanical could take as much ibuprofen and not tracked. Data suggest modest superiority of MTM vs. MAM or usual care at 4 weeks, but not longer term.
Glover 1974 RCT Supported by a grant from the Nuffield Foundation. No mention of COI.	5.5	N = 84 with largely acute LBP; neurological signs excluded	Rotational manipulation of trunk for 15 minutes (n = 43) vs. sham diathermy for 15 minutes, follow-up for at least 1 month (n = 41).	No demonstrable difference between two groups.	"It is puzzling to understand why both the untreated and treated groups started to improve immediately after entry to the trial, no matter whether their back pain had lasted for 15 minutes or one month."	Short follow-up period. No true control group. Data suggest lack of efficacy.
Rasmussen 2008 RCT No mention of COI or industry sponsorship.	5.5	N = 72 with LBP lasting longer than 3 months	Extension exercises with manipulation (n = 35) vs. no manipulation (n = 37).	No difference between VAS pain scores at baseline, 4 weeks, and on year follow-up. No significant difference in any pain scores for back or leg pain scores ($p >0.05$).	"In our group of patients with chronic LBP a specific manipulation had no effect per se on pain or mobility during an	Success of attempted blinding not noted. Some baseline differences suggest controls more severe cases. Data suggest no differences in pain ratings.

					observation period of one year."	
Learman 2009 RCT No mention of COI or industry sponsorship.	5.5	N = 33 with at least 1 episode of LBP lasting >3 months in past year or recurrent LBP with 2 significant bouts in past year.	Spinal manipulation therapy (SMT) first (n = 17) vs. sham procedure first (n = 16).	No statistically significant difference between groups for force reproduction (p = 0.791) or direction of movement (p = 0.63).	"The results of this study indicate that there was no consistent effect of SMT on conscious proprioception in this sample."	No discussion whether sham successful. No pain at baseline limits applicability to theory. Crossover trial.
Paatelma 2008 RCT No mention of COI or industry sponsorship.	5.5	N = 134 with non-specific LBP with or without radiating pain in one or both lower legs	Orthopedic manual therapy: 2-3 sets of 15-20 repetitions for each exercise, and lumbar stabilization exercises with 10 repetitions of 10 seconds, and stretching exercises performed once a day for 45-60 seconds (n = 45) vs. McKenzie Method: 10-15 reps every 1-2 hours with or without a sustained end-range position on a regular basis according to symptom response (n = 42) vs. advice only who received 45-60 minutes counselling from physiotherapist concerning good prognosis for LBP (n = 37). Treatments at 3, 6, and 12 month visits.	No difference between OMT and McKenzie group in leg pain, LBP, and Roland-Morris, except at 6-month follow-up (p <0.05). Advice-only had 11 dropouts.	"[S]ome improvements appeared in all the groups in leg and LBP and in disability. The OMT and McKenzie groups showed no consistent treatment effect at different follow-up points compared with advice-only group…"	Acute or chronic LBP. Radiating pain below knee.
Jayson 1981 RCT Supported by Department of Health and Social Security. No COI mentioned.	5.0	N = 188 with acute, subacute, and chronic LBP, a minority of whom had pain below knee	Mobilization and manipulation, Maitland techniques (n = 94) vs. placebo physiotherapy for 1 month, daily for first week and then 3 times a week for next 3 weeks (lowest possible setting of microwave radiation for 15 minutes) (n = 94).	No differences in outcomes at 1 year.	"[T]he results suggest that most sufferers from nonspecific back pain obtain relief without mobilization and manipulation. However, this form of treatment may hasten improvement, particularly in patients with the shorter length	Study compared groups of patients (hospital vs. GP) rather than manipulation vs. placebo. Mixture of LBP patients and lack of blinding are study weaknesses.

					of history of symptoms. However, it makes no difference to the long-term prognosis."	
MacDonald 1990 RCT Support provided by Osteopathic Trust Ltd. No COI mentioned.	5.0	N = 100 with non-specific acute LBP of 14 to 28 days	Osteopathic manipulation 2x a week until patients deemed themselves recovered or manipulator decided further treatment would not produce any benefit (OMT, n = 50) vs. control (n = 50). All received advice. Weekly for 3 weeks after trial entry, then weekly until recovered or 3 months if unrecovered.	Both groups responded well over time. No significant differences between groups for recovery rate.	"Even with the small numbers appropriate to a pilot trial, we have confirmed a significant benefit from manipulation to one identifiable group of back pain patients."	Rare quality study of osteopathic manipulation. Data do not clearly support the intervention.
Sims-Williams 1978 RCT Supported by a grant from the Department of Health and Social Security (DHSS). No mention of COI.	5.0	N = 94 with LBP; excluded those with loss of reflex, muscle weakness, or sensory abnormalities	Individualized mobilization and manipulation including traction, Maitland vs. placebo physiotherapy (microwave therapy at lowest possible setting for 15 minutes). Treatments daily for 1 week and 3 times a week for 3 weeks.	At 1 month, more of those in the active treatment group were able to perform at least light work (p value not provided). At 1 year, groups were identical.	"A course of mobilization and manipulation may hasten improvement but does not affect the long-term prognosis."	A follow-up report concluded that no definite advantage could be associated with mobilization and manipulation. Authors found high rate of spontaneous resolution of LBP.
Sims-Williams 1979	5.0	See Sims-Williams 1978				
Doran 1975 RCT No mention of COI or industry sponsorship.	5.0	N = 456 with acute, subacute, or chronic LBP	Manipulation (individualized 2 times a week, n = 98) vs. physiotherapy (individualized 2 times a week, n = 104) vs. corset (not standardized, n = 93) vs. Paracetamol (2 tablets every 4 hours, n = 100) for 3 weeks.	Percentage of patients who reported improvement or complete relief: 74%, 65%, 83%, and 76%. Never any important differences among 4 patient groups.	"[N]one of the methods of treating low back pain compared in this trial showed any great superiority. Patients treated with analgesics alone fared marginally worse than those on the other three treatments."	Study not well described. Study included many interventions that were not well standardized.
Wreje 1992 RCT No mention of COI or industry sponsorship.	5.0	N = 46 with LBP felt to be from pelvic joint dysfunction	Muscle energy technique (symphysis and SI joints) and segmental mobilization of SI joints (n = 18) vs. placebo treatment of manual transverse frictions on gluteus medius muscles for 3 minutes, with follow-up after 3 weeks (n = 21).	More use of paracetamol in control group (median 0 vs. 3.5, $p < 0.05$). Median duration of sick leave 7 vs. 14 days, $p < 0.05$. But, no difference in pain ratings. No differences between groups for Patrick's test.	"[M]anual treatment methods of this type can be used in a primary care setting, where the treatment can reach the patient at an early stage."	Does not include a true placebo group. Two possible conclusions are equal efficacy and treatments are equally ineffective.

Koes Br Med J 1992 RCT Supported by a grant by Dutch Ministry of Welfare, Health and Cultural Affairs and by the Dutch National Health Insurance Council. No mention of COI.	5.0	N = 256 with subacute and chronic LBP ≥6 weeks; herniated discs excluded	Manual therapy, manipulation and mobilization, Dutch Society for Manual Therapy (n = 65) vs. physiotherapy, exercises, massage, heat, electro-therapy, ultrasound, diathermy (n = 66) vs. placebo therapy, (physical exam, placebo ultrasound and placebo diathermy) (n = 64) vs. GP, analgesics, NSAIDs, advice about posture, home exercises, participation in sports, bedrest, etc.) for 3 months (n = 61).	Manipulative group showed better results in physical functioning when compared to physiotherapy group at 12 month follow-up 0.9 (95% CI 0.1-1.7). Manipulative group had largest improvement at 12 month follow-up (4.5 SD 2.2).	"Manipulative therapy and physiotherapy are better than general practitioner and placebo treatment. Furthermore, manipulative therapy is slightly better than physiotherapy after 12 months."	Study details not well described. General practice arm in particular may include suboptimal management.
Ljunggren 1997 RCT Supported by Skedsmokorset Fysikalske Institutt, SA, rlandet Fysikalske Institutt, Voldgata Fysiotherapinsenter, and Fjellgata Fysioterapisenter. No COI mentioned.	5.0	N = 153 with history of back problems (inclusion criteria non-specific-back problems of undefined duration, severity, or diagnosis)	Conventional physiotherapy exercise program (n = 64) vs. exercise on machine (TerapiMaster, n = 62); 8 follow-up appointments to encourage compliance. Home exercises for 15 to 30 minutes, 3 times a week encouraged.	No significant differences between groups according to absenteeism at any time.	"Both exercise programs reduced absenteeism (61.6 to 15.4 days vs. 82.5 to 17.2 days) and there were no discernible differences in the effects of the two programs."	Baseline differences and effects difficult to predict (TerapiMaster absenteeism days 61.6±14.7 vs. 82.5±19.8; prior back episodes with absenteeism 84% vs. 69%). Compared conventional stretching/strengthening with commercial apparatus. No control group and non-specific nature of pain in study group limits conclusions. Data suggest no differences.
Hondras 2009 RCT No mention of COI.	5.0	N = 240 without significant co-morbidities eligible for study if at least age 55, presented with non-specific LBP at least 4 weeks duration, and met diagnostic classificatio	Participants received 6 weeks of care including 12 visits of high-velocity, low-amplitude (HVLA)-SM (n = 94) vs. low-velocity, variable-amplitude (LVVA)-SM (n = 91) vs. 3 visits of minimal conservative medical care (MCMC) (n = 40).	Adjusted mean Roland Morris Disability change scores (95% confidence intervals) from baseline to end of active care were 2.9 (2.2, 3.6) and 2.7 (2.0, 3.3) in the LVVA-SM and HVLA-SM groups, respectively, and 1.6 (0.5, 2.8) in MCMC group. No significant differences between LVVA-SM and HVLA-SM at any of end points. LVVA-SM group had significant improvements in mean functional status ranging	"We believe this is the first trial examining different types of SM for LBP patients older than 55 years. There were no significant differences in outcomes between 2 biomechanically distinct forms of spinal manipulation; both manipulative procedures were associated with clinically important changes in functional status by the end of treatment, and there were no serious adverse events associated with any of the interventions. On the whole, these results are in line with many recent trials, reviews, and guidelines that have examined SM for LBP where	Some baseline differences. Low compliance and follow-up in medical management. Medical treatment does not reflect current standard of practice. Medical treatment delivery was paracetamol then NSAID then muscle relaxants. Treatment contact bias. Non-treatment control and wait-list control bias likely biases results.

		n of 1 (pain without radiation), 2 (pain plus radiation to extremity, proximally), or 3 (pain plus radiation to extremity, distally) according to Quebec Task Force on Spinal Disorders.		from 1.3-2.2 points over MCMC group. No serious adverse events associated with any of interventions.	SM appears to confer a mild treatment effect advantage when compared to other available therapies. Because participants attending a research clinic at a chiropractic college campus may have different expectations about receiving chiropractic care and be less likely to comply with medical care alone, future studies should be conducted in multi- and interdisciplinary healthcare settings and examine integrated models of care for older patients with and without significant comorbid conditions."	
Hurwitz 2002 RCT Supported by grants from Health Resources and Services Administration and from National Center for Complementary and Alternative Medicine. No mention of COI.	5.0	N = 681 with LBP, WC excluded	1) Chiropractic care with physical modalities (DCPm) (n = 172); 2) chiropractic care without physical modalities (DC) (n = 169); 3) medical care with PT (MDPt) (n = 170); or 4) medical care without PT (MD) (n = 170). Medical care group had instruction in back care, strengthening, flexibility, weight loss, physical activities; other treatments were pain killers, muscle relaxants, NSAIDs, other medications, bed rest. Chiropractic care included spinal manipulation or other spinal adjusting technique (e.g., mobilization), strengthening, flexibility, proper back care. Medical care with PT with medical care plus heat and cold therapy, ultrasound, electrical muscle stimulation, soft tissue and joint mobilization, traction, supervised therapeutic exercise, strengthening and	Six-month follow-up with improvements in all categories, with similar results for medical and chiropractic groups and slightly better pain in physical therapy groups. Those performing more physical activity (as measured by assigning METS to questionnaire responses) had less back disability. Borderline results with less psychological distress (no test for trend). Risks for severe pain not significant, though psychological distress and average pain trended lower across categories of METS. Results for performance of back exercises more difficult to interpret. Risks for subsequent severe LBP higher among those performing back exercises, but risks for subsequent psychological distress borderline lower.	"Differences in outcomes between medical and chiropractic care without physical therapy or modalities are not clinically meaningful, although chiropractic may result in a greater likelihood of perceived improvement, perhaps reflecting satisfaction or lack of blinding. Physical therapy may be more effective than medical care alone for some patients, while physical modalities appear to have no benefit in chiropractic care."	Lack of control for numerous co-interventions which limits the conclusions about any one intervention. Report at 18 months found "differences in outcomes between medical and chiropractic care without physical therapy or modalities are not clinically meaningful…" Also noted that "physical therapy may be more effective than medical care alone for some patients, while physical modalities appear to have no benefit in chiropractic care."

			flexibility exercise. Chiropractic plus physical modalities included heat or cold, ultrasound, electrical muscle stimulation. Follow-up at 6 and 18 months.			
Hurwitz 2005 Study supported by grants from Agency for Healthcare Research and Quality and Southern California University of Health Sciences. Hurwity supported by grant from National Center for Complementary and Alternative Medicine.	5.0	See Hurwitz Spine 2002				
Hurwitz 2006 Study supported by grants from Agency for Healthcare Research and Quality and Southern California University of Health Sciences. Hurwity supported by grant from National Center for Complementary and Alternative Medicine.	5.0	See Hurwitz Spine 2002				
Triano 1995 RCT Supported in part by restricted grants from Lincoln College Education and Research fund, The Foundation for Chiropractic Education and Research, and foundation for Advancement of Chiropractic Education. No mention of COI.	4.5	N = 209 with chronic LBP (>50 days duration or at least 6 episodes in the prior year)	Chiropractic adjustments (high-velocity, low-amplitude spinal manipulation) vs. sham adjustments (high-velocity, low-force mimic) vs. a back education program (no exercises) for 2 weeks of treatment 6 days a week and follow-up 2 weeks after treatment. Dropped 25 more subjects from analyses.	Oswestry scores: chiropractic manipulation 17.5±12.8 to 9.5±6.3 at 2 weeks to 10.6±11.7 at 4 weeks vs. sham 21.7±15.0 to 15.5±10.8 to 14.0±11.7 vs. education: 20.2±13.6 to 12.3±8.4 to 11.4±10.3, p = 0.012 between groups at 2 weeks. VAS scores: DC 38.4±23.4 to 13.9±15.3 at 2 weeks to 13.3±15.9 at 4 weeks vs. sham 37.4±23.7 to 19.8±18.3 to 21.7±24.4 vs. education: 35.6±23.0 to 19.6±17.6 to 15.1±19.4. Zung scores: not significant between groups.	"In human terms, however, there appears to be clinical value to treatment according to a defined plan using manipulation even in low back pain exceeding 7 weeks duration."	Attempted sham, blinded assessor and potentially blinded patient (not assessed). Baseline data comparability between groups not provided. Dropouts 31%. No intermediate/long-term follow-up. Reporting wide varying sample sizes (n = 39 for ODI vs. n = 47 for same group at same time for VAS). At 4 weeks, no difference between manipulation and back education. Data do not support significant manipulation efficacy vs. education. Practicality of daily appointments for 2 weeks dubious in WC setting.

Hadler 1987 RCT Supported by grant 9064 in Research and Development Program to Improve Patient Functional Status of Robert Wood Johnson Foundation. No mention of COI.	4.5	N = 54 with acute LBP (a few had asymmetric reflexes)	Spinal manipulation (n = 26) vs. spinal mobilization without rotational forces and leverage on facet joints (n = 28). Subjects contacted by phone every 3 days for 2 weeks.	With exception of 1st follow-up questionnaire, at which point manipulation favored (p = 0.009), no differences between groups, including on subsequent follow-up.	"A treatment effect of manipulation was demonstrated only in the strata with more prolonged illness at entry."	Data suggest manipulation has limited benefits; however, not particularly well described.
Sanders 1990 RCT Supported in part by grant from Foundation for Chiropractic Education and Research. No mention of COI.	4.5	N = 18 with acute LBP	Manipulation (n = 6) vs. light touch (n = 6) vs. control (n = 6) for 1 treatment. Study evaluated endorphin levels after single spinal manipulation.	Five minutes after treatment, reduction in perceived pain by manipulation group vs. controls and light touch, p = 0.03 but no difference between groups for beta-endorphin change.	"[I]n this experimental group of subjects, the subjective reduction of pain following a single adjustive manipulation at a specific lumbar segment was not mediated by an endorphin-blockade of pain perception and that these manipulations did not stimulate the hypothalamus to the extent of activating detectable humoral β-endorphin responses."	Data appear to note same degree of effect on plasma endorphin levels in control as in experimental group.
Mathews 1988 See also Mathews 1987 RCT Supported by Department of Health and Social Security and Special Trustees of St. Thomas' Hospital. No mention of COI.	4.5	N = 434 with lumbago and sciatica	Manipulation treated on alternate days as required vs. continuous traction 30 minutes each weekday until pain relieved or 3 weeks vs. controls receiving infrared heat with comparable frequency 3 times a week for 2-3 weeks. Patients assessed at least 4 times at 8 days, 2 weeks, and 1, 3, 6, 12 months.	Treated patients had greater improvement compared to controls, p between 0.05 and 0.1. Trial B2: 98 treated patients and 56 controls had recovered, p = 0.05. Trial C: On 8th day, more than twice as many treated patients than control patients recovered, p between 0.05 and 0.1.	"[M]anipulation for patients with low back pain and restriction of movement hastens relief of pain by an amount whose significance compared with controls varies with the group studied. The traction trial also shows that treatment hastens recovery by an amount of borderline statistical significance compared with controls."	Study methods not well described and included individualization of treatments which limit conclusions. Study population does not clearly distinguish clinical sciatica, rather may be suggestive of thigh pain.
Mathews 1987 RCT Supported by Department of Health and Social Security and Special Trustees of St. Thomas' Hospital. No mention of COI.	4.0	N = 895 back pain and sciatica, and sclerosant patients for local tenderness	Manipulation up to 2 weeks daily (n = 58, Trial B1, Trial B2, n = 233) vs. Traction: 1 session QD of at least 45kg for 30 minutes (n = 143, Trial C) vs. epidural injection 20ml 0.125% plain bupivacaine and 2ml methyl-prednisolone acetate Q14 days up to 3 times (n = 57, Trial D) vs. sclerosant	At 1 month, 67% of epidural vs. 56% controls had recovered. At 3 months, data favored epidural injections. No differences at 1 year for further pain. Trial A: no differences between groups. Trial BI: no differences between groups. Trial B2: treatment group recovered better (80%) vs. controls (67%), p <0.05. Trial C: no between-group differences.	"It might be supposed that mechanical or injection forms of treatment involve a hazard of unwanted side-effects which could detract from the value of short-term pain relief. None was seen."	Traction patients more likely to require surgery. Study population does not clearly distinguish clinical sciatica; rather it may include those with thigh pain. Five multiple trials. Substantially unequal groups occurred for unclear reasons. Sparse details for any one trial thus of limited use for evidence-based medicine.

			injection (n = 22, Trial A) of phenol 2.5%, dextrose 25%, and glycerine 30% in distilled water 3 times at 2 week intervals.	Trial D: at 3 months, treated group more pain free, p <0.05.		
Coxhead 1981 RCT Supported by a grant from Department of Health. No mention of COI.	4.0	N = 322 outpatients with pain of sciatic at least as far as buttock crease with or without back pain	Traction with motor-driven "Tru-Trac" apparatus giving traction at pre-set forces and time intervals vs. exercises for all ROM and muscle groups vs. manipulation vs. corset for 4 weeks; 16 treatment groups.	At 4 weeks, mean improvement scores were: traction 50.1, manipulation 52.6, exercises 49.0, and corset 49.8. Authors concluded no beneficial effects of treatment detectable at 4 or 16 months. At 4 weeks, pain scores improved greater in the manipulation group, p <0.05.	"There were no beneficial effects of treatment detectable at four or sixteen months. In the short-term, active physiotherapy with several treatments appears to be of value in the outpatient management of patients with sciatic symptoms, but it does not seem to confer any longer-term benefit."	Entry criteria included those with pain "at least as far as the buttock crease," thus diagnosis of sciatica appears to not follow typical medical practice and the breakdown between LBP and true sciatica patients is unclear.
Farrell 1982 RCT Supported by Western Australian Institute of Technology and Spinal Pain Research Foundation of Western Australian Manipulative Therapy Association. No mention of COI.	4.0	N = 48 with acute LBP	Passive mobilization and manipulation (Group XE, n = 24) vs. diathermy (15 minutes), isometric abdominal exercises (10 reps), ergonomic instructions (Group YC, n = 24) 3 times a week up to 3 weeks.	Average number of treatments to become symptom free favored experimental group: 3.5±1.6 vs. 5.8±2.3 (p <0.001). Passive mobilization and manipulation had larger range of lumbar extension movements on final day, p <0.05.	"The major conclusion from our study was that the duration of low back pain symptoms was significantly less for patients who received an alternative conservative treatment."	An analysis of presented data also suggests that there were no differences in pain ratings over time.
Pope 1994 Supported by Foundation for Chiropractic Research and Education. No mention of COI.	4.0	N = 164 with subacute LBP	A trial of manipulation, TMS, massage and corsets.	Manipulation group scored greatest improvements in flexion and pain.	"None of the changes in physical outcome measures (range of motion, fatigue, strength or pain) were significantly different between any of the groups."	Heterogeneous mixture of interventions.

MANIPULATION UNDER ANESTHESIA (MUA) AND MEDICATION-ASSISTED SPINAL MANIPULATION (MASM)

Manipulation under anesthesia (MUA) and medication-assisted spinal manipulation (MASM) involves the administration of anesthesia or medication followed by manipulation of the spine with the intended effect of relieving LBP.(1406-1411) Proponents believe this method of manipulation is superior to manipulation without anesthesia due to factors including the reduction in resistance to movement that occurs after the administration of the anesthetic. However, such reductions in resistance may increase the likelihood of injuries to the patient.(1412)

Recommendation: MUA and MASM for Treatment of Acute, Subacute, or Chronic Low Back Pain
MUA and MASM are not recommended for treatment of acute, subacute, or chronic low back pain.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation
MUA and MASM have been evaluated in chronic LBP patients in one RCT; however, that study used a complex mixture of interventions and changed multiple interventions between the two groups.(1413) Thus, there is no quality study reported comparing these with either a non-interventional control or other conservative treatment. There are also no quality studies that solely evaluate MUA or MASM. MUA/MASM is high cost, is invasive when combined with injections, and has the potential for significant adverse effects (e.g., herniations, fracture)(1414) although no reports of complications with the use of more modern osteopathic and chiropractic techniques as the result of anesthesia or subsequent to 1986 were found.(1415)

Evidence for the Use of MUA and MASM
There is 1 moderate-quality RCT incorporated into this analysis.(1413)

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates. The following search terms were used: "(manipulation under anesthesia OR medication assisted spinal manipulation) AND (low back pain OR chronic low back pain)" to find 15,391 articles. Of those 15,391 articles, we reviewed 9 articles, included 7 articles (4 RCTs and 3 reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Ongley 1987 RCT No mention of COI or industry sponsorship.	7.5	N = 81 with chronic LBP, mean duration 10 years	Experimental group (n = 40): dextrose 25%, glycerine 25%, phenol 2.5%, and pyrogen-free water to 100% and diluted in 0.5% plain lignocaine hydrochloride plus forceful manipulation vs. placebo (n = 41): 0.9% saline plus non-forceful manipulation. Each group received 6 injections of 20ml of same solution weekly. Both groups instructed in specific series of flexion exercises. Follow-up at 1, 3, 6 months.	At 6-month follow-up, 15 in experimental group had 0 disability vs. 4 in controls (p <0.003). Disability scores (entry/6 months): placebo (11.82±0.92/8.291.10) vs. experimental (11.45±0.83/3.43± 0.72), p <0.001. VAS pain scores: placebo (3.99±0.19/3.08±0.28) vs. experimental (3.78±0.19/1.50±0.21), p <0.001. Pain (grid): (10.27±1.6/8.24±1.20) vs. (10.1±1.24/3.6± 0.37), p <0.001.	"[T]he experimental regimen is a safe and effective treatment for chronic low back pain."	Treatment groups differed by more than injections. Results cannot be ascribed to one intervention. Discussion section also states prolotherapy group also injected with triamcinolone, although methods section does not note that, thus appears to be another difference between groups.

HOT AND COLD THERAPIES

Cold and heat are believed to have therapeutic benefits to modify the disease processes (e.g., cold to reduce acute inflammation and swelling, and heat to speed healing through increased blood supply).(335, 1416-1418) However, some practitioners believe that these various modalities are all distractants that do not materially alter the clinical course. Others believe the distractants allow increased activity levels, thus even though there may be no direct action of these modalities and the disease processes, this theory supports using these modalities through indirect mechanism(s) of action.

Cryotherapies

Cold or cryotherapies involve applications of cold or cooling devices to the skin, such as towels moistened with cold water, ice wrapped in a blanket, ice massage, cold water and/or ice placed in a "water bottle," gel packs, cooling sprays, or single-use chemical packets that produce cooling on breaking one pouch inside the other to start a chemical reaction.(1419) There also are chemical sprays which produce cooling based on evaporation; however, the administration of these sprays is considerably more expensive. There is considerably less scientific literature focused on this set of therapeutics, and essentially no quality research on moist versus dry cryotherapy.(1420)

Cryotherapy purportedly delays or reduces inflammation.(1416) Application of cold will result in vasoconstriction, though a subsequent vasodilatory response to reassert homeostasis is also likely. Similar to heat therapies, most researchers believe that cryotherapies do not directly result in healing. Rather, the general beliefs are that these may distract the patient from other painful stimuli, thus allowing faster resumption of normal activities or increased tolerance of therapeutic exercises. Despite the lack of evidence for direct healing benefits because of the potential for increased function and earlier recovery, the use of cryotherapies for the patient's benefits may still be worthwhile, particularly as the cost for some of these methods for intervention is essentially nil.

1. *Recommendation: Cryotherapies for Treatment of Acute, Subacute, or Chronic Low Back Pain*
   Self-applications of low-tech cryotherapies are recommended for treatment of acute low back pain. Cryotherapies may be tried for subacute or chronic low back pain, though they may be less beneficial.

   Indications – Moderate to severe acute LBP patients with sufficient symptoms that an NSAID/acetaminophen and progressive graded activity are believed to be insufficient. May be tried as well for subacute or chronic pain, but suggested threshold for discontinuation is lower, particularly as active modalities are generally far preferable to passive modalities for rehabilitation of non-acute LBP.
   Indications for Discontinuation – Non-tolerance, including exacerbation of LBP.
   Benefits – Potential modest reduction in LBP. Self-efficacy, although relying on a passive modality.
   Harms – Cold injuries. Time may be devoted to passive modality instead of active exercises.
   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Routine Use of Cryotherapies for Treatment of Low Back Pain*
   Routine use of cryotherapies in health care provider offices or home use of a high-tech device is not recommended for treatment of low back pain. However, single use of low-tech cryotherapy (ice in a plastic bag) for severe exacerbations is reasonable.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
One trial with scant results suggests ice better than heat or alternating ice-heat for chronic LBP,(1419) thus, precluding strong conclusions. Self-applications of cryotherapies using towels or reusable devices are not invasive, are without complications, and do not have any appreciable costs. These are recommended as potential distractants or counter-irritants. Other forms of cryotherapy can be considerably more expensive, including chemicals or cryotherapeutic applications in clinical settings, and are not recommended.

Evidence for the Use of Cryotherapies
There is 1 moderate-quality RCT incorporated into this analysis.(1419) There is 1 low-quality RCT in Appendix 1.(1421)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: cryotherapies, ice, cold, ice pack, cold pack, and low back pain to find 17,506 articles. Of the 17,506 articles we reviewed one article and included one article.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Roberts 1992 RCT No mention of COI or industry sponsorship.	4.0	N = 36 with chronic LBP	Hot packs (6-8 layers of towels 160° 20 minutes), cold packs 0° (2 layers damp towels 20 minutes), ice massage with light rubbing of back with ice cake (ice massage until numbness vs. ice massage for 10 minutes vs. 1 of each ice massage) for 2 weeks.	VAS scores (pre-/immediate post-treatment/1 hour later): hot packs (12.1/9.34/12.0), cold packs (12.4/10.0/12.0), and ice massage (12.5/6.5/10.2), p >0.0001. Dunnet test showed significant reduction in pain for ice pack vs. hot packs, p >0.01.	"Ice massage was found to be significantly more effective than either hot packs or cold backs for relief of chronic low-back pain."	No long-term results reported. Data suggest ice superior to heat or alternating for chronic LBP. However, many details sparse.

Heat Therapies
There are many forms of heat therapy for treatment of LBP. These include hot packs, moist hot packs, sauna, warm baths, infrared, diathermy, and ultrasound. The depth of penetration of heat is minimal for local convective means, but the other modalities have deeper penetration.(1422) A particular methodological problem with most of these studies is that, despite occasional attempts at and claims of successful blinding, it is essentially impossible to blind the patient from these interventions as they produce noticeable, perceptible tissue warming. Some of these heat-related modalities have been shown to reduce pain ratings more than placebo (see below), it is less clear whether there are meaningful long-term benefits.

Hot Packs, Heat Wraps, and Moist Heat
The application of warmth or heat is frequently divided into dry or moist heat. Moist heat involves the application of a wet towel or other device that brings the warmed water into direct contact with the skin. Dry heat does not involve direct application of water on the skin surface. Thus, a water bottle is still generally classified as dry heat. Hot or heat packs are common household items or commercial products that are heated and then applied to the skin. In the simplest form, a heated towel is used. Heat wraps include devices that produce heat at greater depth than typical convective heat.(1423, 1424) Some chemical products, frequently marked as glove warmers for cold ambient conditions, are also now available that produce warmth. Electrical blankets are another of the more commonly used sources of dry heat.(1425)

Moist heat most commonly involves heating wet towels, soaking a towel in warm water, or using commercial products that are soaked in a warm bath prior to application on the skin surface. Some patients heat moist towels in a microwave oven; however, this is ill-advised as the potential for steam burns is considerable.

1. *Recommendation: Heat Therapy for Treatment of Acute, Subacute, or Chronic Low Back Pain*
   Self-applications of heat therapy, including a heat wrap, are recommended for treatment of acute, subacute, or chronic low back pain. However, use in chronic LBP is suggested to be minimized to flare-ups with the primary emphasis in chronic LBP patients being placed on functional restoration elements including aerobic and strengthening exercises. Application of moist heat by a health care provider in conjunction with an exercise program may have some short-term value in the treatment of acute LBP for a single treatment primarily for demonstrative and educational purposes. However, education regarding home application should be part of the treatment.

   Indications – Acute, subacute, or chronic LBP.
   Frequency/Duration – Self-applications may be periodic or continuous and include different regimens – e.g., 15 to 20 minutes, 3 to 5 times a day. These applications should be home-based as there is no evidence for particular efficacy of provider-based heat treatments.

   Indications for Discontinuation – Intolerance, increased pain, or development of a burn or other adverse event.
   Benefits – Potential modest reduction in LBP. Self-efficacy, although relying on a passive modality.
   Harms – Heat injuries. Time may be devoted to passive modality instead of active exercises.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Application of Heat Therapy by a Health Care Provider for Chronic Low Back Pain*
   Application of heat (such as infrared, moist heat, whirlpool) by a health care provider is not recommended for chronic low back pain as the patient can perform this application independently.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

Rationale for Recommendations
Heat therapy in the form of a commercial heat wrap is studied in a few trials.(839, 1426-1429) Caution should be taken in interpreting these heat wrap studies as their design was suboptimal to determine true efficacy particularly compared with standard care. For example, a low dose of ibuprofen (1,200mg a day) was used as one of the control arms, yet detailed data on efficacy of that arm are not reported. Another study used only education as the control, thus appearing to the patient to be doing nothing and biasing in favor of the heat wrap.(1430) Still, there appears to be some evidence of efficacy. Non-proprietary self-applications of heat therapies are not invasive, have low adverse effects provided excessive heat is not used, and may have no associated costs. Thus, heat therapy is recommended for management of LBP.

Evidence for the Use of Hot Packs, Heat Wraps, and Moist Heat
There are 8 moderate-quality RCTs (one with 2 reports) incorporated into this analysis.(839, 1425-1432) There are 6 low-quality RCTs in Appendix 1.(707, 1433-1437)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: self-applied heat therapy, heat wrap, hot packs, moist heat, heating pad, subacute low back pain, acute low back pain, chronic low back pain low back pain, clinical trial, randomized controlled trial, random, systematic review, population study, epidemiological study, and prospective cohort to find 1,775 articles. Of the 1,775 articles, we reviewed 0 articles and included 0 articles. We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: heat application by a health care provider, heat therapy, heat, infrared, moist heat, whirlpool, heat pack, low back pain and chronic low back pain to find 33,710 articles. Of the 33,710 articles, we reviewed 18 articles and included 18 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Nadler 2002 RCT Corporate/industry funds received to support this work. One or more author(s) received/will receive benefits for personal or professional use from commercial party related directly or indirectly to subject of this manuscript: e.g., royalties, stocks, stock options, decision-making position.	6.0	N = 371 with acute LBP	Low-level heat wrap therapy 40° C, 8 hours a day (n = 113) vs. ibuprofen 1200mg a day (n = 106) vs. acetaminophen 4000mg a day (n = 113) for 2-day period.	Heat wrap pain relief superior Day 1 to acetaminophen (mean 1.32; p = 0.0001) or ibuprofen (mean 1.51; p = 0.0007). Disability reduced with heat wrap (mean, 4.9) vs. ibuprofen (mean, 2.7; p = 0.01) and acetaminophen (mean, 2.9; p = 0.0007), Day 4.	"Continuous low-level heat wrap therapy was superior to both acetaminophen and ibuprofen for treating low back pain."	Heat wrap superior to OTC medications. Selection of submaximal ibuprofen vs. supra-maximal dose of acetaminophen results in inability to conclude regarding prescription strength NSAID.
Lloyd 2004 Study analysis funded by grant from Procter and Gamble Health Sciences Institute. No mention of COI.	6.0	See Nadler 2002.				
Nadler Arch Phys Med Rehabil 2003;84(3):335-42 RCT A commercial party with direct financial interest in results of research supporting article has conferred/ will confer financial benefit upon one or more authors. Petty, Erasala, Hengehold, Weingand employees of Procter & Gamble. Nadler paid consultant for Procter & Gamble.	6.0	N = 76 with non-specific LBP	Heat wrap for 8 hours (n = 33) vs. oral placebo (n = 34) or blinding (unheated wrap, n = 5 or oral ibuprofen 400mg, n = 4) for 3 consecutive nights with 2 days follow-up.	Day 4 reduced muscle stiffness heat wrap (36.3±3.1) vs. placebo (47.9±2.9), p <0.001. Increased Day 4 lateral trunk flexibility heat wrap (20.0±0.9 cm) vs. placebo (17.0±0.8 cm), p <0.002. Mean morning pain relief score after 3 nights heat wrap (2.75±0.250 vs. placebo (1.45±0.23), p = 0.00005. Day 4 disability scores reduced with heat wrap (3.6±0.7) vs. placebo (5.8±0.7), p = 0.005.	"Overnight use of heatwrap therapy provided effective pain relief throughout the next day, reduced muscle stiffness and disability, and improved trunk flexibility."	Randomization, allocation, compliance details sparse. Used OTC ibuprofen dose. Data suggest continuous heat (104˚) applied to low back may provide benefit in short-term pain relief, however, unbalanced control groups limits conclusions.

Nadler Arch Phys Med Rehabil 2003 RCT A commercial party with a direct financial interest in results of the research supporting this article has conferred/will confer a financial benefit upon one or more authors. Erasala, Hengehold, Weingand employees of Procter & Gamble. Nadler paid consultant for Procter & Gamble.	6.0	N = 219 with acute non-specific LBP	Wearable heat wrap for at least 8 hours (n = 95) vs. oral placebo TID (n = 96) (as well as non-heated wrap (n = 16) plus ibuprofen 400mg TID (n = 12) for blinding) for 3 consecutive days with 2 days follow-up.	Greater reduction in pain with heat wrap on Day 1. Mean pain relief days 1-5 greater for heat wrap (15.4% incidence) vs. placebo (6.6% incidence), p = 0.04. Mean muscle stiffness for days 4 and 5 lower for heat wrap (32.2±1.99) vs. placebo (43.1±2.03), p <0.0002.	"Continuous low-level heatwrap therapy was shown to be effective for the treatment of acute nonspecific LBP."	Randomization, allocation, compliance details sparse. Used OTC ibuprofen. Suggests heat may be effective, but weaknesses limit conclusions.
Garra 2010 RCT No mention of COI or industry sponsorship.	6.0	N= 60 all initially given 400mg of ibuprofen	Heat (electrical heating pad, n = 31) between 130˚F and 135.6˚F vs. cold (instant cold pack, n = 29) between 19.9˚F and 34.1˚F. No blinding possible because of nature of intervention. Randomization done using a "computerized random number program using a random allocation procedure." Each group used a 30 minute treatment time.	No differences in VAS pain scores before or after in either group. Mean ± SD decrease in pain scores similar in both groups as well (heat 9±16mm vs. cold 8±10mm, respectively). Although tatistically significant, decrease in pain in both groups did not achieve predefined reduction in pain. Additional analgesia: heat 18⁄31 (58.1%) and cold 12⁄29 (41.4%) (p = 0.24).	"The addition of a 30-minute topical application of a heating pad or cold pack to ibuprofen therapy for the treatment of acute neck or back strain results in a mild yet similar improvement in the pain severity. However, it is possible that pain relief is mainly the result of ibuprofen therapy. Choice of heat or cold therapy should be based on patient and practitioner preferences and availability."	Lack of control group. All patients received ibuprofen 400mg at start of treatment. Single 30 minute application with results measured 30 minutes post treatment. Patients had no significant pain relief in this short follow-up.
Nuhr 2004 RCT Supported by unrestricted study grant of Vienna Red Cross. No COI mentioned.	5.0	N = 100 with acute LBP	Warming with carbon-fiber electric heating blanket (n = 50) vs. passive warming with a woolen blanket (n = 50) during transfer to hospital.	Pain score reductions on arrival after transport: 74.2±8.5 vs. 41.9±18.9, p <0.01. Anxiety scores significantly reduced for active warming (92.7±17.8 to 59.0±14.0) vs. no change in passive warming, p <0.01.	"Active warming reduces acute LBP during rescue transport."	Randomization, allocation, compliance details sparse. Data suggest use of active warming blanket for acute LBP is beneficial. Duration of effect is unknown.
Mayer 2005 RCT Support in whole or in part received from The Procter & Gamble Company, Author	4.5	N = 100 with acute and subacute LBP	Continuous low-level heat wrap therapy 8 hours a day (n = 25) vs. directional preference-based exercise individually based (n = 25) vs. heat wrap therapy and exercise (n = 24) vs. educational booklet about	At 2 days, functional improvement for heat and exercise 84%, 95%, and 175% greater than heat wrap, exercise, and an educational booklet, respectively. Functional improvement at Day 7 higher for heat plus exercise vs. booklet, p =	"Combining continuous low-level heat wrap therapy with directional preference-based exercise was found to significantly improve functional outcomes compared with either	Allocation unclear, no blinding, no control for co-interventions. Data suggest benefit from combination of heat therapy and preference-based exercises for acute and subacute LBP.

GNE acknowledges financial relationship (employee of The Procter & Gamble Co.)			low back problems (control, n = 26) for 5 consecutive days.	0.005. Day 7 disability scores for heat plus exercise greater than heat wrap (p = 0.0267), exercise (p = 0.0066), and booklet (p = 0.0003). Pain relief at Day 7 for heat plus exercise greater vs. exercise (p = 0.007) and booklet (p <0.0001).	intervention alone or control."	
Gale 2006 RCT No mention of COI or industry sponsorship.	4.5	N = 40 with chronic LBP pain of over 6 years duration	Infrared therapy, infrared pain wrap (IR, n = 21) vs. placebo, given wrap without power source connected to circuit board (n = 18). Results measured on weekly basis for 7 weeks.	Mean Numerical Rating Scale (NRS) score in IR group fell 6.9/10 pre-treatment to 3/10 after treatment vs. placebo 7.4/10 pre- vs. 6/10 after. (p <0.0001) IR group also showed progressive decline of about 50% which became greater towards week 7.	"In a double-blind, placebo-controlled trial, the IR wrap has clearly demonstrated that it is easy to use, safe and effective, and reduced chronic back pain by 50% over six weeks."	Methods details sparse. Patients not well described. One paragraph of results also sparse.
Tao 2005 RCT No mention of COI or industry sponsorship.	4.0	N = 43 with work-related acute muscular LBP	Education only: written materials describing LBP (n =18) vs. education with ThermaCare Heat Wrap: heat wrap worn for 3 consecutive days during daytime hours and taken off at end of each day (n = 25) with follow-up at Days 4, 7, and 14.	Pain intensity (day 0/day 14): heat wrap (0.00/-3.85) vs. education (0.0/-2.22), p = 0.0046. Pain relief (Day 0/Day 14): heat wrap (0.00/4.04) vs. education (0.00/2.83), p = 0.0032. Roland Morris Score (Day 0/Day 14): heat wrap (0.00/-6.55) vs. education (0.00/-2.53), p = 0.0026.	"[H]eat wrap therapy using ThermaCare Heat Wrap significantly reduced pain intensity, increased pain relief, and improved disability scores during and after treatment adjusting for sex, age, baseline pain intensity, and pain medications."	Use of only education as comparison likely biased in favor of finding an effect.

DIATHERMY

Diathermy is a type of heat treatment that has been used clinically to heat tissue and has been used to treat low back pain.(1438) There are two forms of diathermy – short wave and microwave. (High-dose diathermy is also used to coagulate tissue.) Proponents of diathermy utilize it to treat a wide range of conditions as they believe it penetrates deeper than hot packs or heating pads and stimulates healing.

Recommendation: Diathermy for Treatment of Low Back Pain

Diathermy is not recommended for treatment of any low back pain-related condition.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendation

Trials suggest a lack of efficacy of diathermy.(1322, 1387) Multiple other trials have utilized diathermy as a no-effect/low-effect control group or as part of a control group.(1322, 1377, 1387) It also has not been shown to be more effective than placebo diathermy. Diathermy has lack of efficacy, is not invasive, has low adverse effects and is of moderate cost. Therefore, diathermy is not recommended for treatment of LBP. No trial has assessed diathermy in patients with sciatica alone. However, one moderate-quality trial evaluated diathermy and included a comparison with sham diathermy with substantial numbers of patients that could be classified as having sciatica.(1322) No quality evidence of benefit for the treatment of acute, subacute or chronic LBP patients with pain in a lower extremity with diathermy is available. Among acute, subacute, and chronic sciatica patients, diathermy is not recommended.

Evidence for the Use of Diathermy

There are 6 moderate-quality RCTs (one with 4 reports) incorporated into this analysis.(668, 670, 857, 1322, 1377, 1387, 1439-1441) Two studies were primarily designed to evaluate the efficacy of manipulative therapies and utilized diathermy as a control group. There are 5 low-quality RCT in Appendix 1.(1442-1446)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: Diathermy, heat therapy, Electrical induced heat, low back pain, subacute low back pain, chronic low back pain radicular pain syndromes (including 'sciatica'), Spinal stenosis, spinal fractures, sacroiliitis, and spondylolisthesis, to find 68,489 articles. Of the 68,489 articles, we reviewed 14 articles, and included 13 articles (12 RCTs and 1 Review).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Costa 2009 RCT Funded by Research & Development grant from The University of Sydney and by Physiotherapy Research Foundation–Australian Physiotherapy Association. Dr. Costa's PhD supported by CAPES – Ministe´rio da Educacao–Brazil and Pontifi´cia Universidade Cato´ lica de Minas Gerais–Brazil; Drs. Maher, Hodges, and Herbert hold research fellowships funded by National Health and Medical Research, Council of Australia, but no mention of COI.	7.5	N = 154 with chronic LBP for >12 weeks duration	Active intervention, with motor control exercises in two stages: 1) motor coordination retraining multifidus and transversus abdominis; 2) increment of exercise by functional tasks and exercise targeting coordination of trunk and limb muscles, for 12 sessions over 8 week period (n = 77) vs. placebo, consisting in 20 minutes of detuned short-wave diathermy, and 5 minutes of detuned ultrasound for 12 sessions over 8 weeks (n = 77).	At 2 months, exercise improved activity by mean 1.1 (95% CI = 1.8 to 0.3). No clear effect of exercise on pain intensity at 2 months (-0.9 points, 95% C I= 1.8 to 0.0, p = 0.053), yet differed at 12 months (-1.0 points, 95% CI= -1.9 to -0.1, p = 0.030). Intervention group (88%) vs. placebo (98%) had persistent or recurrent pain (95% CI = 1% TO 19%).	"Motor control exercise produced short-term improvements in global impression of recovery and activity, but not pain, for people with chronic low back pain. Most of the effects observed in the short term were maintained at the 6- and 12-month follow-ups."	Some baseline differences with exercise group tending to be less active. Data suggest exercise superior to detuned ultrasound and short wave diathermy.
Sweetman 1993 RCT Study financed by Arthritis and Rheumatism Council.	6.0	N = 400 with localized LBP or pain down a leg (50% having pain in knee or lower)	Extension exercises: leg raises, arm raises, bridging, head and shoulder raises (n = 100) vs. diathermy TID for 20 minutes (n =100) vs. traction: constant pull for 10 minutes (n = 100) vs. control sham diathermy (n = 100).	No significant differences between groups.	"[A] randomized trial of different forms of physiotherapy showed no obvious differences between the treatment and control groups."	Control was sham diathermy. No control for co-interventions detailed; 25% withdrew. Data suggest no differences in treatment groups, but conclusions limited by study weaknesses.
Glover 1974 RCT Trial part of back pain project supported by grant from Nuffield Foundation. No mention of COI.	5.5	N = 84 with largely acute LBP; neurological signs excluded	Rotational manipulation of trunk for 15 minutes (n = 43) vs. sham diathermy for 15 minutes, follow-up for at least 1 month (n = 41).	No demonstrable difference between two groups.	"It is puzzling to understand why both the untreated and treated groups started to improve immediately after entry to the trial, no matter whether their back pain had lasted for 15 minutes or one month."	Short follow-up period. No true control group.

Koes Spine 1992 RCT Supported by grants from Dutch Ministry of Welfare, Health and Cultural Affairs and Dutch National Health Insurance Council. No mention of COI.	5.0	N = 256 with subacute and chronic LBP (≥6 weeks duration); herniated discs excluded	Manual therapy (n = 65) (manipulation and mobilization, Dutch Society for Manual Therapy) vs. physiotherapy (n = 66) (exercises, massage, heat, electrotherapy, ultrasound, diathermy) vs. placebo therapy (n = 64) (physical exam, placebo ultrasound, placebo diathermy) vs. general practice (n = 61) (analgesics, NSAIDs, posture advice, home exercises, participation in sports, bedrest, etc.) for 3 months.	Manipulative group showed better results in physical functioning compared to physiotherapy group at 12 month follow-up, 0.9 (95% CI 0.1-1.7). Manipulative group had largest improvement at 12 month follow-up (4.5 SD 2.2).	"Manipulative therapy and physiotherapy are better than general practitioner and placebo treatment. Furthermore, manipulative therapy is slightly better than physiotherapy after 12 months."	Value of this type of trial diminished today when therapies may have been heavily relied upon that have been subsequently shown to be ineffective. The heterogeneous nature of these largely unstructured interventions prevents strong conclusions regarding efficacy of any given intervention, including manipulation compared with other treatments.
Koes J Man Physiol Ther 1992	5.0	See Koes Spine 1992.				
Koes BMJ 1992 Study funded by Dutch Ministry of Welfare, Health, and Cultural Affairs and Dutch National Health Insurance Council. No mention of COI.	5.0	See Koes Spine 1992.				
Koes 1993 Supported by grant from Dutch Ministry of Welfare, Public Health, and Cultural Affairs and Dutch National Health Insurance Council. No mention of COI.	5.0	See Koes Spine 1992.				
Farrell 1982 RCT Supported by David Watkins and Lorna Chan of Western Australian Institute of Technology, Denis Boyd, and Spinal Pain Research Foundation of Western Australian Manipulative Therapy	4.0	N = 48 with acute LBP	Passive mobilization and manipulation (Group XE, n = 24) vs. diathermy (15 minutes), isometric abdominal exercises (10 reps), ergonomic instructions (Group YC, n = 24) 3 times a week up to 3 weeks.	Average number of treatments to become symptom-free favored experimental group: 3.5±1.6 vs. 5.8±2.3 ($p < 0.001$). Passive mobilization and manipulation had larger range of lumbar extension movements on final day, $p < 0.05$.	"The major conclusion from our study was that the duration of low back pain symptoms was significantly less for patients who received an alternative conservative treatment."	Data suggest no differences in pain ratings over time.

Association. No mention of COI.						
Bi 2013 RCT Supported by grants from Science and Technology Development Fund of Shanghai Pudong (PKJ2008-Y39), Program of Shanghai Pudong Subject Chief Scientist (PWRd2010-06), and Science and Technology Development Fund of Shanghai Pudong (PKJ2011-Y05). Authors declared no COI.	4.0	N = 47 with chronic, "nonspecific" low back pain for ≥3 months, yet included with or without radiculopathy. Excluded VAS >8.	Control group treated with ultrasound (1MHz continuous at 1.2 W/cm2 for 5 minutes), short-wave diathermy (continuous mode for 15 minutes) and lumbar strengthening exercises (10 repetitions of prone leg elevation, prone chest elevation and supine bridging) 3 times a week for 24 weeks (n = 24) vs. Intervention group (n = 23) with contraction of pelvic floor muscles for 6 seconds then resting for 6 seconds, resulting in 5 contraction cycles/minute. Number of contractions increased over 24 week treatment period.	Mean±SD on pain severity at baseline and at 24-weeks: 5.22±2.64. and 2.97±2.27 for control group vs. 5.35±3.57 and 2.08±1.63 (p = 0.045). Mean±SD of ODI at baseline and 24-weeks: 31.27±7.85 and 19.57±9.83 in control vs. 32.57±6.25 and 2.08±1.63 for intervention group (p = 0.034).	"[P]elvic floor exercises in combination with routine treatment provide significant benefits in terms of pain relief and disability over routine treatment alone."	Many details sparse. Double blinding implausible. Intervention(s) not well described.

INFRARED THERAPY

Infrared is a heat treatment created by various devices producing electromagnetic radiation in the infrared spectrum.

Recommendation: Infrared Therapy for Treatment of Acute, Subacute, Chronic, Post-operative or Radicular Low Back Pain

There is no recommendation for or against the use of infrared therapy in the home for treatment of acute, subacute, chronic, radicular or post-operative low back pain.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendations

Infrared is of moderate cost, not invasive, and has little potential for adverse effects. It is more expensive than other alternatives such as heat and has not been shown to be superior to less expensive forms of heat therapy. There is limited evidence on which to base a recommendation and available information conflicts. Therefore, there is no recommendation regarding the use of infrared therapy for treatment of low back pain.

Evidence for the Use of Infrared Therapy

There are 5 moderate-quality RCTs incorporated into this analysis.(691, 1325, 1431, 1447, 1448) There are 2 low-quality RCT in Appendix 1.(1294, 1437)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates. We used the following terms: infrared, near-infrared spectroscopies, spectroscopies, near-infrared, NIR spectroscopy, NIR spectroscopies, spectroscopies, NIR, spectrometry near-infrared, near-infrared spectrometries, subacute low back pain, and chronic low back pain. Of the 1,443 articles, we reviewed 1 article and included 1 articles. We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: provider-based infrared therapy, and low back pain to find 35 articles. Of the 35 articles we reviewed one article and included one article.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Glazov 2009 RCT, Double-blind Australian Medical Acupuncture College purchased Acupack research laser and provided funding for study. No COI.	6.5	N = 100 with chronic non-specific LBP for at least 3 months	Laser Acupuncture Group (LAG): Participants treated with an 830nm (infrared), 10mW, Ga-Al-As laser diode (n = 45) vs. Sham Laser Group (SLG): Participants treated with sham laser (n = 45). Follow-up at 6 weeks and 6 months after completion of study.	No significant difference in pain between groups at 6 weeks and 6 months. Significant difference between groups on depression, anxiety, and stress between treatment (LAG: 4.9 vs. SLG: 4.5), at completion (LAG: 3.0 vs. SLG: 3.3), and 6 weeks after treatment (LAG: 2.5 vs. SLG: 3.1, $p < 0.01$, using repeated measures ANOVA).	"[T]here are many more factors than the placebo effect which may have contributed to the positive therapeutic response in both groups. From this study it is not possible to determine their relative contribution. It would also be incorrect to state that the LA intervention is only a placebo."	Details sparse, some baseline differences, errors in statistical differences in table of baseline differences. Data suggest lack of efficacy.
Gale 2006 RCT Industry sponsored (MSCT Infrared Wraps Inc provided supplies). No COI.	5.5	N = 39 with chronic LBP, mean duration 6.5 years	Infrared therapy: IR waist wrap (n = 21) vs. a sham device (n = 18) for 7 weeks.	Active treatment group experienced a 50% pain reduction over 7 weeks vs. 15% in sham group, p <00001.	"[T]he IR wrap has clearly demonstrated that it is easy to use, safe and effective, and reduced chronic back pain by 50% over 6 weeks."	Study reported essentially no baseline descriptive data. Sparse details require replication.
Diab 2012 RCT No mention of COI or industry sponsorship.	5.0	N = 80 with chronic mechanical LBP	Traction group attended sessions 3 times a week for 10 weeks with traction beginning at 3 minutes and increasing by 1 minute per session to 20 minutes (n = 40) vs. comparison group who were told to do a stretching program 3 times a week and infrared radiation for 15 minutes per session (n = 40). Follow-ups were after 10 weeks and at 3 months.	Variation among mean values significantly greater than chance ($p < 0.0001$) for traction and comparison groups and stable at follow-up ($p < 0.05$) in pain, but no differences between groups in pain. Only difference in absolute rotatory angle was for traction group ($p = 0.00$), but this was lost from 10 week to 3 month follow-up ($p = 0.6$). For traction, difference among 3 measurement intervals for all measured levels, but for comparison group, was only seen for L3-L4 and L5-S1 ($p = 0.000$ and 0.005) levels in translational displacement.	"Lumbar extension traction with stretching exercises and infrared radiation was superior to stretching exercises and infrared radiation alone for improving the sagittal lumbar curve, pain, and intervertebral movement in CMLBP."	Assessment of traction as additive treatment, biases in favor of traction. Outcomes not blinded and included ROM, susceptible to data errors. Conclusions on intervention efficacy that was used in both groups unwarranted. Despite design bias in favor of traction, no differences in pain and ODI at 10 weeks suggesting no significant benefit. That later modest differences at 6 months present is not well explained.
Mathews 1988 RCT Supported by grant from Department of Health and Social Security and	4.5	N = 434 with lumbago and sciatica	Manipulation treated on alternate days as required vs. continuous traction 30 minutes each weekday until pain relieved or 3 weeks vs. controls receiving infrared heat with comparable frequency 3 times a week for	Treated patients had greater improvement compared to controls, p between 0.05 and 0.1. Trial B2: 98 treated patients and 56 controls had recovered, $p = 0.05$. Trial C: On the 8th day, more than twice as many treated patients than control patients	"[M]anipulation for patients with low back pain and restriction of movement hastens relief of pain by an amount whose significance compared with controls varies with the group studied. The traction trial also shows that treatment hastens recovery by an	Study methods not well described.

Special Trustees of St Thomas' Hospital.			2-3 weeks. Patients assessed at least 4 times at 8 days, 2 weeks, and 1, 3, 6, 12 months.	recovered, p between 0.05 and 0.1.	amount of borderline statistical significance compared with controls."	
Güvenol 2000 RCT No mention of COI or industry sponsorship.	4.5	N = 29 with lumbar disc herniation and chronic pain	Inverted spinal traction for 5 minutes 1st day, 8 minutes second day, 10 minutes 3rd, onward through 7 days (n = 15) vs. conventional spinal traction for 20 minutes (n = 14) both administered for 10 days and 15 minutes of infrared radiation.	Both groups improved. Decreases in disc protrusion favored conventional traction (69.2% vs. 35.7%, p=0.0185); no significant differences between groups for pain scores.	"[T]here was significant clinical improvement after the treatment in both traction groups and this improvement continued until after follow-up examination. There were no significant differences between efficacies of two different traction techniques clinically."	No descriptions of type of CT findings or blinding procedures. Interpretation could also be that both equally inefficacious.

ULTRASOUND

Ultrasound has been used for treatment of low back pain.(1291, 1449-1452) Ultrasound treatment is achieved using a wand or probe to administer ultrasound waves which are generated by a piezoelectric effect of crystals within the head of the instrument and result in a deep heat, with purported increases in tissue relaxation, improved blood flow, and scar tissue breakdown. Continuous ultrasound at 1.5 to 2 W/cm^2 is capable of heating lumbar periarticular tissue. "The higher intensity ultrasound resulted in greater and faster temperature increase."(1453) Ultrasound waves can be continuous or pulsed; the latter can reduce the heating effect and is commonly used for acute injuries to minimize edema. The head of the ultrasound instrument should be kept in constant motion to minimize discomfort and prevent tissue damage.

Therapeutic ultrasound has more than 60 years of clinical history. It has been frequently used for the treatment of pain, soft-tissue lesions, and a host of musculoskeletal disorders, although it is used more for upper extremity musculoskeletal disorders than for spine-related disorders.(1454)

Recommendation: Ultrasound for Treatment of Low Back Pain

There is no recommendation for or against the use of ultrasound for treatment of low back pain. In situations where deeper heating is desirable, a limited trial of ultrasound is reasonable for treatment of acute low back pain, but only if performed as an adjunct with exercise.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendation

There is one small study,(1455) but no large-size quality studies of ultrasound for the treatment of LBP. Most studies used ultrasound as either part of a group of interventions, as a control or as a sham treatment that also limits the ability to develop guidance. Ultrasound is not invasive, has few adverse effects, but is moderately costly. Therefore, there is no recommendation for or against its use in treatment of LBP.

Evidence for the Use of Ultrasound

There are 1 high-(1456) and 19 moderate-quality RCT incorporated into this analysis.(595, 599, 602, 608, 670, 696, 703, 707, 720, 728, 857, 1067, 1297, 1341, 1353, 1455, 1457-1459) There is 1 low-quality RCT in Appendix 1.(1396)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms Ultrasound therapy, sub-acute low back pain, chronic low back pain to find 73,183 articles. Of the 73,183 articles, we reviewed 6 articles and included 6 articles (5 RCTs and 1 review).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Licciardone 2013 RCT Study funded by grants to J.C.L. from National Institutes of Health–National Center for Complementary and Alternative Medicine (K24-AT002422) and Osteopathic Heritage Foundation. No mention of COI.	8.0	N = 455 adults (age 21-69) non-pregnant individuals with LBP at least 3 months	Osteopathic Manual Treatment (OMT) (n = 230) vs. sham OMT (n = 225) and Ultrasound (UST) (n = 233) or sham UST (n = 222). Allocation of patients to osteopathic manual treatment and ultrasound therapy interventions using 2×2 factorial design.US intervention after OMT intervention. OMT techniques delivered after standard diagnostic evaluation at each treatment session. Lumbosacral, iliac, and pubic regions targeted using high-velocity, low-amplitude thrusts; moderate velocity, moderate-amplitude thrusts; soft tissue stretching, kneading, and pressure; myofascial stretching and release; positional treatment of myofascial tender points; and patient's isometric muscle activation against physician's unyielding, equal counterforce. Sham OMT aimed at same anatomical regions as active OMT.	RMDQ (wk 4/8/12): OMT (4/3/2) vs. Sham OMT (5/3/3). RMDQ US (4/3/3) vs. Sham US (5/4/3). SF36 GH did not differ for either intervention. No interaction between OMT and UST.	"In conclusion, the OMT patients achieved moderate to substantial improvements in low back pain, which met or exceeded the Cochrane Back Review Group criterion for a medium effect size. The OMT patients also reported less frequent concurrent use of prescription drugs. They did not, however, report corresponding improvements in back-specific functioning, general health, or work disability. The OMT regimen was safe, parsimonious, and well accepted by patients as demonstrated by high levels of treatment adherence and satisfaction with back care. By contrast, UST was not efficacious in relieving chronic low back pain."	Did not exclude prior manipulation. Success of blinding unclear. Large quantities and uncontrolled other treatments. Data conflict. Data in tables do not support efficacy of manipulation (e.g., RMDQ). Sparse data in one paragraph suggest efficacy. Tabular data suggest manipulation not effective although associated with satisfaction.
Costa 2009 RCT Funded by Research & Development grant from The University of Sydney and Physiotherapy Research Foundation–Australian Physiotherapy Association. Dr. Costa's PhD supported by CAPES – Ministe´rio da Educacao–Brazil and Pontifi´cia Universidade Cato´ lica de Minas	7.5	N = 154 with chronic LBP of >12 weeks duration	Active intervention, consisting on motor control exercises in 2 stages: 1) motor coordination to retrain multifidus and transversus abdominis; 2) increment of exercise by functional tasks and exercise targeting coordination of trunk and limb muscles, for 12 sessions over an 8 week period (n = 77) vs. placebo, consisting in 20 minutes of detuned short wave diathermy, and 5 minutes of detuned ultrasound for 12 sessions over 8 weeks (n = 77).	At 2 months, exercise improved activity by a mean of 1.1 (95% CI = 1.8 to 0.3). No clear effect of exercise on pain intensity at 2 months (-0.9 points, 95% CI = 1.8 to 0.0, p = 0.053), but at 12 months (-1.0 points, 95% CI = -1.9 to -0.1, p = 0.030). Intervention group (88%) vs. placebo (98%) had persistent or recurrent pain (95% CI = 1% TO 19%).	"Motor control exercise produced short-term improvements in global impression of recovery and activity, but not pain, for people with chronic low back pain. Most of the effects observed in the short term were maintained at the 6- and 12-month follow-ups."	Some baseline differences with exercise group tending to be less active. Data suggest exercise superior to detuned US and short wave diathermy.

Gerais–Brazil; Drs. Maher, Hodges, and Herbert hold research fellowships funded by National Health and Medical Research, Council of Australia. No mention of COI.						
Chan 2011 RCT Supported by Department of Rehabilitation Sciences, Hong Kong Polytechnic University and Department of Physiotherapy, David Trench Rehabilitation Centre. No COI declared.	7.0	N = 46 with CLBP or CLBP in reducing pain and disability	Intervention group received additional aerobic training program for 8 weeks, individually prescribed and supervised by physiotherapist (n = 22) vs. control or conventional physiotherapy (n = 24). Both groups received conventional physiotherapy treatment (ultrasound, heat pack, interferential therapy).	Significant improvements in pain and functional disability reported in both groups, p <0.001. Improvements in disability sustained in both groups at 12 months when compared to baseline, p <0.001.	"The addition of aerobic training to conventional physiotherapy treatment did not enhance either short- or longterm improvement of pain and disability in patients with chronic LBP."	Small sample size. Lack of blinding. Data suggests no added benefit of aerobic exercise to passive modalities.
Goren 2010 RCT No mention of COI or industry sponsorship.	7.0	N = 45 with lumbar spinal stenosis	Ultrasound plus exercise group (Group 1, n = 15) vs. sham ultrasound plus exercise (Group 2, n = 15) vs. no treatment/no exercise group (Control, n = 15). Follow-up at 15 weeks.	VAS back pain (mean±SD) pre-/post-treatment Group 1 vs. Group 2 vs. Group 3: 5.53±1.96/3.33±2.79 (p = 0.015) vs. 6.20±2.60/ 4.26±3.26 (p = 0.018) vs. 5.26±3.36/5.66±2.90 (p = 0.280). VAS leg pain: 5.80± 2.90/4.33±2.99 (p = 0.074) vs. 6.33±3.33/3.86±3.02 (p = 0.027) vs. 6.60±2.80/7.13± 3.04 (p = 0.184), post-treatment p = 0.006, group 1 control p = 0.007, group 2 control p = 0.011; Oswestry Disability index: 25.46±7.70/ 21.50±9.30, (p = 0.041) vs. 26.90±10.19/19.10±8.00 (p = 0.012) vs. 32.20±9.60/28.60 ±9.20 (p = 0.366), post-treatment p = 0.024, group 1 control p = 0.014, group 2 control p = 0.011.	"[O]ur study showed that therapeutic exercise including stretching, strengthening and low-intensity cycling exercise were beneficial with respect to improvement in level of pain and disability in patients with lumbar spinal stenosis. Supplementation of ultrasound with therapeutic exercises is found to reduce the amount of analgesic consumption."	Possible randomization failure, short treatment and follow up time.
Andersson 1999 RCT No mention of COI or industry sponsorship.	7.0	N = 178 with subacute LBP	Manual therapy, osteopathic treatment individualized (n = 83) vs. standard medical therapies: analgesics, anti-inflammatory medication, active PT, or therapies (ultrasonography, diathermy,	NSAID use 54.3% vs. 24.3% (p <0.001). Muscle relaxant use 25.1% vs. 6.3% (p <0.001). Physical therapy use 2.6% vs. 0.2% (p <0.05). VAS pain ratings changed: DO: 49.0±23.6 to 32.0±23.0	"Osteopathic manual care and standard medical care have similar clinical results in patients with subacute low back pain. However, the use of medication is greater with standard care."	Multiple co-interventions. Outcome measures not statistically significantly different, but pain ratings trended towards improvements in osteopathic manual therapy over

			hot or cold packs or both, use of corset, or TENS); 10 minute educational video on back pain for 12 weeks; 4 weekly visits initially then 4 more visits at 2 week intervals (n = 72).	and standard care 45.0±20.6 decreased to 26.3±24.1. Oswestry ratings 25.0±12.2 decreasing to 13.6±13.4 and 23.1±11.8 to 12.9±13.4. No significant differences in pain ratings (p = 0.19) or Oswestry ratings (p = 0.97) over duration of observation.		"standard medical treatment." The standard treatment group does not appear to have standard treatment as would be performed based on a review of the literature.
Blomberg 1992 RCT Study supported by grants from Kopparberg County Council, National Health Insurance Company, The Save Our Backs Association, and The Swedish Association for Orthopaedic Medicine. No mention of COI.	7.0	N = 101 with acute and subacute LBP thought to have herniated disc, but not surgical candidates	Standard care: medication, LBP school, active back exercises, corsets, taping, short wave, ultrasonic wave, TENS, TEMS, heat, cold, postural exercises, plunge-bath training and massage (n = 53) vs. complex manual treatments: Swedish manual therapy; thrust techniques or specific mobilization, muscle stretching, taught muscle stretching exercises, auto-traction, steroid injections (n = 48).	After 8 months, sick leave proportion 2.3 times larger in conventional group vs. treated group, p = 0.015.	"In the early phase as well as at the 90 days follow-up, the group receiving manual therapy had significantly less pain, less disability, a faster rate of recovery, and lower drug consumption, indicating that this type of treatment is superior to conventional treatment."	Due to study design, not possible to determine role of injections, needling, manipulation, mobilization, and traction on outcomes.
Unsgaard-Tøndel 2010 RCT Sponsored by Norwegian Fund for Post-Graduate Training in Physiotherapy. No mention of COI.	6.5	N = 109 with chronic non-specific LBP at least 3 months.	Low-load, individually instructed, ultrasound-guided motor control exercises (MCE group, n = 36) vs. high-load, individually instructed sling exercises (SE, n = 36) vs. general exercises (GE, n = 37). All attended group treatments once a week for 8 weeks. Follow up at 8 weeks and 1 year.	No significant difference between groups.	"This study gave no evidence that 8 treatments with individually instructed motor control exercises or sling exercises were superior to general exercises for chronic low back pain."	Partial assessor blinding. No compliance data for home exercises. Data suggest no significant differences in exercise groups for non-specific chronic LBP. All groups had modest improvement, although baseline pain scores were low to begin with.

Gam 1998 RCT Kebo Care A/S, Denmark provided apparatus and soundhead and technical control of apparatus. No mention of COI or industry sponsorship.	6.0	N = 67 with MTrP in neck and shoulder at least 3 months duration	Ultrasound plus exercise plus massage applied to 5 most tender trigger points; exercises were handouts for at home program focused on strength and mobility of neck and shoulders (Group A, n = 18) vs. sham ultrasound plus exercise plus massage (Group B, n = 22) vs. control group (Group C, n = 18) for 6 weeks.	No significant differences found in analgesic usage and VAS scores at rest and on function between groups.	"[M]assage and exercise reduces the number of intensity of MTrP, but this reduction had little impact on the patients' neck and shoulder complaints."	Compliance with exercise 68% at 6 months. Control group's worse ratings week after randomization and treatment initiation, and higher medication use suggest problem of bias from using wait-listing controls. Baseline differences considerable, controls had longer symptom duration (12 vs. 7.5 months for placebo ultrasound vs. 4 months active ultrasound). Utilization of massage in first 2 groups a co-intervention and somewhat limits conclusions.
Ansari 2006 RCT No mention of COI or industry sponsorship.	5.5	N = 10 with non-radiating chronic LBP >3 months duration	Ultrasound (n = 5) vs. placebo (n = 5) for 10 sessions, 3 times a week.	Functional Rating Index scores ultrasound (pre/after 5 sessions/after 10 sessions: 56.5/45.2/34.5) vs. placebo (47.0/41.6/39.9). ROM during 2nd 5 treatments better with ultrasound vs. placebo, p = 0.016 and 0.032, respectively.	"The present study supports the significant effect of US on LBP, and suggests that US may improve the functional ability of patients with non specific low back pain."	Results support minimal if any significant benefit.
Murtezani 2011 RCT, prospective controlled-trial No mention of sponsorship or COI.	5.5	N = 101 with LBP	Aerobic exercise group began with 10-15 minutes warm-up period stationary bicycling, 3 days/week, 30-45 minutes (n = 50) vs. passive modalities group: interferential current, TENS, ultrasound, heat, involving 3x weekly attendance without any physical activity (n = 51). Follow-up 12 weeks.	Significant improvements in comparison with basic values in pain intensity, disability, anxiety and depression, fingertip-to-floor distance, p <0.001. The p <0.0001, rejects hypothesis of equal equivalence.	"The addition of aerobic training to conventional physiotherapy treatment did not enhance either short- or longterm improvement of pain and disability in patients with chronic LBP."	No blinding described. Lack of details for control of cointerventions, compliance. Data suggests workers with chronic LBP improved in pain and function with aerobic exercise compared to passive modalities.
Doğan 2008 RCT No mention of COI or industry sponsorship.	5.0	N = 60 with chronic LBP exceeding 3 months	Group 1 (n = 20) aerobic exercise for 40-50 minutes 3 times a week for 6 weeks vs. Group 2 (n = 20) physical therapy: hot packs, ultrasound, transcutaneous electrical nerve stimulation 3 times/week for 6 weeks vs. Group 3 (n = 20) home exercise for 6 weeks. Follow-up for 1 month.	Mean±SD VAS (mm) at baseline/post-treatment/1 month follow-up for Group 1 vs. Group 2 vs. Group 3: 57.05±24.5/34.9±30.8/34.1± 27.6 (p = 0.002) vs. 61.2± 20.5/38.9±23.4/28.8±28.1 (p = 0.0001) vs. 56.0±19.9/40.0 ±21.8/33.6±24.3 (p = 0.001). Roland-Morris disability questionnaire: 11.9±5.4/8.9 ±6.8/9.2±7.3 (p = 0.083) vs. 11.9±5.9/8.9±6.0/8.3±5.8 (p	"[T]hree different treatment approaches are found to be effective in decreasing the pain in patients with the chronic low back pain. This study showed that the patients should absolutely be recommended home exercise programs, which is the lowest cost alternative. However, the home exercise program alone did not have any effect on the disability	Possible randomization failure, short treatment and follow up time.

				= 0.011) vs. 13.6±7.4/13.6± 6.6/13.3±7.3 (p = 0.81). General health questionnaire: 15.1±6.8/11.6±7.3/11.7±8.1 (p = 0.027) vs. 14.3±5.9/9.7 ±4.8/8.8±6.06 (p = 0.01) vs. 12.8±7.5/11.5±7.5/12.2±6.6 (p = 0.65). Beck depression inventory: 14.1±9.2/14.2± 10.5/12.7±9.8 (p = 1.79) vs. 12.2±8.7/8.6±7.01/8.5±7.6 (p = 0.044) vs. 12.8±9.2/13.3± 9.8/12.5±8.06 (p = 0.743).	and the psychological state, whereas physical therapy plus home exercise program provides improvement in disability and psychological condition. There is a correlation between the increased fitness level and the decreased pain or vice versa."	
Balthazard 2012 RCT Study financed by DO-RE Funds of Swiss National Science Foundation (13DPD3-109903). No mention of COI.	5.0	N = 42 with chronic non-specific LBP	MT group: Spinal manipulation/mobilization plus active exercises (AE) (n = 22) vs. ST group: Detuned ultrasound plus AE (n = 20). 8 sessions delivered in 4 -8 weeks. Follow-up before treatments, after 8th therapeutic session, and at 3 and 6 months.	MT group greater decrease in mean pain level vs. ST (-0.76 VAS units; 95% CI -1.22 to -0.3). For MT+AE/ST+AE treatment a larger decrease in pain and reduced disability favored in MT over ST (VAS-pain mean group difference: -1.24; 95%; CI: -2.37 to -0.30; p = 0.032) and (ODI mean group difference: -7.14; 95% CI: -12.8 to -1.52; p = 0.013). No other significant effects.	"The present study confirms the immediate analgesic effect of manual therapy for CNSLBP."	Pilot study. Higher baseline VAS in ST (6.5 vs. 5.3). Data suggest manual therapy of additive benefit, however, exercise did not emphasize strengthening and aerobic.
Ebadi 2012 Single blind RCT No COI or industry sponsorship.	5.0	N = 50 with diagnosis of non-specific LBP	Patients received Continuous US plus "semi"supervised exercise for 4 weeks, 10 sessions, 3x a week, QOD (n = 25) vs. Placebo US plus exercise for 4 weeks, 10 sessions, 3x a week, QOD (n = 25).	Both groups had improved regarding function (FRI) and global pain (VAS) (p <0.001). Lumbar ROM and Sorensen holding time test and median frequency slope of all measured paravertebral muscles NS in either group (p >0.05). Improvement in function, lumbar ROM, and endurance time greater with US (p <0.05).	"This single blind, placebo -controlled, randomized clinical trial showed that adding 1 MHz, 1.5 W/cm2 US to a semi-supervised regimen of exercise had significantly beneficial effects on function, lumbar flexion and extension ROM, and endurance time in patients with NSCLBP."	Trend toward longer duration LBP in placebo US (8.1 v. 5.8 years, p = 0.08), may bias in favor of treatment. Multiple other trends in baseline differences especially for health outcome measures concerning for potential randomization failure. High dropouts in placebo US. Weaknesses impair a robust conclusion.
Chatzitheodorou 2007 RCT No mention of COI or industry sponsorship.	5.0	N = 20 with chronic LBP (15 disc disruption, 3 spondylosis, 2 facet joint pain)	12-week, high-intensity aerobic exercise program (n = 10) vs. 12-week passive interventions without any form of physical activity (n = 10). Aerobic exercise treadmill running at 60% of HR maximum 30 minutes 3 times a week 1st 3 weeks, then 85% HR maximum, 50 minutes 3 times a week for 9 weeks	Mean (SD) McGill Pain Questionnaire baseline/12 week for exercise group vs. control group: 53.9 (10.4)/32.3 (7.9) vs. 53.0 (11.7)/53.3 (10.0), p <0.05. Roland-Morris Disability Questionnaire disability: 13.8 (2.4)/9.6 (2.6) vs. 14.4 (2.8)/14.3 (3.6), p <0.05. Hospital anxiety and	"Regular high-intensity aerobic exercise alleviated pain, disability, and psychological strain in subjects with chronic low back pain but did not improve serum cortisol concentrations."	Data suggest reductions in pain with aerobic exercise, disability, and psychological strain, all strongly in favor of high intensity aerobic exercise. Trial also had specific exercise-dose prescription.

			supervised by physiotherapist. Controls received diathermy, ultrasound, laser, difase fixe, and electrotherapy.	depression scale: 24.8 (5.0)/16.2 (3.4) vs. 22.6 (4.1)/21.9 (4.5), p <0.05.		
Koes 1992 RCT Supported by grants from Dutch Ministry of Welfare, Health and Cultural Affairs and Dutch National Health Insurance Council. No mention of COI.	5.0	N = 256 with subacute and chronic LBP (≥6 weeks duration); herniated discs excluded	Manual therapy, n = 65 (manipulation and mobilization, Dutch Society for Manual Therapy) vs. physiotherapy, n = 66 (exercises, massage, heat, electrotherapy, ultrasound, diathermy) vs. placebo therapy, n = 64 (physical exam, placebo ultrasound, placebo diathermy) vs. general practice, n = 61 (analgesics, NSAIDs, posture advice, home exercises, participation in sports, bedrest) for 3 months.	Manipulative group showed better results in physical functioning compared to physiotherapy group at 12 month follow-up, 0.9 (95% CI 0.1-1.7). Manipulative group had largest improvement at 12 month follow-up (4.5 SD 2.2).	"Manipulative therapy and physiotherapy are better than general practitioner and placebo treatment. Furthermore, manipulative therapy is slightly better than physiotherapy after 12 months."	Value of this type of trial diminished today when therapies may have been heavily relied upon that have been subsequently shown to be ineffective. The heterogeneous nature of these largely unstructured interventions prevents strong conclusions regarding efficacy of any given intervention, including manipulation compared with other treatments.
Hurwitz 2002 RCT Supported by grants from Health Resources and Services Administration and National Center for Complementary and Alternative Medicine. No mention of COI.	5.0	N = 681 with LBP, WC excluded	1) chiropractic care with physical modalities (DCPm) (n = 172); 2) chiropractic care without physical modalities (DC) (n = 169); 3) medical care with PT (MDPt) (n = 170); or 4) medical care without PT (MD) (n = 170). Medical care: back care instruction, strengthening, flexibility, weight loss, physical activities; other treatments: pain killers, muscle relaxants, NSAIDs, other meds, bed rest. Chiropractic care: spinal manipulation or other spinal adjusting technique, strengthening, flexibility, proper back care. Medical care PT plus heat/cold therapy, ultrasound, electrical muscle stimulation, soft tissue/joint mobilization, traction, supervised therapeutic exercise, strengthening, flexibility exercise. Chiropractic plus physical modalities: heat or cold, ultrasound, electrical muscle stimulation. Follow-up 6 and 18 months.	Six-month follow-up with improvements in all categories, with similar results for medical and chiropractic groups and slightly better pain in physical therapy groups. Those performing more physical activity (measured by assigning METS to questionnaire responses) had less back disability. Borderline results with less psychological distress (no test for trend). Risks for severe pain not significant, though psychological distress and average pain trended lower across categories of METS. Results for performance of back exercises more difficult to interpret. Risks for subsequent severe LBP higher among those performing back exercises, but risks for subsequent psychological distress borderline lower.	"Differences in outcomes between medical and chiropractic care without physical therapy or modalities are not clinically meaningful, although chiropractic may result in a greater likelihood of perceived improvement, perhaps reflecting satisfaction or lack of blinding. Physical therapy may be more effective than medical care alone for some patients, while physical modalities appear to have no benefit in chiropractic care."	Lack of control for numerous co-interventions which limits the conclusions about any one intervention. Report at 18 months found "differences in outcomes between medical and chiropractic care without physical therapy or modalities are not clinically meaningful…" Also noted that "physical therapy may be more effective than medical care alone for some patients, while physical modalities appear to have no benefit in chiropractic care."

Galiano 2007 RCT No mention of sponsorship or COI.	5.0	N = 40 with chronic LBP >6 months	Ultrasound-guided procedure (n = 20) vs. computed tomography-controlled procedure (n = 20).	Both groups showed significant benefit from facet joint injection (p <0.01) with no differences detected between groups.	"[T]he ultrasound approach to the facet joints is feasible and has minimal risk in the large majority of patients and results in a significant time and radiation does reduction."	Small group. Study suggests ultrasound may be successful for ultrasound-guided facet injections.
Chon 2010 RCT No mention of COI or industry sponsorship.	4.0	N = 40 (22 females, 18 males) young, healthy adults	Experimental Group (n = 20) vs. Control Group (n = 20). Both groups performed ultrasound guided abdominal draw-in maneuver (ADIM) for 30 minutes per day, 5 days per week, over 2-week period. Experimental Group also did ankle dorsiflexion with ADIM.	Significant difference in thickness of Transverse Abdominal (Experimental: 0.86±0.31cm vs. Control: 0.62±0.16cm, p = 0.005). No significant differences between groups in thickness of Internal Oblique or External Oblique.	"This study provides empirical evidence to show that the ADIM combined with ankle dorsiflexion is useful in enhancing muscle activity and associated morphological changes in the TrA muscle. It offers clinical insights into the additive effect of ankle dorsiflexion in selectively stimulating the TrA muscle, and suggests that it may be used as an alternative core stabilisation technique for the management of patients with low back pain."	Lack of study details for baseline comparability, cointerventions, compliance, completion of study, timing of assessment unclear. Data suggest intervention increases thickness of transverse abdominal group. No clinical correlation and thus result is of uncertain significance.
Kumar 2009 RCT No mention of industry sponsorship and no COI.	4.0	N = 102 with nonspecific, sub-acute (6-12 weeks) or chronic (>12 weeks) LBP	Conventional treatment: ultrasound, short wave diathermy, lumbar strengthening exercises (n = 51) vs. dynamic muscular stabilization techniques (n = 51) over 20 days. Patients further stratified by occupational subgroup: sedentary, desk workers, movement job, shop keepers, other. Follow-up 180 days	Pain significantly decreased for all subgroups in both treatment groups (p <0.01 all points). Back pressure changes for physical strength significantly increased for all subgroups in both treatment groups (p <0.01 all points). Anterior pressure change for physical strength significantly increased for all except group 3 in DMST group (p <0.01 all points).	"Study concluded that for the management of occupational LBP, DMST is more effective than conventional treatment. The Pain of Sedentary and Shopkeepers and physical strength of Movement job and Others may need more clinical attention. Findings of this study may be helpful in the management of occupational LBP."	Possible randomization failure.
Borman 2003 RCT No mention of COI or industry sponsorship.	4.0	N = 42 with LBP	Group receiving standard PT (hot pack, ultrasound, active exercise program) with (n = 21) and without traction (n = 21) for 10 sessions in 2 weeks.	No differences in pain ratings or global improvements after therapy or after 3 months; no specific effect of traction on standard PT observed.	"Our results do not provide evidence for the additional effects of traction on traditional physical therapy in patients with persistent, nonspecific LBP."	Randomization, allocation, baseline comparability, compliance, co-intervention details sparse. Data suggest no short- or long-term benefit of traction therapy.

LOW-LEVEL LASER THERAPY

Low-level laser treatment usually involves laser energy that does not induce significant heating. It is theorized that a mechanism of action is through photoactivation of the oxidative chain.(1460)

Recommendation: Low-level Laser Therapy for Treatment of Low Back Pain

Low-level laser therapy is not recommended for treatment of low back pain.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendation

There are different lasers and different treatment regimens. There are multiple trials available. Among the highest quality studies with successful randomization, most indicate a lack of efficacy.(1461-1465) One study suggests this is ineffective for either acute or chronic LBP.(1461) One of the positive studies appears to have significant problems with baseline differences, which seem likely to be significantly responsible for at least some of the subsequent differences found.(1462) Low-level laser therapy is not invasive, not likely to have significant adverse effects, but some of these intensive treatment regimens would be quite costly. Longer term evaluation, utilization of objective measures, and standardization of the treatment regimens is required prior to consideration of a recommendation for utilization in treatments for chronic LBP. There are alternative effective treatments that promote patient independence and autonomy.

Evidence for the Use of Low-level Laser Therapy

There are 3 high-(1462, 1463, 1465) and 5 moderate-quality RCTs(858, 1447, 1461, 1462, 1464, 1466) incorporated into this analysis. There are 2 low-quality RCTs in Appendix 1.(1467, 1468)

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates. The following search terms were used "(low level laser therapy) AND (chronic low back pain OR back pain)" to find 71,156 articles. Of those 71,156 articles, we reviewed 8 articles and included 7 articles (all RCTs).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Klein 1990 RCT Study supported by grants from Santa Barbara Cottage Hospital and Sunsum Medical Research Foundation.	8.5	N = 20 with chronic LBP	Low-level gallium-arsenide laser with a frequency of 1000 Hz for 20 minute sessions 3 times a week for 4 weeks (n = 10) vs. placebo laser (n = 10) plus exercise for upper extremities.	No differences in VAS pain scales (p = 0.49) or disability scores (p = 0.92).	"[L]ow-energy laser stimulation under the short-term conditions of this study does not appear to provide any advantage over exercise alone."	Small sample size. Data suggest lack of efficacy.
Basford 1999 RCT Supported by LaserBiotherapy, Inc., Dallas, TX. No COI declared.	8.0	N = 63 with mostly chronic LBP	Low level Nd: YAG laser irradiation (n = 30) vs. inactive placebo probes (n = 29) for 90 seconds on 8 points 3 times a week for 4 weeks.	At midpoint, Oswestry scores: 17.2 vs. 22.9; at final evaluation scores 13.3 vs. 22.6. Oswestry score: 13.3±14.0 vs. 22.6±22.0, p = 0.001. Lumbar mobility: NS between groups. Maximal pain last 24 hours: 17.1±16.8 vs. 32.8±28.5, p = 0.007. Pain with bending: 1.1±0 vs. 2.3±1.0, p = 0.036.	"Treatment with low-intensity 1.06μm laser irradiation produced a moderate reduction in pain and improvement in function in patients with musculoskeletal low back pain. Benefits, however, were limited and decreased with time."	Baseline differences favored laser group as assessed by multiple major pain variables (e.g., duration of symptoms 6.9±4.5 vs. 12.8±6.5 months; Oswestry median = 21 vs. 25). As apparent randomization failure, strong conclusions precluded.
Toya 1994 RCT No mention of COI or industry sponsorship.	8.0	N = 115 with multiple MSDs including LBP	Diode laser (Group A) vs. placebo laser (Group D) for 1 treatment session of 5 to 10 minutes. Subjects grouped by pain region.	For lumbar site, 15/16 in active group vs. 12/25 in sham effectively treated. Pain improvement following therapy significantly better in diode group than placebo (p <0.0001).	"[D]iode laser therapy, at the parameters used in the trial, was both safe and effective for the alleviation of pain in the groups treated."	Study largely combines multiple MSDs and is not particularly detailed, precluding strong conclusions regarding LBP treatment.
Ay 2010 RCT No mention of COI or industry sponsorship.	7.5	N = 80 with acute LBP and chronic LBP attributed to disc herniation	All hot-packs. Group 1 (acute) LLL (n = 20) vs. Group 2 (acute) placebo laser therapy (n = 20) vs. Group 3 (chronic) LLLT (n = 20) vs. Group 4 (chronic) PLT (n = 20). Follow-up before/after 3 weeks treatment.	No significant difference between 4 groups in pain severity, patient/physician global assessments, range of motion, Roland Disability Questionnaire, and Modified Oswestry Disability Questionnaire.	"[A]lthough all groups showed improvements on assessment parameters, we failed to show the superiority of laser therapy over placebo laser on pain severity and functional capacity in patients with acute and chronic LBP."	Data suggest laser ineffective for either acute or chronic LBP.
Konstantinovic 2010 RCT No mention of COI or industry sponsorship.	7.5	N = 546 with acute LBP and unilateral radiculopathy caused by prolapsed interverte-bral disc	(Group A) COX-2 inhibitor nimesulide 200mg day with low level laser therapy (LLLT) (n = 182) vs. (Group B) only nimesulide 200mg day (n = 182) vs. (Group C) nimesulide 200mg day and placebo LLLT for 5 times weekly for 3 weeks.	Group A showed better results vs. Group B (p <0.0005) and Group C (p <0.0005). Group C had better results than Group B (p <0.0005).	"Our results show statistically significant improvement in all groups, with better results for all investigated parameters in group A compared with other groups."	Study population mostly hospitalized suggesting potential non-applicability to western population. Data suggest improvement in all groups, best improvement in NSAID plus LLLT, then NSAID plus sham, then NSAID alone, suggesting some placebo effect of LLLT.

Soriano 1998 RCT No mention of COI or industry sponsorship.	7.0	N = 85 with chronic LBP over age of 60	Gallium arsenide laser treatment 10,000 Hz frequency (Group A, n = 43) vs. placebo (Group B, n = 42) for 10 sessions.	Patients rating results as good or excellent 71.1% vs. 36.4%, p <0.007. Pain disappeared completely in 44.7% in laser group vs. 15.2% for placebo, p <0.01.	"[A]t the doses used and techniques applied in this study, relieves chronic low back pain in older patients in a statistically significant percentage of the patients but without causing any adverse side effects."	Study reported results in percentage of pain relief. No comparison of VAS scores provided. Results therefore of uncertain clinical significance. No radiculopathy patients. Co-interventions other than NSAIDs and formal therapy not addressed.
Glazov 2009 Double-blind, two group parallel RCT Industry sponsored (Australian Medical Acupuncture College). No mention of COI.	6.5	N = 100, with chronic non-specific LBP, at least 3 months, age 19-70	830nm, 10mW, Ga-Al-As laser intervention (n = 50) vs. Sham Group (n = 50), at least 10 weekly sessions required.	VAScm and ODI (range, 0-10)/ DASS-depression and stress (range, 0-42), at start and 6 months; (p <0.001 and p <0.001)/(p <0.01 and p <0.001). Overall, 40% reduction of pain at end of treatment and 30% maintained at 6 weeks.	"This study did not show a specific effect for LA using infrared laser at 0.2 Joules per point for chronic low back pain."	Details sparse, some baseline differences, errors in statistical differences in table of baseline differences. Data suggest lack of efficacy.
Djavid 2007 RCT No mention of COI or industry sponsorship.	6.5	N = 61, with LBP for minimum of 12 weeks, age 20-60	Low-level laser therapy or LLLT, GaAlAs λ=810 nm, 50 mW, & 0.221 cm2 spot area laser (n = 16) vs. LLLT+Exercise or Ex (n=19) vs. Placebo LLLT+Ex (n = 18), for 12 sessions. Patients with LLLT alone blinded; 1year follow-up.	LLLT+Ex pain reduction by 1.8 cm (95% CI 0.1 to 3.3, p = 0.03), lumbar range of movement increased by 0.9 cm (95% CI 0.2 to 1.8, p<0.01 of active flexion, and ODI reduction by 9.4 points (95% CI 2.7 to 16.0, p= 0.03), more than in placebo laser therapy + exercise, after another 6 weeks, of no intervention.	"In conclusion, low level laser therapy seemed to be an effective method of decreasing pain and reducing disability in chronic low back pain in combination with exercise compared with exercise alone."	Gender ratio statistically different suggesting possible randomization failure; attention bias. Sparse between-group results statistically tested/presented. Conclusions limited as results largely negative after treatment period end, but 6 weeks later became positive.

ACUPUNCTURE

Acupuncture originated in China and is based in part on the theory that many diseases are manifestations of an imbalance between yin and yang as reflected by disruption of normal vital energy flow (qi) in specific locations, referred to as meridians.(1469-1477) Needling along one of the 361 classical acupuncture points on these meridians is believed to restore balance. This stimulation is classically done with thin, solid, metallic needles which are then manipulated (or turned) manually or stimulated electrically (electroacupuncture). In addition to needling, acupuncture frequently involves moxibustion and cupping. Besides traditional Chinese acupuncture, there are many other types of acupuncture that have arisen, including accessing non-traditional acupuncture points.(1478) Acupuncture has been used for treatment of low back pain.(651, 1278, 1449, 1478-1481)

1. *Recommendation: Acupuncture for Treatment of Acute, or Subacute, Radicular and Post-operative Low Back Pain*

   Acupuncture is not recommended for treatment of acute, subacute, radicular, or post-operative low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Acupuncture for Treatment of Chronic to Severe Low Back Pain*

   Acupuncture is recommended for select use in the treatment of chronic moderate to severe low back pain as an adjunct to more efficacious treatments.

   Indications – Chronic LBP patients should have had NSAIDs and/or acetaminophen, stretching and aerobic exercise instituted and have insufficient results. Acupuncture may be considered as a treatment for chronic LBP as a limited course during which time there are clear objective and functional goals to be achieved. Consideration is for time-limited use in patients with chronic LBP without underlying serious pathology as an adjunct to a conditioning program that has both graded aerobic exercise and strengthening exercises. Acupuncture is only recommended to assist in increasing functional activity levels more rapidly and the primary attention should remain on the conditioning program. In those not involved in a conditioning program, or who are non-compliant with graded increases in activity levels, this intervention is not recommended.

   Frequency/Duration – Evidence does not support specific Chinese meridian approaches, as needling the affected area appears sufficient. Patterns used in quality studies ranging from weekly for a month to 20 appointments over 6 months. However, the norm is generally no more than 8 to 12 sessions. An initial trial of 5 to 6 appointments is recommended in combination with a conditioning program of aerobic and strengthening exercises. Future appointments should be tied to improvements in objective measures and would justify an additional 6 sessions, for a total of 12 sessions.

   Indications for Discontinuation – Resolution, intolerance, or non-compliance, including non-compliance with aerobic and strengthening exercises.

   Harms – Rare needling of deep tissue, such as artery, lung, etc. and resultant complications. Use of acupuncture may theoretically increase reliance on passive modality(ies) for chronic pain.

   Benefits – Modest reduction in pain.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendations

Quality studies evaluating efficacy of acupuncture for treating chronic LBP, are largely positive, although they somewhat conflict. There is no quality evidence on acute or subacute LBP, radicular pain syndromes, post-operative or other LBP-related conditions. The mechanism(s) of action is (are)

unclear. The possibility that acupuncture is not superior to other treatments cannot be eliminated. Studies generally fail to control for attention bias, and also suggest that needling in locations other than traditional acupuncture points and/or sham acupuncture treatments may provide equal benefit(1479, 1482, 1483) which leads to questions regarding whether it is the needling rather than the acupuncture per se that was of benefit. There are a lack of systematized acupuncture approaches. There also is no quality evidence for many other forms of acupuncture outside of traditional Chinese or the sham acupuncture (e.g., Japanese, French, scalp, hand, foot, auricular, etc.).

Acupuncture performed by skilled professionals is minimally invasive, has minimal adverse effects, and is moderately costly although it could be high cost with ongoing treatments. In some of the studies that demonstrated efficacy for patients with chronic LBP, longer lasting benefits were found beyond the treatment period. Despite significant reservations regarding its true mechanism of action, a limited course of acupuncture may be recommended for treatment of chronic LBP as an adjunct to a conditioning program. It is not recommended for other back-pain related conditions as there is no evidence of its efficacy and particularly for acute pain, it would not be expected to materially alter the natural history.

Evidence for the Use of Acupuncture
There are 10 high-(1479, 1482-1491) (one with 2 reports) and 25 moderate-quality(750, 838, 866, 1087, 1292, 1447, 1461, 1466, 1492-1509) RCTs (one with 2 reports) incorporated into this analysis. Trials enrolling only the elderly were not included.(1085, 1510-1512) There are 5 low-quality RCTs(1138, 1513-1516) and 1 other study(1517) in Appendix 1.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: acupuncture, chronic low back pain, subacute low back pain, radicular pain, and sciatica to find 54,349 articles. Of the 52,349 articles we reviewed 32 articles and included 32 articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Haake 2007 RCT Industry sponsored (German public health insurance companies: AllgemeineOrtskrankenkasse, Betriebskrankenkasse, Innungskrankenkasse, Bundesknappschaft, Bundesverband der Landwirtschaftlichen Krankenkassen, and Seekasse). No mention of COI.	10.5	N = 1,162 with chronic LBP average 8 years duration	Verum acupuncture: needling fixed points and additional traditional Chinese medicine diagnosis (n = 387) vs. sham acupuncture (n = 387) vs. conventional therapy: medication, PT, exercise (n = 388) for 30 minutes a session for 10 sessions.	More patients dropped out of conventional treatment (12.9% vs. 8.8% traditional acupuncture, and 10.1% sham).Verum not superior to sham acupuncture (p = 0.39). Treatment response significantly greater in sham and verum acupuncture compared to conventional (p <0.001).	"Low back pain improved after acupuncture treatment for at least 6 months. Effectiveness of acupuncture, either verum or sham, was almost twice that of conventional therapy."	Optional additional appointments provide potential uncontrolled confounder. Conventional therapy not blinded and appears to have same previous modalities, thus may be inadequate control. Data suggest traditional acupuncture not superior to sham; both superior to controls.
Cherkin 2009 RCT Industry sponsored (Lhasa OMS donated Seirin acupuncture supplies) and no COI.	9.5	N = 638, uncomplicated chronic LBP, at least 3 months of chronic pain, age 18-70	Individualized acupuncture: treatments averaged 18 minutes with average of 10.8 needles, 74 distinct points used, half on "bladder meridian" (n = 157) vs. standardized care: 8 acupuncture points commonly used for CLBP on low back and lower leg for 20 minutes. Therapist manipulated needles to elicit "de qu" (n = 158) vs. simulated acupuncture in which all acupuncture points stimulated with toothpicks at 10 minutes and again at 20 minutes. Same 8 acupuncture points used as in standardized treatment (n = 162) vs. participants in usual care group received no study related care (n = 161). All patients treated twice weekly for 3 weeks, then weekly for 4 weeks: 10 treatments total.	Mean dysfunction scores for individualized, standardized, and simulated acupuncture groups improved by 4.4, 4.5, 4.4 points, compared with 2.1 points for those receiving usual care (p <0.001) at 8 weeks. Symptoms improved by 1.6 to 1.9 points in treatment groups compared with 0.7 points in usual care group (p <0.001). Participants in usual care group less likely than those in treatment group to experience clinically meaningful improvement in dysfunction (50% vs. 59% to 65%, p = 0.02) but not in symptoms after 1 year.	"[A]lthough acupuncture was found effective for chronic low back pain, tailoring needling sites to each patient and penetration of the skin appear to be unimportant in eliciting therapeutic benefits. These findings raise questions about acupuncture's purported mechanism of action. It remains unclear whether acupuncture or our simulated method of acupuncture provide physiologically important stimulation or represent placebo or nonspecific effects."	Data suggest traditional acupuncture and penetration of skin unnecessary. As no differences in the acupuncture groups and usual care associated with attention bias, unclear if acupuncture is effective at all.
Brinkhaus 2006 RCT (Two reports)	9.0	N = 301 with chronic	Semi-standardized acupuncture (n = 147): series of local and distal points vs.	Pain intensity decreased by mean of 28.7 for acupuncture, 23.6 in	"Acupuncture was more effective in improving pain than no acupuncture treatment in patients	Lack of details on co-interventions such as exercise. No placebo or

Industry sponsored (German social health insurance funds and insurance: Techniker Krankenkasse, BKK Aktiv, Betriebskrankenkasse der Allianz Gesellschaften, Bertelsmann BKK, Bosch BKK, BKK BMW, DaimlerChrysler BKK, BKK Deutsche Bank, Ford Betriebskrankenkasse, BKK Hoechst, HypoVereinsbank Betriebskrankenkasse, Siemens-Betriebskrankenkasse, Handelskrankenkasse, and Innungskrankenkasse Hamburg, Deutsche Angestellten-Krankenkasse, Barmer Ersatzkasse, Kaufmannische Krankenkasse, Hamburg-Munchener Krankenkasse, Hanseatische Krankenkasse,Gmunder Ersatzkasse,HZKKrankenkasse fur Bau- und Holzberufe, Bruhler Ersatzkasse, Krankenkasse Eintracht Heusenstamm, and Buchdrucker Krankenkasse). No mention of COI.		LBP >6 months	minimal acupuncture (n = 75): superficial needling at non-acupuncture points vs. wait list control (n = 79) for 12 30-minute sessions for 8 weeks.	minimal acupuncture group, and 6.9 in control group. Difference between acupuncture and minimal acupuncture 5.1mm (p = 0.26) and between acupuncture and control 21.7mm (p <0.001).	with chronic low back pain, whereas there were no significant differences between acupuncture and minimal acupuncture."	sham placebo group making comparison difficult. Data suggest acupuncture superior to non-acupuncture.
Di Cesare 2011 RCT No mention of COI or industry sponsorship.	8.5	N = 62 with LBP at least 6 months, age 45+, no pharma-logical therapy, no previous meso-therapy for CLBP	TRP group of 2 cc of local anesthetic lidocaine cloridrate 2% using a point by point injection technique (30 G 0.4mm X 44mm) fully inserted at 18 injection groups with 18 local superficial trigger points using Travell and Simons trigger point manus (n = 29) vs. ARP group of local anesthetic lidocaine cloridrate 2% using point-by-point injection technique (30 G 0.4mm X 44mm) fully inserted at 18 injection groups vs. ACP group	Statistically significant differences between groups not found at baseline but found at 12 weeks for VSR: TRP vs. ACP Mean (SD): 3.27 (0.20) vs. 2.49 (0.19), p <0.008). VAS: 4.73 (0.25) vs. 3.53 (0.24), p <0.001. SF-MPQ: 12.00 (1.09) vs. 7.26 (1.02), p <0.002. ODQ: 19.42 (1.55) vs. 14.80 (1.46), p <0.034.	"[T]he preliminary findings of the present study showed evidence of the beneficial effects of ACP mesotherapy in patients affected by CLBP. It is our opinion that this technique could be nevertheless a able option as an adjunct treatment in overall treatment planning of CLBP patients; with initial pain reduction in fact, other rehabilitation programs could be more likely to accepted by these patients, thus resulting in improved outcome."	Data suggest similar efficacy for both groups during treatment but treatment gains remained during follow up for acupoints mesotherapy but not for trigger point mesotherapy.

			received acupuncture to 18 fixed body acupoints: gall gladder 30, bladder 31, bilateral 52, governor vessel 3, dorsal and points at a distance: gall bladder 34 and 41, bladder 60, kidney 4 bilateral, triple energizer 5 (n = 33). All patients received 1 treatment per week for 4 weeks. Follow-up 12 weeks after last treatment.			
Kennedy 2008 RCT COI (Dr. Park developed Park Shame Device and supplied samples for use in study) and no mention of industry sponsorship.	8.5	N = 48 with non-specific LBP <12 weeks duration, age 18-70	Verum acupuncture, based on unilateral or bilateral points chosen to effect analgesia according to patient's pattern of pain (n = 24) vs. control using non-penetrating sham needles (n = 24). All patients treated minimum 3, maximum 12 treatments over 4-6 weeks with 1-2 treatments per week with 8-13 needles inserted.	VAS worst end of treatment and 3 month follow-up, verum vs. placebo mean (SD): 40.4 ± 6.1 vs. 52.8 ± 6.1 p = 0.152. 3 month follow-up: 33.1±6.1 vs. 51.8±61 p = 0.034.	"[T]his study has demonstrated the feasibility of a randomized controlled trial of penetrating needle acupuncture compared to a non-penetrating sham for the treatment of acute LBP in primary care; 120 participants would be required in a fully powered trial. The placebo needle used in this study proved to be a credible form of control."	Large loss to follow-up of sham group.
Leibing 2002 RCT Industry sponsored (Ministry of Education, Science, Research and Technology (BMBFT) and Federal Republic of Germany (01 KT 9407). No mention of COI.	8.0	N = 131 with chronic LBP	Acupuncture (n=40) vs. sham (n=45) vs. physiotherapy (n=46) for 20 sessions, 5 days a week for 2 weeks, then weekly for 10 weeks.	Acupuncture with less pain disability (p = 0.016) only difference between groups. Acupuncture had decrease in psychological distress vs. sham (p = 0.040) post treatment. Pain intensity post treatment significant between acupuncture and control, p <0.001.	"We found a significant improvement by traditional acupuncture in chronic LBP compared to routine care (physiotherapy) but not compared to sham-acupuncture. The trial demonstrated a placebo effect of traditional acupuncture in chronic LBP."	High dropout rate for sham and control group. Co-intervention not well recorded. Acupuncture appears to have some efficacy.
Yuan 2009 RCT Industry sponsorship (Strategic Priority Grant). No mention of COI.	8.0	N = 30 with non-specific LBP defined as pain below 12th costal margin and above inferior gluteal folds, regardless	Low frequency (n = 15) received 20-30 minute sessions 2 times a week until 10 sessions reached vs. high frequency (n = 15) 5 times per week. "De qi" was outcome for each session.	Baseline differences not statistically significant. None of the results significant. Smallest p value (p <0.26) measured on Roland Morris Disability score with change between groups at 3 months.	"It is feasible to conduct a main RCT, to compare different frequencies of acupuncture for LBP, using sensitive measurements. Also the trend for early clinically important improvement within a minimum of four measurements is worthy of further study."	Significant drop out at 1 year point. Data do not support higher frequency treatment.

		of radiating leg pain and >3 months, age 18-60				
Inoue 2006 RCT No mention of COI or industry sponsorship.	8.0	N = 31 with LBP in limited area exacerbated in particular postures	Acupuncture group (n = 15) vs. sham acupuncture (n = 16). Both procedures performed at most pain point on back. For sham group, word "sham" not mentioned and guide tube without needle placed at point and tapped on skin; 1 treatment each participant, outcomes assessed immediately before/after treatment.	VAS mean (SD) before/ after treatment: Acupuncture 61±11 vs. 47±7 (p <0.001) and sham acupuncture 61±9 and 55±13 (p = 0.033). Between-group difference p = 0.020.	"[T]hese results suggest that acupuncture at the most painful point gives immediate relief to low back pain."	Only assessed immediately before and after 1 treatment.
Molsberger 2002 RCT Industry sponsored (grant by German Ministry of Education, Science and Research). No mention of COI.	7.5	N = 186 with chronic LBP	Conservative orthopedic treatment (COT, n = 60) vs. verum acupuncture and COT: 12 acupuncture treatments 3 times a week for 30 minutes (n = 65) vs. sham acupuncture and COT: 12 sham treatments 3 times a week for 30 minutes (n = 61) for 4 weeks.	After 3 months, verum significantly improved in VAS scores compared to sham (p <0.00003) and COT (p <0.00001). No other significant differences between groups.	"Acupuncture can be an important supplement of conservative orthopedic treatment in the management of chronic LBP."	Data suggest benefit of acupuncture in this population in VAS pain scores, although clinically the benefit may be small as there was no difference in NSAID consumption or functional limitation.
Cherkin 2001 RCT Industry sponsored (Group Health Cooperative, The Group Health Foundation, and John E. Fetzer Institute. Grant HS09351 from Agency for Healthcare Research and Quality). No mention of COI.	7.0	N = 262 with subacute and chronic LBP	Traditional Chinese acupuncture (n = 94) vs. massage (n = 78) vs. self-care education (n = 90) for 10 weeks with follow-up at 4, 10, and 52 weeks.	At 10 weeks, massage superior to self-care on symptom scale, (3.41 vs. 4.71; p = 0.01) and disability scale (5.89 vs 8.25; p = 0.01). Massage superior to acupuncture on disability scale (3.08 vs. 4.74; p = 0.002) After 1 year, massage not superior to self-care but superior to acupuncture on symptom scale (3.08 vs. 4.74, p = 0.002), dysfunction scale (6.29 vs. 8.21, p = 0.05).	"Traditional Chinese Medical acupuncture was relatively ineffective. Massage might be an effective alternative to conventional medical care for persistent back pain."	Lack of control group limits conclusions. Results suggest all groups improved, with additional benefit in therapeutic massage group vs. acupuncture. However, outcome of uncertain clinical significance. Massage not well described.
Yeung 2003 RCT Industry sponsored (The Hong Kong Polytechnic University	7.0	N = 52 with chronic LBP	Exercise, n = 26 (warm up, stretching, back extensions, abdominal exercises 1 hour session each week for 4 weeks) vs. exercise plus electro-acupuncture, n = 26	No differences for analgesic consumption and exercise level. Numerical rating scale (NRS) for average pain: post treatment exercise	"This study provides additional data on the potential role of (electro-acupuncture) in the treatment of LBP, and indicates that the combination of EA and back exercise might be an	This trial appears to have largely used traditional Chinese acupuncture and tried to achieve te chi.

Area of Strategy Development Fund (A106) and Tung Wah Board Fund). No mention of COI.			(EA 3 times a week for 4 weeks) with follow-up at 8 weeks (1 month after treatment) and 3 months.	(5.12±2.18) vs. exercise plus EA (3.81±2.10, p = 0.032; 1 month post exercise (5.19±2.47) vs. exercise plus EA (3.77±2.12), p = 0.030; 3 month post.	effective option in the treatment of pain and disability associated with chronic LBP."	
Lehmann 1983 RCT Industry sponsored (NIHR Grant 23P59176). No mention of COI.	7.0	N = 54 with chronic LBP	TENS 60 Hz frequency (n = 18) vs. electroacupuncture twice weekly (n = 17) vs. placebo TENS (n = 18) for 3 weeks. All patients attended comprehensive multi-disciplinary educational program and exercises training sessions twice daily.	Positive non-organic signs ("invalid") more defensive on MMPI. Significant differences for depression (p <0.05) and anxiety (p <0.02). 80% who over reported pain retained lawyer vs. 17% of valid patients, p <0.005. Valid patients more peak pain with sham than TENS. Invalid more pain with sham-TENS than TENS than acupuncture. Acupuncture had greater peak pain relief then placebo TENS or TENS.	"Both emotional factors and secondary gain factors have been found to be associated with the presence of nonorganic physical findings…Most importantly; however, patients with nonorganic physical findings have been shown to be a contaminating bias in this trial."	Finding has potentially worrisome implications in other RCTs on other subjects where psychosocial factors not assessed. Data suggest that psychosocial factors have significant impact on outcomes in chronic LBP patients.
Giles 2003 RCT No COI or industry sponsorship.	6.5	N = 115 with mostly chronic LBP or neck pain	Post-randomization individualized treatment in all 3 arms: acupuncture (near and far technique) (n = 36); manipulation; high velocity, low amplitude thrust spinal manipulation to joint 2 times a week (n = 36) and medication (63% celecoxib, 26% rofecoxib and 11% paracetamol; apparently unblinded) (n = 43) for 9 weeks.	Manipulation better overall improvements of 50% (p = 0.01) on ODI, 38% (p = 0.08) NDI, 47% (p <0.001) SF-36, 50% (p <0.01) VAS for back pain, 38% (p <0.001) for lumbar standing flexion, 20% (p <0.001) lumbar sitting flexion, 25% (p = 0.1) cervical sitting flexion, 18% (p = 0.02) cervical sitting extension. Acupuncture better than manipulation on neck pain VAS (50% and 42%). Asymptomatic status: manipulation (n = 9) vs. acupuncture (n = 3) vs. medication (n = 2), p = 0.05.	"In summary, the significance of the study is that for chronic spinal pain syndromes, it appears that spinal manipulation provided the best overall short-term results, despite the fact that the spinal manipulation group had experienced the longest pretreatment duration of pain."	Individualization of treatments results in lack of standardization and substantially precludes drawing robust conclusions. Post-randomized individualized treatment in all three arms. Ill-defined mixture of diagnoses, combined with non-randomization arguably relegates study to a non-RCT.
Garvey 1989	6.5	N = 63 with subacute	Injection of 1.5ml of 1% lidocaine (n = 13) vs.	Percentage of patients improved 40% vs. 45% vs.	"[T]he critical factor in giving relief of pain is not the injected	Data suggest steroid of no additive benefit. Also,

RCT No mention of COI or industry sponsorship.		low back strain at least 4 weeks duration	injection with 0.75ml 1% lidocaine, 0.75ml Aristospan (20mg/ml) (n = 14) vs. single dry needle (n = 20) vs. 10 2nd spray ethyl chloride from 6 inches away and acupressure (20 seconds with plastic needle guard) (n = 16), followed at 2-week intervals.	61% vs. 67%. No significant differences found.	substance but, rather, some type of mechanical stimulus to the trigger point. We recommend the use of topical vapocoolant, followed by acupressure or acupuncture, since this modality resulted in the greatest pain relief of the four methods used and had no obvious side effects."	suggest dry needling may be at least as effective as injection.
Carlsson 2001 RCT Industry sponsored (Grant No. 05658 from Swedish Emdical Research Council project (to B.S.)). No mention of COI.	6.5	N = 50 with chronic LBP	Manual acupuncture (n = 18) vs. electroacupuncture (n = 16) vs. active placebo (mock TENS, n = 16) once a week for 8 weeks. Eight treatments given in 2 months, then once at 4 months, with last treatment at 6 months.	After 1-month treatment, 16/34 (47.1%) acupuncture vs. 2/16 (12.5%) placebo showed improvement. At 6 months, values 41.1% vs. 12.5%. Mean VAS differed at 1 (p = 0.00) and 3 (p = 0.001) months but not 6 months. Activity changes significant in acupuncture group (p = 0.024) but not placebo (p = 0.655).	"The authors found a long-term pain-relieving effect of needle acupuncture compared with true placebo in some patients with chronic nociceptive low back pain."	Type of acupuncture not clearly specified, but appears largely traditional Chinese and achieved te chi. Data suggest long term benefit from acupuncture.
Sator-Katzenschlager 2004 RCT No mention of COI or industry sponsorship.	6.5	N = 87 with lumbar or lumbo-sacral LBP ≥6 months, normal neurologic function of lumbo-sacral nerves, and no pain radiation	Electrical acupuncture: continuous low frequency EA using P-Stim over 48 hours (EA, n = 31) vs. manual acupuncture (CO, n = 30) once a week for 6 weeks; follow-up for 3 months.	Pain reduction better in EA vs. CO (p <0.001). Psychological well-being, activity, sleep also improved with EA vs. CO, p <0.05. Rescue analgesics consumed less for EA (150 vs. 6 tablets; p <0.001) and neuropathic pain improved for EA 82% vs. CO 54% (p = 0.067). Frequencies of nociceptive pain decreased in 75% of EA vs. 43% for CO (p = 0.009).	"[T]he treatment of chronic low back pain is significantly improved with regard to long-term clinical outcome through the use of electrical stimulation of auricular acupuncture points with the new P-Stim device."	Adequacy of double blinding would seem a bit doubtful. No placebo or other control group for comparison.
Tsukayama 2002 RCT Industry sponsored (Foundation for Training and Licensure Examination in Anma-Massage-Acupressure, Acupuncture and Moxibustion and Tsukuba College of Technology). No mention of COI.	6.0	N = 20 with LBP	TENS (n = 10) vs. electroacupuncture (EA, n = 10) twice a week for 2 weeks, 4 sessions total.	Pain relief favored electroacupuncture (65mm for EA vs. 86mm TENS), p = 0.02. Statistically significant change over time (p <0.01) and no significant group by time interaction (p = 0.10). Not significant between groups for JOA score.	"[A] significant reduction in pain relief in both groups, but…change in the EA group was greater than that in the TENS group." "These findings suggest that EA was more effective than TENS for short-term treatment of LBP in this study."	Data suggest electroacupuncture provides greater benefit than TENS for back pain. Small sample size, unknown duration of symptoms at study inclusion (appears to be chronic but not defined) limits conclusions.

Lehmann 1986 RCT Industry sponsored (NIHR Grants 23P59176 and G008435055). No mention of COI.	5.0	N = 54 with chronic disabling LBP	Electroacupuncture 2-4 Hz frequency twice weekly (n = 17) vs. TENS 60 Hz frequency daily (n = 18) vs. sham TENS daily (n = 18) for 3 weeks.	All groups showed significant long-term improvements (p = 0.01, p = 0.001, p = 0.004). Study unable to detect any differences between active subthreshold TENS and dead-battery TENS.	"[N]either electrical stimulation modality was shown to affect that patients' rehabilitation. Electro-acupuncture demonstrated the ability to reduce some pain reports. Subthreshold TENS was no more effective than a dead-battery control."	Dropout rate high, thus, robust conclusions not possible.
Tsui 2004 RCT No mentioned of COI or industry sponsorship.	5.0	N = 42 with LBP that radiated to thigh or calf	Electroacupuncture (EA, n = 14) vs. electrical heat treatment (EH, n = 14) vs. control group (n = 14) twice a week for 4 weeks (total 8 sessions). Back exercises also given to all subjects including control group as home program.	Significant reduction of NPRS found in EA (p = 0.000), EH (p = 0.000), and control group (p = 0.013) across sessions. Significant between-group differences in Session 4, 8, and 1 month follow-up. Post-hoc tests showed NPRS of EH group significantly lower than EA group and control group by Session 4 (p = 0.004). After Session 8, NPRS of both EA group (p = 0.003) and EH group (p = 0.001) significantly lower than control group. Maintained up to 1 month follow-up.	"[4] sessions of EH treatment over 2 weeks produced significantly greater reduction in the numerical rating scale of pain than that of the EA or the control."	Lack of details for randomization, allocation, control of co-interventions, and small sample size limit results. Data suggest benefit from electro-acupuncture and electric heat acupuncture compared with back exercises alone.
Thomas 2006 RCT Industry sponsored (UK NHS Executive health technology programme). No COI.	5.0	N = 241 with persistent non-specific LBP, 4-52 weeks duration	Acupuncture - 10 individualized treatments over 3 months (n = 160) vs. usual care from general practitioner (n = 81) with follow-up at 3, 12, and 24 months.	Acupuncture found most cost-effective at 24 months. SF-36 bodily pain score difference between groups: 12 months (5.7, p = 0.11), 24 months (8.2, p = 0.031). Oswestry pain disability index difference between groups: not significant at 12 and 24 months. McGill present pain index: not significant at 12 and 24 months.	"Weak evidence was found of an effect of acupuncture on persistent non-specific low back pain at 12 months, but stronger evidence of a small benefit at 24 months."	Data suggest short-and long-term benefit for pain relief with acupuncture over non-specific "usual care." Lack of control for co-interventions and probable selection bias at time of randomization may have affected results.
Thomas 2005 No mention of COI or industry sponsorship.	See Thomas 2006					

Zaringhalam 2010 RCT No mention of COI or industry sponsorship.	5.0	N = 80 males with LBP at least 6 months and no radiation of LBP, age 50-60	Control group (n = 20) vs. baclofen (n = 20) at 30mg per day for 5 weeks vs. acupuncture (n = 20) using 10-12 needles for 20-25 minutes. Using neurohumoral mechanism theory of acupuncture vs. acupuncture + baclofen (n = 20). All groups received treatment for 5 weeks.	VAS mean (SD) Week 1: BA compared to AC 52.8 (19.4) p <0.05. Week 2: AC compared to BA: 50.5 (20.1) p <0.05. Week 4,5,10 AC compared to BA; 49.1 (19.3), 47.3 (18.9), 47 (19.1), 50.1 (20.3) p <0.001. Week 3,4,5,10; BA+AC compared with BA: 45.6 (14.7), 42.3 (13.9), 40.1 (13.3), 47.3 (14.1) p <0.05. RDQ: AC compared to BC, week 5 and 10 mean (SD): 6.4 (2.9), 7.2 (3.1) p <0.05. BA+AC compared with BA: 5.7 (1.4) and 58 p <0.001.	"[T]he present study indicates that the combined treatment of acupuncture and baclofen is more effective than baclofen treatment alone to reduce pain in patients with non specific chronic LBP."	Study population only includes males.
Macdonald 1983 RCT Industry sponsored (North West Thames Regional Health Authority). No mention of COI.	4.5	N = 17 with LBP, 1 year in duration	Acupuncture (n = 8) (electroacupuncture used if acupuncture failed) vs. placebo (n = 9) once a week for a maximum of 10 treatments.	Pain relief (%) after each treatment: acupuncture 77.35 vs. placebo 30.14, p <0.01. Pain score reduction (%): not significant between groups. Activity pain score reduction (%): acupuncture 52.04 vs. placebo 5.83, p <0.05. Physical signs reduction (%): acupuncture 96.78 vs. placebo 29.17, p <0.01. Severity and pain area reduction (%): acupuncture 73.75 vs. placebo 18.80, p <0.01. Combined average % reduction: acupuncture 71.41 vs. placebo 21.35, p <0.01.	"[U]nequivocal support for a beneficial effect of superficial acupuncture in reducing an overall mean of five measures of chronic low back pain severity."	Small sample size limits conclusions.
Wasan 2010 RCT Industry sponsored (NIDA 1K23DA020681-01A1 and NCCAM P01 AT002048-01(ADW)). No COI.	4.5	N = 40 with average back pain score of 4 on scale from 0-10 and pain at least 6 months, and	Low psych (n = 21) vs. high psych (n = 19). Verum large intestine 4 was acupoint vs. placebo (condition needle with retractable point). Each patient received 2 sessions for 30 minutes 5 to 21 days apart.	Difference between low and high psych group mean: Acupuncture session; 2.9 vs. 3.7 nonsignificant. Placebo session; 2.7 vs. 4.1 p=.03.	"[I]n both groups, expectations were only a significant predictor of verum acupuncture response, p = .002, such that those with greater expectations had greater pain relief. Psychiatric comorbidity does not significantly impact acupuncture or placebo acupuncture analgesia	Not randomized, but utilized crossover design, blinding success questionable.

		low or high levels of psycho-pathology age 21-65			in CLBP. It does not affect the positive impact of expectations on reported pain relief from real acupuncture."	
Inoue 2009 RCT No COI or industry sponsorship.	4.5	N = 26 with LBP using MRI diagnoses	Acupuncture group (n=13) vs. local anesthetic injection group (n = 13) using dibucaine hydrochloride/5ml. Both groups received treatment at 2-5 of most tender points as determined by palpation once a week for 4 weeks.	VAS mean (SD) immediately after 1st treatment, end of treatment, 2 weeks after completion, 4 weeks after completion vs. before treatment. Acupuncture: baseline (61.3±19.0), 18.2±17.2 p <0.01, 16.5± 20.3 p <0.01, 11.9± 21.5 p <0.01 9.5±17.1 p <0.01. Anesthetic: immediately after 1st treatment vs. baseline (60.6±13.8) 45.3±25.1 p <0.05.	"[B]oth injection and acupuncture relieved pain, but acupuncture was superior for the immediate and sustained effects, suggesting that it is a useful treatment for low back pain. The difference in the effects may be attributable to differences in the mechanism of pain suppression."	Small sample size.
Witt 2006 RCT Industry sponsored (German social health insurance funds, including Techniker Krankenkasse BKK Aktiv, Betriebskrankenkasse der Allianz Gesellschaften, Bertelsmann BKK, Bosch BKK, BKK BMW, DaimlerChrysler BKK, BKK Deutsche Bank, Ford Betriebskrankenkasse, BKK Hoechst, HypoVereinsbank Betriebskrankenkasse, Siemens-Betriebskrankenkasse, Handelskrankenkasse, and Innungskrankenkasse Hamburg). COI: Dr. Bodo Liecker employee of Techniker Krankankasse.	4.0	N = 3,093 with chronic LBP	Acupuncture (n = 1,549) vs. control (n = 1,544) for a maximum of 15 sessions for 3 months followed by 3 months of follow-up.	Three month change from baseline: back function loss (HFAQ) reduction % (acupuncture 33.3 vs. control 11.3, p <0.001); back pain loss (LBP rating scale) reduction % (acupuncture 37.0 vs. control 9.8, p <0.001); 6 month change from baseline: back function loss reduction (%) (acupuncture 32.4 vs. control 28.6, p = 0.015), NS between groups for back pain loss. Quality-adjusted life years over duration of study: acupuncture (0.65±0.10) vs. control (0.62±0.10), p <0.001.	"Acupuncture plus routine care was associated with marked clinical improvements in these patients and was relatively cost-effective."	Control group had delayed acupuncture, thus biased in favor of intervention. Type of acupuncture used not standardized. Mean number of sessions was 10.3.
Hackett 1988 RCT	4.0	N = 41 with acute LBP	Electroacupuncture 2 treatments within 96 hours plus dummy paracetamol 2 tabs Q 4 hour PRN (Group A) vs. dummy	At Week 6, pain in paracetamol group 13.7 vs. 3.3 in EA group, p >0.01. Mobility at Week 6: paracetamol group 15.8 vs.	"Our results show a trend for electroacupuncture to be superior to paracetamol in terms of patient assessment of pain and mobility."	Acupuncture protocol poorly described. Co-interventions not well described. Lack of details

No mentioned industry sponsorship or COI			electroacupuncture 2 treatments within 96 hours plus paracetamol 2 tabs Q 4 hour PRN (Group B); 37 of 41 completed trial.	EA 1.9, p >0.01. No significant differences between groups.		prevents drawing strong conclusions on treatment.
Itoh 2009 RCT No mentioned of COI or industry sponsorship.	4.0	N = 32 with lumbar or lumbo-sacral LBP for at least 6 months not receiving acupuncture age 60+	Control group (n = 7, no specific treatment) vs. acupuncture group (n = 7, acupuncture at selected acupoints for 15 minutes on affected LBP using Sparrow pecking acupuncture technique until de qi achieved) vs. TENS group (n = 6, treatment at affected LBP for 15 minutes from single channel portable TENS unit frequency waves of 4.0 and 4.122kHZ and beat frequency of 122Hz) vs. ACP and TENS received combined treatments of 15 minutes of TENS then 15 minutes of ACP at affected LBP (n = 6). Each patient received total 5 treatments 1x a week, follow-up for 10 weeks after first treatment.	Statistical significance was not detected between groups. However, for VAS scores from week 4 and week 5 for combined therapy, means statistically significant: mean (SD) 40.8 (5.7) to 36.6 (8.0), p <0.008. For RMQ index, only week 5 statistically significant for combined therapies with mean and SD of 3.8 (0.8) p <0.008.	"[Combined acupuncture and TENS treatment is effective in pain relief and QOL of low back improvement for the sampled patients suffering from chronic LBP."	Very small groups. Used block randomization. Only reported p <0.008, small sample size (n = 26).
Mendelson 1983 RCT No mention of COI or industry sponsorship.	4.0	N= 77 with chronic LBP	Group I (n = 36) vs. Group II (n = 41). Acupuncture using traditional Chinese methods for 30 minutes average of 8 needles. Placebo intradermal injection 2% lidocaine given at non-acupuncture non-tender sites in lumbar area. Acupuncture needles then inserted superficially into infiltrated areas left 30 minutes without stimulation. All procedures 2x a week for 30 minutes for 4 weeks.	Mean and SE of VASP score before vs. after treatment. Phase I, Group I: 50.5 (3.4) vs. 30.2 (3.0) p <0.001; Group II: 53.7 (3.9) vs. 40.0 (3.8) p <0.001. Phase II, Group I: 34.6 (3.7) vs. 20.8 (2.8) p <0.001; Group II: 38.9 (4.2) vs. 31.5 (3.6) p <0.03.	"[O]verall reduction in individual patient's pain score was best predicted by initial pain severity (r=0.43; p<0.001) and psychotropic drug intake (r=0.37; p<0.001). None of the variables tested predicted which patients would specifically respond to acupuncture or placebo."	High drop out rate.
Low-Level Laser Therapy plus Exercise vs. Low-Level Laser Therapy vs. Placebo Laser Therapy plus Exercise						

Djavid 2007 RCT No mention of COI or industry sponsorship.	7.0	N = 61 age 20-60 with LBP for minimum of 12 weeks	Group 1 (G1) treated with low-level laser therapy (LLLT) (n = 20) vs. Group 2 (G2) treated with LLLT and exercise (n = 21) vs. Group 3 (G3) treated with placebo LLLT and exercise (n = 20).	Week 0-12 significant difference between G2 and G3 with respect to change in pain severity (G2: -3.8±1.7cm vs. G3: -2.0±1.7, p = 0.03), Lumbar range of movement on Schober Test (G2: 1.8±1.0cm vs. G3: 0.9±0.9cm, p <0.01), Active Flexion (G2: 21 ± 16^0 vs. G3: 6 ± 11^0, p <0.01) and ODI Index (G2: -17.2±9.5 vs. G3: -7.7±7.3, p = 0.03)	"[L]ow level laser therapy seemed to be an effective method of decreasing pain and reducing disability in chronic low back pain in combination with exercise compared with exercise alone."	One arm not blinded (LLLT). No details on control of interventions, compliance. Gender appears in baseline comparison. No difference between LLLT and placebo LLLT at 12 weeks. Data suggest possible benefits of LLT with exercise, although gender and education may explain results.
Hot Pack plus Low-Level Laser Therapy vs. Hot Pack plus Placebo Laser Therapy						
Ay 2010 RCT No mention of COI or industry sponsorship.	7.5	N = 80 with acute LBP and chronic LBP attributed to disc herniation	All hot-packs and Group 1 (acute) Low-Level Laser Therapy (LLLT) (n = 20) vs. Group 2 (acute) Placebo Laser Therapy (PLT) (n = 20) vs. Group 3 (chronic) LLLT (n = 20) vs. Group 4 (chronic) PLT (n = 20). Follow-up before/ after 3 weeks treatment.	No significant difference between 4 groups in pain severity, patients/physician global assessments, range of motion, Roland Disability Questionnaire, and Modified Oswestry Disability Questionnaire.	"[A]lthough all groups showed improvements on assessment parameters, we failed to show the superiority of laser therapy over placebo laser on pain severity and functional capacity in patients with acute and chronic LBP."	Data suggest laser ineffective for either acute or chronic LBP.
Laser Acupuncture vs. Sham Laser						
Sherman 2010 RCT Secondary analyses. See Cherkin 2009. Study funded by National Center for Complementary and Alternative Medicine (NCCAM). Dr. Khalsa (Project Officer for NCCAM) involved in analysis and interpretation of data.	9.5	N = 477 with chronic non-specific LBP	Acupuncture group (n = 167) vs. other CAM group (n = 186) vs. Conventional medical care group (n = 76) vs. Missing group (n =8). Patients received 10 treatments over 7 weeks.	Roland Dysfunction (% improved by 2+ scale points) scores significantly different in acupuncture expectation responses high (68), medium (59), low (51), and missing (62), p = 0.049. In treatment preference scores, Roland Dysfunction (% improved by 3+ scale points) scores were significantly different in acupuncture group (68), other CAM group (51), conventional medical care group (63) and missing group (67), p = 0.01.	"Our study demonstrates that positive pre-treatment beliefs about medical therapies do not always lead to enhanced outcomes, even for CAM therapies. The relationship between patient expectations and treatment outcomes appears to be complex. Advances in this burgeoning area of research will require development of more sophisticated conceptual models and measures of expectation."	Secondary analyses of Cherkin 2009. Pooled simulated with actual acupuncture as "no significant effects."
Cho 2013 RCT No mention of COI or industry sponsorship.	8.0	N = 130 age 18-65, lower back pain in last 3 months; received	Real acupuncture treatment (n = 65) vs. sham acupuncture treatment (n = 65). VAS score taken at follow up: baseline, week 6, 8, 12, and 24; primary	Primary outcome to see if a change of VAS score for bothersomeness of chronic LBP. Mean VAS for bothersomeness scores in real acupuncture group	"This randomized sham-controlled trial suggests that acupuncture treatment shows better effect on the reduction of the bothersomeness and pain	Both groups improved. Six months follow-up. Largely female population. Worse disability (ODI) in acupuncture group at baseline. Data suggest

		real acupuncture treatments or sham acupuncture treatments >6 weeks 2x a week	endpoint at week 8. ODI 11 questions about daily activities related with LBP. Back Depression Inventory (BDI).	decreased 3.36 points vs. 2.27 points for sham acupuncture group. ODI, BDI scores improved in both groups. Significant differences between groups in VAS score for bothersomeness and pain intensity (p <0.05).	intensity than sham control in participants with cLBP."	improvements with both arms, somewhat greater with real vs. sham acupuncture.
Vas 2012 RCT Study funded by Spanish Ministry of Health and Consumer Affairs and Andalusian Public Health System. No COI.	6.5	N = 275 with non-specific LBP (new episodes of LBP lasting <6 months)	True acupuncture following traditional Chinese medicine using selected individualized pain points (n = 68) vs. sham acupuncture (SA) using nonspecific points (n = 68) vs. placebo acupuncture using nonspecific points with pressure applied with blunt needles (n = 69) vs. conventional treatment (GP advice, n = 70).	No significant differences between all 3 acupuncture treatment groups in regards to expectations and confidence in treatment; 40.6% to 60% of patients in acupuncture groups not taking any medication by end of study, whereas, 25% of CT not taking medication.	"The results obtained indicate that TA associated with CT, by both ITT and PP analysis, is more effective than CT alone. However, there were no differences among the different types of treatment with acupuncture (TA, SA, and PA) associated with CT, although clinically relevant improvement with respect to CT alone was achieved after 3 weeks."	Lack of details for allocation, compliance. Data suggest no differences between acupuncture and sham and placebo group.
Glazov 2009 RCT, Double Blind Australian Medical Acupuncture College purchased Acupack research laser and provided funding for study. No COI.	6.5	N = 100 with chronic non-specific LBP for at least 3 months	Laser Acupuncture Group (LAG): Participants treated with 830nm (infrared), 10mW, Ga-Al-As laser diode (n = 45) vs. Sham Laser Group (SLG): Participants treated with sham laser (n = 45). Follow- up at 6 weeks after completion of study, and 6 months after completion of study.	No significant difference in pain between groups at 6 weeks, 6 months. Significant difference in depression, anxiety, stress between treatment (LAG: 4.9 vs. SLG: 4.5), at completion (LAG: 3.0 vs. SLG: 3.3), 6 weeks after treatment (LAG: 2.5 vs. SLG: 3.1, p <0.01, using repeated measures.	"[T]here are many more factors than the placebo effect which may have contributed to the positive therapeutic response in both groups. From this study, it is not possible to determine their relative contribution. It would also be incorrect to state that the LA intervention is only a placebo."	Details sparse, some baseline differences, errors in statistical differences in table of baseline differences. Data suggest lack of efficacy.
Yun 2012 RCT No mention of industry sponsorship. No COI.	4.0	N = 187 with chronic LBP, mean age 34+/- 11 years	Hegu acupuncture (n = 64) vs. standard acupuncture (n = 60) vs. usual care (n = 63).	At 48-weeks follow-up, Roland-Morris Disability Questionnaire (RMDQ) scores were significantly improved in the Hegu group (5.3 +/-1.6) vs. usual care (7.6 +/- 2.2) (p<0.001). VAS pain scores were significantly improved in both Hegu and standard acupuncture compared to usual care (p <0.001).	"Hegu acupuncture and standardized acupuncture have beneficial and persistent effects on CLBP compared with usual care, and both can result in clinically significant improvement in function and mental condition. However, Hegu acupuncture was significantly more effective than standardized acupuncture, especially with regard to long-term effects."	Lack of study details. Data suggest clinical significance of outcomes is questionable between both methods and control.

NEUROREFLEXOTHERAPY

Neuroreflexotherapy is an alternative treatment that was developed in Spain and involves implantation of numerous epidermal staples in "trigger" points in the back as well as burins (small metallic punches) in "referred tender points in the ear"(1518) at depths up to 2mm.(1519, 1520) In contrast with acupuncture, the sites are chosen by dermatomal innervation. Implantation does not require anesthesia and staples remain in place for up to 90 days. Significant reductions in LBP have been reported at 1 year in uncontrolled studies.(1521)

1. *Recommendation: Neuroreflexotherapy for Treatment of Moderate to Severe Chronic Low Back Pain*

   Neuroreflexotherapy is recommended for treatment of moderate to severe chronic low back pain in patients who have failed management with NSAIDs, progressive aerobic exercise program or other exercises, or manipulation.

   Harms – Irritant or allergic reactions to the metals.

   Benefits – Modest reductions in low back pain.

   Strength of Evidence – **Recommended, Evidence (C)**

   Level of Confidence – Moderate

2. *Recommendation: Neuroreflexotherapy for Treatment of Acute or Subacute Low Back Pain or Radicular Pain*

   There is no recommendation for or against the use of neuroreflexotherapy for treatment of acute or subacute low back pain or radicular pain syndromes.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendations

Neuroreflexotherapy may be modestly efficacious for the treatment of chronic LBP.(1518, 1522) It appears to have some analogy to treatment with non-traditional acupuncture and superficial needling. Reports are mostly foreign language and this treatment is currently largely unavailable in the U.S. There are reports of relatively few adverse effects. Thus, neuroreflexotherapy is minimally invasive, has some adverse effects, and is moderate cost. It needs to be replicated by other research groups in other settings. It has not been shown to be efficacious for the treatment of acute or subacute LBP or radicular pain syndromes. There are other treatments that have been shown to be efficacious.

Evidence for the Use of Neuroreflexotherapy

There is 1 high-(1518) and 1 moderate-quality(1522) RCT incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates. The following search terms were used: Neuroreflexotherapy AND (sub-acute low back pain OR Chronic low back pain)" to find 218 articles. Of those, we reviewed 3 articles and included 2 articles (2 RCT, zero reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Kovacs 1997 RCT Study supported by research grants from Fundación Kovacs and Fondo de Investigaciones Sanitarias. No mention of COI.	8.5	N = 78 with chronic LBP or LBP >3 years	Active neuroreflexotherapy (n = 41) vs. sham treatment with follow-up at 45 days (n = 37).	Neuroreflexotherapy pain better at 5 minutes and 45 days. Medication use not different. Outcomes 45 days after treatment. LBP VAS (1st/2nd assessment): control (0.34±2.98/0.91±3.23) vs. intervention (3.09±2.56/ 3.31±2.62), p <0.001. Pain on movement VAS, p <0.001/ 0.002. Change in quality of life: (2.83±0.85/2.72±0.91) vs. (2.45±1.11/2.21±0.04), p = 0.095/0.028. Not significant between groups for overall health and quality of life.	"Neuroreflexotherapy intervention seems to be a simple and effective treatment for rapid amelioration of pain episodes in patients with chronic low back pain."	Data suggest short term benefit in pain and functional score improvement immediately after treatment and continued at 45 days. Clinical significance and results uncertain.
Kovacs 2002 RCT Study supported by research grants from Fundación Kovas and INSALUD-Balears. No COI.	4.0	N = 104 with subacute and chronic LBP	Standard therapy (n = 45) vs. standard therapy plus neuroreflexotherapy (n=59).	Median improvements in pain scores 1.92 vs. 5.5 (p = 0.000), referred pain of 0.58 vs. 3.63 (p = 0.001) and Roland-Morris 2.05 vs. 8.67 (p = 0.007). Median sick days favored neuroreflexotherapy (median 105.2 vs. 3.2, p = 0.001).	"Referral to neuro-reflexotherapy intervention improves the effectiveness and cost–effectiveness of the management of nonspecific low back pain."	Many measures incompletely assessed. Randomization at clinic level, thus, not technically randomized. Data suggest neuroreflexotherapy superior.

Electrical Therapies

There are multiple forms of electrical therapies used to treat musculoskeletal pain. These include interferential therapy, transcutaneous electrical stimulation (TENS), neuromuscular electrical stimulation (NMES), percutaneous electrical nerve stimulation (PENS), microcurrent electrical stimulation, H-wave® Device Stimulation, and high voltage galvanic therapy. The mechanism(s) of action, if any, are unclear.

INTERFERENTIAL THERAPY

Interferential therapy (IFT) is a form of electrical stimulation using amplitude modulation of two out-of-phase medium-frequency currents to produce a low-frequency current that has been used to treat low back pain.(1449, 1523) This procedure is similar to TENS and differs by having less impedance in the tissues and is reportedly more comfortable than traditional TENS treatment. IFT is commonly used in the U.K.

Recommendation: Interferential Therapy for Treatment of Acute, Subacute or Chronic Low Back Pain, Chronic Radicular Pain Syndromes or Other Back Disorders

There is no recommendation for or against the use of interferential therapy for treatment of acute, subacute or chronic low back pain, chronic radicular pain syndromes, or other back-related disorders.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendation

Evidence is conflicting regarding whether interferential therapy produces any benefits in comparison with no treatment among acute, subacute and chronic LBP patients. There also is no quality evidence that interferential therapy produces any incremental benefits when added to a treatment regimen. Interferential therapy is non-invasive, does not have significant adverse effects, but is moderately costly.

Evidence for the Use of Interferential Therapy

There are 1 high-(1524) and 7 moderate-quality RCTs incorporated into this analysis.(1220, 1290, 1525-1529)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with limits on dates for 2011-2012. We used the following terms: interferential therapy, subacute low back pain, chronic low back pain, radicular pain syndromes (including 'sciatica'), spinal stenosis, spinal fractures, sacroiliitis, spondylolisthesis, clinical trial or randomized controlled trial, systematic reviews or reviews to find 106 articles. Of the 106 articles we reviewed 10 articles and included 8 RCTs (2 review articles).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Facci 2011 Authors state no industry sponsorship and no COI.	8.0	N = 150 with chronic LBP, with or without leg pain for >3 months (pain nonspecific)	Interferential current (IFC) therapy group treated with Endophasys I-ET9702 (n = 50) vs. TENS therapy group treated with TENYS-ET 9771 (n = 50) vs. control group (n = 50).	Pain intensity between groups before treatment not significant (p = 0.19). However, there was difference between sessions for the IFC and TENS groups: 4.44 vs. 5.75 (p<0.01). Assessments of mean pain intensity (VAS) before and after treatment on IFC group vs. TENS group vs. control group: 4.48cm vs. 3.91 cm vs. 0.85 (p <0.01). Decreases in Pain Intensity Index (PPI) and number of words chosen (NWC) evaluated in ANOVA and showed decrease between groups on PPI (p <0.01), Pain Rating Index (PRI) (0.01) and NWC.	"The results from this study showed that TENS and IFC had significant effects in relation to pain intensity reduction, disability improvement and reduction of medication consumption, immediately after each electrotherapy session and after ten sessions, in comparison with the controls."	Baseline differences in outcome measures. Control group had no interaction with researchers in a 2 week waiting period for PT.
Hurley 2004 RCT Study funded by Society of Orthopaedic Medicine Project Grants, Manipulation and Association of Chartered Physiotherapists Churchill Livingstone Award and Research Presentation Award. Devices provided by TensCare Ltd. No COI.	7.5	N = 240 with acute LBP	Interferential therapy: 140 Hz (IFT, n = 80) vs. manipulative therapy: mobilization or manipulation (MT, n = 80) vs. combined therapy: MT before IFT (CT, n = 80) for 4-10 treatments over 8 weeks. All received back education booklet. Follow-up at 6 and 12 months.	No differences in effects of manipulative therapy or interferential therapy found whether used in combination or in isolation. At 12 months, significant differences favor of CT over MT for SF-36 Physical Functioning (p = 0.04) and Bodily Pain scales (p = 0.036) and CT over IFT on mental health, p = 0.023.	"For acute low back pain, there is no difference between the effects of a combined manipulative therapy and interferential therapy package and either manipulative therapy or interferential therapy alone."	Lack of control group in patients with acute LBP limits conclusions. Data suggest lack of efficacy.
Hurley 2001 RCT Study supported by Society of Orthopaedic Medicine and Manipulation Association of Chartered Physiotherapists	6.0	N = 60 with LBP for 1-3 months duration	Back book alone (evidence-based patient education booklet) (n = 20) vs. interferential therapy (IF) with carrier frequency 3.85 kHz, 140Hz constant; pulse duration 130µs; for 30 minutes, in the painful area with back book (n = 18) vs. IF on spinal nerve root with	Back book group scored significantly greater in Roland-Morris Disability Questionnaire over IFT in spinal nerve and IFT in painful area (1, 0, and -1 respectively, p = 0.045). IFT spinal nerve scored greater difference in RMDQ than either IFT painful area or back book	"[I]FT electrode placement technique affects LBP-specific functional disability, providing preliminary implications for future clinical studies."	Pilot study. Claim of double blinding dubious. Large range in treatment sessions. Concerning differences at baseline in duration (4 vs. 5 vs. 7 weeks) and RMD (5 vs. 9). Most data do not support differences.

Churchill Livingsonte Award. Devices provided by TensCare Ltd. No COI.			back book (n = 22). Follow-up at 3 months.	groups, (6, 3, 4 respectively, (p = 0.03).		
Zambito 2006 RCT No mention of COI or industry sponsorship.	5.5	N = 120 with history of chronic stable LBP with pain stable for past 6 months	Interferential therapy (IFT) in standard dermatomal pattern stimulated for 10 minutes at modulated frequency 200 Hz (n = 45) vs. horizontal therapy (HT) with stimulation frequency oscillating at 100 Hz between 4400 and 12300 Hz first 20 minutes and fixed frequency 4400 Hz further 20 minutes (n = 45) vs. sham HT with same placement but no electrical stimulation applied (n = 30). All treatments 5 days a week for 2 weeks. Follow-up 2, 6, 14 weeks.	Changes in Backill score in HT group significantly greater than those observed in sham HT group at week 14 (p <0.05). Use of analgesic medication significantly improved at week 14, only in HT and HT group and proportion of patients who improved significant over Sham HT group, 57.8% and 36.6% respectively (p = 0.05).	"[I]FT and HT therapy are significantly effective in alleviating both pain and disability in patients with CLBP. The placebo effect is remarkable at the beginning of the treatment but it tends to vanish within a couple of weeks."	Mixed patients, nearly all vertebral compression fractures. Some differences in baseline medication consumption. Adherence to exercise variable, could not address. Data suggest interferential ineffective. Results may be confounded by exercise/activity compliance issues.
Lara-Palomo 2012 RCT No industry sponsorship or COI declared.	5.5	N = 62 with choric non-specific LBP	Experimental group received treatment of 20 sessions of massage with interferential current in the lumbar and dorsal–lumbar area (n = 30) vs. Control group received superficial lower back massage; effleurage, superficial pressure and skin rolling (n = 31); 10 week follow-up.	Statistically significant group x time interaction for VAS, F = 12.839; p = 0.001/ODI, F = 5.850; p = 0.019/RMDQ, F = 8.237; p = 0.006 Quality of life (physical function/physical role / and body pain): F= 16.792; p = 0.001/F = 14.839; p = 0.001/ and F = 11.247; p = 0.001. Post-treatment improvements in McQuade Test/VAS/RMDQ/ range of trunk ante flexion motion/quality of life/physical role/body pain/general health/ vitality/social functioning/ emotional role/mental health: p = 0.004/0.001/0.038/0.004/ 0.001/0.001/0.001/0.001/0.021/ 0.036/0.002/0.049, superficial massage group significant differences in physical function/range of trunk ante flexion motion; 0.044/0.048.	"In individuals with chronic non-specific low back pain, interferential current electro-massage achieved a significantly greater improvement in disability, pain and quality of life in comparison to superficial massage after 20 treatment sessions."	Two interactions preclude assessment of effect of either.
Zambito 2007	5.5	N = 105 females with chronic	Interferential therapy (IFT) in standard dermatomal	Scores for Backill test favored both IFT and HT over sham	"[I]FT and HT therapy are significantly effective in	Patient population of multiple vertebral

RCT No mention of COI or industry sponsorship.		stable back pain at least 3 months due to multiple compression fractures, history of chronic back pain with pain stable for past 3 months and pain due to previous multiple vertebral osteoporotic fractures (CBPMF)	pattern stimulated for 30 minutes at modulated frequency of 200 Hz (n = 35) vs. horizontal therapy with stimulation frequency oscillating at 100Hz between 4400 and 12300 Hz first 20 minutes and fixed frequency of 4400 Hz for additional further 20 minutes (n=35) vs. sham HT treatment with same probe placement, but no electrical stimulation applied (n = 35). All treatments 5 days a week for 2 weeks. Follow-up at 2, 6, 14 weeks.	group (p <0.01). Use of analgesic medications improved from baseline to week 14 by 57.1%, 48.6 %, and 31% in HT, IFT, and sham group, respectively. Proportion of patients who improved in HT group significant over those in sham group (OR = 0.34, 95% CI 0.13-0.91; p = 0.03).	alleviating both pain and disability in patients with CBPMF."	osteoporotic fractures. Short trial of 14 days. Treatment differed and did not assess adequacy of attempted blinding.
Werners 1999 RCT No mention of COI or industry sponsorship.	5.0	N = 152 with mostly chronic LBP	Traction and mechanical massage (n = 73) vs. interferential therapy (n = 74) for 6 sessions over a 2-3 week period.	No significant differences between groups for ODI questionnaire and VAS scores throughout study.	"There was no difference in the improvement between the two groups at the end of treatment."	Entry criteria unclear. Most had many years of LBP, although unclear if new episode. No control group. Data suggest no differences.
Vong 2011 RCT No COI or industry sponsorship declared.	5.0	N = 88 patients with 3+months LBP	Physical therapy alone or PT session in 8 weeks; 15 minutes of interferential therapy and tailor-made back exercise program or PT (n = 43) vs. motivational enhancement therapy and physical therapy group or MET+PT (n = 45). Baseline to 1 month follow-up.	No significant group or interaction effect; both groups showed significant vs. baseline, p <0.001. Pain intensity/ Physical Function; VAS scores for both groups decreased over time (within-group effect, p < 0.001). Group and interaction effects not significant, p=0.50/ no group effect in ranges of motion.	"The addition of MET to PT treatment can effectively enhance motivation and exercise compliance and show better improvement in physical function in patients with chronic LBP compared with PT alone."	Baseline difference in secondary outcome. Compliance data appear low. Data suggest intervention improves motivation but clinical significance related to pain, disability less clear.

TRANSCUTANEOUS ELECTRICAL NEUROSTIMULATION (TENS) AND NEUROMUSCULAR ELECTRICAL STIMULATION (NMES)

Transcutaneous electrical nerve stimulation (TENS) has been used to treat LBP.(593, 1449, 1530-1536) TENS is a modality to control pain through electrical stimulation delivered by pads placed on the surface of the skin for the treatment of many painful conditions including both non-inflammatory and inflammatory disorders.(1524, 1537-1540) Neuromuscular electrical stimulation is somewhat similar, but considered a stronger device that causes muscular contraction and thus purportedly re-educates muscles.(1541)

1. *Recommendation: TENS and NMES for Treatment of Acute or Subacute Low Back Pain or Acute Radicular Pain Syndromes*

   TENS and NMES are not recommended for treatment of acute or subacute low back pain or acute radicular pain syndromes.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: TENS for Treatment of Chronic Low Back Pain or Chronic Radicular Pain Syndrome*

   TENS is recommended for select use in treatment of chronic low back pain or chronic radicular pain syndrome as an adjunct for more efficacious treatments.

   Indications – Chronic LBP insufficiently managed with prior NSAIDs, aerobic exercise, and strengthening exercise with which compliance is documented. Many providers would also require failure with TCA and/or SNRI anti-depressants. TENS (single or dual channel) may be recommended as treatment for chronic LBP when clear objective and functional goals are being achieved which includes objective functional improvements such as return to work, increased exercise tolerance and reductions in medication use. TENS is used as adjunctive treatment in chronic pain conditions to support graded aerobic exercise and strengthening exercises. For patients who are not involved in a conditioning program or who are non-compliant with graded increases in activity levels, this intervention is not recommended. There is no quality evidence that more complex TENS units beyond the single or dual channel models are more efficacious, thus those models are not recommended.

   TENS units should be trialed prior to purchase to demonstrate efficacy and increase function. Two or 3 visits with a therapist may be necessary to instruct the patient in the application and use of the unit and to determine the most effective electrode placement and current parameters. If the patient has a TENS unit, then electrical stimulation for pain management should not be performed as part of any ongoing rehabilitative program. Either a low-intensity prolonged (30 plus minutes) stimulation through an active electrode over the painful area or a higher intensity over the painful area for 15 to 30 minutes (commonly referred to as hyperstimulation analgesia) are the two most common treatment protocols.(1542) High-frequency stimulation is generally 80 to 200 Hz, whereas low-frequency is generally 4 to 8 Hz.
   Indications for Discontinuation – Resolution, intolerance, or non-compliance including non-compliance with aerobic and strengthening exercises.
   Benefits – Modest pain reduction. Potential improved exercise and exertion tolerances.
   Harms – Minor skin irritation.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

3. Recommendation: NMES for Treatment of Chronic Low Back Pain or Chronic Radicular Pain Syndrome

There is no recommendation for or against the use of NMES for chronic low back pain or chronic radicular pain syndrome as an adjunct for more efficacious treatments.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendations
There are quality studies evaluating the utility of TENS, particularly for chronic LBP. There is insufficient evidence on NMES and thus no recommendations regarding this treatment. There was no quality study identified evaluating acute LBP, and one with a minority of patients having subacute LBP.(1543) There are studies evaluating TENS for sciatica patients. In reviewing these studies, there is not clear evidence of benefit. Of the high-quality studies for chronic LBP, 3(1524, 1544, 1545) suggest benefit and 2(1048, 1546) suggest no benefit. While the highest quality study(1545) did find benefit, not all of the higher quality trials did, thus the evidence conflicts. There is no study finding strong evidence of major benefits, thus any benefit appears likely to be modest.

TENS is not invasive, has no significant adverse effects, and is moderately costly. It has no clear benefits and is not recommended for treatment of acute, subacute, or chronic LBP or radicular pain syndromes. In rare cases where more efficacious strategies have been exhausted, it may be reasonable to prescribe TENS for select subacute LBP patients, but only as an adjunct to a conditioning program.

Evidence for the Use of Transcutaneous Electrical Nerve Stimulation (TENS) and Neuromuscular Electrical Stimulation (NMES)
There are 5 high-(1048, 1524, 1544-1546) and 25 moderate-quality RCTs or crossover trials(1289, 1337, 1494, 1498, 1501, 1502, 1510, 1543, 1547-1563) incorporated into this analysis. There are 7 low-quality RCTs in Appendix 1.(1514, 1564-1569)

We searched PubMed, EBSCO, Cochrane Review, Google Scholar without limits on publication dates. We used the following search terms: Transcutaneous Electrical Nerve Stimulation, TENS, Electrical Stimulation, subacute low back pain, chronic low back pain, radicular pain syndromes, sciatica, spinal stenosis, spinal fractures, sacroiliitis, and spondylolisthesis to find 11,703 articles. Of the 11,703 articles, we reviewed 58 articles and included 40 articles (40 RCTs and 9 summaries).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Jarzem 2005 RCT/Crossover Trial No mention of COI or industry sponsorship.	9.0	N = 50 with LBP	TENS vs. sham TENS 20 minutes for 3 treatment periods before crossing over.	VAS (p = 0.0001) greater carryover effect from one treatment to next with TENS (p <0.05), and forward flexion (p = 0.0001). Extension better with TENS, p = 0.0093. Using TENS, able to lift more weight on isolift machine (p = 0.0001), perform more back extensions (p = 0.0001), side flexions (p = 0.0001), sit-ups (p = 0.001), oblique sit-ups (p = 0.0001).	"[T]ENS may be a useful therapy for the short-term relief of chronic low back pain."	Data suggest short-term treatment effect with TENS compared with placebo. However, clinical significance is unknown, as actual scores not presented in analysis.
Bloodworth 2004 RCT/Crossover Trial Supported in part by the Office of Naval Research, but no stated COI.	8.0	N = 11 with electro-myographic documented radiculopathy	Stochastic TENS (TENS-R) vs. conventional TENS vs. placebo for 1 day treatment including 6 trials.	MPQ scores for part 2 not significant between TENS-R, placebo and TENS (p = 0.096, p = 0.519); TENS-R vs. conventional TENS significant, p = 0.006. No patient preference for type of TENS (p = 0.407). No differences for VAS and MPQ part 1 pain scores.	"TENS-R for the treatment of chronic radicular LBP was found to more effectively mitigate qualitative aspects of pain than conventional TENS, as measured by MPQ Part 2."	Small sample size with low power. Data suggest no clinical benefit from TENS or TENS-R compared with placebo.
Deyo 1990 RCT TENS units loaned by EMPI Corp. But no COI reported.	8.0	N = 122 with chronic LBP median duration 4.1 years	TENS 3 times a day for 45 minutes (n=36) vs. sham TENS (n=36) vs. TENS plus stretching exercises (n=37) vs. sham TENS plus exercise (n=36) 2 times weekly for 4 weeks.	No treatment effects for all TENS outcomes (p = 0.7) or for any individual outcomes (p >0.2 in each case). Main effect of exercise was significant (p=0.03) overall. No significant interaction of TENS with exercise.	"[F]or patients with chronic low back pain, treatment with TENS is no more effective than treatment with a placebo, and TENS adds no apparent benefit to that of exercise alone."	Data suggest no clinical benefit from TENS in chronic LBP patients, and benefit from actively performing stretching/ strengthening exercises.
Bertalanffy 2005 RCT Supported by unrestricted study grant of Vienna Red Cross, Vienna, Austria. No mention of COI.	8.0	N = 72 with first episode of acute LBP transplanted via ambulance	Group 1 Dual channel TENStem eco stimulator (n = 36) vs. group 2 (n = 36) with sham TENS.	Heart rate mean±SD for group 1: 67±10 beats/minute vs. 99±7 beats per minute, p <0.01; VAS pain score (95 % CI) 49±8mm (43.54) vs. 77±11mm (73.81), p <0.01; VAS anxiety score 69±12mm (62.75) vs. 84±9mm (79.81), p <0.01.	"We found TENS to be an effective and fast-acting therapy for patients with acute low back pain being transported by out-of-hospital personnel. Due to its simplicity and lack of side effects, this method should be considered in these patients."	Short duration of follow-up. Data suggest modest efficacy.

Facci 2011 Authors state no industry sponsorship and no COI.	8.0	N = 150 with chronic LBP, with or without leg pain for >3 months (pain nonspecific)	Interferential current (IFC) therapy group treated with Endophasys I-ET9702 (n=50) vs. TENS therapy group treated with TENYS-ET 9771 (n=50) vs. control group (n=50).	Pain intensity between groups before treatment not significant (p = 0.19). But difference between sessions for IFC and TENS groups: 4.44 vs. 5.75 (p <0.01). Assessments of mean pain intensity (VAS) before/after treatment on IFC group vs. TENS group vs. control group: 4.48cm vs. 3.91cm vs. 0.85 (p <0.01). Decreases in Pain Intensity Index and number of words chosen (NWC) evaluated in ANOVA showed decrease between groups on Pain Index (p <0.01), Pain Rating Index (0.01) and NWC.	"The results from this study showed that TENS and IFC had significant effects in relation to pain intensity reduction, disability improvement and reduction of medication consumption, immediately after each electrotherapy session and after ten sessions, in comparison with the controls."	Baseline differences in outcome measures. Control group had no interaction with researchers in a 2 week waiting period for PT.
Thorsteinsson 1977 RCT/Crossover Trial No mention of COI or industry sponsorship.	7.0	N = 93 with chronic LBP and neuropathies	TENS vs. placebo; 3 treatment sessions for each group before switching over. Each treatment lasted 20 minutes and 6 sessions completed in 3 days.	Stimulator more effective than placebo during application over center of pain (p <0.005), subsequent to application over center of pain (p <0.005) and during application over unrelated nerve trunk (p <0.01).	"Transcutaneous electrical stimulation was successful (relieved pain) in only 48%...[t]he placebo device was successful in 32%. This difference is not enough to allow the indiscriminant use of the stimulator in these patients."	Data suggest immediate benefit was greater in the TENS group, but no differences were found soon after treatment, limiting utility of TENS to select patients that are not well defined in this study.
Moore 1997 RCT/Crossover Trial Electrical Stimulation devices provided by Vision Quest Inc., but no COI stated.	7.0	N = 24 with chronic back pain	TENS vs. neuromuscular electrical stimulation (NMES) vs. combined TENS/NMES vs. placebo (modified TENS unit) for 5 consecutive hours per day for 2 days with 2 days between treatments.	PPI pain intensity decreased in 31 vs. 17 subject-days (placebo) with combined p <0.05. Combined treatment greater pain reduction than TENS (p <0.001) and NMES (p = 0.007). Pain relief measured by VAS-R greater for combined (p <0.001), NMES (p <0.001), and TENS (p <0.001) vs. placebo. Combined treatment had greater pain relief vs. TENS (p = 0.001) or NMES (p = 0.003).	"Combined treatment was also significantly more effective than either TENS or NMES alone on a majority of the dependent measures assessed, with group trends in the direction of superior performance by combined treatment on every dependent measure."	Double blinding is stated, but the procedures used are unclear. Data suggest combined therapy more effective than placebo or individual therapy.
Herman 1994 RCT Supported by grant from National Health Welfare Canada, but no COI stated.	7.0	N = 58 with acute occupational LBP	Active TENS/codetron for 30 minutes (applied 30 minutes before exercise program) plus exercise (n = 29) vs. placebo TENS/ codetron plus exercise (n = 29) 4 hours a day 5 days a week for 4 weeks.	No difference in treatment (time x treatment interaction p = 0.455).	"The results of our study do not indicate that TENS/ codetron treatments contributed to improved functional status, decrease in perceived pain, or earlier return to work in a homogeneous sample of Workers' Compensation Board workers with acute occupational LBP."	Significant proportion of experiment group did not complete full regimen. Data suggest no benefit over exercise alone.

Lehmann 1983 RCT Supported by NIHR Grant 23P59176, but no stated COI.	7.0	N = 54 with chronic LBP	TENS 60 Hz frequency (n = 18) vs. electroacupuncture twice weekly (n = 17) vs. placebo TENS (n = 18) for 3 weeks. All patients attended comprehensive multidisciplinary educational program and exercise training sessions twice daily.	Positive non-organic signs ("invalid") more defensive on MMPI. Significant differences for depression ($p < 0.05$) and anxiety ($p < 0.02$). 80% who over reported pain retained a lawyer vs. 17% of valid patients, $p < 0.005$. Valid patients had more peak pain with sham than TENS. Invalid patients had more pain with sham-TENS than with TENS than with acupuncture. Acupuncture had greater peak pain relief than placebo TENS and TENS.	"Both emotional factors and secondary gain factors have been found to be associated with the presence of nonorganic physical findings…Most importantly; however, patients with nonorganic physical findings have been shown to be a contaminating bias in this trial."	This finding has potentially worrisome implications in other RCTs on other subjects where psychosocial factors were not assessed. Data suggest that psychosocial factors have a significant impact on outcomes in chronic LBP patients.
Thompson 2008 RCT No mention of COI or industry sponsorship.	7.0	N = 60 with LBP for not less than 1 year and no more than 12 years	Group A: 0 kHz, 0 µs, 0 V (n = ?) vs. Group B: 1.66 kHz, pulse duration each half wave 4, 140 V (n = ?) vs. Group C: 2.20 kHz, pulse duration each half wave 4, 160 V (n = ?) vs. Group D: 0 kHz, 0 µs, 0 V (n = ?).	No significant differences between groups.	"These results show unequivocally that treatment with a TSE machine lasting 20 min, producing pulses with a differentiated biphasic waveform of 4 µs duration at a suppose frequency of 2 kHz, with electrodes placed over the spinous processes of the first thoracic (T1) and twelfth (T12) thoracic vertebrae, fails to alter the mean VAS pain scores either immediately after treatment nor in the subsequent week."	Short duration of follow-up.
Jarzem 2005 RCT No COI or industry sponsorship.	7.0	N = 324 with continuous LBP for ≥3 months	Conventional TENS (n = 84) vs. acupuncture TENS (n = 78) vs. biphasic TENS (n = 79) vs. sham TENS (n = 83).	Significant omnibus effect of time on recovery for all groups. Mean (SD) for Roland Disability score at baseline and 3rd assessment for Sham: 10.3(5.1) and 9.7 (5.8) vs. Conventional: 11.3 (5.3) and 9.9 (5.9) vs. Acupuncture: 9.9 (5.6) and 9.0 (6.1) vs. Nu Wave 10.5 (5.2) and 9.1 (5.7); $p < 0.05$.	"These data suggest that TENS is no better than placebo for treatment of chronic low back pain without sciatica."	Large sample size. Data suggest TENS ineffective.
Shimoji 2007 RCT Investigation supported financially in part by Omron Healthcare Co,	7.0	N = 49 with chronic back pain suffering mostly from spondylosis deformans with or	TENS treatments (n = 28): Bidirectional Modulated Sine Wave (BMW) (n = 11) vs. Conventional Bidirectional Pulsed Wave (CPW) (n = 9) vs. sham electrotherapy (SHM) (n =	BMW group had significant decrease in numerical rating scale (NRS) 0-5 minutes (2.8±1.4, $p < 0.05$) and 1 hour (3.0±0.9, $p < 0.01$) after treatment. BMW group showed significant reduction in pain intensity vs. SHM group after	"The present study demonstrated that TENS with BMW was more effective for treating low back pain than TENS with CPW. The study also indicated that there was no	Mixed and used massage +- TENS.

Ltd, Kyoto, Japan, but no COI was stated.		without osteoarthritis	8). Treatments administered for 5 weeks. Comparison study between massage (n = 21): massage + sham TENS (n = 10) vs. massage + TENS (n = 11). Subjects received massage + TENS or massage + sham TENS, with at least 2-day intervals between treatments, for 5 weeks.	1 hour treatment (p = 0.028). No significant difference in pain rating between massage + TENS and massage + sham TENS. However, significant reduction in pain intensity rating in massage + sham TENS (before: 5.0±1.5 and after: 3.6±0.4, p <0.05) and massage + TENS (before: 4.5±1.1 and after: 3.4±0.6, p <0.05). Straight-leg raising in massage + sham TENS improved from 82±4° to 87±3°, p <0.05 and in massage + TENS from 78±6° to 85±2°, p <0.05.	significant interactive effect between TENS and massage for treatment of low back pain."	
Hsieh 2002 RCT No mention of COI or industry sponsorship.	6.5	N = 133 with many disorders: herniated disc, spondylosis, sprain, strain; most (56%) acute LBP, 20% subacute, 24% chronic LBP	PENS 1-shot treatment for 15 minutes and medication (Group 2, n = 53) vs. medication diclofenac 25mg per tablet, mephenoxalone 200mg per tablet and antacid, 2-3 tablets a day for 2-3 days (Group 1, n = 31) vs. 1-shot TENS treatment and medication (Group 3, n = 49). All received educational material.	PENS in acupuncture sites no different than diclofenac, mephenoxalone (a muscle relaxant), and an antacid, or medications combined with TENS either immediately or 1 week later. No differences between groups immediately after treatment or 1 week after treatment for VAS scores, body surface scores, pain pressure threshold, or Quebec Back Pain Disability scale.	"Simple one-shot treatment with percutaneous electrical nerve stimulation or transcutaneous electrical nerve stimulation provided immediate pain relief for low back pain patients. One-shot Transcutaneous electrical nerve stimulation treatment is recommended due to the rarity of side effects and its convenient application."	Co-interventions not well described. Data suggest no significant difference between medication alone, PENS, or TENS.
Barker 2008 RCT Authors state no COI; however, if FairMed product were marketed, it would be patented for one of the authors.	6.5	N = 60 from Physiotherapy Department with chronic LBP for ≥3months.	FairMed (16 vibrators applied to lumbar spine) for 30 minute sessions (n=32) vs. TENS TPN 200 PLUS at high frequency 80 Hz and 100 µs pulses (n = 28).	Mean difference between participants in the TENS group and FairMed was -0.1 (p = 0.82). Mean difference ODI score between TENS group and FairMed 0.4 (p = 0.85). 27% of FairMed group more able to cope with pain at 3 weeks vs. 45% of TENS group.	"The findings presented in this study are not able to demonstrate a reduction in chronic low back pain using the FairMed."	Data suggest comparable (in)efficacy.
Gabis 2009 RCT No mention of COI or industry sponsorship.	6.0	N = 119 with chronic pain (cervical, LBP, and headache)	TCES group (n = 58): 19 cervical, 17 LBP, and 22 headache vs. Active-Placebo group (n = 61): 23 cervical, 16 LBP, and 22 headache.	Significant decrease in pain in TCES group vs active-placebo group (p = 0.0017). Baseline VAS score for LBP (TCES n = 17, 5.82(1.81)) vs. (Active-placebo n = 16, 7.00(1.51)); p = 0.046 No significant results at 3 weeks, and 3 months.	"Transcranial electrical stimulation is an effective non-invasive method for pain relief. The active placebo device has a powerful effect on reported pain, which diminishes in the long-term. The involvement of possible neural mechanisms is discussed."	Small sample size. Multiple outcomes. Not well randomized for LBP patients. Duration different at baseline (8.5 vs. 4.7). As device increased to tolerance, at least partial unblinding likely. LBP outcomes mostly negative.

Tsukayama 2002 RCT Study funded by grant from Foundation for Training and Licensure Examination in Anma-Massage-Acupressure, Acupuncture and Moxibustion, and Tsukuba College of Technology, but no COI stated.	6.0	N = 20 with LBP	TENS (n = 10) vs. electroacupuncture (EA, n = 10) twice a week for 2 weeks, 4 sessions total.	Pain relief favored electro-acupuncture (65mm for EA vs. 86mm for TENS), p = 0.02. Statistically significant change over time (p <0.01) and no significant group by time interaction (p = 0.10). Not significant between groups for JOA score.	"[A] significant reduction in pain relief in both groups, but…change in the EA group was greater than that in the TENS group." "These findings suggest that EA was more effective than TENS for short-term treatment of LBP in this study."	Data suggest electro-acupuncture provides greater benefit than TENS for back pain. Small sample size, unknown duration of symptoms at study inclusion (appears to be chronic but not defined) limits conclusions.
Marchand 1993 RCT No mention of COI or industry sponsorship.	6.0	N = 42 with LBP	TENS for 30 minutes (n = 14) vs. placebo-TENS (n = 12) vs. control, no treatment (n = 16) twice a week for 10 weeks.	Between-group differences for pain not significant. Effect of TENS for reduction in intensity rating greater for TENS than placebo-TENS, p = 0.05. 1 week after end of treatment, TENS more effective than placebo for reducing pain intensity, p <0.05.	"[T]ENS should be used as a short-term analgesic procedure in a multi-disciplinary program for low back pain rather than as an exclusive or long-term treatment."	Small sample size lack of study details for randomization allocation, baseline comparability. Data suggest limited short-term pain reduction from TENS for chronic LBP although clinical significance is likely small.
Cheing 1999 RCT Supported by Fonds de la Recherche en Sante de Quebec. No COI stated.	6.0	N = 30 with chronic LBP	TENS at 80 Hz frequency (n = 15) vs. placebo-TENS (n = 15) for 60 minutes.	LBP scores for TENS decreased from 100% before, to 72.1%±25.9% during, to 63.1%±31.2% after (p <0.001) vs. placebo: 100% to 96.6%±15.2% to 96.7%±23.1% (p = 0.786). No other significant differences between groups.	"This study is the first to demonstrate that TENS, but not placebo stimulation significantly reduced chronic clinical pain (LBP) both during treatment and up to 1 hour after treatment was stopped."	Lack of details on baseline characteristics. Small numbers. Age at baseline older in placebo group (p = 0.039). Data suggest TENS decreases VAS during and immediately following single treatment.
Buchmuller 2012 RCT, Multicenter One author is member of a board (COI).	6.0	N = 236 with chronic LBP ≥40 on VAS scale with or without radicular pain	Active TENS group (n = 117) vs. Sham TENS group (n = 119).	Improvement in functional status at 3 months on active TENS group vs. sham TENS group: 26.4% vs. 25.0% [RR = 1.05 (0.67; 1.65), p = 0.816]. Improvement of at least 50% in lumbar pain between 1st and last assessments between active TENS vs. sham TENS: 25% vs. 6.7% (p = 0.0003).	"The overall results of this study do not support the use of TENS in the treatment of patients with chronic LBP."	Longer duration BP with active TENS. High dropouts. Data suggest trend in modest benefit in LBP and radicular pain, but not in function although not significant.
Grant 1999 RCT No stated COI.	6.0	N = 60 age 60 or over with back pain for at least 6 months	TENS up to 30 minutes a session, maximum of 6 hours a day; also 20 minutes twice weekly by a physiotherapist (n = 28) vs. acupuncture 20	Both groups improved in VAS scores by 50% between baseline and completion (p <0.001). NHP results similar. 50% reduction on tablet use in acupuncture and 33% reduction for TENS.	"[B]oth acupuncture and TENS are effective treatments for chronic back pain in the elderly, and provide some grounds for	Acupuncture protocol not well described. Both groups improved but no significant differences reported between groups.

			minute sessions 2 sessions a week (n = 32) for 4 weeks.		therapeutic optimism in both patients and staff."	Both have evidence of efficacy.
Ghoname 1999 RCT/Crossover Trial No mention of COI or industry sponsorship.	5.5	N = 60 with LBP secondary to degenerative disc disease and LBP at least 3 months duration	TENS vs. sham PENS vs. PENS vs. exercise (flexion-extension only). Each treatment for 30 minutes a day 3 times a week for 3 weeks with 1 week off in between modalities for 15 weeks.	Degree of pain (before/after): sham PENS (5.7±1.8/5.5±1.9) vs. PENS (6.3±1.5/3.4±1.4) vs. TENS (6.2± 1.7/5.6±1.9) vs. exercise (6.5±1.4/ 6.4±1.9), p <0.02. Level of activity (before/after): 5.1±2.1/4.9±2.1 vs. 5.5±2.0/3.2±1.7 vs. 5.5±2.1/4.7±1.9 vs. 5.7±1.8/5.7±1.8, p <0.02.	"[P]ENS was more effective than TENS or exercise therapy in providing short-term pain relief and improved physical function in patients with long-term LBP."	Population not well described. Study protocol details sparse at times, particularly blinding issues. Issues such as psychosocial factors not well described.
Yip 2007 RCT Partially supported by School of Nursing Departamental Research Committee, but no mention of COI.	5.5	N = 47 with non-specific subacute neck or LBP most days 2 weeks prior to enrollement, and no acupuncture, physiotherapy or manipulative therapy in last 2 weeks	Intervention group (IG) treated 8 times over 3 weeks for 35-40 minutes with TENS E704 and painkiller (n = 23) vs. control group (CG) treated with painkiller alone (n = 24).	LBP subgroup (n = 24), significant reduction of pain intensity at intervention group immediate post intervention (p = 0.007), but not sustained at both follow-ups (p = 0.16, and p = 0.39). Significant decrease on stiffness level and stress level immediate post-intervention (p = 0.009, and p = 0.003), but values not sustained at 1 week, or 3 month follow-up. Mean change in disability score similar for IG and CG at immediate post intervention (p = 0.21).	"Our study shows that there was relief in pain intensity, stress and stiffness level immediately after eight sessions of combined TAES [transcutaneous acupoint electrical stimulation] and EMMW [electromagnetic millimeter wave] treatment, although, in general, the effect is not sustained over a week."	Treatment group had 8 treatments over 3 weeks. TENS and EMMW, also used 'pain killers'.
Sherry 2001 RCT One author (Dr. Russell Smart) is contracted to and shareholder in VAX-D Australasia Pty. Ltd, a company that delivers VAX-D in Australia.	5.0	N = 44 with chronic LBP	Vertebral axial decompression (VAX-D, n = 22) 30 minute sessions 5 times a week for 4 weeks and then once a week for 4 weeks vs. TENS (n = 22) 30 minutes a day for 20 days then once a week for 4 weeks.	Efficacy rate 68.4% for VAX-D group vs. 0% for TENS, p <0.001. Results reported by TENS group suggest they may have come under negative placebo effect and highlights one difficulty in studying medical devices where it is not possible to blind patients to treatment.	"[V]AX-D can achieve a statistically significant improvement in pain and functional outcome for patients suffering from disc-related chronic low back pain."	Small sample size. Lack of randomization details, allocation, baseline comparability. Data suggest VAX-D more beneficial than TENS. Patient bias likely as TENS treated in clinic for VAX-D resulting in potential negative placebo effect.
Lehmann 1986 RCT Supported by NIHR Grants, but no COI was stated.	5.0	N = 54 with chronic disabling LBP	Electroacupuncture 2-4 Hz frequency twice weekly (n = 17) vs. TENS 60 Hz frequency daily (n = 18) vs. sham TENS daily (n = 18) for 3 weeks.	All groups showed significant long-term improvements (p = 0.01, p = 0.001, p = 0.004). Study unable to detect any differences between active subthreshold TENS and dead-battery TENS.	"[N]either electrical stimulation modality was shown to affect that patients' rehabilitation. Electro-acupuncture demonstrated the ability to reduce some pain reports. Subthreshold TENS was no more effective than a dead-battery control."	Dropout rate high, thus, robust conclusions not possible.

Al-Smadi 2003 RCT Supported by Multiple Sclerosis Society of Great Britain and Northern Ireland, but no stated COI.	5.0	N = 15 clinically diagnosed with multiple sclerosis suffering from stable LBP at least 3 months and not responded to other conventional treatments	TENS 1 (4 Hz, 200µs, n = 5) vs. TENS 2 (110 Hz, 200µs, n = 5) vs. placebo TENS (n = 5). Follow up at 1, 6 and 10 weeks.	No significant differences between groups.	"Active TENS was more effective than placebo TENS in decreasing VAS scores following each treatment although results were not statistically significant."	Small sample size and sparse details.
Melzack 1983 RCT Study supported by Natural Sciences and Engineering Research Council of Canada. No mention of COI.	4.5	N = 41 with acute or chronic LBP	TENS (n = 20) vs. massage (n = 21) twice a week for 30 minutes for total of 10 treatments.	Mean percentage decreases in Pain Rating Index for TENS 69.5 vs. massage 37.2, p = 0.01; for decrease in present pain intensity 80.8 vs. 40.9, p = 0.001; for change in back flexion -2.5 vs. -4.7, p=NS; for change in straight left leg raising -9.6 vs. +3.4, p = 0.02; for change in straight right leg raising -16.1 vs. +1.7, p = 0.03.	"The results show clearly that TENS is an effective modality for the treatment of low back pain. Because of the double-blind, randomized design of the study, the significant effectiveness of TENS cannot be attributed to other factors such as placebo efficiency or other psychological effects. The significant correlations between pain-relief scores and range-of-motion scores highlight the usefulness of pain evaluation. The [present pain intensity] score of the [McGill pain questionnaire] can be obtained in less than a minute and provides valuable information about subjective pain relief that can complement range-of-motion scores."	Gentle massage used could conceivably be viewed as a placebo control procedure for evaluating effectiveness of TENS.
Kofotolis 2008 RCT/Sequentially allocated No mention of COI or industry sponsorship.	4.5	N = 88 females with chronic LBP for >24 weeks	Rhythmic stabilization (RS) via isometric contraction for 10 seconds and 15 repetitions at maximum resistance with resting intervals of 30, 60 seconds (n = 23) vs. Rhythmic stabilization and TENS (RS-	RS group with significant decline ranging from 26.3±5.9% to 42.1± 8.7% in Oswestry score vs. 12.1± 3.4% to 21.2±7.3% in RS-TENS group (p <0.05). Pain scores for RS lower than PS and TENS (p <0.05). RS group showed increase in trunk range of motion after training:	"[S]hort-term static rhythmic stabilization exercise is particularly effective in improving muscle endurance, flexibility of the trunk, and functional performance as well as reducing back pain	Randomization unclear with possible quasi ("sequentially"). Many details sparse. Data suggest TENS ineffective. Data suggest rhythmic stabilization

			TENS) with 20 minutes of TENS, 5 minute rest, and 20 minutes of RS (n = 21) vs. TENS treatment for 40-45 minutes while resting prone using 120 Z unit (n = 23) vs. placebo (PS) which consisted of units similar to TENS in appearance (n = 21).	10.1±1.9% to 25.5± 4.2%, while RS-TENS showed increase on flexion that ranged from 7.1±1.3% to 9.2±2.7% (p <0.05).	severity in women with chronic low back pain. Treatment with TENS appears to be more effective than treatment with a placebo, less effective than a combination of rhythmic stabilization and TENS, and adds no apparent benefit to that of rhythmic stabilization alone."	exercise superior to TENS.
Fox 1976 RCT/Crossover Trial Author supported by Johnson and Johnson Company during her sabbatical leave, but COI not stated.	4.0	N = 12 with chronic LBP	TENS for 2 treatments vs. acupuncture for 2 treatments. Treatments at weekly intervals.	Greater relief with acupuncture (75%) than TENS (66%). No significant differences between treatments.	"[A]cupuncture and transcutaneous electrical stimulation are equally effective in the relief of chronic low-back pain."	Data show clearly that acupuncture and transcutaneous electrical stimulation equally effective in relief of chronic LBP.
Itoh 2009 RCT No mention of COI.	4.0	N = 32 with lumbar or lumbosacral LBP ≥6 months, no radiation of LBP, normal neurological findings of lumbosacral nerve, no acupuncture treatment for >6 months.	Control group: no treatment (n = 8) vs. ACP group: acupuncture in selected acupoints 15 minutes in affected LBP (n = 8) vs. TENS group: 15 minute treatment in affected LBP from single-channel TENS unit (122 Hz beat frequency and 4.0 and 4.12 kHz feed frequency, n = 8) vs. Acupuncture and TENS (A&T) 15 minutes acupuncture and 15 minutes TENS of affected LBP (n = 8).	VAS score in A&T group at weeks 0, 4 (or 5) different (p <0.008). Although VAS decreased in all groups, not significant for other groups. RDQ scores decreased in all groups, but only one that shows statistically difference – A&T group between week 0 and 5 (p <0.008).	"The present study clearly demonstrated that combined acupuncture and TENS treatment is effective for pain relief in terms of VAS and QOL improvement in terms of RDQ in patients suffering from chronic LBP."	Small sample sizes. Many study design weaknesses. No-treatment control bias.
Transcranial Electrostimulation						
Gabis 2003 RCT No COI or industry sponsorship.	5.0	N = 20 with chronic LBP	Transcranial Electro-stimulation (TCES) (n = 10) vs. active placebo device group (n = 10).	Beta-Endorphin level increased in 7/10 patients in TCES group compared to only 2/10 in placebo group (p = 0.057).	"Transcranial electrostimulation is a nonpharmacologic method of pain relief accompanied or mediated by -endorphin release. The comparable degree of the initial clinical response emphasizes the powerful placebo effect on reported pain not mediated by endorphin release."	Small sample size. Data show lack of efficacy in placebo.

PERCUTANEOUS ELECTRICAL NERVE STIMULATION (PENS)

Percutaneous electrical nerve stimulation (PENS) involves inserting needles to a depth of 1 to 4 centimeters around a nerve serving a painful area. The techniques described in the studies differ.

Recommendation: PENS for Treatment of Acute, Subacute, or Chronic Low Back Pain or Radicular Pain Syndromes

PENS is not recommended for treatment of acute, subacute, or chronic low back pain or radicular pain syndromes.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

Rationale for Recommendation

PENS has been evaluated in small-scale, short-term studies, but there are no high-quality studies.(1543, 1570-1572) The two highest quality studies suggest no efficacy.(1543, 1573) Four of the RCTs were reported by one group (*JAMA* reported a significant potential financial conflict of interest for this group's study following publication of the article). All of the studies that showed improvement over placebo or sham treatment failed to show any improvement over baseline in the placebo treated group, which is unusual. Most studies of chronic LBP report a 2-week outcome for treatment with PENS, which generally is insufficient for chronic pain patients. The one study that evaluated duration of improvement after PENS treatment was stopped and found no effect 4 weeks after treatment ceased. No study documented a significant improvement in function. Hseih and Lee did not find the use of one-time PENS to be superior to a combination of diclofenac, mephenoxalone, and an antacid.(1543) There were no studies that compared PENS to heat therapies. Although Ghoname, et al., found PENS to be superior to exercise, the exercise consisted of simple spinal flexion and extension while seated, which would appear insufficient.(1570)

PENS has not been convincingly demonstrated to be superior to other less expensive and/or proven interventions. Most PENS studies have been conducted in chronic non-radicular back pain patients. In acute LBP, the natural history is to resolve, and PENS has not been shown to accelerate that natural healing process. Short-term pain relief can be achieved more easily with analgesics. PENS is minimally invasive and no significant adverse effects have been reported (although most articles failed to include a section on complications). However, it is high cost.

Evidence for the Use of PENS

A comprehensive literature search was conducted using PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates using the following terms: percutaneous electrical nerve field stimulat, percutaneious electrical nerve stimulat*, PENS, PNRS, NSS2 Bridge, NSS1 NeuroStim; Back, low back pain, Random* to find 42,805 articles. Of the 42,805 articles, we reviewed 123 articles and included 19 articles (18 randomized controlled trials and 1 systematic review).*

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Hsieh 2002 (score=6.5)	PENS	RCT	No mention of COI or industry sponsorship.	N = 133 with many disorders included (herniated disc, spondylosis, sprain, and strain); most (56%) had acute LBP, 20% had subacute, and 24% had chronic LBP	No mention of mean age, age range from 16 to 79 years; 44 males, 89 females	PENS 1-shot treatment for 15 minutes and medication (Group 2, n = 53) vs. medication diclofenac 25mg per tablet, mephenoxalone 200mg per tablet and antacid 2-3 tablets a, day for 2-3 days (Group 1, n = 31) vs. 1-shot TENS treatment and medication (Group 3, n = 49). All received educational material.	3 days and 1 week	PENS in acupuncture sites no different than diclofenac, mephenoxalone, and antacid, or medications combined with TENS either immediately or 1 week later. No differences between groups immediately after treatment or 1 week after treatment for VAS scores, body surface scores, pain pressure threshold, or Quebec Back Pain Disability scale.	"Simple one-shot treatment with percutaneous electrical nerve stimulation or transcutaneous electrical nerve stimulation provided immediate pain relief for low back pain patients. One-shot transcutaneous electrical nerve stimulation treatment is recommended due to the rarity of side effects and its convenient application."	Co-interventions not well described. Data suggest no significant difference between medication alone, PENS, or TENS.
Pérez-Palomares 2010 (score=6.5)	PENS	RCT	Study supported by Aragonese Health Service (Spain) and Research Network on Preventive Activities and Health Promotion (Health Institute Carlos III) and Aragonese Health Science Institute.	N = 122 with chronic LBP evolving for 4 months or more or fewer duration if it had been a recidivate	Mean age: 45.85 years; 31 males, 91 females	PENS (n = 67) vs. dry needling therapy (n = 67).	No follow-up after post-treatment.	No significant differences between groups.	"In brief, we can state that both techniques are equally effective for short-term treatment of non-specific [chronic low back pain]. [Dry needling] proved to be more cost-effective, but postreatment	Data suggest lack of meaningful differences.

			Authors declare no COI.						soreness associated to it can cause a higher rate of abandonment with regard to PENS. Therefore, we have two useful tools to deal with chronic muscular pain the action of which have been confirmed in different ways in the context of neuromuscular chronic pain matrix."	
Brennan 2006 (score=6.0)	PENS	RCT	Study supported by research grant from Deseret Foundation. No COI.	N = 123 with acute and subacute LBP	Mean age: 37.7 years, 67 males, 56 females	Manipulation (n = 40): including thrust manipulation or low amplitude mobilization vs. specific exercise (n = 37): instruction in repeated ROM exercises into either lumbar flexion or extension; directional exercises determined by treating therapist vs. stabilization (n = 46): trunk strengthening and stabilization	1 month, 1 year	Improvements in Oswestry Disability Index (ODI) for those with matched treatment were 29.9 vs. 23.3 for non-matched. More who were matched advanced to next stage (78% vs. 60%). No significant differences between randomized groups.	"Nonspecific LBP should not be viewed as a homogenous condition and that outcomes can be improved when subgrouping is used to guide treatment decision-making."	Outcomes for those who were "not matched" to the purported proper treatment also realized sizable improvements in ODI scores.

						exercises 2x a week for 4 weeks; maximum 8 sessions.				
Ghoname 1999 (score=5.5)	PENS	RCT/Crossover Trial	No mention of COI or industry sponsorship.	N = 60 with degenerative disc disease and LBP (at least 3 months duration)	Mean age: 43±1.9 years; 29 males, 31 females	TENS vs. sham PENS vs. PENS vs. exercise (flexion-extension only). Each treatment was administered for 30 minutes a day 3x a week for 3 weeks with 1 week off in between modalities for 15 weeks total.	No follow-up post-treatment	Degree of pain (before/after): sham PENS (5.7±1.8/5.5±1.9) vs. PENS (6.3±1.5/3.4±1.4) vs. TENS (6.2±1.7/5.6±1.9) vs. exercise (6.5±1.4/6.4±1.9), p <0.02. Level of activity (before/ after): 5.1±2.1/4.9±2.1 vs. 5.5±2.0/3.2±1.7 vs. 5.5±2.1/4.7±1.9 vs. 5.7±1.8/5.7±1.8, p <0.02.	"[P]ENS was more effective than TENS or exercise therapy in providing short-term pain relief and improved physical function in patients with long-term LBP."	Population not well described. Study protocol details sparse at times, particularly blinding issues. Issues such as psychosocial factors not well described.
McRoberts 2013 (score = 5.5)	PENS	RCT	Sponsored by St. Jude Medical Neuromodulation Division. No COI.	N=30 patients with chronic, intractable back pain	Mean age: 51.6±12.8 years; 19 males, 11 females	Group A: received minimal stimulation vs Group B: received subthreshold stimulation vs Group C: received low frequency stimulation vs Group D: received standard stimulation. All patients rotated through the four stimulation groups.	4, 12, 24, 52 weeks	VAS scores showed a difference of 42% across the stimulation groups (p<0.001). VAS scores varied by 33.3% between minimal stimulation and low frequency groups (p<0.001), 21.7% between minimal stimulation and subthreshold groups (p=0.003). Phase II VAS scores	"The results provide evidence to support safety and effectiveness of PNfS as an aid in the management of chronic, localized back pain."	Randomized controlled crossover study. Nearly all participants on opioids, 43% reduced opioid use but 22% increased opioid use. Data suggest PNFS improved chronic intractable back pain. Study reported significant AEs.

								improved from baseline to follow up (P<0.001).		
Weiner 2003 (score = 5.5)	PENS	RCT	Sponsored by USPHS Research Grants from the National Institutes of Health. No mention of COI.	N=34 adults with chronic low back pain	Mean age: 73.8 years; 16 males, 18 females	PENS+PT: received physical therapy and percutaneous electrical stimulation (2-200 Hz) (n=17) vs SHAM PENS+PT: received physical therapy sessions and acupuncture technique identical to PENS group without any electrical stimulation (30 min sessions) (n=17)	6 weeks, 3 months	PENS+PT group showed reductions in pain intensity (p<0.001) compared to no reduction in sham group (p=0.94). Reduction in pain intensity for treatment group did not vary from post-treatment to follow up (p=0.84). Reduction in pain-related disability for treatment group were observed (p0.002), but not for sham group (p=0.81).	"This preliminary study suggests that PENS may be a promising treatment modality for community-dwelling older adults with CLBP, as demonstrated by reduction in pain intensity and self-reported disability, and improvement in mood, life control, and physical performance."	Small sample size with 3 month follow-up. Dissimilar pain duration in years between groups (PENS group 10.6 years, SHAM group 16.6 years). PENS may benefit older adults with chronic low back pain by reducing both pain intensity and disability. Data suggest PENS may provide analgesic effects which could initiate an exercise program in older adults.
Hamza 1999 (score=5.5)	PENS	RCT/Crossover Trial	No mention of COI or industry sponsorship.	N = 75 with chronic LBP at least 3 months	Mean age: 47±18 years; 34 males, 41 females	Electrical stimulation vs. sham for duration of 0, 15, 30, or 45 minute treatment sessions 3 times a week for 2 weeks with 1 week off in between treatments for 11 weeks.	24 hours after last session for each treatment method	Sessions of 30 and 45-minutes better pain relief than pre-test (p <0.001). Decrease in daily oral non-opioid pain relief greater in 30 and 45 than 15 minute session (p <0.05). Electrical stimulation 15-	"[T]he duration of electrical stimulation influences the short-term outcome with PENS therapy. Of the different durations of electrical stimulation studied, the	Patients and study details not well described.

								45 minutes better SF-36 mental and physical improvements vs. sham (p <0.01 for 15 minutes, p <0.001 30 and 45 minutes).	30-min interval appears to be most suitable for this LBP population."	
White 2001 (score=5.5)	PENS	RCT/Crossover Trial	Study funded in part by White Mountain Institute (P.F. White, Director).	N = 72 with LBP >6 months	No mention of mean age, age range from 21 to 76 years; 31 males, 41 females	Standard montage (I) placement of percutaneous neuromodulation therapy (PNT) vs. 3 alternative (II, III, IV)) 30 minutes 3x a week for 2 weeks with 1 week washout period between treatments for 11 weeks.	No follow-up post-treatment	Use of oral analgesic decreased significantly greater in Montage I and II compared to other Montages (p <0.05). By treatment 6, all Montage groups had significantly improved VAS scores compared to pre-treatment session 1 (p <0.05).	"…Montage I produced both acute and cumulative analgesic effects over the course of the two-week treatment period."	Study suggests similar pain relief from 4 PENS techniques in short-term follow-up. Lack of control arm limits conclusions as no differentiation with natural history.
Murtezani 2011 (score=5.5)	PENS	RCT/Prospective controlled trial	No mention of COI or industry sponsorship.	N = 101 with chronic LBP	No mention of mean age, age range from 28 to 67 years; 52 males, 49 females	Aerobic exercise group began with 10-15 minutes warm-up period stationary bicycling, 3 days/week, 30-45 minutes (n = 50) vs. passive modalities group received interferential current, TENS, ultrasound, heat, involving thrice-weekly attendance without any form of	12 weeks	Significant improvements in comparison with basic values in pain intensity, disability, anxiety and depression, fingertip-to-floor distance, p < 0.001. P < 0.0001, rejects hypothesis of equal equivalence.	"The addition of aerobic training to conventional physiotherapy treatment did not enhance either short- or longterm improvement of pain and disability in patients with chronic LBP."	No blinding described. Lack of details for control of cointervention s, compliance. Data suggests workers with chronic LBP improved in pain and function with aerobic exercise compared to passive modalities.

						physical activity (n = 51). Follow-up 12 weeks.				
Chatzitheodorou 2007 (score=5.0)	PENS	RCT	No mention of COI or industry sponsorship.	N = 20 with chronic LBP (15 disc disruption, 3 spondylosis, 2 facet joint pain)	Mean age: 41.95 years; 11 males, 9 females	12 week high-intensity aerobic exercise program (n = 10) vs. 12 week passive interventions without any physical activity (n = 10). Aerobic exercise treadmill running at 60% of HR maximum for 30 minutes 3x a week 1st 3 weeks, then 85% HR maximum, 50 minutes 3x a week for 9 weeks and supervised by physiotherapist. Controls received diathermy, ultrasound, laser, difase fixe, and electrotherapy.	No follow-up post-treatment	Mean (SD) McGill Pain Questionnaire baseline/12 week for exercise group vs. control group: 53.9 (10.4)/32.3 (7.9) vs. 53.0 (11.7)/53.3 (10.0), p <0.05. Roland-Morris Disability Questionnaire disability: 13.8 (2.4)/9.6 (2.6) vs. 14.4 (2.8)/14.3 (3.6), p <0.05. Hospital anxiety and depression scale: 24.8 (5.0)/16.2 (3.4) vs. 22.6 (4.1)/21.9 (4.5), p <0.05.	"Regular high-intensity aerobic exercise alleviated pain, disability, and psychological strain in subjects with chronic low back pain but did not improve serum cortisol concentrations. "	Data suggest reductions in pain with aerobic exercise, disability, and psychological strain, all strongly in favor of high intensity aerobic exercise. Trial also had specific exercise-dose prescription.
Tritilanunt 2001 (score=5.0)	PENS	RCT	No mention of COI or industry sponsorship.	N = 72 with chronic LBP for longer than 3 months	Mean age: 40.54 years; 41 males, 27 females	Aerobic exercise/health education (n = 36) vs. lumbar flexion back exercise/health education (n = 36). Aerobic exercise series	12 weeks	Aerobic group's mean pain scores decreased at 3 months from 5.6±1.8 to 2.3±1.8 vs. 5.42±1.8 to 4.0±1.9 in flexion group	"[T]he results of the study demonstrated that aerobic exercise and a health education program are useful in the	Exercise program not well described. Data imply aerobic exercise beneficial based on biological

						of 3 health education sessions with group discussion, modeling and demonstration, self practice. Back exercise included regular health education, postural and behavioral instruction, lumbar flexion exercise training		(both p <0.001). Resting heart rates decreased in aerobic group (70.1±3.8 to 66.8±3.8, p <0.001) vs. no change in flexion group (71.5±5.90 to 70.2±6.22). HDL cholesterol increased with aerobic exercise (54.6±11.4 to 57.1±12.0, p <0.005), but decreased in flexion group (57.64±11.84 to 56.12 ±11.58, p <0.005).	treatment of chronic low back pain, particularly in pain relief."	indices; however, strong conclusions not warranted.
Weiner 2008 (score=4.5)	PENS	RCT	Study supported by Grant R01 AT000985 from National Center for Complementary and Alternative Medicine and National Institute on Aging, National Institutes of Health. Dr. Perera also supported by Pittsburgh Claude D. Pepper Older Americans Independence Center. COI: Dr. Perera received funding from Eli Lily and Co.	N = 184 older than 65 who had LBP every day or almost every day for more than 3 months	Mean age: 73.91 years; 86 males, 98 females	PENS (administered by acupuncturist): 32 gauge 40mm needles placed just below skin into subcutaneous fascia, approximately 15mm in depth. Ten needles used each session, placed bilaterally at dermatomal, myotomal, sclerotomal, and sympathetic levels corresponding to T-12, L3, L5 and S2.	1 week, 6 months	Baseline to post-intervention; Mean and SD. Pain and Function MPQ total: PENS -2.9±9.2 (p=0.03); PENS+CGAE -4.1±8.2 (p=.0017); Sham Only -2.3±6.3 (p= 0.0145); Sham +CGAE -3.1±7.9 (p=0.0123). Roland Questionnaire: PENS only -2.6±4.5 (p = 0.0002); PENS+CGAE -2.6±4.6 (p=0.0005); Sham Only -	"[I]n conclusion, lumbar PENS administered twice a week for 6 weeks to community dwelling older adults with CLBP is safe and well-tolerated. It reduces pain and improves self-reported pain-associated disability, and these benefits are sustained after 6 months. Minimal electrical stimulation (i.e., 5 min as compared with	200 patients were randomized. 16 dropped out before post-intervention analysis. Data only available for 184 patients.

						Electrical stimulation applied for 30 minutes using specific pattern at moderate intensity 2x a week for 6 weeks (n = 47) vs. control-PENS procedure 10 32-gauge 40mm acupuncture needles applied in identical location and in depth as in PENS. In addition, 2 needles placed bilaterally at T-12 dermatome for 30 minutes. Acupuncturist delivered electrical stimulation only at T-12 dermatome using same PENS. Frequency of 100Hz used all 12 treatment sessions. 5 minutes following initiation for electrical stimulation, electrostimulator unit turned off to avoid delivery of potentially		2.7±3.8 (p<.0001); Sham+CGAE - 3.0±4.7 (p = 0.0001).	30 min.) has similar benefits. General conditioning and aerobic exercise do not further reduce pain or improve function. Given its safety and efficacy, costs associated with lumbar PENS should be reimbursed by third party payers. The efficacy of particular therapeutic exercise protocols should be demonstrated in older adults with CLBP before they are prescribed routinely."	

						therapeutic microcurrent (n = 45) vs. General conditional and aerobic exercise (GCAE) supervised by PT at home and on-site. On-site sessions 60 minutes. Aerobic exercises 30 minutes. Home exercise flexibility exercise and graded walking program 3x a week for 6 weeks. Walk 30 minutes a day. Kept diary (n = 48) vs. PENS + GCAE (n = 44).				
Kankaanpää 1999 (score=4.5)	PENS	RCT	Study supported in part by Ministry of Education and Academy of Finland (TULES Graduate School); Finnish Work Environmental Fund, Finnish Medical Society Duodecim; Yrjö Jahnsson, Eemil Aaltonen, and Instrumentarium Science Foundations, and grant from	N = 59 with chronic LBP (mean times since first episode ranged 5.8-10.9 years); those with pain radiating below knee excluded	Mean age: 39.52 years; 37 males, 22 females	Active rehabilitation (n = 30) vs. passive modalities (n = 24). Active treatment consisted of 24 1.5 hour, small group exercise sessions with progressive increases over 12 weeks. Controls received thermal therapy and massage as they are	6 months, 1 year	Mean (SD) pain intensity (100mm VAS) at baseline/after/6-months/1-year for active group vs. control: 55.2 (22.8)/35.5 (26.3)/26.6 (28.4)/23.9 (17.8) vs. 47.0 (29.3)/43.8 (25.0)/43.3 (19.8)/45.1 (22.2), after p = 0.033, at 6 months p = 0.000, at 1 year p = 0.000. Mean	"The active progressive treatment program was more successful in reducing pain and self experienced disability and also in improving lumbar endurance than was the passive control treatment. However, the group difference in	Data suggest active exercise superior to passive modalities. Lumbar endurance measured by sEMG improved in active treatment group.

			Kuopio University EVO Fund. No mention of COI.			"assumed to be ineffective."		(SD) functional disability (PDI score):13.2 (10.2)/10.8 (11.2)/5.7 (6.6)/5.7 (8.1) vs. 9.5 (8.3)/10.9 (10.7)/12.6 (10.2)/11.4 (11.4), after p = 0.043, at 6 months p = 0.006, at 1 year p = 0.004.	lumbar endurance tended to diminish at the 1-year follow-up."	
Ghoname 1999 b (score = 4.0)	PENS	RCT/Crossover	No mention of sponsorship or COI.	N = 68 patients with lower back pain associated with radiologically confirmed degenerative lumbar disc disease	Mean age: 43±1.9 years; 30 males, 38 females	Sham-PENS, no electrical stimulation (n=68) vs. PENS with 4 Hz electrical stimulation (n=68) vs. PENS with alternating 15 and 30 Hz stimulation (n=68) vs. PENS with 100 Hz stimulation (n=68). Each participant received all four treatments in random sequence. Each treatment was administered at 30 minute interval, three times per week for 2 weeks, there was one week without treatment in between each stimulation level	No follow-up post-intervention	Posttreatment health status survey short form (SF-36) reported significant improvements in physical component summary (PCS) and mental component summary (MCS) in 4 Hz, 15/30 Hz, and 100 Hz frequencies (P < 0.01). Sham treatment did not show significant improvements after treatment. The 15/30 Hz frequency produced the most effective decrease in pain, increase in physical activity, and improvement in the quality of sleep (P < 0.05)	"In conclusion, using a mixed frequency (alternating 15 Hz and 30 Hz) of PENS was more effective than either low (4 Hz) or high (100 Hz) frequencies alone in improving short-term outcome measures in patients with LBP."	Sparse methods, patients not effectively blinded, short follow-up period (2 weeks). Data suggest mixed frequency stimulation (15 Hz/30 Hz) was more effective than either the low or high frequency stimulation and showed pain reduction, improved sleep quality and a reduction in oral analgesic consumption.

Ghoname 1999 c (score = 4.0)	PENS	RCT/Crossover	No mention of sponsorship or COI.	N = 64 patients with typical radicular pain lasting between 6 to 28 months due to radiologically -confirmed lumbar disc hernitation	Mean age: 43±19 years; 30 males, 34 females	PENS therapy: 4 Hz frequency (n=64) vs. TENS therapy: 4 Hz frequency (n=64) vs. Sham therapy: no electrical stimulation, same needle placement as PENS (n=64). All participants were randomized to receive all treatments in a different order. All treatments were administered for 30 min three times per week for 3 weeks, with one week of no treatment between each method	No follow-up post-interventio n	PENS produced more significant improvement in physical component summary (PCS) (35.3±8.2) and mental component summary (MCS) (44.2±6.4) in the health status survey short form (SF-36) ($p < 0.001$) compared to TENS (29.6±7.4 to 42.1±6.0, $P < 0.05$) and sham-PENS (28.4±6.7 to 41.7±6.2, $P < 0.05$).	"In conclusion, this sham-controlled study demonstrates that PENS is more effective than TENS in improving short-term outcome in patients with sciatica. The use of PENS therapy improves physical activity and the quality of sleep while decreasing the need for oral non-opioid analgesic medications."	Sparse methods, no patient blinding. Data suggest both PENS and TENS improved VAS pain scores with statistically significant reductions I oral analgesic use in both groups ($p<0.01$ and $p<0.05$ respectively).
Low Quality										
Topuz 2004 (score=3.0)	PENS	RCT	No mention of COI or sponsorship.	N = 55 with chronic LBP 15-21 months	Mean age: 44.11 years; 14 males, 41 females	Percutaneous neuromodulatio n therapy: 4 Hz (PNT, n = 13) vs. conventional TENS: high frequency electrical stimulation of 80 Hz (n = 15) vs. low-frequency TENS: 4 Hz (n = 15) vs. placebo-TENS	No follow-up post-treatment	PNT and TENS more effective than placebo TENS for current pain, activity pain, LBP Outcome Scale, ODI and SF-36, $p <0.05$. PNT better than conventional TENS and low-frequency TENS for activity pain score, general	"PNT was more effective than C-TENS and low-TENS in both relieving activity pain and relieving limitations of emotional role, increasing vitality and general health perception."	Randomizatio n process in doubt with unequal size groups and baseline comparability issues. Dropouts also high.

						(n = 12) for 20 minutes 5 x a week for 2 weeks.		health score on SF-36, p <0.05.		
Yokoyama 2004 (score=3.0)	PENS	RCT	No mention of COI or sponsorship.	N = 53 with chronic LBP	Mean age: 59.02 years; 23 males, 30 females	PENS 8 weeks (Group A, n = 18) vs. PENS first 4 weeks and TENS for second 4 weeks (Group B, n = 17) vs. TENS for 8 weeks (Group C, n = 18) 2x week for 8 weeks.	1 and 2 months	Peak pain VAS lower Group A vs. Group C. At 2 weeks: p <0.05; 4 weeks: p <0.01; 8 weeks: p <0.01; 1 month follow-up, p <0.01. VAS scores in Group A lower than Group B at 8 and 12 weeks.	"[R]epeated PENS is more effective than TENS for chronic LBP but must be continued to sustain the analgesic effect."	Conclusion that treatment must be continued to sustain improvement not directly tented with this study.
North 2002, 2005 (score=2.5)	PENS	RCT	Sponsored in part by the Medtronic, Inc., to the Johns Hopkins University. No mention of COI.	N = 24 with lumbosacral root injury pain, and pain prior to back surgery	No mention of mean age or gender distributio n	Percutaneous 4-contact electrode (n = 12) vs. insulated 4-contact array electrode via laminectomy (n = 12).	No follow-up post-treatment	Laminectomy vs. percutaneous had significant reduction in reliance on prescription analgesics, p <0.05.	"Laminectomy electrode placement, although more invasive than percutaneous placement, yields significantly better clinical results in patients with failed back surgery syndrome at mean 1.9 years follow-up."	Methods sparse.

MICROCURRENT ELECTRICAL STIMULATION

Microcurrent electrical stimulation is a type of electrotherapy. Proponents believe that it will relieve pain and contribute to healing while using lower currents than are used in TENS or interferential and galvanic stimulation. If effective, this modality does not work through distraction, as the current is too low to be perceived.

Recommendation: Microcurrent Electrical Stimulation for Treatment of Acute, Subacute, or Chronic Low Back Pain or Radicular Pain Syndrome

Microcurrent electrical stimulation is not recommended for treatment of acute, subacute, or chronic low back pain or for radicular pain syndrome.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

One small study has suggested a lack of efficacy.(1576) Microcurrent electrical stimulation is not recommended as other modalities have been shown to be effective in the treatment of acute, subacute, and chronic LBP. Microcurrent electrical stimulation is not invasive, has little potential for adverse effects, and is moderately costly.

Evidence for the Use of Microcurrent Electrical Stimulation

There is 1 moderate-quality study incorporated into this analysis.(1576)

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates. The following search terms were used:"Micro current electrical stimulation, sub-acute low back pain, chronic low back pain, radicular pain syndromes including sciatica" to find 869 articles. Of those 869 articles, we reviewed one article and included one article.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Koopman 2009 Randomized Crossover Trial Third author, Albert J.M. van Wijck received compensation from manufacturer.	6.5	N = 10 age 18-65 with chronic non-specific LBP	Microcurrent (25µA, 71.5kHz, 3V) vs. placebo. 5 days each treatment arm.	VAS mean pre 6.23/post 6.14. VAS mean placebo pre 5.99/post 6.33 (not significant).	"A positive trend in MCT use for aspecific, chronic low-back pain is reported."	Pilot study, small sample. Compliance unclear. NSAID use may have confounded results. Data suggest no differences.

H-WAVE® DEVICE STIMULATION

Proponents believe these electrical currents stimulate healing.

Recommendation: H-Wave® Device Stimulation for Treatment of Low Back Pain and Radicular Pain Syndromes

There is no recommendation for or against H-Wave® Device stimulation for treatment of acute, subacute, or chronic low back pain or radicular pain syndromes.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendation

Other modalities have been shown to be effective in the treatment of acute, subacute and chronic LBP and radicular pain syndromes. H-Wave® Device stimulation is more costly than other self-administered electrical stimulation modalities. It is not invasive and has low adverse effects, but is moderate cost and becomes high cost after 6 weeks.

Evidence for the Use of H-Wave® Device Stimulation
There are no quality studies evaluating H-Wave® Device stimulation for the treatment of acute, subacute, or chronic LBP or radicular pain syndromes.
We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: H-Wave® Device stimulation, subacute low back pain, chronic low back pain, and radicular pain syndromes (including 'sciatica') to find 154 articles. Of the 154 articles we reviewed zero articles and included zero articles.

HIGH-VOLTAGE GALVANIC THERAPY

High-voltage galvanic is an electrical therapy.

Recommendation: High-voltage Galvanic Therapy for Treatment of Low Back Pain
There is no recommendation for or against high-voltage galvanic therapy for treatment of acute, subacute, or chronic low back pain or for radicular pain syndromes or other back-related conditions.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Rationale for Recommendation
High-voltage galvanic is not shown to be efficacious for the treatment of acute, subacute, or chronic LBP or radicular pain syndromes or other back-related problems. It is not invasive, but is not low cost. There are other interventions shown to be efficacious.

Evidence for the Use of High-voltage Galvanic
There are no quality studies evaluating the use of high-voltage galvanic for the treatment of LBP.

We search PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates. The following search terms were used "High-voltage galvanic) AND (sub-acute low back pain OR radicular pain syndromes OR spinal stenosis OR spinal fractures OR sacroiliitis)" to find 27 articles. Of those 27 articles, we reviewed zero articles and included zero articles.

INVERSION THERAPY

Inversion has been used for treatment of patients with herniated discs(1331, 1577) and low back pain.(1578)

Recommendation: Inversion Therapy for Treatment of Radicular Pain or Low Back Pain
There is no recommendation for or against the use of inversion therapy for treatment of either radicular pain or low back pain.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation
The overall quality of the literature base for inversion therapy is poor. Two trials have attempted to address treatment in patients with radiculopathy, with one suggesting lower surgical rates in the inversion therapy group,(1577) yet many outcome data may be confounded. Most results for treatment of LBP were also negative in another study.(1578) Trial inclusion criteria (age, body mass index) would restrict most patients from this treatment.(1577) Inversion therapy is not invasive, has moderate adverse effects especially in older individuals but the evidence base is too weak to support an evidence-based recommendation for or against treatment. There are many other effective treatments.

Evidence for the Use of Inversion Therapy
There is 1 moderate-quality RCT incorporated into this analysis.(1577) There are 2 low-quality RCTs in Appendix 1.(1331, 1578)

We searched PubMed, CINAHL, Cochrane Library and Google Scholar without date limits using the following terms; Inversion table, inversion tables, inversion therapy, inversion therapy table, inversion therapies, inversion traction therapy, inversion traction, subacute low back pain, chronic low back pain, low back pain, controlled clinical trial, controlled trials, randomized controlled trial, randomized controlled trials, random allocation, random, randomized, randomization, randomly; systematic, systematic review, retrospective, and prospective studies. We found and reviewed 10 articles in PubMed, 3 in CINAHL, 7 in Cochrane Library, and 2,100 in Google Scholar. We considered for inclusion 1 from PubMed, 0 from CINAHL, 1 from Cochrane Library, 2 from Google Scholar and 0 from other sources. Of the 4 articles considered for inclusion, 3 randomized trials and 1 systematic studies met the inclusion criteria.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Manjunath Prasad 2012 RCT Sponsored by Jacobson Charitable Trust. No mention of COI.	4.0	N = 24 with LBP from nerve root impingement induced by unilateral single level disc protrusion. Excluded sequestration age 18-45.	PT plus Inversion group receiving 6 table inversions for 2 minutes each, 3x a week for 4 weeks (n = 13) vs. Physiotherapy (PT) control group (n = 11). Both groups received physiotherapy during treatment period. Assessments at baseline and 6 weeks.	No significant differences reported between inversion and control groups at 6 weeks as per VAS, post-treatment MRI results, Oswestry Disability Index, SF 36, or Roland Morris Disability Questionnaire. Operative rate 23.1% vs. 77.8% favoring inversion.	"Our hypothesis was that inversion therapy would reduce the need for a surgical procedure in subjects with sciatica due to single level disc protrusion. The results of this study do support this; surgery was avoided in 77% in the inversion group while it was averted in only 22% in the non inversion group...a larger multicentre prospective randomized control trial is justified."	Excluded over 140kg, >20% over ideal body weight, and sequestration. Study addressed additive value of inversion. Very brief inversion of 2min, of unclear physical benefit. Few baseline data provided. Data at followup comparable, but differences in surgery rates may have confounded.

Injection Therapies……
There are several types of injections included in this section. These include epidural injections (caudal, interlaminar and transforaminal), intradiscal injections, chemonucleolysis, tender or "trigger point" injections, facet joint injections, sacroiliac joint injections, intrathecal drugs, ligamentous injections (prolotherapy), and botulinum injections.

LUMBAR EPIDURAL INJECTIONS
Epidural glucocorticosteroid injections deliver the steroid close to the herniated disc or area of spinal stenosis.(1092, 1096-1098, 1100, 1101, 1110, 1112-1114, 1579-1597) The three approaches most commonly used are caudal, interlaminar, and transforaminal.(1598-1601) The technical performance including precise placement of these injections is reportedly related to the efficacy.(1602) Interlaminar epidural injections are the least technical and place the steroid immediately adjacent to the dural sac in the posterior spinal column. Fluoroscopic guidance improves the placement accuracy of injection, as blind targeting has been shown to be 77% accurate.(1603) Injections have also been performed after epiduroscopy.(1604) Transforaminal injections most closely target the herniated disc and neurological impingement with the least volume of agent,(1598, 1605) but are technically more difficult and fluoroscopic or CT guidance is usually used.(1606) Transforaminal injections also necessitate better

diagnostic precision to ensure proximity to the affected level.(1601) A technique has also been described using electrical stimulation to assist with nerve root identification.(1607) As these injections are most frequently performed as a combination of a glucocorticoid with an anesthetic, they are considered both diagnostic and therapeutic.(1608)

1. *Recommendation: Epidural Glucocorticosteroid Injections for Treatment of Acute or Subacute Radicular Pain*
   An epidural glucocorticosteroid injection is recommended as an option for treatment of acute or subacute radicular pain syndromes. Its purpose is to provide a few weeks of partial pain relief while awaiting spontaneous improvement and remaining as active as practical. An epidural steroid injection may cause short-term improvement(1591, 1609-1613) which may assist in successfully accruing sufficient time to ascertain if non-operative care will succeed. An "option" means there should be no requirement that a patient receive and fail treatment with epidural glucocorticosteroids, especially repeated injections, prior to discectomy.

   Indications – Radicular pain syndromes lasting at least 3 weeks having been treated with NSAIDs and without evidence of trending towards spontaneous resolution.

   Frequency/Duration – Each injection's results should be evaluated with objective improvement before scheduling an additional injection, such as improved functional ability or reduction in opioids requirements. Medications most often used in the RCTs were triamcinolone and methylprednisolone combined with an anesthetic (most often bupivacaine). There are no head-to-head comparisons of different medications to ascertain the optimum medication(s) and/or dose(s).

   Indications for Discontinuation – A second epidural steroid injection is not recommended if following the first injection there has been sufficient resolution of the symptoms, particularly leg symptoms, or a decrease in symptoms to a tolerable level. If there has been no response to a first epidural injection, there would be no recommendation for a second injection. In patients who respond with a pharmacologically appropriate 3 to 6 weeks of temporary, partial relief of leg pain, but who then have a worsening of leg pain and function, and who are not (yet) interested in surgical discectomy, a repeat epidural steroid injection is an option. Generally, there are not benefits beyond 3 injections for a given episode of radicular pain. Patients requesting a fourth injection should be counseled for discectomy or considered to have chronic radicular symptoms for which epidural steroids are not recommended.
   Benefits – Short to intermediate term reduction in pain. Theoretical, though likely infrequent avoidance of surgery if sufficient pain reduction occurs.
   Harms – Rare complications of paralysis, infections.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Epidural Glucocorticosteroid Injections for Treatment of Acute Flare-ups of Spinal Stenosis*
   Epidural glucocorticosteroid injections are moderately not recommended for treatment of spinal stenosis.(1614) (Friedly 14)

   Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
   Level of Confidence – Moderate

3. *Recommendation: Epidural Glucocorticosteroid Injections for Treatment of Acute, Subacute, or Chronic Low Back Pain without Radicular Symptoms*
   Epidural glucocorticosteroid injections are not recommended for treatment of acute, subacute, or chronic low back pain in the absence of significant radicular symptoms. They are

also not recommended as first- or second-line treatment in individuals with LBP symptoms that predominate over leg pain. They are not recommended as treatment for any chronic problem.

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – High

Rationale for Recommendations
The natural history of sciatica and disc herniations is natural resolution for a majority of patients.(1615) Glucocorticosteroid injections have been evaluated in moderate to high-quality studies. Most of the 7 high-quality studies that included acute to subacute pain patients with followups over 3 to 6 weeks demonstrated short-term reductions in short-term leg and back pain ratings for those with herniated intervertebral discs. Data also suggest that benefits disappear by approximately 6 weeks with no long-term benefits. Most of the evidence suggests no change in function or the need for surgery. Importantly, there is good evidence across numerous studies that the natural history of symptoms from a herniated disc trend towards resolution over time. Thus, the purpose of these injections for acute radicular pain syndromes is perhaps best stated as "buying time" through a period of natural recovery that decreases the patient's pain while herniated disc shrinkage or resorption occurs.

The American Academy of Neurology's guideline has recommended against routine use of these injections.(1616) Systematic reviews have arrived at contradictory conclusions. Those with the highest standards for evidence have generally not found glucocorticosteroid injections to be a cost effective treatment. Most of the RCTs have studied blind interlaminar epidural injection. Fluoroscopic guidance may improve results; however, that theory has not been well tested. Evidence of efficacy appears relatively consistent in the higher quality studies, however, as all suggest short term benefits and no long term benefits, the assessment of the value of that time with incremental benefit appears critical and there is no clear method to assign a value.

Complications are infrequent, but in rare cases may be serious(1094, 1109, 1111, 1115, 1582, 1617-1622) including infection (meningitis, epidural abscess, etc.) and hemorrhage related to penetration of an anatomical variant artery. A resulting epidural hematoma may compress the nerve or spinal cord(1598) and generally requires emergency surgery. Suppression of the pituitary-adrenal axis does occur.(1623) Uncontrolled data suggest psychological factors may be associated with treatment failure,(1624) but that is not a universal finding. There are radiation exposure concerns for fluoroscope operators and patients that should be addressed(1100) and longer term potential risks of osteoporotic fractures.(1102)

Since the relief from epidural steroid injections is brief, and since by definition chronic non-specific back pain and chronic radicular pain with or without prior back surgery are chronic problems, epidural steroid injections are not recommended as a transient treatment for these long-term problems. There also is no quality evidence that accomplishing these injections earlier in the course of the syndrome results in any improvement in the condition. On the contrary, there is some evidence inferred suggesting it may make no difference.

One high-quality trial found no or minimal short-term benefit of epidural glucocorticosteroid injection for treatment of spinal stenosis.(1614) Two moderate-quality RCTs similarly suggested only minor short-term symptom reduction of spinal stenosis.(1625, 1626) No long-term benefits were reported in another trial (2410). Therefore, epidural glucocorticosteroid injections are not recommended for treatment of spinal stenosis.

Technique may be important as well as the anatomical approach chosen.(1602) However, there is insufficient evidence presently to recommend one technique over the other for an initial approach

(caudal vs. interlaminar vs. transforaminal), other than to note that there is evidence that endoscopy for steroid injection has not been shown to be beneficial.(1627) Although it is suspected that fluoroscopic or CT guidance for these injections is helpful, there is not sufficient evidence for guidance on that topic. Predictive factors of unresponsive patients include greater number of medications used for pain, greater number of past treatments for pain, walking less, and coughing, household chores, sitting, unemployment due to pain,(1590, 1628) as well as potential sex differences.(1629)

Most studies assessed only one injection, although three studies used a series of *up to* 3 injections over 6 weeks,(1609, 1610, 1613) and there is no quality study that performed 3 injections without an assessment after each injection to determine whether an additional injection was appropriate and recommended. Thus, there is no quality evidence to either support or require a series of 3 injections. There is no evidence that there is a limit of 3 in a year or lifetime, although if there is no clear benefit, then repeated injections are not recommended.

Current practice in the U.S. is generally to obtain an MRI or CT prior to an epidural injection. Yet, at least four of the trials solely relied on the clinical examination to address the level targeted with subsequent epidural glucocorticosteroid injection, and thus there is some evidence that imaging may not be necessary.(1118, 1609, 1610, 1630) Additional studies may be needed to determine whether imaging is required or not, as if unnecessary, it can be eliminated and markedly reduce costs.

Epidural glucocorticoid injections are invasive, have some adverse effects,(1610) and are costly. The number needed to treat (NNT) to achieve partial pain relief at 3 weeks was 11.4, but there was no benefit from weeks 6 to 52.(1610) These injections are an option in acute radiculopathy, but as a second-line treatment after prior treatment with NSAIDs, possibly a short course of an oral corticosteroid and a suggested waiting period of at least 3 weeks.

Evidence for the Use of Lumbar Epidural Injections

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates and then an updated search was conducted using PubMed for publications between 1/1/2013 and 11/15/2017. We used the following search terms: acute low back pain, subacute low back pain, chronic low back pain, radicular pain syndrome, sciatica, spinal stenosis, Epidural Glucocorticosteroid Injection, Dexamethasone, Glucocorticosteroid injection, Methylprednisolone, Triamcinolone, Steroid injection, Corticosteroid injection, betamethasone, Peridural Injection, Extradural Injection, Epidural Injection, clinical trial, randomized controlled trial, random, systematic review, review, population study, epidemiological study, and prospective cohort as well as reviewed references to find 44,715 articles. Of the 44.691 articles, we reviewed 190 articles and included 59 articles (59 randomized controlled trials and 0 systematic reviews).

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Arden 2005 (score= 9.5)	Epidural Steroid injections	RCT	Sponsored by National Health Service Research and Development program. Arden funded by Arthritis Research Campaign as Senior Lecturer. COI, Price received grants from Pfizer UK to develop National Pain Database. Other authors declare no COI.	N = 228 with unilateral sciatica of 1-18 months duration.	Mean Age: 43.27; 120 males, 108 females	Series of 3 blind interlaminar lumbar epidural corticosteroid injections of triamcinolone acetonide 80mg plus 10mL bupivacaine 0.25% (n = 120) vs. Interligamentous normal saline injections (n = 108). Follow-up weeks 0, 3, 6, 12, 26, and 52.	Follow up at 3, 6, 12, 26, 52 weeks.	Oswestry scores different at 3 weeks (10.3±14.8 vs. 6.6±15.6), but not at 6, 12, 26 or 52 weeks.	"[E]SIs offered transient benefit in symptoms at 3 weeks in patients with sciatica, but no sustained benefits in terms of pain, function or need for surgery. Sciatica is a chronic condition requiring a multidisciplinary approach. To fully investigate the value of ESIs, they need to be evaluated as part of a multidisciplinary approach."	Included acute, subacute and chronic patients. If patients did not improve at 12 weeks they were withdrawn. By 6 weeks no differences. Repeat injections did not increase success for radicular pain. Data suggest efficacy at 3 weeks but not beyond.
Price 2005 (score= 9.5)	Epidural Steroid injections	RCT	No mention of sponsorship. COI, Price: consultant in Pain Management; Rogers: consultant in Pain Management.	N = 228 with unilateral sciatica, duration 4 weeks to 18 months; acute (<4 months) vs. chronic (4 to 18 months).	Mean age: 43.47 years; 120 males, 108 females	Three blind interlaminar epidural injections (triamcinolone acetate 80mg plus bupivacaine 0.125% 10mL (n = 120) vs NS 2ml interspinous ligament NS 2mL injections (n = 108). All received physiotherapy and PRN analgesics and NSAIDs.	Follow up at 12 months	Oswestry Disability Questionnaire results different at 3 weeks favoring injection (p = 0.017). No other differences.	"(ESIs) confer only transient benefit in symptoms and self-reported function in a small group of patients with sciatica at substantial costs. ESIs do not provide good value for money if NICE recommendations are followed."	Co-interventions not well described. Data suggest short-term but not long-term benefits.

Karppinen 2001 (score= 9.5)	Epidural Steroid injections	RCT	Sponsored by grants from Yrjö Jahnsson Foundation, Finnish Office for Health Technology Assessment, Finnish Work Environment Fund, and the International Spinal Injection Society. No mention of COI.	N = 160 with sciatica with unilateral symptoms for 1-6 months.	Mean age: 43.75 years; 98 males, 62 females	Methylprednisolone (40mg/mL)-bupivacaine (5mg/mL Solomet), n = 80) combination vs Isotonic (0.9% sodium chloride (n = 80).	Follow-up at 2 weeks and months 1, 3, 6, and 12.	Leg pain better with steroid (11.9; 95% CI, 2-21.8; p = 0.02). No differences in back pain. At 2 weeks both had significant improvement. Satisfaction favored steroid (12.1; 95% CI, 1.2-23; p = 0.03). No differences at 4 weeks. Saline favored at 6 months. No differences at 1 year.	"This double-blind, controlled study of nerve root infiltration for sciatica suggests that the combination of methylprednisolone and bupivacaine offers only short-term clinical and economic benefit as compared with saline. In addition, methylprednisolone/ bupivacaine infiltration seems to be associated with a rebound phenomenon at 3 and 6 months."	Variable duration of sciatica prior to enrollment, including chronic pain. MRI costs included for both groups. Injections with methylprednisolone – bupivacaine appear minimally effective for 2 weeks, but no longer term.
Iversen 2011 (score= 8.5)	Epidural Steroid injections	RCT	Sponsored by North Norway Regional Health Authority and Health Region Nord-Trøndelag, Norway. No COI.	N = 133 with unilateral lumbar radiculopathy lasting more than 12 weeks	Mean age: 41.94 years; 64 males, 69 females	Caudal epidural steroid injection (N = 37) vs caudal epidural saline injection (N = 39) vs. Sham injection (N = 40).	Follow up at 6, 12, and 52 weeks	At 6, 12, and 52 week follow-up no significant difference between injection and sham groups. Confidence Intervals for sham at 6 weeks -4 (-0.6 to -8.8), 12 weeks -11.4 (-6.3 to -14.5), and -14.3 (-10.0 to -18.7) at 52 weeks.	"[T]reatment of chronic lumbar radiculopathy with caudal epidural injection of steroids or isotonic saline has no clinically important effect."	Co-interventions not well controlled. Some baseline differences. Suggests no benefit in chronic patients. Mean duration of leg and back pain less in subcutaneous only group.
Carette 1997 (score= 8.5)	Epidural Steroid injections	RCT	Sponsored by research grant from Medical Research Council of Canada and Canadian Arthritis	N = 158 with sciatica of 4-52 weeks duration due to a herniated	Mean age: 39.81 years; 103 males, 55 females	Up to 3 epidural injections of methylprednisolone 80mg, 2 ml plus NS 8mL (N = 78) vs 1ml of isotonic saline NS (N = 80). Up to 2 more injections at 3 and 6 weeks if not marked or very marked improvement and had ODI >20.	Follow-up at 3 and 6 weeks, and 3 and 12 months.	Three injections: 1st 22% steroid vs. 24% placebo; 2nd 49% vs. 46%; 3rd 29% vs. 30%. Acetaminophen used 1st 3 weeks 60 vs. 76; Weeks 3-6, 17 vs. 50 tablets. Also took narcotics, NSAIDs,	"[E]pidural injections of methylprednisolone, as compared with saline injections, afforded mild-to-moderate improvement in leg pain and sensory deficits and reduced the need for analgesics. However,	No local anesthetic was co-administered. ESI did not have significant effect on functional

			Society. COI: Dr. Carette holds a research scholar grant from Fonds de la Recherche, Dr. Marcoux is a National Health Research Scholar of Health Canada.	nucleus pulposus				anxiolytics, and muscle relaxants despite discouragement. No differences at 3 months.	the injections had no effect on functioning or the need for subsequent surgery."	outcomes longer term. Data suggest modest short-term benefits.
Valat 2003 (score= 8.5)	Epidural Steroid injections	RCT	Sponsored by grant from PHRC 1995, Ministry of Health, France. No mention of COI.	N = 85 with first time sciatica or current episode lasting >15 and <180 days and pain intensity >30mm on VAS	Mean age: 40.98 years; 52 males, 33 females	2ml prednisolone acetate 50mg (steroids, n = 43) vs. 2ml isotonic saline (control, n = 42). All received 3 epidural injections at 2-day intervals; lumber interlaminar approach without fluoroscopic guidance; no lumbar exercises or other spinal injections; use of NSAIDs allowed only 20 days after 1st injection, non-opioid analgesics, bed rest, mild lumbar tractions, lumbar belts allowed.	Follow-up: 5 days after last injection and 20 and 35 days after first injection.	No significant differences between groups.	"[W]e cannot exclude the efficacy of isotonic saline administered epidurally for sciatica, but epidural corticosteroid injections provide no additional improvement.	No difference at day 20.
Ng 2005 (score= 8.0)	Epidural Steroid injections	RCT	No sponsorship or COI.	N = 86 with unilateral leg pain comparable to back pain; no benefit 6 weeks of non-operative management with	Mean age: 50.44 years; 43 males, 38 females	Periradicular infiltration under fluoroscopic guidance of 2ml 0.25% bupivacaine only (n = 43) vs. 2ml of 0.25% bupivacaine with 40mg methylprednisolone (n = 43).	Follow-up at 6 weeks and 12 weeks after injection.	No differences at 3 months in leg pain (p = 0.94), back pain (p = 0.72), and Oswestry Disability Index (p = 0.91).	"Clinical improvement occurred in both groups of patients. Corticosteroids did not provide additional benefit."	Patient satisfaction only statistically significant outcome. Chronic radicular symptoms. Data suggest glucocorticosteroid ineffective.

				nonsteroidal anti-inflammatory medication and PT						Data are not given on effects at less than 6 weeks
Datta 2011 (score= 8.0)	Epidural Steroid injections	RCT	No mention of sponsorship. No COI.	N = 207 with ASA grade I-II for sciatica; age 20-70; BMI 18-30 kg/m^2; recurrent episodes sciatica for 4 weeks to 1 year with failure of at least 6 weeks of conservative therapy; CT evidence of herniated nucleus pulposus; >20 score on Roland-Morris Disability Questionnaire	Mean age: 41.03 years; 190 males, 17 females	Caudal injection 10-15 ml 0.125% bupivacaine only (Group A, n = 55) vs caudal injection 10-15ml 0.125% bupivacaine and 80mg methylprednisolone (Group B, n = 50) vs. caudal injection 10-15ml 0.125% bupivacaine and 80mg triamcinolone (Group C, n = 52) vs caudal injection 10-15ml 0.125% bupivacaine and 15mg dexamethasone (Group D, n = 50). All allowed 50mg tablets of Diclofenac up to 4 times daily.	Follow-up 1 hour after injection and 1, 3, 6, 12 weeks after 1st injection	Methylprednisolone group had greater improvement in finger-to-floor distance (20.3 at 12 weeks vs. 22.8 Group C, 29.7 Group D, and 36.5 Group A, p = 0.006) and smaller proportion of patients with sensory deficits (p <0.005). Large number in dexamethasone group required third injection. Pain relief better at all follow-ups in steroid group vs. control group, p <0.001.	"[E]SI is a simple, cost-effective and minimally invasive treatment for sciatica due to prolapsed disc."	Significant dropouts in many groups. Results suggest corticosteroid in combination with bupivacaine is superior to bupivacaine alone, although differentiation between corticosteroids is not presented.
Dashfield 2005 (score= 7.0)	Epidural Steroid injections	RCT	Sponsored by the Defense Secondary Care Agency. No	N = 60 with 6-18 month history of sciatica.	Mean age: 46.29 years; 33 males,	Endoscopical placement of epidural steroid along affected nerve root causing sciatica (n = 27) vs. fluoroscopically guided caudal ESI with	Follow-up 6 weeks, 3 and 6 months.	VAS scores – caudal group: 6.6±1.7 (baseline) to 5.7±2.8 (6 weeks) to 5.2±2.7 (6 months) vs.	"We did not show that targeted placement of corticosteroid onto the affected nerve root was superior to caudal steroid epidural. The	Claims double blinding, but procedures different and sedation with

			mention of COI.		27 females	triamcinolone 40mg plus lidocaine 1% 10mL (n = 33).		epiduroscopy: 7.2±1.8 to 6.7±2.3 to 6.0±3.3.	role of epiduroscopic adhesiolysis in patients with epidural scar tissue affecting nerve root nutrition warrants further investigation."	midazolam thus concerns about blinding. Data suggest no advantage of spinal endoscopic steroid placement
Klenerman 1984 (score= 6.0)	Epidural Steroid injections	RCT	No mention of sponsorship or COI.	N = 74 suffering from unilateral sciatica with or without neurological signs for no longer than 6 months.	No mention of mean age or gender distribution.	20ml normal saline (n = 16) vs. 80mg Depomedrone in normal saline made up to 20ml (n = 19) vs. 20ml 0.25% bupivacaine solution (made up in normal saline) (n = 16) vs. needling with standard Touhy injection needle into inter-spinous ligament with no actual injection (acupuncture, n = 12); 11 withdrew. Patients who had severe symptoms during follow-up given supplementary treatment (physiotherapy).	Follow-up 2 weeks and 2 months after treatment.	No significant differences between groups except for visual analogue score and back flexion, p <0.005 and 0.01 but no straight leg raising, p <0.05.	"The lack of obvious advantage of the Depomedrone and bupivacaine treatments does not detract from the occasional dramatic help provided for individual patients and should give a perspective to the severity of the patients' symptoms if they do not improve."	Follow up interval may have missed the typical time window of efficacy of 4-6 weeks. Mixed duration of disease. Somewhat variable length follow-ups. Overall, 75% of patients improved or were cured and included interspinous ligament needling group. Data suggest lack of efficacy.
Kolsi 2000 (score= 5.0)	Epidural Steroid injections	RCT	No mention of sponsorship or COI.	N = 30 age 18-75 with sciatica or femoral neuralgia with pain radiating at least to knee; positive straight	Mean age: 42.85 years; 12 males, 18 females	Nerve root injection (n = 17) vs. interspinous injection (n =13). All received 2ml iohexol to verify needle placement, 2ml lidocaine hydrochloride, 1.5ml cortivazol. Remained in hospital 7 days after injection/treatments: bed rest, physiotherapy, acetaminophen/	Daily for 7 days and weekly for 3 weeks.	No significant differences between groups.	"The unusually high level of efficacy of glucocorticoid injection in our study may be ascribable in part to strong placebo and Hawthorne effects and in part to the intrinsic effects of the injections."	Pilot study. Small sample size (n = 30).

				leg raising test; pain duration for at least 15 days; initial pain scale score of ≥5cm on 0-10cm scale and evidence of impingement of disk on nerve root by CT or MRI.		dextropropoxyphene combination. Those whose pain decreased by 50% discharged with lumbar corset, others received open-label nerve root injection.				
Mathews 1987 (score= 4.5)	Epidural Steroid injections	RCT	Sponsorship by Department of Health and Social Security and Special Trustees of St. Thomas' Hospital. No mention of COI.	N = 57 with clinical sciatica.	No mean age listed. Median age of epidural group: 38 years. Median age of control group: 41 years; 43 males, 14 females	Epidural injections methylprednisolone acetate 80mg plus bupivacaine 20mL, up to 3 injections) (n = 23) vs. Lignocaine 2mL injections (n = 34)	Follow-up at 1 and 3 months.	Only difference at 3 months when more of treated group pain free ($p < 0.05$) with full 6-point pain score.	"A larger proportion of the treated patients were improved at every assessment point up to 1 year, with the most marked effect at 3 months….. Epidural injection was not shown to have any effect on the neurological deficit."	Study population does not clearly distinguish clinical sciatica; rather may include thigh pain. First follow-up at 1 month maybe too late for differences. Suggest minimal differences in favor of steroid at 3 months.

Spijker-Huiges, b 2014 (score= 7.5)	Epidural Steroid injections	RCT	No sponsorship or COI.	N=63 with acute radiculopathy	Mean age: 43.66 years; 30 males, 33 females	Group I was control group, treated with usual care (n=33) vs. Group II treated with usual care plus receiving one segmental epidural steroid injection containing 80 mg of triamcinolone as well (n=30)	Follow up at 2, 4, 6, 13, 26, and 56 weeks	The intervention group showed significant difference from control group, for back pain (p = 0.0115), self-perceived impairment (p = 0.0361), and the Roland-Morris disability score (p = 0.0173).	"The effect on pain and disability of epidural steroids in lumbosacral radicular syndrome is small but significant, and at lower costs with no reported complications or adverse effects. Segmental epidural steroid injections could be considered by policy makers as an additional treatment option.	Usual care bias. Single injection intervention. Data suggest epidural steroids for the treatment of lumbosacral radicular pain via a single injection has a small favorable effect.
Park 2013 (score= 5.5)	Epidural Steroid injections	RCT	Study supported by a 2012 research grant from Inje University and no COI.	N = 120 with lumbar radicular pain	Mean age: 57.87 years; 40 males, 70 females	Ultrasound (US) guided epidural steroid injection (ESI) 5ml nonionic contrast medium + 15ml (13.0ml 0.5% lidocaine + 2ml dexamethasone 10mg) (n = 60) vs. Fluoroscopy (FL) guided ESI 5ml nonionic contrast medium + 15ml (13ml 0.5% lidocaine +2ml dexamethasone 10mg) (n = 60). Received 2 injections, 2 weeks apart	Follow-up at 2 and 12 weeks	No significant differences between groups for study outcomes.	"[T]he US-guided approach showed similar improvements in pain relief, function, and patient satisfaction scores as the FL-guided approach, without the risk of radiation exposure."	Data suggest comparable results. Likely underpowered for unusual complications.
Cuckler 1985 (score= 4.0)	Epidural Steroid injections	RCT	No mention of industry sponsorship or COI.	N = 73 with lumbar radicular pain syndromes	Mean age: 48.92 years; 37 males, 36 females	Interlaminar ESI methyl-prednisolone acetate 80mg, 7mL 2mL plus 5mL 1% and procaine (n = 42) vs . NS 7mL 2mL plus 5mL, 1% procaine (n = 31).	Follow-up 20 months.	Neither group had significant benefit at 24 hours or at long-term follow-up (13-30 months).	"[D]id not demonstrate any therapeutic efficacy of epidural methylprednisolone acetate in the treatment of either acute or chronic neural compression syndromes in the lumbar spine."	Mixed patients with herniated discs with spinal stenosis; did not stratify enrollments. Differences in duration of symptoms at baseline favor placebo. Data suggest no short- or long-

										term benefits over placebo.
Kraemer 1997 (score= 4.0)	Epidural Steroid injections	RCT	No mention of industry sponsorship or COI.	N = 182 with lumbar radicular syndromes; 49 with lumbar radicular syndromes	No mention of mean age or gender distribution.	Epidural perineural (1mL local anaesthetic, 10mg triamcinolone) (n = 47) vs. conventional posterior epidural (n = 40) vs. Paravertebral local anesthetic injections (n = 46); 3 injections in 1 week. Perineural injections triamcinolone 10mg (n = 24) vs NS (n = 25).	Follow-up pre/post-treatment, 3 weeks, 3 months.	Epidural perineural injections group had significantly better outcome than conventional epidural group. Both groups had significantly better outcome than control group. Better results seen in steroid group.	"Single-shot epidural perineural injection has a good effect on lumbar radicular syndrome with a reasonable LIRCE factor."	Medication doses and volumes not well described. Few data presented. May have used triamcinolone 10mg for both of first 2 treatment arms. In mixing 2 RCTs into 1 report, neither well described.
Manchikanti 2011 (score= 9.5)	Epidural Steroid injections	RCT	No mention of industry sponsorship or COI.	N = 120 with disc herniation or radiculitis; age 18 with chronic function-limiting low back and lower extremity pain at least 6 months duration.	Mean age: 45.85 years; 42 males, 78 females	Group I: caudal epidural injections with an injection of local anesthetic, lidocaine 0.5%, 10 mL (n = 60) vs. Group II: caudal epidural injections with 0.5% lidocaine 9 mL mixed with 1 mL of steroid (n = 60).	Patients observed at 3, 6, and 12 months.	Significant pain relief at 3, 6, 12 months: 77%, 77%, 70% in group I vs. 80%, 82%, 77% in group II. NRS mean ± SD in baseline 8.1±0.9 in group I vs. 7.8±0.9 group II (p = 0.077), and 3 months 4.1±1.8 in group I vs. 3.4±1.7 in group II, p = 0.022. Therapeutic Procedural Characteristics for 1st and 2nd procedure in relief 3.8±2.5 and 7.6±4.6 in group I vs. 6.3±6.1 and 13.2±18.7 group II, (p <0.05). Average relief per procedure in weeks 7.9±4.0 in group I vs. 10.4 ± 6.1 group II, p <0.05. ODI mean±SD scores with baseline 29.2±4.6 group I vs. 27.9±4.8 in group II (p	"The assessment of 1-year results of this randomized, controlled, double-blind trial of caudal epidural injections in chronic function-limiting low back pain and lower extremity pain with disc herniation and radiculitis demonstrated effectiveness in more than 70% of the patients with improvement in functional status, requiring an average of three to four procedures per year and providing over 40 weeks of relief during a 52-week period in appropriately selected patients, with potential superiority with steroids."	Data suggest epidural effectiveness.

								= 0.158), and 3 months 16.5±7.2 group I vs. 13.6±6.5 group II, (p = 0.023). ODI score from baseline at 3, 6, 12 months: 62%, 72% and 67% in group I vs. 73%, 73% and 75% group II. Total number of injections per year 3.8±1.4 in group I and 3.6±1.1 in group II.		
Ghai 2015 (score= 8.5)	Epidural Steroid injections	RCT		N = 69 within 18-60 years old with chronic low back pain; patients exhibit lower radicular pain for longer than 12 weeks	Mean age: 45.3; 34 males, 35 females	Group L, treated with epidural injections (EI) and local anesthetics (n=34) vs. Group LS, treated with EI and local anesthetics with steroid shots. (n=35)	Follow up conducted at 1, 2, 3, 6, 9, 12 months	There is a larger proportion of patients who have reached effective pain relief at the 3 month follow up and beyond in group LS S [30 (86%, 90% CI 73% – 93%)] as compared to group L [17 (50%, 90% CI 36% – 64%)] (P = 0.02).	"Using a PIL approach and the addition of steroid to LA for EI may provide superior effectiveness in terms of extent and duration of pain relief for managing CLBP with unilateral LRP, even though, local anesthetic alone also was effective."	Data suggest PIL approach with steroid plus local anesthetic may extend duration of pain relief in CLBP patients but stand alone local anesthesia was effective as well.
Koh 2013 (score= 7.5)	Epidural Steroid injections	RCT	No industry sponsorship and no COI.	N = 53 with chronic lumbosacral unilateral radiculopathy secondary to spinal stenosis for 12 weeks or longer, at least 20 years of age.	Mean age: 64.87 years; 15 males, 38 females	Transforaminal epidural injection (TFEI) under fluoroscopic guidance with 2ml 10% sodium chloride solution mixed with 20mg triamcinolone acetonide (hypertonic group, n = 34) vs 2ml 0.9% saline mixed with 20mg triamcinolone (control group, n = 34).	Follow-up 1, 2, 3, 4, and 6 months after injection.	Numerical rating scale (NRS) pain (mean±SD): at 2 months – hypertonic (3.22±2.42) vs. control (1.94±2.04), p=0.024; at 3 months – hypertonic (2.93±2.54) vs. control (1.52±1.83), p=0.011.	"[T]he TFEI is a useful modality in treating pain secondary to lateral canal spinal stenosis, and the short-term functional outcomes were also improved significantly, but the TFEI showed limited long-term effects in treating patients with spinal stenosis."	5 patients excluded after randomization.
Manchikanti 2010	Epidural Steroid injections	RCT	Authors state no external	N = 140 with history of	Mean age: 50.20	Caudal epidural injections of 10ml lidocaine 0.5% (Group I, n = 70) vs. caudal	Follow-up 3, 6,	Weight at beginning of study (lbs., mean±SD): group I 200.5±46.8 vs.	"One year results by this randomized, double-blind, active	Multiple injections allowed. High

(score= 6.0)			funding. Datta receives research support from Sucampo Pharmaceuticals and honorarium from Smith and Nephew.	chronic LBP with or without lower extremity pain at least 6 months, surgery performed at least 6 months earlier, age 18.	years; 63 males, 77 females	epidural injections 0.5% lidocaine 9ml mixed with 1ml non-particulate Celestone (betamethasone) 6mg for total volume 10ml followed by injection of 2ml 0.9% sodium chloride solution for flush (Group II, n = 70). All injections fluoroscopy guided. Received 2nd injection if 1st improved physical and functional status.	12 months.	group II 183.2±41.8, p = 0.023. Weight at 1 year (lbs., mean±SD): group I 197.0±47.7 vs. group II 180.2±42.1, p = 0.028. No other significant differences between groups.	controlled trial of epidural effectiveness in the post lumbar surgery syndrome illustrates 53% of patients with local anesthetic and 59% of patients with local anesthetic and steroids show significant improvement in both pain relief and functional status."	dropout as "not completed" the study period.
Blomberg 1993 (score= 7.0)	Epidural Steroid injections	RCT	Study funded by grants from Kopparberg y County Council, National Research Council, Bengt Kåring, The Save Our Backs Association, and the Swedish Association for Orthopaedic Medicine. No mention of COI.	N = 101 age 20-60 with acute or subacute LBP with or without pain radiating to one of both legs for 3 months or less, preceded by at least 2 months of relative freedom from symptoms.	No mention of mean age or gender distribution.	Experimental group: Swedish manual therapy techniques – mobilization, manipulation and muscle stretching; steroid injections of triamcinolone in combination with needling and local anaesthetics (0.1% prilocaine hydrochloride) all treated with thrust techniques or specific mobilization (n = 48) vs. Conventional treatment group: drugs, ergonomic/other advice, LBP school training, sick-leave, active back exercises, corsets, taping, short-wave, ultrasonic waves, TENS, TEMS, electric stimulation, heat, cold, postural instructions and postural exercises, plunge-bath training and massage (n = 53).	Follow-up for 4 months.	Quality of life measures (VAS scale 0-100), baseline/4 months. Health: conventional (65/70) vs. experimental (63/84), p = 0.0019. Hearing: conventional (84/82) vs. experimental (86/92), p = 0.010. Memory: conventional (73/76) vs. experimental (75/83), p = 0.016. Energy: conventional (71/73) vs. experimental (73/82), p = 0.054. Headache: conventional (73/76) vs. experimental (76/84), p = 0.052. Depression: conventional (40/44) vs. experimental (31/20), p = 0.016. Abdominal pain: conventional (19/29) vs. experimental (19/7), p = 0.0078. Sweating: conventional (19/21) vs. experimental (10/4), p = 0.027.	"The results of this study show that manual therapy with steroid injections is better than conventional optimized activating treatment in Swedish primary health care, when it comes to reducing the presence of general symptoms in parallel with reduction of pain and restoration of everyday function in patients suffering from low-back pain."	Significant changes in self-reported factors after 4 months.
Blomberg 1994 (score= 5.0)	Epidural Steroid injections	RCT	Study funded by grants from Kopparberg County	N = 101 age 20-60 with acute or subacute	No mention of mean age or	Experimental group: Swedish manual therapy techniques – mobilization, manipulation and muscle stretching; steroid	Follow-up for 4 months.	Mean pain scores (3 days/7 days/14 days/21 days/90 days): conventional 4.8 vs. experimental 3.8, p =	"The results of this study indicate that a pragmatic approach to low-back pain including manual therapy, muscle	Improved ROM but no change in exam

			Council, National Health Insurance Company, Swedish Medical Research Council, Bengt Kåring, the Save Our Backs Association, and the Swedish Association for Orthopaedic Medicine. No mention of COI.	LBP with or without pain radiating to one of both legs for 3 months or less, preceded by at least 2 months of relative freedom from symptoms.	gender distribution.	injections of triamcinolone in combination with needling and local anaesthetics (0.1% prilocaine hydrochloride) (n = 48) all patients were treated with thrust techniques or specific mobilization vs. Conventional treatment group: drugs, ergonomic and other advice both written and verbally, low back pain school training, sick-leave, active back exercises, corsets, taping, short-wave, ultrasonic waves, TENS, TEMS, electric stimulation, heat, cold, postural instructions and postural exercises, and plunge-bath training and massage (n = 53).		0.020/conventional 4.2 vs. experimental 3.1, p = 0.016/ conventional 3.4 vs. experimental 2, p = 0.004/ conventional 3.4 vs. experimental 1.7, p = 0.0004/conventional 2.4 vs. experimental 1.4, p = 0.037. Mean disability rating score (3 days/7 days/14 days/21 days/90 days): conventional 4.6 vs. experimental 3.5, p = 0.023/ conventional 3.9 vs. experimental 2.6, p = 0.005/ conventional 3.2 vs. experimental 1.8, p = 0.005/ conventional 3 vs. experimental 1.4, p = 0.0003/conventional 1.9 vs. experimental 1.2, NS. Mean level recovery: 5.7 vs. 6.6, p = 0.0005/6.3 vs. 7.1, p = 0.020/7.1 vs. 8.1, p = 0.008/7.2 vs. 8.4, p = 0.002/8.2 vs. 8.9, p = 0.055. Over study period, experimental group consumed less drugs	stretching, autotraction and steroid injections is superior to the predominant conventional, activating treatment in Swedish primary health care as far as reducing pain, disability and drug consumption, and facilitating recovery is concerned."	findings at 4 months.
Bonetti 2005 (score= 4.0)	Epidural Steroid injections	RCT	No mention of industry sponsorship or COI.	N = 306 patients, age range 26-72, with acute or chronic low back pain and sciatic nerve pain for 1-20 months	Mean age: 48.0 years; 178 males, 128 females	CT-guided infiltration O_2-O_3 gas mixture of 3ml at rate of 25µg/ml into neural foramen followed by another 5 ml of mixture into the facet joint region (n = 156) vs CT-guided steroid infiltration of 2 ml 80 mg methylprednisolone acetate (n = 150).	Follow-up 1 week, 3 months, and 6 months after infiltration.	At 6 months follow-up: patients with disk disease in the O_2-O_3 group, 74.4% reported complete remission of pain, p=0.0021. Patients without disk disease, 21.4% had poor out comes with steroid injections, p = 0.0332.	"[W]e suggest the administration of the gas mixture as a first-choice treatment to replace epidural steroid infiltration to avoid surgery."	Sparse details.
Ghai 2014	Epidural Steroid injections	RCT		N = 62 with diagnosis	Mean age: 44.39	Transforaminal (TF) approach of epidural injection (n=30) Vs.	Follow up at 3, 6, 9,	Proportion of the relief was within equivalence width. EPR at 3 monts	"Epidural injection delivered through the PIL approach is	Data suggest-comparable

(Score= 8.0)				of CLBP and unilateral lumbosacral radicular pain; 3 month minimum duration of no response to reatment.	years; 36 males, 26 females	Parasagittal interlaminar (PIL) route (n=32)	and 12 months	was 76% (90% Cl 60.6%-88.5%) in the TF group and 78% (90% Cl 62.8%-89.3%) in the PIL group (=1.00).	equivalent in achieving effective pain relief and functional improvement to the TF approach for the management of low back pain with lumbosacral radicular pain. The PIL approach can be considered a suitable alternative to the TF approach for its equivalent effectiveness, probable better safety profile, and technical ease."	efficacy between the 2 delivery routes.
Turner 2015 (score= n/a)	Epidural Steroid Injections	Secondary analyses of 16 RCTS		N = 400 with lumbar spinal stenosis	Mean age: 68 years; 221 males, 170 females	Corticosteroid + Lidocaine Group: received 1 to 3 ml of 0.25% to 1% lidocaine followed by 1 to 3 ml of triamcinolone (60 to 120 mg), betamethasone (6 to 12 mg), dexamethasone (8 to 10 mg), or methylprednisolone (60 to 120 mg) (n=200 Lidocaine Group: received only lidocaine the same dosing as corticosteroid group except that the injectable solution was an equivalent volume of 0.25% to 1% lidocaine alone. (n=200)	3, 6 weeks	Patients with low EQ-5D score (0-1) showed better improvement from corticosteroid group compared with higher scores. Patients that scored 0.4 for EQ-5D showed better RMDQ score when treated with steroid and lidocaine group compared to only lidocaine (2.8 pts lower). Patients that scored 0.8 on EQ-5D and corticosteroid treatment only scored 0.9 pts lower on RMDQ than lidocaine only. Overall observed improvement was an interaction coefficient=2.94 (95% CI 0.11-5.76; p=.04).	"Among 21 baseline patient characteristics examined, none, including clinician-rate spinal stenosis severity, were consistent predictors of benefit from epidural injections of lidocaine + corticosteroid versus lidocaine only."	Data suggest none of the 21 patient characteristics inclusive of baseline spinal stenosis severity is predictive for a benefit from epidural corticosteroid injections.
Cohen 2015 (score= 7.5)	Epidural Steroid injections	RCT	Sponsored by a congressional grant from the Center for Rehabilitation Sciences	N = 145 with average radicular leg pain score ≥4 on 0-10 scale over	Mean age: 42.76 years; 107 males, 38	60mg depomethylprednisolone +1ml 0.25% bupivacaine single injection 3ml plus placebo pills (n = 73) vs. 3ml saline injection single injection plus gabapentin dose ranging from 1800	Follow-up 1 month after start of treatment and 3 months.	No significant difference between groups for the primary outcome of average leg pain at one month (p = 0.25) or 3 months (p = 0.43)	"Gabapentin and epidural steroid injections used to treat lumbosacral radicular pain both resulted in modest improvements in pain and function,	High dropout rate. Modest efficacy of steroid at 1 month but not at 3 months.

			Research, Bethesda, MD. COI: SPC is a consultant for Semnur Pharmaceuticals.	past week or 3/10 if leg pain bad or worse than back pain for ≥6 weeks to 4 years. Mean age epidural steroid 43.8±14.0 years, gabapentin 41.7±11.9 years.	females	mg/day to 3600 mg/day 3 times a day (n = 72).			which persisted through three months."	
Spijker-Huiges 2014, b (score= 7.5)	Epidural Steroid Injections	RCT		N = 63 patients with acute radiculopathy	Mean age: 43.7 years; 30 males, 33 females	Intervention group: (n=30) vs Control Group: (n=33)	2, 4, 6, 13, 26, and 52 weeks, and 1 year	Symptoms of remained more severe in the control group than in the intervention group for back pain (P=0.0115), self-percieved impairment (P=0.0361), and Roland-Morris disability score (P=0.0173). The CEAC showed that the probability that epidural steroids in acute radiculopathy are cost-effective rises to 100% with and additional investment of about $1627 per patient.	"The effect on pain and disability of epidural steroids in lumbosacral radicular syndrome is small but significant, and at lower costs with no reported complications or adverse effects. Segmental epidural steroid injections could be considered by policy makers as an additional treatment option."	Usual care bias. Single injection intervention. Data suggest epidural steroids for the treatment of lumbosacral radicular pain via a single injection has a small favorable effect.
Gerszten 2010 (score= 5.5)	Epidural Steroid injections	RCT	Study funded by ArthroCare Corp. Following authors are consultants for ArthroCare	N = 90 age 18-75, BMI <40, radicular pain scores 50 or greater on 0-	Mean age: 44.12 years; 46 males, 44 females	Fluoroscopy-guided transforaminal epidural injection up to 2 injections scheduled 3 weeks apart; medication type and dose were left to the discretion of clinician (TFESI, N = 44) vs Plasma disc decompression (PDD, n =	Follow-up 6 months to 2 years.	Mean±SD change in leg pain VAS score (6 weeks/3 months/ 6 months): PDD -42±5 vs. TFESI -21±4, p = 0.002/ PDD -46±4 vs. TFESI -23+5, p = 0.0001/PDD -47±6 vs. TFESI -21±5, p =	"The results of this randomized, controlled clinical study of patients with radicular pain associated with a contained lumbar disc herniation showed that the PDD procedure following a failed	Injection frequency and dose variable up to physician discretion. Randomized Trial phase only 6

			Corp: Crabtress, Bloch, Gerszten, and Smuck (Smuck reports financial support from ArthroCare Corp for non-study related clinical or research effort overseen by him).	100mm VAS, and received epidural corticosteroid injection for same symptoms between 3 week and 6 months before enrolling in study.		46). All patients allowed additional conservative therapies (bed rest, braces, physical therapy, narcotic analgesics, or NSAIDs).		0.0008. Mean±SD change in back pain VAS score (6 weeks/3 months/6 months): PDD -18±4 vs. TFESI 1±3, p = 0.0005/ PDD -17±5 vs. TFESI 7±4, p = 0.0001/ PDD -21±5 vs. TFESI -0.4±4, p = 0.002. Mean±SD change in ODI score (6 weeks/3 months/6 months): PDD -13±3 vs. TFESI -5±2, p = 0.002/ PDD -11±3 vs. TFESI -2±2, p = 0.002/ PDD -14±4 vs. TFESI -4±2, p = 0.002. Of patients with pre-procedure pain duration of 1-3 years, those in the PDD group had greater reduction in leg pain vs. TFESI, p=0.009. SF-36: PDD showed greater improvement for physical function (p = 0.0016), bodily pain (p = 0.0039), social function (p = 0.0312), and physical components summary scores (p = 0.0040) vs. TFESI.	TFESI was associated with clinically significant benefits over a repeated course of TFESI, the current standard care."	months in duration.
Yang 2016 (score= 4.5)	Epidural steroid injections	RCT		N = 80 patients with low back pain and radicular pain	Mean age: 57.5 years; 35 females, 45 females	FL Group: received fluoroscopy guided epidural injections (4 mL 0.5% lidocaine and 1 mL of diprospan) vs US Group: received ultrasound guided epidural injections (4 mL 0.5% lidocaine and 1 mL of diprospan)	Pre-operatively, .5 hour, 1 week, 1 month	VAS pain scores showed minimal differences between groups, but decreased for both with time. Operation time was shorter in US group (518±103 s) compared to FL group (929±228s).	"Lumbar TFEI under US guidance was feasible, safe, and required less radiation to achieve the same benefit as the FL-guided interventions."	Data suggest similar efficacy although US-guided approach requires less exposure to radiation.
Ghai 2013	Epidural Steroid injections	RCT		N = 37 with ASA physical	Mean age: 41.49;	Lateral parasagittal interlaminar, needle through most lateral	Follow up at 15 days, 1 2,	Total number of epidural steroid injections (ESIs)	"Epidural steroid administration under fluoroscopic guidance	Small sample. Data suggest PIL

(score= 7.5)				status I and II, either gender, between the ages of 18-65 with low back pain associated with unilateral lumbosacral radicular pain for at least 3 months without response to medications and physical therapies.	22 males, 15 females	epidural space of affected side or PIL group (n = 19) vs Midline interlaminar, needle through midpoint between 2 spinous processes or MIL group (n = 18). Both groups received 2ml methylprednisolone acetate with 2ml sterile normal saline and fluoroscopy guided injection. Follow-up for 6 months at 15 day intervals, 1, 2, 3, and 6 months.	3, 6 months	administered: PIL 29 vs. MIL 41, p = 0.043. Mean±SD injections required over 6 months: PIL 1.53±0.84 vs. MIL 2.28±0.90, p = 0.013. Effective pain relief (%) (15 days/1 month/2 months/3 months/6 months): PIL 78.9 vs. MIL 38.9, p = 0.013/PIL 78.9 vs. MIL 38.9, p = 0.013/PIL 84.3 vs. MIL 44.4, p = 0.011/PIL 78.9 vs. MIL 38.9, p = 0.013/ PIL 68.4 vs. MIL 16.7, p = 0.001. Ventral epidural spread (%): PIL 89.65% vs. MIL 31.7%, p = 0.001. Perineural spread (%): PIL 44.82% vs. MIL 14.63%, p = 0.005. Modified Oswestry Disability Questionnaire (MODQ) (15 days/1 month/2 month/3 month/6 month, PIL vs. MIL): p = 0.001/p <0.001/p = 0.006/p = 0.013/p = 0.002, scores significantly lower in PIL vs. MIL. VAS (15 days/1 month/2 month/3 month/6 month, PIL vs. MIL): p = 0.009/p = 0.001/p = 0.001/p = 0.01/p = 0.001, scores significantly lower in PIL vs. MIL.	with a lateral PIL approach was significantly more effective compared with a MIL approach for management of chronic low back pain with lumbosacral radicular pain."	administration of lumbar epidural steroid injections was significantly superior to MIL for pain relief and improved disability at 6 months.
Soneji 2015 (score= 6.5)	Sacroiliac Joint Injection	RCT		N = 40 patients with chronic moderate-to-severe LBP secondary	Mean age: 48.9 years; 11 males, 29	US SIJ Injection: received ultra-sound guided unilateral sacroiliac joint injections (40 mg methylprednisolone acetate diluted in 3 mL of bupivacaine 0.25% with epinephrine total of 4 mL)	24 hours, 72 hours, 1 week, 1 month, 3 months	Reduced NRS pain score for US group was 22.7% (p=.03) and 37.3% for FL group (p<.01). ODI scores were reduced in the FL group by 11.8%	"Ultrasound-guided SIJ injection with fluoroscopic confirmation has similar accuracy and efficacy to fluoroscopy alone for SIJ injections in patients with chronic low back	Data suggest comparable accuracy and efficacy in both techniques at any time interval.

				to SIJ arthritis.	females	(n=20) vs FL SIJ Injection: received fluoroscopy guided unilateral SIJ injections (40 mg methylprednisolone acetate diluted in 3 mL of bupivacaine 0.25% with epinephrine total of 4 mL) (n=20)		(p=.02), and 4.7% for the US group (p=.54).	pain secondary to SIJ arthritis."	
Evansa 2014 (score= 6.0)	Epidural Steroid Injections	RCT		N = 112 patients with axial lower back pain and extremity pain	Mean age: 69.2 years; 20 males, 92 females	US Group: received ultrasound-assisted epidural steroid injections (80 mg of methylprednisolone acetate with 4 mL of 1% lidocaine (total 5mL)) vs FL group: received fluoroscopy-controlled epidural steroid injections (80 mg of methylprednisolone acetate with 4 mL of 1% lidocaine (total 5mL))	1, 3 months	Improvement in VAS pain score improved similarly for both groups from 7.5±1.0 to 4.0±2.3 for FL group (p<.05) compared to US group from 7.3±1.3 to 4.1±2.0 (p<.05).	"We have demonstrated the feasibility of ultrasound-assisted epidural steroid injections."	Data suggest comparable efficacy at 3 months, 3 steroid injections per group.
Cohen 2009 (score= 9.0)	Epidural Steroid Injections	RCT	Study supported in part by a Congressional Grant from the John P. Murtha Neuroscience and Pain Institute, the United States Army, and the Army Regional Anesthesia and Pain Medication Imitative. No mention of COI.	N = 25 patients with lumbosacral radiculopathy for at least 2 months but less than 1 year failing to respond to conservative therapy with MRI evidence of a herniated disc.	Mean age: 44 years; 17 males, 7 females	Two transforaminal epidural injections at 2 week intervals of etanercept (Group I = 2 mg, N=6; Group II = 4 mg, N=6; Group III = 6 mg, N=6) in a 3:1 ratio vs. 2 transforaminal epidural injections of saline (2 ml) in 3:1 ratio (Group 0, n = 6). Follow-up at 1, 3 and 6 months.	1, 3, 6 months	Numerical rating leg pain scores mean±SD (placebo/2mg etanercept/4mg etanercept/6mg etanercept/all etanercept): baseline (8.2±1.0/5.8±1.8/ 6.3±1.3/6.8± 1.7/6.3±1.6); 1 month (6.5±2.4/1±1.3, p <0.05 vs. placebo, p <0.05 vs. baseline/3±2.9/3±3.0/2. 3±2.5, p <0.05 vs. placebo and vs. baseline); 3 months (3/1.1± 0.8/0.5±1.5/0.75±1.2/0. 8±0.9); 6 months (4/1.4±1.4/1.0- 2.0/0.5±0.9/1.1±1.5). Numerical rating back pain scores mean±SD (placebo/2mg etanercept/4 mg	"The results of this study suggest that transforaminal epidural etanercept may someday prove to be a beneficial treatment in patients with lumbosacral radiculopathy."	Small sample size.

								etanercept/6 mg etanercept/all etanercept): baseline (6.6±1.4/5.2±1.4/ 5.4±2.5/7.0±1.7/5.9±2.1); 1 month (5.4±2.0/1.6±0.9, p <0.05 vs. placebo and vs. baseline/1.7±1.6, p <0.05 vs. placebo/4.9±1.6, p <0.05 vs. baseline/2.7±2.1, p <0.05 vs. placebo and vs. baseline); 3 months (4/1.8±1.3/0.8±1.5/ 3.0±1.2/1.8±1.5); 6 months (4/4.8±3.3/1.8±2.2/2.7± 1.0/3.4±2.8). ODI: NS.			
Manchikanti 2012a (score= 8.5)	Medial Branch Blocks	RCT double-blind active-control trial		N = 100 eligible to undergo diagnostic thoracic facet joint nerve blocks with nonspecific mid-back or upper back pain without suspected disc herniation	Mean age: 43.8 years; 37 males, 63 females	Group I or local anesthetic only received branch blocks with injection of bupivacaine 0.25% (n = 50) vs. Group II or local anesthetic with steroid group received bupivacaine and nonparticulate betamethasone, 0.15mg/ml (n = 50).	3, 6, 12, 18, and 24 months	No significant difference between groups with regards to average pain scores and ODI.	"Therapeutic medial branch blocks of thoracic facets with or without steroids may provide a management option for chronic function-limiting thoracic pain of facet joint origin."	Data suggest in population prescreened for positive response to facet injections for chronic thoracic pain, there is no difference in outcomes from serial facet injections using plain bupivacaine compared with bupivacaine and betamethasone.
Manchikanti 2012, b	Epidural steroid Injection	RCT	Authors state no external funding.	N = 120 with disc herniation or	Mean age: 42.0 years;	Lumbar interlaminar epidural injections of lidocaine 0.5% 6ml (Group I, n = 60) vs. lumbar	3, 6, 12 months	Numeric Rating Scale for pain (mean±SD) (baseline/3 months/6 months/12 months):	“This evaluation of the 1-year follow-up of the results of lumbar interlaminar epidurals	Selection of study subjects seems to overlap with

(score= 8.0)			Falco consultant for St. Jude Medical Inc and Joimax Inc.	radiculitis ; at least age 18 and history of at least 6 months of chronic low back and lower extremity pain	38 males, 82 females	interlaminar epidural injections 0.5% lidocaine 5ml mixed with 1ml non-particulate betamethasone (Group II, n = 60). All injections performed under fluoroscopy. All patients continued previous treatments. Assessments at baseline, and 3, 6, and 12 months after treatment.		Group I 8.2±0.8 vs. Group II 8.0±1.0/Group I 3.9±1.6 vs. Group II 3.5±1.0/ Group I 4.1±1.6 vs. Group II 3.5±1.0/Group I 4.0±1.6 vs. 3.4±1.2), p=0.020. Oswestry Disability Index (mean±SD) (baseline/3 months/6 months/12 months): Group I 30.3±4.7 vs. Group II 29.6±5.)/ Group I 15.8±6.3 vs. Group II 14.0±4.2/Group I 16.1±6.6 vs. Group II 13.5±4.2/Group I 15.9±6.9 vs. Group II 13.0±4.2), p = 0.026. Number of procedures per year: Group I 3.6±1.3 vs. Group II 4.1±1.02, p <0.05. Weight at beginning (lbs.): Group I 201.8±49.4 vs. Group II 181.8±41.1, p = 0.018. Weight at 1 year (lbs.): Group I 197.1±48.4 vs. Group II 180.5±41.3, p = 0.045.	utilizing a randomized, double-blind, active-control design in chronic function-limiting back pain and lower extremity pain secondary to disc herniation or radiculitis, demonstrated significant effectiveness with improvement in pain and function in 67% of patients receiving local anesthetic only and in 85% of patients receiving local anesthetic and steroid with approximately 4 procedures per year."	other published articles. Same Clinical Trial Registry as other publications.
Manchikanti 2013 (score= 7.0)	Epidural Steroid Injections	Follow-up report of Manchikanti 2012b	Dr. Benyamin is a consultant and lecturer for Boston Scientific and Kimberly Clark. No external funding.	N = 120 with lumbar axial or discogenic pain for at least 6 months.	Mean age: 45.6 years; 53 males, 67 females	Group A: lumbar interlaminar epidural injections with 0.5% lidocaine 6ml (n = 60) vs. Group B: lumbar interlaminal epidural injections with a total volume of 6 ml derived from lidocaine 0.5%, 5 ml mixed with 1ml of 6mg nonparticulate betamethasone (n = 60).	Follow up at 3,6, 12, 18, and 24 months	Oswestry Disability Index (ODI) and numeric pain rating scale used to measure results. No significant differences between groups. Results limited because of lack of placebo group.	"The results of this trial shows lumbar interlaminar epidural injections of local anesthetic with or without steroids are effective in patients with chronic axial low back pain of discogenic origin without facet joint pain, disc herniation, radiculitis, and/or sacroiliac joint pain."	Results at 2 year are similar to one year, with no significant differences between the groups. Lack of control or placebo group limits conclusions. Data suggest cervical epidural injections

										may benefit chronic pain patients.
Manchikanti 2015 (score= 7.0)	Epidural Steroid Injection	2 year Follow up of Manchikanti study		N=120 with central spinal stenosis with radicular pain of a least 6 months	Mean age: 52.3 years; 52 males, 62 females	Group I patients received lumbar interlaminar epidural injections of local anesthetic (lidocaine 0.5%) 6mL (n=60) Vs Group II received lumbar interlaminar epidural injections with local anesthetic (lidocaine 0.5%) 5mL mixed with 1mL of steroids and 6 mg of betamethasone (n=60)	3, 6, 12, 18, and 24 months	Significant improvement was achieved for 65.7 ± 37.3 weeks in Group 1 and 68.9 ± 37.7 weeks in Group II at the end of 2 years when all participants were considered; whereas, this was 77 ± 27.8 weeks and 77.9 ± 30.2 weeks when they were separated into successful categories.	"Lumbar interlaminar epidural injections of local anesthetic with or without steroids provide reliec in a significant proportion of patients with lumbar central spinal stenosis."	Baseline differences in weight between group as well as male and female participants. No placebo goup. Data suggests lumbar interlaminar epidural injections may improve pain.
Thomas 2003 (score= 7.5)	Corticosteroid injection	RCT	No mention of industry sponsorship or COI.	N = 31 hospitalized for sciatica secondary to disc herniation; over age 18; radicular pain <3 months; disc herniation confirmed by CT or MRI; radicular pain intensity above 30 mm on VAS.	Mean age: 50.6 years; 13 males, 18 females	Interspinous injection (N = 16) vs. transforaminal injection (n = 15) of 5mg dexamethasone acetate in 2ml solution. After injection all patients underwent same treatment of rest and lumbar physiotherapy. Follow-up 6 days, 30 days, and 6 months after injection.	6 days, 30 days, 6 months	Results at day 6 (day 0/day 6, mean±SD). VAS (mm): NS. Schober (cm): interspinous 2.2±0.8 vs. transforaminal 1.7±0.8/interspinous 2.6±0.7 vs. transforaminal 2.9±0.9, p = 0.009. Finger-to-floor (cm): interspinous 39.6±18.2 vs. transforaminal 39±18.6/interspinous 33.8±20 vs. transforaminal 23.3±15, p = 0.04. Straight-leg raising test: NS. Dallas daily activities: interspinous 84.3±16.2 vs. transforaminal 84.2±21/ interspinous 79.5±21.8 vs. transforaminal 61.2±29.1, p = 0.03. Dallas work and leisure activities: interspinous	"[B]oth interspinous and transforaminal epidural corticosteroid injections showed short-term efficacy in the treatment of discal radiculalgia."	Small sample size (N=31). Few changes at 30 days but many at 6 days and 6 months.

								95.6±8.3 vs. transforaminal 98.6±3/84±19.2 vs. 85.6±22.1, p = 0.03. Dallas anxiety-depression, Dallas sociability, Roland-Morris: NS. Results at day 30 (mean±SD). VAS (mm): interspinous 31±26.2 vs. transforaminal 17.2±24, p = 0.04. Results at month 6 (mean±SD). VAS: interspinous 43.7±25.2 vs. transforaminal 21.7±21.7, p = 0.04. Dallas daily activities: interspinous 69±26.3 vs. transforaminal 46.5±26.7, p = 0.05. Dallas work and leisure activities: interspinous 59.5±23.3 vs. transforaminal 37±29.7, p = 0.02. Dallas anxiety-depression: interspinous 55±27.3 vs. transforaminal 33.5±25.7, p = 0.04. Dallas sociability: NS. Roland-Morris: interspinous 10.2±6.7 vs. transforaminal 5.3±5.2, p = 0.05.		
Wilson-MacDonald 2005 (score= 7.0)	Epidural steroid injection	RCT	Authors state no COI. No mention of industry sponsorship.	N = 93 with herniated discs (n = 42), spinal stenosis (n = 32), and both (n = 18); all potential	Mean age: 48.8 years; 37 males, 55 females	Intramuscular (control, n = 48) vs. epidural steroid injection (n = 44). All methylprednisolone 2ml (80mg, 2mL) plus Bupivacaine 0.5%, 8mL. Follow-up for 2 plus years.	6 weeks, 3 months, 1 year, 2 years	Difference at 10 days favored ESI (p <0.004).	"[E]pidural steroid injection does not affect the ultimate need for surgery in this group of patients, but it is useful for reducing symptoms in the acute stages of nerve root compression."	Mixed patients. Study carried forward for 2 years, but included non-randomized surgical interventions, thus this evaluation considers

				surgery candidates						results through 35 days. Data suggest modest short-term benefits.
Rasmussen 2008 (score= 6.0)	Epidural Steroid Injection	RCT	Authors state no funding for the study and no COI.	N = 200 with lumbar herniated disc disease who received conservative treatment with intensive exercises and 18 years of age or older eligible for back surgery (discectomy).	Mean age: 42.5 years; 122 males, 78 females	After completion of surgery: 1 ml methylprednisolone acetate 40 mg/ml (n = 100) vs Placebo – nothing instilled at decompressed nerve root (N = 100). All received up to 1 week of standardized post-op mobilization and training program. Follow-up at 6-8 weeks and 1-2 years post-op.	2 months, 1 year, 2 years	Neurologic impairment reduced at 2 months after surgery: steroid 70% vs. control 44%, p = 0.0004. Secondary outcomes (2 months/1 year/2 years): leg pain – steroid 7 vs. control 13, p = 0.002/steroid 5 vs. control 12, p = 0.002/steroid 5 vs. control 10, p = 0.002. RTW: NS/steroid 95 vs. control 80, p = 0.0028/steroid 94 vs. control 80, p = 0.0046. Positive straight leg test: NS/steroid 10 vs. control 33, p = 0.0046/steroid 11 vs. control 23, p = 0.013. Reflex deficit: 14 vs. 37, p = 0.0030/12 vs. 36, p = 0.002/13 vs. 38, p = 0.002. Sensory deficit: 21 vs. 38, p = 0.0043/20 vs. 38, p=0.0034/20 vs. 38, p = 0.0034. Motor deficit: 8 vs. 25, p = 0.0027/8 vs. 23, p = 0.0032/9 vs. 24, p = 0.0034.	"[E]pidural steroid administration during lumbar discectomy reduces early neurologic impairment, pain, and convalescence and enhances recovery without increasing risks of complications."	Data suggest graded exercise (stabilization) improve perceived disability up to 1-year and perceived health up to three years. Neither intervention resulted in long term pain improvement.
Cohen 2012 (score= 6.0)	Epidural Steroid Injections	RCT	Industry sponsored (John P. Murtha Neuroscience and Pain Institute, Johnstown, PA	N = 132 with signs and symptoms or lumbosacral radiculopathy	Mean age: 52.0±15.0 years; 57 males, 75	Transforaminal injection of 2 mL solution containing 60 mg of depo-methylprednisone, 1 ml of bupivacaine, 0.25%, and 1.5mL saline or interlaminar injection 4mL solution containing 60mg depo-methylprednisone,	1, 3 months	3 month results: Mean (SD) leg pain: (MRI no change in treatment plan) 2.4 [2.7] vs (MRI with different injection than physician planned) 4.8 [3.2], p = 0.01; ODI scores (SD): 28.2 [15.5] vs 38.7 [15.5], p = 0.04.	"Magnetic resonance imaging does not improve outcomes in patients who are clinical candidates for ESI and has only a minor effect on decision making."	One month follow up. Data suggest MRI may not be necessary.

			(through Defense and Veterans Pain Management Initiative, Rockville, MD)). No COI.	clinically warranting epidural steroid injections (ESI), leg pain great or greater than back pain.	females	1mL bupivacaine, 0.25%, and 1.5mL of saline. ESI based on history and physical examination (n = 65) vs. ESI based on history, physical exam and magnetic resonance imaging (MRI) (n = 67). Second ESI 2 week after 1st injection. Follow-up 1 and 3 months after 2nd injection.				
Ghahreman 2010 (score= 6.0)	Steroid Injections	RCT	No mention of industry sponsorship or COI.	N = 150 adults with pain radiating in to lower limb associated with limitation of straight leg raises to less than 30 degrees and disc herniation seen on CT or MRI.	Mean age: 46.1 years; 89 males, 61 females	Intramuscular injection 1.75ml triamcinolone (IMST, n = 28) vs. Intramuscular saline 2ml (IMNS, n = 30) vs transforaminal injection 0.75ml 0.5% bupivacaine then 1/75ml triamcinolone in concentration 40mg/ml (TFST, n = 28) vs. transforaminal local anesthetic 2ml 0.5% bupivacaine (TFLA, n = 27) vs. transforaminal saline 2ml (TFNS, n = 37). Follow-up 1 week after treatment, 1, 3, 6, 12 months after treatment or until pain relief ended.	1, 12 months	Most successful outcomes achieved in the transforaminal injections of steroids group, including the proportion of patients who responded to treatment.	"[T]ransforaminal injection of steroids is a viable alternative to surgery for lumbar radicular pain due to disc herniation."	Patients allowed multiple injections for those who "felt they benefitted". Small numbers in each group. High dropouts. Data suggest TFST effective and appears to have delayed and reduced need for surgery.
Lotfinia 2007 (score= 5.0)	Epidural Steroid Injection	RCT	No mention of industry sponsorship or COI.	N = 130 age 30-50 surgery scheduled for lumbar disc herniation ; acute onset single level unilateral herniated nucleous pulposus	Mean age: 38.1 years; 67 males, 83 females	40mg methylprednisolone with 3ml normal saline (group 1) vs. 2ml bupivacaine 0.5% with 2 ml normal saline (group 2) vs. 4ml of normal saline (group 3) prior to suturing at the end of surgery. Post-op pain management: 100mg meperidine intramuscularly twice, 4 hours apart. Assessments: day before surgery, 24, 48, 72, and 96 hours after surgery.	24, 48, 72, 96 hours post-operatively	No significant differences between groups.	"[In]traoperative use of epidural methyl-prednisolone or bupivacaine compared with that of normal saline (placebo) has no beneficial effect on postoperative pain relief during the 96 hours following lumbar disc surgery."	Details sparse.

				no response to 6 weeks conservative treatment (analgesic and NSAID drugs).						
Riew 2000 (score= 4.0)	Nerve Root injection	RCT	Industry sponsored (Barnes-Jewish Christian Health System's Innovations in Health Care Grant and Washington University School of Medicine). No COI.	N = 55 with degenerative lumbar radicular pain with a disc herniation or central or foraminal spinal stenosis confirmed by magnetic resonance imaging or computed tomography myelography	No mention of mean age or gender.	Bupivacaine 0.25%, 1mL and 6mg/mL of betamethasone (n = 28) (8 opted for treatment) vs. bupivacaine 0.25% , 1mL only (n = 27) (9 opted for treatment). Follow-up: 4 weeks following injection, 12 months, 28 months	13-28 months	Opted for operation intervention: 18 received bupivacaine alone vs. 8 received bupivacaine and betamethasone, p <0.004. Bupivacaine only: difference between baseline and follow-up regarding treatment expectations p <0.001. Bupivacaine and betamethasone (stenosis diagnosis) difference between baseline and follow-up regarding relief of back pain p <0.049; treatment expectations p <0.002; (herniated nucleus pulposus) treatment expectations p = 0.001	"Our data demonstrate that selective nerve-root injections of corticosteroids are significantly more effective than those of bupivacaine alone in obviating the need for a decompression for up to thirteen to twenty-eight months following the injections in operative candidates. This finding suggests that patients who have lumbar radicular pain at one or two levels should be considered for treatment with selective nerve-root injections of corticosteroids prior to being considered for operative intervention."	Multiple injections allowed. Baseline Data not provided. Data suggest corticosteroid of additive benefit to avoid surgery (28.6% vs. 66.7%p<0.004).
Jiraratta naphochai 2007 (score= 8.5)	Epidural Steroid Injection	RCT	Supported by research grant from Khon Kaen University, and Institutional funds were received in support of the work in this article, but no	N = 103 with degenerative spinal disease, and scheduled to undergo elective posterior lumbar discectom	Mean age: 52.0 years; 48 males, 55 females	Methylprednisolone-Bupivacaine group received 2mL of methylprednisolone sodium succinate locally to affected nerve roots and 30mL of 0.375% bupivacaine infiltrated into paravertebral muscle and subcutaneous tissue on top, bottom, middle of wound (n = 51) vs Placebo group treated with 2mL saline	1, 2, 3, 6, 12, 24, and 48 hours after surgery, and 1, 3 months	Difference between groups on overall morphine use during 48 hours: -8.24 (95% CI= -18.47 to -1.30; p = 0.01). ODI scores lower in study group than placebo: -0.52 (95% CI = -3.91 to 2.87; (p= 0.763)). SF-36 in vitality/mental health higher in study group and higher than in	"This study indicates that the combination of peridural methyl-prednisolone and wound infiltration with bupivacaine in patients undergoing posterior lumbar spine surgery for discectomy, decompressive laminectomy, and/or spinal fusion results in a reduction of morphine	Data suggest some efficacy.

			benefits in any form was received from a commercial party related directly or indirectly to the subject of the article.	y, decompressive laminectomy with or without instrumented spinal fusion.		injected to affected nerve roots and 30mL saline into paravertebral muscle and subcutaneous tissue on each side at top, middle, and bottom of wound (n =52).		placebo group: -3.53 (95% CI = 1.23 to 5.83) and 3.78 (95% CI = 1.28 to 6.26; p = 0.003).	consumption and decreased in postoperative pain without complications. It can be benefit in postoperative lumbar spine surgery."	
Hurlbert 1999 (score= 7.5)	Analgesic Paste	RCT	Partial funding from Davol Pharmaceuticals. No mention of COI.	N = 60 undergoing routine elective lumbar surgery for discectomy or spinal stenosis	Mean age: 51.5 years; 30 males, 30 females	Paste consisting of microfibrillar collagen, methylprednisolone, morphine, and aminocaproic acid (active, n =30) vs. paste consisting of microfibrillar collagen, normal saline, and aminocaproic acid (placebo, N =30). Paste applied to exposure dura prior to wound closure. Follow-up at 1 day postop, 1 week, 3 weeks, 6 weeks, 3 months and 1 year post-op.	3, 6, 9, 12 weeks	McGill Pain Questionnaire (MPQ): lower for active paste vs. placebo paste for duration of postop period. Pain rating index (PRI(R)) and number of words chosen (NWC) at 6 weeks: significant between groups, p=0.022 and p=0.035 respectively. Present pain intensity (PPI): lower for active paste vs. placebo at weeks 1 and 3, p=0.005.	"[A]pplication of an analgesic paste to the exposed dura after lumbar decompressive surgery not only reduces the need for in- and outpatient analgesic administration (by a factor of 2-3 times) but also provides significantly better pain control compared with the current standard of medical practice."	No statistical significant differences at 12 weeks for primary outcome.
Chadduck 1999 (score= 7.0)	Epidural Steroid Injections	RCT	No mention of industry sponsorship or COI.	N = 50 age 18 and older undergoing surgery for lumbar spine	Mean age: 46.6 years; 29 males, 21 females	40ml 0.9% saline (placebo, n = 24) vs. 40ml 0.25% (bupivacaine, n = 26) bupivacaine post-op during wound closure into paravertebral muscles and subcutaneous tissues. Follow-up 3, 12, 24 hours post-op.	3, 12, 24 hours	No significant differences between groups.	"We have been unable to demonstrate any benefit of paravertebral wound infiltration with bupivacaine in the present study."	Short FU (24 hours). No change between groups.
Ersayli 2006 (score= 5.5)	Epidural Steroid Injections	RCT	No industry sponsorship and no COI.	N = 75 undergoing surgery for unilateral lumbar disc herniation; first	Mean age: 47.8 years; 43 males, 32 females	Musculus multifidi near operation site infiltrated with 30ml 0.25% bupivacaine and 40mg methylprednisolone just before wound closure (Group I, n = 15) vs. musculus multifidi near operation site infiltrated	1, 4, 8, and 16, 24 hours post-surgery	Mean±SD for first analgesic requirement (min): Group I (48.3±22.4) vs. Group II (44.6±21.2) vs. Group III (68.3±22.5) vs. Group IV (57.3±13.7) vs. Group C (32.3±16.7), p<0.05	"Preemptive administration of bupivacaine or bupivacaine-methylprednisolone to the paravertebral muscles in patients undergoing lumbar discectomy provides	Short follow-up (12 hours).

				lumbar disc surgery; age 17-70; failed conservative treatment for 4 weeks		with 30ml 0.25% bupivacaine alone just before closure (Group II, n = 15) vs. musculus multifidi near operation site infiltrated with 30ml 0.25% bupivacaine and 40mg methylprednisolone just before incision (Group III, n = 15) vs. musculus multifidi near operation site infiltrated with 30ml 0.25% bupivacaine alone just before incision (Group IV, n = 15) vs. musculus multifidi near operation site infiltrated with 30 ml of 0.9% NaCl just before wound closure (controls, Group C, n = 15). Follow-up 1, 4, 8, 16, 20, 24 hours after surgery.		Group I, II and IV vs. Group C; p <0.01 Group III vs. Groups I and II. Mean±SD for VAS during movement: 1 hour – Group I (3.4±1.9) vs. Group II (3.6±2.2) vs. Group III (2.7± 2.3) vs. Group IV (2.4±2.3) vs. Group C (4.6±2.8), p <0.05 Group III and IV vs. Groups I, II, and C; 4 hours – Group I (2.8±2.1) vs. Group II (2.6± 1.9) vs. Group III (0.8±1.3) vs. Group IV (1.4±1.8) vs. Group C (2.6±2.8), p <0.05 Groups III and IV vs. Groups I, II, and C; 8 hours – Group I (2.4±1.7) vs. Group II (1.8±1.7) vs. Group III (0.2±0.7) vs. Group IV (0.5±0.9) vs. Group C (1.3±1.2), p <0.05; Groups III and IV vs. Groups I, II, and C; 16 hours – Group I (0.9±1.7) vs. Group II (0.9±1.2) vs. Group III (0) vs. Group IV (0) vs. Group C (0.6±0.9), p <0.05; Groups III and IV vs. Groups I, II and C. Mean±SD VAS at rest – 1 hour Group I (2.2±0.5) vs. Group II (1.3± 1.3) vs. Group III (0.4±1.0) vs. Group IV (0.8±1.7) vs. Group C (2.6±2.1), p <0.01 Group III vs. Groups I, II and C; 4 hours – Group I (0.6±0.9) vs. Group II (0.8±1.3) vs. Group III (0) vs. Group	effective analgesia, starting immediately after the operation."	

								IV (0.2±1.1) vs. Group C (0.8±1.5), p <0.01 Group III vs. Groups I, II, C.		
Fredman 1999 (score= 5.0)	Epidural Nerve Block	RCT		N=50; 46 completed the study	Mean age: 53.5 years; 26 males, 24 females	Group Bupivacaine (B): n=23 (14 males); mean age=54.3 years Group Saline (S): n=23 (12 males);	5 days, 1 week, 1 month, 3 months	-VAS was marginally lower in group B (not statistically significant) -SLR in both groups significantly (p=0.008) improved with time, but no difference between groups -In both groups, 1 week, 1 month, and 3 months after discharge, the SLR was comparable to prestudy recordings -In group B, at 1 week, 1 month, and 3 months after discharge, patient-generated VAS were significantly (p=0.002) higher when compared to pain scores at the time of patient discharge	"We conclude that repeated low-dose epidural bupivacaine administration does not effectively decrease immediate and long-term back pain in 'failed back surgery syndrome.'"	Mechanism of blinding unclear
Gurbet 2008 (score= 4.5)	Epidural Steroid injection	RCT	No mention of industry sponsorship or COI.	N = 100 undergoing unilateral lumbar disc herniation; first lumbar disc surgery; age 18-60; no benefit from conservative treatment for 4 weeks	Mean age: 44.8 years; 56 males, 39 females	Musculus multifidi near operation site infiltrated with 30ml 0.25% levobupivacaine and 40mg methylprednisolone just before wound closure (Group I, n = 20) vs. musculus multifidi near operation site infiltrated 30ml 0.25% levobupivacaine alone before closure (Group II, n = 20) vs. musculus multifidi near operation site infiltrated with 30ml 0.25% levobupivacaine and 40mg methylprednisolone before incision made (Group III, n = 20) vs. musculus multifidi near operation site	1, 4, 8, 16, 20, 24 hours	First analgesic requirement (min) (mean±SD): Group I (38.6±19.5) vs. Group II (42.2±18.9) vs. Group III (62.7±21.3) vs. Group IV (60.6±21) vs. Group C (27.3±18.3), p <0.05 all treatment groups vs. Group C; p <0.001 Group III and Group IV vs. Group C; p <0.01 Group III and Group IV vs. Group I and Group II. Patient-controlled analgesia (PCA) demands (n) (mean±SD): Group I (16.3±7.8) vs. Group II (15.8±7.2) vs. Group III	"Preemptive administration of levobupivacaine or levobupivacaine-methylprednisolone to the paravertebral muscles in patients who undergo lumbar discectomy provides effective analgesia, if started immediately after the operation."	Short follow-up.

						infiltrated with 30ml of 0.25% levobupivacaine alone before incision (Group IV, n = 20) vs. musculus multifidi near operation site infiltrated with 30ml 0.9% NaCl before closure (controls, Group C, n = 20). Follow-up 1, 4, 8, 16, 20, 24 hours after surgery.		(12.3±7.4) vs. Group IV (13.2 ±6.9) vs. Group C (37.3±11.6), p <0.001 all treatment groups vs. Group C.		
Kim 2011 (score= 4.5)	Epidural Steroid Injection	RCT	Authors report no conflict of interest. There was no mention of study sponsorship.	N = 60 (50 female, 10 male) lumbar radicular symptoms below knee correspond to lumbar magnetic resonance imaging pathology, pain at least 6 months, failed medication and PT, no litigation, history psychopathology, Beck Depression Inventory <15, no history substance abuse, no contra-indication	Mean age: 64.8 years; 10 males, 50 females	Epidural Methylprednisolone Acetate (MPA, n = 30) vs. Epidural Dexamethasone Phosphate (DP, n = 30) at 80mg and 15mg mixed with saline and 2mL of 0.25% marcaine to total volume of 10mL. Patients scheduled for 2nd epidural 1-2 months later. At 2nd epidural, VAS scores obtained.	1, 3 months	At baseline, no significant differences between groups. At 2nd epidural, no differences between groups in mean decrease in VAS, mean increase in VAS, and postprocedure VAS.	"Lumbar translaminar epidural injection using DP does appear effective in the short-term in the treatment of chronic lumbar radiculopathy without significant side effects."	Patient blinding unclear. Many details sparse. Timing of possible second injection and routine follow ups variable. Dropout rate unclear. Data suggest no differences, thus steroid did not matter. No placebo.

				to intra-axial procedures.						
Lundin 2003 (score= 4.0)	Epidural Steroid Injection	RCT	Supported by the Orebro County Council, but there was no mention of conflict of interest (COI).	N = 80 with lumbar disc herniation, and <1 year duration of sciatica	Mean age: 41.2 years; 44 males, 36 females	Treatment group 160mg intramuscular methylprednisolone acetate, 250mg intravenous methylprednisolone sodium succinate, fat graft soaked on 80mg methylprednisolone acetate placed over affected nerve root (n =3 8) vs. Control same treatment, but methylprednisolone substituted for saline solution. (n = 42).	2, 6, 12, 26, 52 and 104 weeks postoperatively	Mean post-op stay for treatment group vs. control group: 1.7 days vs. 2.3 days (p = 0.01). For VAS, treatment group had lower scores than control group for week prior to follow-up visit (p = 0.02). Disability Rating Index (DRI) lower on treatment group than in control group thoughout study (p = 0.08).	"We concluded that systematic perioperative treatment with corticosteroids at lumbar discectomy reduces pain, and shortens length of hospital stay and the time taken to return to work."	The result part was not very detailed regarding to the difference of scores. Heterogenous study population.
Kang 2013 (score= 10.5)	Epidural Steroid Injection	RCT	Authors state no COI and no study sponsorship	N = 60 with planned 1-level posterior lumbar interbody arthrodesis with decompression for stenosis and/or spondylolisthesis.	No mention of age or sex.	Ropivacaine 0.1%, 10ml 20 minutes before skin incision (injection group, n = 30) vs. normal saline 0.9% epidural injection 10ml 20 minutes before skin incision (control group, n = 30). Assessments at 2, 4, 8, 12, 24, and 48 hours after surgery and at time of discharge.	2, 4, 8, 12, 24, 48 hours	Pain scores higher in control vs. injection group 2-12 hours, p <0.05. Total frequency of pushed buttons (mean number of pushes): control 34.50 vs. injection 17.00, p <0.001. Fentanyl (mean±SD, μg): total dose – control 777.62±169.02 vs. injection 601.63±144.19, p <0.001; patient-controlled analgesia dose – control 712.92±164.96 vs. injection 570.38±139.14, p <0.001; rescue dose – control 50.00 vs. injection 0.00, p = 0.020. Rescue dose needed (number of patients): yes – control 22 vs. injection 12; no – control 12 vs. injection 20, p = 0.027. Post-op	"The results of our study provide evidence that a single epidural injection of 0.1% ropivacaine (10 ml) before one-level posterior lumbar interbody arthrodesis is effective and suitable for reducing early postoperative pain and opioid use without procedure-related complications."	Short follow up time (48hours). Replaced excluded patients with randomization (n = 6, 10%).

								C-reactive protein higher in control group vs. injection group on day 3 post-op, p = 0.016.		
Friedly 2014 (score= 9.0)	Epidural Steroid Injections	RCT	Supported by grant from Agency for Healthcare Research and Quality. COI: One or more of the authors have received or will receive benefits for personal or professional use.	N = 400 with evidence of central lumbar spinal stenosis on MRI or computed tomography. Mean age Lidocaine group 68.1. Mean age 68.0 glucocorticoid-lidocaine group	Mean age: 68.1 years; 179 males, 221 females	Glucocorticoids+lidocaine Group: received 1 to 3 ml of 0.25% to 1% lidocaine followed by 1 to 3 ml of triamcinolone (60 to 120 mg), betamethasone (6 to 12 mg), dexamethasone (8 to 10 mg), or methylprednisolone (60 to 120 mg) (n = 200) vs Lidocaine only Group: received identical to that for the glucocorticoid–lidocaine injection except that the injectable solution was an equivalent volume of 0.25% to 1% lidocaine alone (n = 200)	3, 6 weeks	At 3 week follow-up, glucocorticoid group showed significant improvement (-4.4 mean change from baseline) compared to lidocaine group (-2.6 mean change) for RMDQ score. (p <0.001). However, difference not significant at 6 weeks (p = 0.07). At 6 weeks, both groups showed significant difference compared to baseline. Glucocorticoid also showed significant improvement for leg pain score at 3 weeks (-2.9 mean difference from baseline) compared to lidocaine only (-2.2 mean difference) (p = 0.02). This difference no longer significant at 6 weeks. (p = 0.48).	"In conclusion, in the treatment of symptoms of lumbar spinal stenosis, epidural injections of glucocorticoids plus lidocaine offered minimal or no benefit over epidural injections of lidocaine alone at 6 weeks."	Co-interventions not controlled. Baseline pain differed (40(20.1%) vs. 24 (12.0%) and 42(21.1%) vs. 67 (33.5%). ESIs without superiority to lidocaine injection and 58 vs 34 adverse effects in steroid group.
Brown 2012 (score= 7.5)	Epidural Steroid Injection	RCT	Study funded by Vertos Medical. Data entered and maintained by PharmaPros Corporation. Dr. Brown is a paid consultant to Vertos	N = 38 with lumbar spinal stenosis (LSS) painful lower limb neurogenic claudication and hypertrop	Mean age: 76.2±9.3 years; 21 males, 17 females	Mild® lumbar decompression device (n = 21) vs. Epidural steroid treatment 80mg triamcinolone acetate (n = 17).	6, 12 weeks	Mild group average baseline VAS pain score 6.3 (95% CI +/- 0.7) improved to mean of 3.8 (95% CI+/-1.3) at 6 weeks. ESI group mean VAS baseline scores 6.4 (95% CI+/- 1.0) and at 6-weeks 6.3 (95% CI+/-1.4). Mild group significant improvement in mobility with decrease in mean ODI scores:	"While ESIs may provide pain relief for patients experiencing inflammation because of radiculopathy, the results of this randomized study indicate that LSS patients with symptomatic neurogenic claudication do not demonstrate a sustained decrease in pain or improved function. Conversely, treatment	Data suggest no significant difference in comparisons between groups at 6 weeks in primary outcome measure of VAS, ODI.

			Medical and member of company's Scientific Advisory Board.	hic ligamentum flavum; mean age 76.2+/-9.3 years				38.8 (95% CI+/-4.2) baseline to 6-weeks 27.4 (95% CI+/-7.0; p <0.05). ESI group did not have significant change from baseline to 6-weeks (p >0.05).	with mild statistically significantly improved mobility and reduced pain associated with symptomatic LSS."	
Yousef 2010 (score= 6.0)	Epidural Steroid Injection	RCT	No mention of industry sponsorship or COI.	N = 38 with failed back surgery syndrome (FBSS); at least 18 years old, ASA physical status I, II, and II; had undergone previous spine surgery with history of chronic LBP and/or lower extremity for at least 6 months with minimum VAS pain score of 6/10	Mean age: 48.9 years; 26 males, 12 females	Fluoroscopically guided caudal injections of 10ml 0.25% bupivacaine solution containing 80mg methylprednisolone and 30mg of 3% hypertonic saline (Group 1, n = 20) vs fluoroscopically guided caudal injections of 10ml 0.25% bupivacaine solution containing 80mg methylprednisolone followed by 1500 IU hyaluronidase and 30ml of 3% hypertonic saline (Group 2, n = 18). Assessments before treatment and at 6 weeks, 3 months, 6 months, and 1 year after treatment.	6 weeks, 3 months, 6 months, and 1 year	Pain intensity: 6 months – moderate Group 1, 12 vs. Group 2, 3, p <0.05; 1 year – moderate Group 1, 14 vs. Group 2, 3, p <0.05; 1 year – mild Group 1, 1 vs. Group 2, 6, p <0.05; 1 year – no pain Group 1, 0 vs. Group 9, p <0.05. ROM, flexion: 6 months – Group 1 (24.8±10) vs. Group 2 (33.8±11.7), p <0.05; 1 year – Group 1 (24.8±10.7) vs. Group 2 (37.3±13.5), p <0.05. ROM, extension: 3 months – Group 1 (13.6±6) vs. Group 2 (15.6±5.7), p <0.05; 6 months – Group 1 (10.8±5.8) vs. Group 2 (15.4±5), p <0.05; 1 year – Group 1 (9.7±1.6) vs. Group 2 (15.8±5.7), p <0.05. ROM, lateral flexion: 6 months – Group 1 (7.3±2.9) vs. Group 2 (13.6±5.8), p <0.05; 1 year – Group 1 (7.5±3.2) vs. Group 2 (14.2±5.4), p <0.05. Opioid intake: none – 6 months, Group 1 (3) vs. Group 2 (11), p <0.05; 1 year – Group 1 (3) vs. Group 2 (10), p <0.05.	"The addition of hyaluronidase to fluoroscopically guided caudal epidural steroid and hypertonic saline combination improved long-term pain relief in patients with FBSS."	Study suggests meaningful difference between treatment groups with treatment favoring hyaluronidase combination

Fukusaki 1998 (score= 5.0)	Epidural Steroid Injection	RCT	No mention of industry sponsorship or COI.	N = 53 with severe pseudoclaudication <20m walk distance, degenerative spondylolisthesis, lateral recess stenosis or central-mixed stenosis with overall anterior post. narrowing and lateral recess stenosis	Mean age: 70.4 years; 38 males, 15 females	Group 1 ESI with NS 8mL (n = 16) vs. Group 2 epidural block mepivacaine 1% 8mL (n = 18) vs Group 3 epidural block with methylprednisolone 40mg plus mepivacaine 1% 8mL (n = 19). All translaminar. Follow-up at 1 week, 1, 3, and 12 months.	1 week, 1 month, 3 months	Walking distances: 1 week (Group 1, 23±19m vs. Group 2, 92±66 vs. Group 3, 87±58); 1 month (18±13 vs. 28±24 vs. 26±23); and at 3 months (11±8 vs. 13±7 vs. 10±8). Numbers with excellent or good result favored Groups 2 and 3 and significant after 1 week. No significant differences between Groups 2 and 3.	"[ESI] has no beneficial effect on the pseudoclaudication associated with spinal canal stenosis as compared with epidural block with a local anesthetic alone."	Small numbers in each group. Data suggest short-term benefits.
Revel 1996 (score= 4.0)	Epidural Steroid Injection	RCT	No mention of industry sponsorship or COI.	N = 60 adults with persistent or recurrent lumbosciatic pain after surgery with epidural fibrosis	Mean age: 42 years; 35 males, 25 females	Forceful epidural injections of prednisolone acetate 125mg and saline 40ml (treatment group, n = 29) vs. prednisolone acetate 125mg alone (control group, n = 31), 2 injections every 48 hours on inpatient basis, then 1 injection each month for 4 months on day-care basis, total 6 months.	6, 18 months	Self-evaluation after 6 months (mean±SD): LBP control 0±1 vs. treatment 1±1, p = 0.002; nerve root pain control 0±1 vs. treatment 1±1, p = 0.025. Schöber's index (cm) 6 months: control 0±2 vs. treatment 1±2, p = 0.04. Change at 18 months vs. baseline: VAS lumbar control 0±1 vs. treatment 1±1, p = 0.007.	"[F]orceful epidural steroid injections via the sacral hiatus should be added to the list of available treatments for low back pain and sciatica ascribed to postoperative arachnoepiduritis."	Details sparse.
Ohtori 2012 (score= 4.0)	Epidural Steroid Injections	RCT	No mention on industry sponsorship. Authors state no COI.	N = 60 with low back and leg pain at least 1 month; diagnosed	Mean age: 67.5 years; 34 males, 26	Single spinal nerve block 2ml lidocaine and 80mg tocilizumab (tocilizumab group, n = 30) vs. Singles spinal nerve block 2ml lidocaine and 3.3mg dexamethasone	30 min, 3 days, 1 week, 2 weeks, 4 weeks	Pain score 4 weeks after infiltration (mean±SD). Leg pain VAS: tocilizumab 2.5±0.6 vs. dexamethasone 4.0±0.9, p = 0.02. LBP VAS: tocilizumab 2.3±0.4 vs.	"[B]ased on VAS scale and ODI scores, direct application of the anti-IL-6 receptor monoclonal antibody, onto spinal nerves, reduced low back pain,	Injection associated with pain reduction. Follow-up of 4 weeks. Modest

				with lumbar spinal stenosis or spondylosis and spondylolisthesis.	females	(dexamethasone group, n = 30). Assessments: before treatment, 30 minutes after treatment, 3 days, 1, 2, and 4 weeks after infiltration.		dexamethasone 3.3±1.0, p <0.05. ODI: tocilizumab 20±6.0 vs. dexamethasone 32±7.0, p = 0.045. Leg pain VAS lower in tocilizumab vs. dexamethasone at 3 days (p <0.01), 1 week (p <0.01), 2 weeks (p < 0.01), 4 weeks (p <0.05). Leg numbness lower in tocilizumab group vs. dexamethasone at 3 days (p <0.01), 1 week (p< 0.01), 2 weeks (p <0.05). LBP VAS lower tocilizumab group vs. dexamethasone at 3 days (p <0.01), 1 week (p <0.01), 2 weeks (p <0.01), 4 weeks (p <0.05). Proportion who had surgery within 6 months of treatment higher dexamethasone group vs. tocilizumab group, p <0.05.	leg pain, and leg numbness caused by spinal stenosis."	differences between the 2 groups. No placebo.

INTRADISCAL STEROIDS

Injections of glucocorticoids into the intervertebral disc, often performed under fluoroscopy or other imaging modalities, are classified as "intradiscal steroids."(1659, 1685, 1686) The theory is that these injections help to reduce the degree to which the disc is both herniated and/or producing an inflammatory response. Proponents believe that these injections are better directed at the target tissue. The weakness in the theory is that the target tissue may be that which is impinged by the herniated nucleus pulposus material.

1. *Recommendation: Intradiscal Steroid Injections for Treatment of Acute Low Back Pain*
   Intradiscal steroid injections are not recommended for treatment of acute low back pain.
   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Intradiscal Steroid Injections for Treatment of Subacute or Chronic Low Back Pain*
   Intradiscal steroid injections are not recommended for treatment of subacute or chronic low back pain.
   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

Rationale for Recommendations

For radicular pain and herniated discs, one study is available but it did not include a placebo group, thus there is no evidence regarding efficacy for intradiscal injection.(1687) For chronic LBP, two moderate-quality trials suggest lack of efficacy(1688, 1689) and one suggests efficacy.(1690) Thus, the data somewhat conflict and there is also no pattern of consistent results in the highest quality trial. There is no clear evidence that these injections improve on the natural history of acute LBP. Compared to epidural injections or compared to no treatment, benefits have not been demonstrated. These injections are invasive, have adverse effects and are moderate to high cost.

Evidence for the Use of Intradiscal Steroids

There are 5 moderate-quality(1687-1691) RCTs incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: Intradiscal steroid injections, Epidural steroid injections, sub-acute, chronic, low, back and pain to find 2,675 articles. Of the articles, 2,675 we reviewed eight articles and included seven articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Disc Herniation						
Gallucci 2007 RCT No mention of industry support or COI.	6.5	N = 159 with lumbar disc herniation and radicular pain for at least 8 weeks	Group A: Intradiscal and intraforaminal injections of steroid and anesthetic triamcinolone acetonide (2mL of 40mg/ml) with 1ml injected into epidural spaced and 1ml injected inside disc, 2-4ml 2% ropivacaine, 2ml injected into epidural space and 1ml injected inside disc (n = 77) vs. Group B: Intradiscal and intraforaminal injections of steroid and anesthetic with addition of O2-O3 mixture with ozone concentration of 28µg, 5-7ml O_2-O_3 at intraforaminal level and 5-7ml O_2-O_3 inside disc (n = 82). Follow-up at 6 months	Oswestry Disability Index (ODI) used to measure successful treatment at a 2-week, 3-month, 6-month follow-up for both groups. Comparing groups showed data not significant after 2-weeks (p = 0.72), nor after 3-months (p = 0.136). However, after 6-months, difference between group A and B significant (p <0.001)	"[I]ntraforaminal and intradiscal injections of an O2-O3 mixture, a steroid, and an anesthetic with CT guidance lead to rapid pain relief, with good outcome in most patients. This treatment is easy to perform and is safe. Moreover, it is more effective than the injections of pure steroids and anesthetic in the same sites; therefore, O2-O3 seems to play a role in pain relief. In our opinion, O2-O3 chemodiscolysis should be regarded as a useful treatment for the management of lumbar disk herniation."	No placebo group re. steroid. Data suggest no short term differences in addition of O_2O_3, but difference in "success" at 6 months. Success measured by ODI ≤20%. However difference in ODI score not provided for actual comparison of effectiveness. Therefore, conclusion regarding addition of O_2O_3 to steroids are limited.
Candido 2008 RCT No mention of industry support or conflict of interest (COI)	4.0	N = 60 age 30-80 with LBP and unilateral radiculopathy from herniated or degenerated discs were randomly assigned into 2 groups. Those excluded had history of spinal surgery, allergy to drugs used, or concurrent steroid use, pregnancy, and opioid addiction.	2 groups separated with respect to similar demographics (gender, age weight height) TF Group 1 (n = 30 [28•]) 12F 16M, Age (yr)- 51.96 (95% CI, 47.05–56.88), Height (cm) 169.80 (95% CI, 165.52–174.09), Weight (kg) 85.21 (95% CI, 78.86–91.57)) received Epidural steroid injection (ESI) via midline interlaminar and transforaminal (TF) approach Parasagittal vs. parasagittal approach. PIF Group 2 (n = 30 [29•]) 18F 11M, Age (year) 52.31 (95% CI, 46.29–58.32), Height (cm))169.37 (95% CI, 165.56–173.19), Weight (kg) 81.63 (95% CI, 74.76–88.52))	Mean spread grade: PIL group – 1.93 (95% CI, 1.83-2.0), TF group: 1.46 (95% CI, 1.17–1.46) (p = 0.003). Mean fluoroscopy time 28.96 s (95% CI, 23.9 –34.1 s) in PIL group and 46.25 s (95% CI, 36.27–56.23 s) in TF group (P 0.003).VAS pain scores at 2 weeks TF-48.85 (95% CI, 37.08–60.61);PIL -40.55 (95% CI, 28.81–52.28)(p = 0.31). VAS pain scores at 1 month TF-52.77(95% CI, 40.72–64.83);PIL- 52.14 (95% CI, 39.47– 64.81)(p = 0.94). VAS pain scores at 3 months TF- 42.93(95% CI, 29.07–56.78);PIL- 46.60 (95% CI, 35.08 – 58.13)(P=0.68). VAS pain	"The PIL approach is superior to the TF approach for placing contrast into the anterior epidural space with reduction in fluoroscopy times and an improved spread grade. With increasing attention to neurological injury associated with TF, the PIL approach may be more suitable for routine use."	Data suggest parasagittal interlaminar approach superior for placing injection anteriorly but only non-significantly. B better results at 2 weeks and not later.

			received ESI via parasagittal interlaminar (PIL) approach.	scores at 6 months TF 47.07 (95% CI, 36.79 –57.36); PIL 41.22 (95% CI, 28.59 – 53.85) (p = 0.46).		
Chronic LBP						
Khot 2004 RCT No mention of industry support or conflict of interest (COI)	6.0	N = 120 with LBP without radicular leg pain and degenerative disc disease on MRI and failed >6 weeks conservative treatment	Intradiscal steroid 1mL containing 40mg of DepoMedrone (n = 60) vs. 1mL normal saline injections (n = 60). Study duration 1 year.	No difference in primary outcome between groups (p = 0.71). Those given steroid had mean change of 2.28 (SE 2.49) in percentage disability vs. NS with 3.42 (SE 1.79). No differences in pain scores (p = 0.72).	"Not only are steroids ineffective as a therapeutic effect in discogenic pain, but there are also increasing concerns in the literature that they may have a deleterious long-term effect."	Randomization not well described, but appears successful. Data suggest lack of efficacy.
Cao 2011 RCT Authors report no conflict of interest. No mention of industry sponsorship.	6.0	N = 120, age 20-60 with chronic LBP unresponsive to conventional treatment and unwilling to accept surgery, MRI showing L disk degeneration, with L3, L4, L5, S1 degeneration dominance, end plate Modic changes Types I and II or posterior annulus fibrosis, level of pain, and percentage disability	Group A (n = 60) with Type I Modic changes, Group B (N = 60) with Type II Modic changes. Groups further subdivided into 3 groups (n = 20) (Type I: A1, A2, A3 and Type II: B1, B2, B3). A1 and B1: 3mL NS INJ. A2 and B2: 3mL Diprospan. A3 and B3: 1mL Diprospan, 2 mL songmeile. NS Control. Pain assessed via VAS and ODI (%) at baseline, 3 month, 6 months.	NS Control Group A1 (Modic Type I) VAS & ODI scores at baseline, 3, 6 months: 7.1±1.61, 7.0±1.33, 7.5±1.08 and 37.9±14.65, 42.0±13.92, 44.4±13.98. NS Control Group B1 (Modic Type II) VAS and ODI scores at baseline, 3, 6 months: 6.5±1.20, 6.8±1.03, 6.4±1.07 and 32.4±9.65, 33.3±10.63, 33.8±11.95. Diprospan Group A2: 6.5±1.18 1.8±1.03, 2.3±0.95 and 35.7±11.1,13.1±2.22, 14.7±3.18. Diprospan Group B2: 6.8±1.30 1.6±0.84, 2.1±0.99 and 31.5±5.9, 12.7±2.12, 13.8±2.32. Diprospan+songmeile Group A3: 6.6±1.40 2.0±0.82, 2.2±1.03 and 36.6±12.7, 13.6±3.05, 16.9±4.46. Diprospan+songmeile Group B3: 7.1±1.18 1.6±0.84, 1.8±0.92 and 34.2±7.8, 13.1±3.22, 15.5±4.69.	"Intradiscal injection of corticosteroids could be a short-term efficient alternative for discogenic low back pain patients with end plate Modic changes on Modic changes on MRI who were still unwilling to accept surgical operation when conservative treatment failed."	Data suggest steroid injections superior to saline.
Simmons 1992 RCT	4.0	N = 25 who failed at least 6 weeks treatment for LBP	Intradiscal steroid injection (methylprednisolone, Depo-Medrol 80mg/ml, dosage not specified, n = 14) vs.	No significant differences found between groups.	"When considering both subjective response and objective measurement… there was no apparent benefit	Small groups. Randomization not described. No data to compare success of randomization. Blinding not

No mention of industry sponsorship or COI.			bupivacaine (0.5%, 1.5ml, n = 11). Follow-up at 10-14 days.		from intradiscal administration of steroids."	described. Data suggest lack of efficacy.

CLONIDINE

Clonidine is an α-agonist most typically used as an anti-hypertensive. As α_2 adrenoceptor agonists may affect nociceptive processing,(1692) clonidine has been used to treat CRPS (see Chronic Pain Guideline). Adverse effects include hypotension, dry mouth, drowsiness, and dizziness. Clonidine in combination with monoamine oxidase inhibitors or beta blockers has a complex effect on neuronal catecholamines and may precipitate a hypertensive crisis on discontinuance.

1. *Recommendation: Epidural Clonidine for Treatment of Radicular Pain*
   Epidural clonidine is not recommended for treatment of radicular pain.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Moderate

2. *Recommendation: Epidural Clonidine for Treatment of Chronic Low Back Pain*
   There is no recommendation for or against the use of epidural clonidine for treatment of chronic low back pain.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Moderate

3. *Recommendation: Intramuscular Clonidine for Treatment of Pyriformis Syndrome*
   There is no recommendation for or against the use of intramuscular clonidine for treatment of pyriformis syndrome.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

4. *Recommendation: Intramuscular Clonidine for Treatment of Other Low Back Conditions*
   There is no recommendation for or against the use of intramuscular clonidine for treatment of other low back conditions.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

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Rationale for Recommendations

There is evidence epidural clonidine is inferior to epidural steroid injection for radicular pain.(1693) It is also invasive, has adverse effects and thus, epidural clonidine is not recommended for treatment of radicular pain. A trial of intramuscular clonidine plus bupivacaine superior to bupivacaine plus saline for pyriformis syndrome.(1694) However, prior to recommendation intramuscular injections for pyriformis syndrome need to be independently replicated.(1694)

Evidence for the Use of Clonidine

There are 1 high-(1694) and 1 moderate-quality(1693) RCTs evaluating the use of clonidine for chronic low back pain. There is 1 other study in Appendix 1.(1695)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: clonidine, acute low back pain, subacute low back pain, radicular pain syndrome, sciatica, spinal stenosis, and sacroiliitis to find 1,493 articles. Of the 1,493 articles, we reviewed 4 articles and included four articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Triamcinolone vs. Transforaminal Epidural (TFE) Clonidine						
Burgher 2011 RCT No industry sponsorship or COI.	6.5	N = 26 (19 males, 7 females) with ≥3 months of LBP and leg pain due to intervertebral disc herniation.	Both with lidocaine 2% 1mL then either Corticosteroid Group, n = 15; triamcinolone 40-80mg diluted to 2mL with NS vs. Clonidine Group, n = 11, transforaminal epidural (TFE) clonidine (200 or 400 µg clonidine diluted to 2mL with NS). Follow-up at baseline, 2 weeks, 1 month, and 6 months.	No differences at 2 weeks. At 1month, no difference in pain scale, but Roland-Morris Disability Questionnaire differed (Estimate: 5.67, Standard Error: 2.27, 95% CI: [1.22,10.12]) and ODI (Estimate: 7.04, Standard Error: 3.17, 95% CI: [0.83, 13.25]). No differences at 6 months.	"Patients with acute radicular pain due to IDH demonstrated short-term improvement using a treatment approach, which included either TFE corticosteroid or clonidine. There was no difference in pain score between the two study groups, a finding that could be at least partly due to the small number of patients enrolled."	Allowed up to 3 injections and doses not standardized, thus variable intervention(s). Data suggest clonidine inferior to corticosteroid.
Epidural Clonidine - Acute Low Back Pain						
Naja 2009 RCT No mention of industry sponsorship or conflict of interest (COI).	8.0	N = 80 adults diagnosed with Piriformis syndrome (PS).	Group A (n = 40) received 9mL bupivacaine 0.5% and 1mL clonidine 150mcg/mL vs. Group B (n = 40) received 9mL bupivacaine 0.5% and 1mL saline.	Group A showed lower pain scores than Group B ($p < 0.0001$) and at 6 months Group B (78%) had greater pain scores than Group A (8%) ($p < 0.01$).	"Repeated clonidine-guided piriformis injection relieved PS symptoms and reduce analgesic consumption for a 6-month period."	Data suggest efficacy for this narrow indication.

CHEMONUCLEOLYSIS (CHYMOPAPAIN AND COLLAGENASE)

Chymopapain is an enzyme that has long been used to treat herniated discs.(1696-1698) While collagenase has been utilized more recently,(1699) both enzymes are injected into the disc. **Chymopapain is no longer available in the U.S. due to reimbursement problems and allergic reactions.**(1700) Caution is warranted in those increasingly limited numbers of countries that allow this procedure.(1701)

TENDER AND TRIGGER POINT INJECTIONS

Trigger points are a physical examination finding that is interpreted as abnormal. This finding involves an examiner's opinion that the degree of tenderness particularly on palpating a muscle is abnormally great.(1702) Although controversial, perhaps the most widely accepted criteria for tenderness are the American College of Rheumatology's former criteria for fibromyalgia, and involve an acknowledgement that there is "pain" on 4kg of palpation pressure at a given tender point to diagnose that condition,(1703) but for purposes of tender or trigger points those locations are not necessary. Ideally, examiners seek a palpable "knot" or nodule of muscle tissue and palpating this nodule both reproduces the patient's symptoms and produces a distal radiation of symptoms, such as tingling in the upper extremity denoting a trigger point. However, most patients merely have tender points without radiation of symptoms. In common usage, the terms "trigger" and "tender" are used interchangeably. Studies have attempted to address both findings, although research studies' descriptions of methods have not been particularly clear on distinguishing one condition from another.

Tender and trigger points are primarily diagnosed in the periscapular area, although some are found in the lumbosacral area. These points are integrally involved in "myofascial pain syndrome" and "fibromyalgia." Most practitioners believe these are two distinct entities, while others believe that these are related conditions on a continuum of the same basic disorder.(1702) Robust basic epidemiological studies are lacking. It appears that many people are tender to palpation thus what differentiates normal from abnormal individuals is unclear. There are multiple weaknesses in these theories, including a lack of identification of how common these findings are in normal people, the lack of purely objective findings, subjectivity involved on the part of the examiner, and weaknesses in the pathophysiological theories.

These injections into muscle "knots" typically consist of an anesthetic with or without glucocorticoid.(1702, 1704) The goals of injection are generally thought to involve anesthesia, anti-inflammatory medication, and allowing deep-tissue massage of the area to work out the muscle knot.

1. *Recommendation: Trigger and/or Tender Point Injections for Treatment of Acute Low Back Pain*
   Trigger and/or tender point injections are not recommended for treatment of acute low back pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

2. *Recommendation: Trigger and/or Tender Point Injections for Treatment of Subacute or Chronic Low Back Pain*
   Trigger and/or tender point injections may be recommended as a reasonable second or tertiary option for treatment of subacute or chronic low back pain that is not resolving. These injections are recommended to consist either solely of a topical anesthetic (e.g., bupivacaine) or dry needling without an injection. Repeated injections should be linked to subjective *and* objective improvements. The use of therapeutic injections without participation in an active therapy program or in the context of maintaining employment is not recommended. An alternative option to these injections is acupuncture.

Indications – Subacute or chronic LBP that is not resolving with more conservative means (e.g., NSAID, progressive aerobic exercises, other exercises).

Frequency/Duration – Allow at least 3 to 4 weeks between injections. If results are not satisfactory after first set of injections, a second set is reasonable. If there are not subjective *and* objective improvements at that point, further injections are not recommended.

Indications for Discontinuation – Resolution, intolerance, or completing 2 sets of injections without materially affecting the condition.
Benefits – Modest reduction in pain and potential to speed resolution.
Harms – Hematoma, medicalization of otherwise benign conditions.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence –Low

3. *Recommendation: Trigger Point Injections Using Glucocorticosteroids*
Glucocorticosteroids are not recommended for use in trigger point injections.(1705)

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence –Moderate

Rationale for Recommendations
The literature on this subject is relatively heterogeneous. The main subject of these studies may be arbitrarily categorized into LBP,(1492) trigger points,(1706) or tender points.(1707, 1708) Nevertheless, there are quality studies for subacute and chronic LBP patients. There are no quality studies evaluating this treatment in acute LBP, and the one study that might have included acute LBP patients can be reasonably concluded to suggest that this treatment is not recommended in that population.(1707) These injections are invasive, have rare adverse effects,(1492) and are moderately costly depending on the number administered. There are no studies evaluating these injections on a longer term basis, though there are studies suggesting benefits lasting up to 14 days.(1492) There is no evidence that a steroid is required for efficacy of these injections, particularly those that are tender point injections (see also Shoulder Disorders guideline). As glucocorticosteroids also have adverse effects, their use in these injections is not recommended.

Evidence for the Use of Tender and Trigger Point Injections
There is 1 high-(1707) and 5(1492, 1706, 1708-1710) moderate-quality RCTs or crossover trials incorporated into this analysis.

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates. The following search terms used were "(Trigger OR tender point injections) AND (chronic low back pain)" to find 43,945 articles. Of those articles, we reviewed 8 articles, included 13 articles (6 RCTs and 7 reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Acute LBP						
Collée 1991 RCT No mention of industry sponsorship and COI.	8.5	N = 41 with iliac crest pain syndrome; 2 different populations, ambulatory mostly acute LBP and chronic LBP from rheumatology clinic	Single local injection lignocaine 0.5% 5mL (n = 21) vs. NS at most tender location over medial aspect of iliac crest (n = 20). Follow-up for 2 weeks.	Pain scores at Day 14 different in rheumatology clinic patient population (35.2 lignocaine vs.57.6 saline) than general practice population (24.3 lignocaine vs.23.0 saline). Pain score significantly lower in lignocaine group lasted from 14 days to 2 months in 80% of patients.	"Additional studies in patients with ICPS with a longer study period, larger sample size and more treatment modalities… are warranted to determine the efficacy of local injection therapy in this subgroup of LBP. Our results suggest that a single local injection with lignocaine may be effective in some patients with ICPS."	Study used 2 different populations. Data suggest lack of efficacy in acute LBP patients.
Ikegami 2010 RCT No mention of industry sponsorship and COI.	5.5	N = 36 females postmenopausal ≥50 years with acute LBP; 4 patients excluded before opening study key	Elcatonin group (n = 17) trigger point injection mixture 20 units elcatonin and 1% lidocaine HCl hydrochloride (8ml) vs. placebo group (n = 15) trigger point injection of placebo 1% lidocaine (1ml) 1% lidocaine (8ml) for 5 weeks.	No significant results between elcatonin and placebo groups (p = 0.24)	"Elcecatonin injection (20 units) significantly relieved motion pain in the lower back in postmenopausal women after three weeks of treatment. This analgesic effect continued for the subsequent 3 weeks."	Long-term study. Post-menopausal only. Small sample. Baseline trend in lower BMD in placebo group. Modest differences in one outcome.
Subacute						
Garvey 1989 RCT No mention of industry sponsorship and COI.	6.5	N = 63 with subacute low back "strain" at least 4 weeks duration	Injections lidocaine 1%, 1.5mL (n = 13) vs. Aristospan 15mg (20 mg/ml, 0.75mL) plus lidocaine 1% 0.75mL (n = 14) vs. a single dry needle (n = 20) vs. 10 second spray ethyl chloride 6 inches away and acupressure (20 seconds with plastic needle guard after isopropyl alcohol wipe) (n = 16). Follow-up 2-week intervals.	No significant differences found.	"[T]he critical factor in giving relief of pain is not the injected substance but, rather, some type of mechanical stimulus to the trigger point. We recommend the use of topical vapocoolant, followed by acupressure or acupuncture, since this modality resulted in the greatest pain relief of the four methods used and had no obvious side effects."	Data suggest steroid of no addictive benefit to anesthetics. Also suggests acupressure or dry needling may be at least as effective as injection.
Sonne 1985 RCT No mention of industry sponsorship and COI.	5.0	N = 29 with subacute and chronic LBP of at least 1 month duration	Methylprednisolone acetate and lignocaine (1mL steroid, no dose specified, apparently 4mL lignocaine 1%) (n = 14) vs. NS (n = 15) into iliolumbar ligament Injections repeated Q week up to 3 total.	Decreased pain in steroid group (p <0.01). Greater percentage reported improvement with steroid vs. placebo (p <0.05).	"[A] significantly better effect in the methylprednisolone treated group indicates that certain inflammatory changes in the lumbar ligaments could be the origin of pain in some patients with persistent low-back pain."	Small groups. Doses unclear. Data suggest anesthetic plus steroid superior to saline.
Vad 2002	4.0	N = 50 with back pain >6 weeks, and	Group 1 (n = 25) Technique fluoroscopic epidural steroid	Significant difference of p <0.05. In Group 1, 21 of 25	"Fluoroscopically guided transforaminal injections serve	Patients not well described. Many

RCT No mention of industry sponsorship. "Conflict of interest category: 12."		undergone lumbar spine MRI age >18, followed 12-21 months	injection (TFESIs); 1mL of contrast medium (iohexol) and 1.5mL of both betamethasone acetate (9mg) and 2% preservative-free Xylocaine vs. Group 2 (n = 23) saline trigger point injections (TPIs); 3mL noraml saline between 12 & 21 months.	showed improvement, and Group 2 showed 11 of 23. Group 1: (1) 8.8+-1.2 to 22.1+-1.6; (2) 8.8+-1.4 to 1.6+-.8; (3) 69.6+-2.7cm to 20.3+-1.8cm; (4) .8+-.6 to 2.9+-0.7. Group 2: (1) 9.6+-1.3 to 18.3+-2.1; (2) 9.4+-1.4 to 3.6+-1.1; 24.4+-1.6; (4) 0.8+-0.3 to 1.9+-0.7. *See comments for (#)*	as an important tool in the nonsurgical management of lumbosacral radiculopathy secondary to a herniated nucleus pulposus."	details sparse. Data favor ESI.
Myofascial Pain						
Hameroff 1981 RCT/Crossover Trial Project supported by Astra Pharmaceutical Products, Inc., Worcester, Massachusetts. No mention of COI.	4.0	N = 15 with myofascial pain including both lumbar and cervical trigger points	Bupivacaine 0.5% vs. Etidocaine 1%. Each treatment with 30-36ml injections into 10-18 trigger points and received same volume and number of injections during 3 study treatments. Follow-up at 1 and 7 years.	Bupivacaine and etidocaine superior to saline in average pain, percent time pain felt, and effect of pain on activity; 7 days after treatment, both bupivacaine and etidocaine showed significant improvement.	"[T]rigger point injections with 0.5% bupivacaine or 1% etidocaine provide effective relief of myofascial pain which outlasts the local anesthetics' duration of action."	Small numbers. Lack of details. Data suggest trigger point injections with bupivacaine resulted in less pain compared to saline up to 7 days after injection.

DIAGNOSTIC FACET JOINT INJECTIONS (INTRAARTICULAR AND NERVE BLOCKS)

Facet (zygapophysial) joints are prone to degenerative joint disease, particularly osteoarthrosis, and are thought to be pain-generating sources.(614, 627, 640, 708, 726, 1115, 1711-1719) Facet joint pain prevalence estimates vary from 5 to 90%.(627) Because of the overlapping innervation of the facet joints themselves (each is served by two medial branch nerves – a given medial branch nerve innervates the caudal portion of the facet joint at its level, and the rostral portion of the next lower facet joint) there has been considerable debate regarding whether these injections are truly diagnostic of underlying pathology. Moreover, careful skin mapping shows that the area of skin served by the cervical and lumbar medial branch nerves is more cephalad (in the neck) and more lateral and caudad (in the low back) than the location of the joint itself. Thus, it is often difficult to correlate degenerative joint disease changes seen on imaging studies with the actual nerve involved.

Two types of diagnostic facet injections are performed. The intra-articular injection is performed by injecting a local anesthetic under fluoroscopic or other imaging guidance directly into the facet joint. The second is a medial nerve branch block which is performed by injecting anesthetic along the nerves supplying the facet joints.(1720) (Datta 13) Either can be used to diagnose facet syndrome, but a medial branch block has been used when rhizotomy procedures have been considered.(1713, 1717, 1721) A positive block is considered to occur when there is complete, or nearly complete, relief of the pain the patient has been experiencing for the length of time expected for the anesthetic used.(338, 1722, 1723) The positions of the needle should be verified by fluoroscopy and documented with permanent images. The intra-articular blocks are sometimes combined with a glucocorticosteroid injection and thus, they are potentially a combined diagnostic and therapeutic intervention.(1724) Nerve root blocks are performed prior to attempts at radiofrequency lesioning.(1725)

Another indication for diagnostic intra-articular injections is lumbar segmental rigidity where the block can be both diagnostic and therapeutic.(61) In cases of chronic LBP, loss of mobility at one or more levels, particularly in the L3-S1 segments, is not uncommon. Injections for this indication may be combined with exercise to restore mobility and facilitate the rehabilitation process.

1. *Recommendation: Diagnostic Facet Joint Injection for Chronic Low Back Pain*
   Diagnostic facet joint injections are not recommended for evaluation of patients with chronic low back pain, including that which is significantly exacerbated by extension and rotation or associated with lumbar rigidity.
   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Diagnostic Facet Joint Injections for Acute or Subacute Low Back Pain or Radicular Pain Syndromes*
   Diagnostic facet joint injections are not recommended for acute or subacute low back pain or radicular pain syndromes.
   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

3. *Recommendation: Diagnostic Medial Branch Blocks for Acute or Subacute Low Back Pain or Radicular Pain Syndromes*
   Diagnostic medial branch blocks are not recommended for acute or subacute low back pain or radicular pain syndromes.(1726)
   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendations

Most studies now suggest a lack of utility of diagnostic facet joint injections.(1727-1729) Few studies suggest diagnostic utility of facet joint injections.(1730) Some have suggested a small minority of patients fulfill diagnostic criteria.(61)

One study of radicular pain patients found injection of an anesthetic was diagnostically non-specific.(1731) One study of medial branch blocks reported equal value of those blocks compared with peri-capsular blocks raising some question as to the efficacy vs. inefficacy of either.(1726)

The results of a trial comparing intra-articular injection vs. periarticular injection vs. saline injection also raises concerns about the validity of this construct,(1727) although the resulting improvements in all three groups could be argued to be worth the intervention in select significantly affected patients with chronic LBP thought to be facet mediated. Still, the results demonstrated that relief was not long lasting. Efficacy of facet joint injections is not well established in quality studies' original data. It has been reported that the peri-procedure administration of sedatives may confound the results of facet joint pain.(1732) This may contribute to suboptimal results for these injections. In patients with chronic LBP who have failed initial therapy, a negative diagnostic injection suggests that subsequent therapy directed at facet joint would not be useful. Improved, but still suboptimum range of motion (measured inclinometrically) may be an indication for therapeutic intra-articular injections in cases of lumbar segmental rigidity. Diagnostic medial branch blocks are primarily used to infer a need for rhizotomy.

Diagnostic facet injections are not recommended for acute or subacute LBP or radicular pain syndromes. These injections are invasive. Although they have relatively few adverse effects, the aggregate costs are high.

Evidence for the Use of Diagnostic Facet Joint Injections
We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates and then an updated search was conducted using PubMed for publications between 1/1/2013 and 11/15/2017. We used the following search terms: diagnostic facet joint injections, back, nerve blocks, intraarticular blocks, intraarticular injections, intra-articular injections, medial nerve branch block, subacute low back pain, radicular pain syndrome, sciatica, and random to find 3,098 articles. Of the 3,098 articles, we reviewed 20 articles and 10 articles were included (6 randomized controlled trials and 4 systematic reviews).*

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Facet Joint Injections vs. Methylprednisolone						
Schütz 2011 Prospective triple cross-over No industry sponsorship or COI.	7.0	N = 60 with chronic LBP without successful conservative treatment for at least 6 months, age 22-73 (excluded radicular pain associated with back pain)	Cross-over of three injections verum (V) (1.5ml 1% Mepivacaine), placebo (P), and sham (S) injection. SPV (n = 10) SVP (n= 10) PSV (n = 10) PVS (n = 10) VPS (n = 10) VSP (n = 10)	No carryover effect on injection sequence. Pain relief 6-8 hours after placebo injection vs sham (p = 0.05) and verum vs placebo vs sham (p = 0.05).33% non-responders and rate of positive tests (true verum responder) 16.5%.	"With regard to test validity criteria, a single intraarticular facet block with local anesthetics is not useful to prove a FJS and has to be abandoned from preoperative testing and indication finding."	Experimented 3 conditions in 6 parallel groups.
Marks 1992 RCT No mention of industry sponsorship or COI.	6.5	N = 86 with chronic LBP	Facet joint injections with methylprednisolone 20mg plus 1.5mL lignocaine 1% at LS level with each other level methylprednisolone 20mg and 1.0mL Lignocaine (n = 42) vs. facet nerve blocks same medications/doses as facet joint injections (n = 44). Follow-up 1 and 3 months.	At 1 month, joint injections slightly statistically significant (35.7% vs. 20.5% p <0.05).	"Facet joint injections and facet nerve blocks may be of equal value as diagnostic tests, but neither is a satisfactory treatment for chronic back pain."	Data suggest neither treatment option is beneficial for chronic LBP.
Revel 1998 RCT No mention of industry sponsorship or COI.	6.0	N = 80 with LBP over age 65	Injection of 1mL 2% lidocaine (n = 42) vs 1mL saline into lower facet joint (n = 38). Follow-up for 3 months.	Lidocaine provided greater lower-back pain relief than saline (p = 0.01) and provided greater pain relief in back pain group than non-pain group (p = 0.02).	"[T]the presence of five among seven variables (age greater than 65 years and pain that was not exacerbated by coughing, not worsened by hyperextension, not worsened by forward flexion, not worsened when rising from flexion, not worsened by extension-rotation, and well-relieved by recumbency), always including the last item, distinguished 92% of patients responding to lidocaine injection and 80% of those not responding in the lidocaine group."	Data suggest age not a significant differentiating factor between groups.
Mayer 2004	5.5	N = 70 with chronic LBP	Facet joint injection plus exercise; each joint injected with mixture of	Five of 29 patients (17.2%) met criteria for facet	"Lumbar SR may be found whether or not pain of facet	Some baseline differences. Few met criteria for facet

RCT No industry sponsorship or COI.		thought to have segmental rigidity	1ml 2% lidocaine, 1ml 0.5% bupivacaine, and 1ml of depot corticosteroid preparation; home stretching exercise program and at facility 4-6 hours 1-2x a week (Group A, n = 36) vs. exercise (Group B, n = 34). All levels injected bilaterally due to possibilities of missing affected joints/difficulties in determining which side was limited ROM and causing segmental rigidity.	syndrome involving an 80% reduction in pain 1 to 2 hours after injection.	joint origin is present… There is no evidence that facet injection increase the improvements in pain/disability report noted in both groups."	syndrome (17%). Data suggest minimal benefit of injection. No intermediate- or long-term follow-up.
Lilius 1989 RCT No industry sponsorship or COI.	5.0	N = 109 with unilateral LBP of 3 months duration	Methylprednisolone 80mg, 2mL plus bupivacaine hydrochloride 30mg, 6mL injected into 2 facet joints (n = 28) vs same mixture injected peri-capsularly around 2 facet joints (n = 39) vs. NS, 8mL, injection into 2 facet joints (n = 42). Follow-up at 1 hour, 2 and 6 weeks, 6 months.	Rotation of back to symptomatic side (p = 0.019) and extension (p = 0.046) significantly better with intra-articular over pericapsular, but no differences when comparing groups. All groups had improvement, but no differences between groups.	"Facet joint injection is a non-specific method of treatment and the good results depend on a tendency to spontaneous regression and to the psychosocial aspects of back pain."	Data suggest no significant efficacy.
Medial Branch Blocks						
Birkenmaier 2007 RCT No mention of industry sponsorship or COI.	5.0	N = 26 thought to have facet joint mediated chronic LBP	Medial branch blocks 1ml bupivacaine 0.5% (n = 13) vs. pericapsular blocks 2.0ml bupivacaine 0.5% (n = 13) with 6 month follow-up.	LBP in MBB groups decreased to VAS of 2.2 and 2.3, vs. periscapular block group averaged which averaged 4.2 at both 6 weeks and 3 months; these differences were the only significant differences. No significant differences seen at 6 month follow up.	"[U]ncontrolled medial branch blocks are superior to pericapsular blocks in selecting patients for facet joint cryodenervation, but both blocks work." They also noted that if serial controlled blocks cannot be used, "lumbar facet joint pain remains a diagnostic dilemma."	Small numbers. No placebo group. Data suggest MBB superior to pericapsular blocks to select for cryodenervation. Overall medial branch blocks and pericapsular blocks had similar results, suggesting equal efficacy or equally ineffective.

THERAPEUTIC FACET JOINT INJECTIONS

Therapeutic facet joint injections involve injections of a combination of a local anesthetic with glucocorticosteroids for purposes of relieving pain from the facet to facilitate an active therapy program or to maintain employment.(1711, 1715, 1729, 1733) These are usually performed as combined diagnostic and therapeutic injections, rather than first performing an anesthetic injection followed by a second injection that includes glucocorticosteroid.(1713, 1721, 1724, 1725, 1734) They also may be accomplished either as an intra-articular or as a pericapsular injection, using a number of techniques.(1726, 1727, 1735)

1. *Recommendation: Therapeutic Facet Joint Injections for Treatment of Chronic Low Back Pain*
   Therapeutic facet joint injections are recommended for select treatment of chronic low back pain. (56% panel agreement. 44% agreed with Not Recommended and without a limited recommendation.)

Indications:	Chronic LBP thought to be isolated to one or at most 2 facet joints. Generally with increased pain with extension and axial rotation. Failed to gain sufficient relief with non-invasive treatment options including at least NSAID, aerobic exercise, strengthening exercise.
Benefits:	Potential to improve pain and possibly function.
Harms:	Medicalization, higher opioids use, infection.
Frequency/Dose/Duration:	Usually combination of anesthetic and glucocorticosteroid. Steroids used in trials included: Methylprednisolone acetate 20mg (2411, 2412), 40mg (2413), 80mg (2414), betamethasone, triamcinolone hexacetonide 20mg (2408), dexamethasone sodium phosphate 3.3mg (2415). If there is 80% relief and objective improvement in function, yet symptoms recur, a second injection may be reasonable. Repeated and recurrent injections are not recommended.
Indications for Discontinuation:	Resolution of pain, complications necessitating discontinuation of therapy or device removal, or loss of therapeutic effect.

   Strength of Evidence – **Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

2. *Recommendation: Therapeutic Facet Joint Injections for Treatment of Acute, Subacute, or Radicular Non-specific Axial Pain*
   Therapeutic facet joint injections are not recommended for treatment of acute, subacute, or radicular non-specific axial pain.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Moderate

3. *Recommendation: Therapeutic Facet Joint Injections for Treatment of Chronic Non-specific Axial Pain*
   Therapeutic facet joint injections are moderately not recommended for treatment of chronic non-specific axial pain.

   Strength of Evidence **– Moderately Not Recommended, Evidence (B)**
   Level of Confidence – Moderate

4. *Recommendation: Therapeutic Facet Joint Injections for Patients with a Prior Injection*
   Repeat use of intra-articular therapeutic facet joint injections are moderately not recommended for patients who have failed to achieve lasting functional improvements with a prior injection.

   Strength of Evidence **– Moderately Not Recommended, Evidence (B)**
   Level of Confidence – Moderate

Rationale for Recommendations
Degenerative facet joints become ubiquitous with age.(54-56) High- and moderate-quality studies suggest lack of efficacy of therapeutic facet joint injections for treatment of chronic LBP,(1640, 1719, 1727, 1736, 1737) although one study suggested modest efficacy.(1738) One comparative trial found comparable (in)efficacy with radiofrequency injections which also appear ineffective (see below) (2416, 2417). Another moderate quality trial found comparable (in)efficacy with intramuscular compared with facet joint injections with steroids for treatment of LBP (2408).

Therapeutic facet joint injections are typically performed to address a joint that is felt to be symptomatic on a diagnostic facet joint block. They also have been performed to address a purported cause of segmental rigidity.(61, 62) This involves injection of a local anesthetic and a glucocorticosteroid. Facet injections are not advocated for acute or subacute LBP or radicular pain syndromes. Their proposed use is in treatment of chronic non-specific LBP. These injections are invasive, have relatively low adverse effects, but are costly. Most of the quality studies available on this topic do not support these injections. If they are performed highly selectively, there should be evidence of enduring reductions of pain plus objective functional benefits along with a lack of needing to repeat the treatment other than rarely.

Evidence for the Use of Therapeutic Facet Joint Injections

We searched PubMed, EBSCO, Cochrane Library and Google Scholar without limits on publication dates then an updated search was done in PubMed for publication between 1/1/2013 and 11/15/2017. We used the following search terms: inject, therapeutic facet joint injections, subacute low back pain, chronic low back pain, radicular pain, sciatica, back, and random* to find 4,560 articles. Of the 4,560 articles, we reviewed 448 articles and included 448 articles (19 randomized controlled trials and 429 systematic reviews).*

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Chronic Pain - LBP										
Carette 1991 (score=8.0)	Facet Joint Injections	RCT	Study supported by research grant from Medical Research Council of Canade and scholar grant to Dr. Carette from Canadian Life and Health Insurance Association. Winthrop Laboratories provided Omnipaque contract material and Merck Frosst Canada provided acetaminophen tablets. No mention of COI.	N = 97 who previously responded to anesthetic injections at L4-L5 or L5-S1. LBP duration ≥6 months.	Mean age: 42.7 years; 53 mlaes,44 females.	Fluoroscopic facet injections between L4 and sacrum with methylprednisolone acetate (20mg) (n = 49) vs NS (n= 48).	Follow up at 1 month, 3 months, and 6 months.	Improvements from month 1 to 6 months in self-rated assessment form went from 42 % to 46% MP vs. 33% to 15% with saline (p = 0.002).	"[I]njecting methylprednisolone acetate into the facet joints is of little value in the treatment of patients with chronic low back pain."	Some baseline differences with median pain episode of 18 months in methylprednisolone vs. 24 months placebo. Data suggest minimal efficacy.
Schütz 2011 (score=7.0)	Facet Joint Injections	Prospective triple cross-over	No industry sponsorship or COI.	N = 60 with chronic LBP without successful conservative treatment at least 6 months, age 22-73 (excluded radicular pain associated with back pain)	Mean age= 53.2 years; sex of patients not mention.	Cross-over of three injections verum (V) (1.5ml 1% Mepivacaine), placebo (P), and sham (S) injection. SPV (n = 10); SVP (n = 10); PSV (n = 10); PVS (n = 10); VPS (n = 10); VSP (n = 10).	No follow up mentioned.	No carryover effect on injection sequence. Pain relief 6-8 hours after placebo injection vs sham (p = 0.05) and verum vs. placebo vs. sham (p = 0.05).33% non-responders, rate of positive tests (true verum responder) 16.5%.	"With regard to test validity criteria, a single intraarticular facet block with local anesthetics is not useful to prove a FJS and has to be abandoned from preoperative testing and indication finding."	Experimented 3 conditions in 6 parallel groups.
Kim 2010 (score=6.5)	Facet Joint Injections	RCT	No sponsorship or COI.	N = 50 patients with sacroiliac joint pain.	Mean age: 60.2 years; 14 males, 34 females.	Prolotherapy group (n=24) – patients were injected with 2.5 mL of 25% dextrose solution into the SI joint	2 weeks and 6, 10, and 15 months.	The NRS was significantly decreased from baseline in both groups at 2 weeks after the completion of	"Intra-articular prolotherapy provided significant relief of sacroiliac joint pain, and its	Data suggest at 6 months, 63.5% of prolotherapy group sustained 50% or more improvement compared to

						every other week and repeated this up to three times vs. steroid group (n=26) – patients were injected with 40 mg triamcinolone acetonide in 0.125% levobupivacaine 2.5 mL into the SI joint every other week and repeated this up to three times.		the treatment series, from 6.3±1.1 to 1.4±1.1 for the prolotherapy group and from 6.7±1.0 to 1.9±0.9 for the steroid group (p<0.001). The ODI score improved from baseline to 2-week follow up: 33.9±15.5 to 11.1±10.0 for the prolotherapy group and From 35.7±20.4 to 15.5±10.7 for the steroid groups (p<0.001). The percent positive response at 6 months for the prolotherapy and steroid groups was 63.6 and 27.2 (p<0.01), respectively; at 10 months was 58.7 and 10.2(p<0.01); at 15 months was 58.7 and 10.2(p<0.01).	effects lasted longer than those of steroid injections. Further studies are needed to confirm the safety of the procedure and to validate an appropriate injection protocol."	steroid group at 27.2%.
Manchikanti 2012 (score=6.5)	Facet Joint Injections	RCT, double-blind active-control trial	No sponsorship or COI.	N = 100 eligible to undergo diagnostic thoracic facet joint nerve blocks with nonspecific mid-back or	Mean age= 43.8; 37 males, 63 females.	Group I or local anesthetic only received branch blocks with injection of bupivacaine 0.25% (n = 50) vs. Group II or Local anesthetic with	Follow up at baseline, 3, 6, 12, 18, and 24 months.	No significant difference between groups with regards to average pain scores and ODI.	"Therapeutic medial branch blocks of thoracic facets with or without steroids may provide a management option for	Data suggest in population prescreened for positive response to facet injections for chronic thoracic pain, there is no difference in

				upper back pain without suspected disc herniation.		steroid group received bupivacaine and nonparticulate betamethasone, 0.15mg/ml (n = 50).			chronic function-limiting thoracic pain of facet joint origin."	outcomes from serial facet injections using plain bupivacaine compared with bupivacaine and betamethasone.
Murata 2009 (score=6.5)	Facet Joint Injections	RCT	No industry sponsorship or COI.	N = 246 with LBP treated with NSAIDs at least 2 weeks prior to study	Mean age= 67.5 years; 90 males, 156 females.	L2 block inserted toward L2 spinal nerve and stopped when patient felt pain in anterior region of the ipsilateral thigh of 2ml 1% lidocaine and 3.3mg dexamethasone sodium phosphate (n = 122) vs. control block stopped at 2.5cm from skin of 7ml 1% lidocaine and 3.3mg (n = 124). Follow-up 7 days after injection.	No follow up mentioned.	Average VAS scores LBP (before/5 minutes/7 days after): L2 (69/14/44) vs. control (68/62/59), p <0.0001 5 minutes; p <0.0001 7 days. Average LBP scores: L2 (3.6/1.0/ 2.6) vs. control (3.7/3.4/ 3.2), p <0.0001 5 minutes, p <0.0001 7 days. Average duration of adequate effect: L2 5.0±8.1 weeks vs. control 2.8±7.1 weeks, p <0.05 Average VAS radicular pain (before/5 minutes/7 days after): L2 (69/16/43) vs. control (74/72/67), p <0.0001 5 minutes, p <0.0001 7 days. Average face scores radicular pain: L2 (3.5/1.3/ 2.4) vs.	"[T]he LBP pathway was likely interrupted by L2 block in these clinical cases and the radicular pain pathway was also likely interrupted by L2 block…However, the therapeutic value of an L2 block may be occasionally insufficient to alleviate pain completely because of the short duration of its effect."	Tiny proportion with longer-term relief (n=28 at 10 weeks) concerning for placebo effect.

								control (3.7/3.6/ 3.4), p <0.0001 5 minutes and 7 days.		
Marks 1992 (score=6.5)	Facet Joint Injections	RCT	No mention of industry sponsorship or COI.	N = 86 with chronic LBP at least 6 months.	Mean age= 42.9 years; 46 males, 40 females.	Methylprednisolone 20mg and lignocaine 1%, 1.5mL at lumbosacral level (n = 42) vs. Facet nerve blocks (n=44) along L1 to L4 medial articular branch of posterior primary ramus with follow-up 30-60 minutes after.	Follow up at 1 and 3 months.	Weak significance at l-month, comparing any positive response to no response (p <0.05). Only pain history longer than 7 years correlated with excellent or good results at 1st month (p <0.005).	"Facet joint injections and facet nerve blocks may be of equal value as diagnostic tests, but neither is a satisfactory treatment for chronic back pain."	No placebo comparison. Data suggest equivalent efficacy or equal lack of efficacy.
Mayer 2004 (score=5.5)	Facet Joint Injections	RCT	Supported in part by grants 2K02 MH01107, 2R01 MH46402, and 2R01 DE10713 from National Institute of Health. No mention of COI.	N = 70 with chronic LBP and thought to have segmental rigidity	Mean age= 41.1 years; 50 males, 20 females.	Facet joint injection (lidocaine 2% 1mL, bupivacaine 0.5% 1mL, plus depot corticosteroid 1mL) bilaterally at all affected areas under fluoroscopy plus stretching exercise (Group A, n = 36) vs Stretching exercise alone (Group B, n = 34) seen by physical therapist twice a week. Follow-up at 5-7 weeks.	No mention of follow up.	Improved ROM in combination group vs. exercise group. No differences in pain or disability, although both groups improved.	"In the randomized trial, facet injections significantly increased the percentage of patients with SR showing ROM improvement, as well as the degree of improvement in lumbar mobility after treatment. There is no evidence that facet injections increase the improvements in pain/disability report noted in both groups."	Five of 29 (17.2%) met criteria for facet syndrome (80% pain reduction 1 to 2 hours after injection). All levels injected bilaterally due to possibilities of missing affected joints and difficulties in determining which side was limited ROM and causing segmental rigidity. Data suggest no differences in pain or disability from adding facet injection to exercises.

Lilius 1989 (score=5.0)	Facet Joint Injections	RCT	No industry sponsorship or COI.	N = 109 with unilateral LBP of 3 months duration	Mean = age 44; years 48 males, 61 females.	Methylprednisolone 80mg, 2mL plus bupivacaine hydrochloride 30mg, 6mL injected into 2 facet joints (n = 28) vs Same mixture injected peri-capsularly around 2 facet joints (n = 39) vs. NS, 8mL, injection into 2 facet joints (n = 42).	Follow up at 2 weeks, 6 weeks, and 3 months.	Rotation of back to symptomatic side (p = -0.019) and extension (p = 0.046) significantly better with intra-articular over pericapsular, but no differences when comparing groups. All improved, but no differences between groups.	"Facet joint injection is a non-specific method of treatment and the good results depend on a tendency to spontaneous regression and to the psychosocial aspects of back pain."	Data suggest no significant efficacy.
Galiano 2007 (score=5.0)	Facet Joint Injections	RCT	No mention of industry sponsorship or COI.	N = 40 with chronic LBP for more than 6 months.	Mean age= 49 years; 21 males, 19 females.	Ultrasound-guided procedure facet joint injection of 3ml containing 1ml 1% lidocaine, 1ml of 0.5% bupivacaine hydrochloride, 1ml (4mg) betamethasone (n = 20) vs. Computed tomography-controlled procedure facet joint injection of same mixture as ultrasound group (n = 20).	Follow-up for 6 weeks.	Both groups showed significant benefit from facet joint injection (p <0.01) with no differences detected between groups.	"[T]he ultrasound approach to the facet joints is feasible and has minimal risk in the large majority of patients and results in a significant time and radiation does reduction."	Small group. Study suggests ultrasound may be successful for ultrasound-guided facet injections
Lilius 1990 (score=5.0)	Facet Joint Injections	RCT	No mention of industry sponsorship or COI.	N = 109 with chronic unilateral LBP 3-36 months and no sign of sciatica and actual neurologic deficits.	Mean age= 43.4 years; 48 males, 61 females.	Methylprednisolone 80mg, 2mL plus bupivacaine hydrochloride 30mg, 6mL injected into 2 facet joints (n = 28) vs same mixture injected peri-capsularly around 2 facet		IAS outcome variable differed good vs. poor work outcome (p = 0.039). IAS also differed good vs. poor disability outcome (p <0.001).	"The definition of facet joint syndrome by a complex of symptoms and signs described in the literature is not unspecific. Like Jackson and co-	This was a quantitative study extracted from a previous RCT of same author (Lilius 1989) found above.

						joints (n = 39) vs NS, 8mL, injection into 2 facet joints (n = 42). Follow-up at 1 hour, 2 and 6 weeks, 6 months.		Previous disc surgery (0.008), pain scale (p = 0.062), duration symptoms (p = 0.076) selected as predictors.	workers, we also found that the treatment did not predict the outcome."	
Chronic Pain – Facet Joint Syndrome										
Riberio 2013 (score=7.0)	Facet Joint Injections	RCT	Sponsored by Fundação de Amparo a Pesquisa do Estado de São Paulo. No mention of COI.	N = 60 subjects with a diagnosis of facet joint syndrome.	Mean age: 63.9 years; 11 females; 49 females.	Experimental (n=31) – administered with intra-articular injections of 6 lumbar facet joints with 20 mg triamcinolone hexacetonide vs. Control (n=29) – administered with 20 mg triamcinolone acetonide intramuscular injection of 6 lumbar paravertebral points.	1, 4, 12, and 24 weeks.	The comparison between groups on pain and functional capacity was measured by VAS pain (cm) for the experimental mean (CI), control mean (CI), and intergroup P for the following: T0 – 7.0 (6.5-7.4), 6.8 (6.2-7.3), p=0.54; T1 – 4.0 (3.0–5.0), 4.0 (3.0–4.9), p=0.92; T4 - 4.0 (3.0–5.0), 3.6 (2.3–4.7) , p=0.53; T12 - 4.7 (3.5–5.7), 6.1 (5.0–7.0), p=0.06; T24 - 5.3 (4.4–6.1), 5.8 (4.5–6.9), p=0.54, respectively. The intragroup P for the experimental mean was p<0.001 and for the control mean group was p<0.001.	"Both treatments were effective, with a slight superiority of the intra-articular injection of steroids over intramuscular injection."	Data suggest comparable efficacy with a slight trend of superior results from intra-articular injections of steroids versus intramuscular injection of steroids.

Sae-Jung 2016 (score=6.5)	Facet Joint Injections	RCT	Sponsored by the New Researcher Grant, Khon Kaen University, Khon Kaen, Thailand. No COI.	N = 99 patients with lumbar facet syndrome.	Mean age: 46.4 years; 48 males, 51 females.	Oral diclofenac group (n=33) – received two weeks of oral diclofenac in 50 mg tablets taken twice daily after meals vs. Methylprednisolone facet injection group (n=32) – received 80 mg injections of methylprednisolone acetate combined with 1 ml of 0.5% bupivacaine in each symptomatic facet joint vs. Combined treatment group (n=34) – received both treatments.	4 and 12 weeks.	The initial ODI (mean) for the diclofenac, methylprednisolone and combined treatment was 45.1, 42.9, and 42.2, p=0.61, respectively. The respective four-week ODI was 30.1, 20.2, and 15.1, p<0.001. The 12-week ODI was 42.4, 32.2, and 26.2, p<0.001. The initial VAS was 7.1, 7.6, and 7.3, p=0.28. The four-week VAS was 5.3, 3.6, and 3.3, p<0.001. The 12- week VAS was 6.1, 5.8, and 5.1, p<0.001.	"The combined treatment was more effective in reducing lumbar facet pain and improving the functional index than either treatment alone. This approach should be the preferred treatment."	Short follow up time (12 weeks). Blinding not mentioned. Data suggest combination treatment of oral diclofenac with methylprednisolone better than either medication alone. Maximum treatment effect occurred at 4 weeks and continued to lose effects up to 12 weeks.
Wu 2016 (score=6.5)	Facet Joint Injections	RCT	No mention of sponsorship. No COI.	N = 46 patients with lumbar facet joint syndrome.	Mean age: 52.85 years; 19 males, 27 females.	Group A (intra-articular injection with PRP) (n=21) – patients received approximately 0.5 mL of autologous PRP for every targeted joint was injected slowly vs. Group B (intra-articular injection with LA/corticosteroid) (n=20) – patients	1 week, 1, 2, 3, and 6 months after treatment.	The objective success rate with over 50% pain relief at rest immediately after treatment for group A and Group B was 0 and 0, respectively. At 1 week was 4, 17, p<0.001. At 1 month was 13, 17, p=0.095.	"Both autologous PRP and LA/corticosteroid for intra-articular injection are effective, easy, and safe enough in the treatment of lumbar facet joint syndrome. However, autologous	Data suggest comparable efficacy but at 6 months PRP had superior duration efficacy.

						received the same dose of the mixture of 0.5% lidocaine and 5 mg/mL betamethasone was injected into each targeted segment		At 2 months was 15, 12, p=0.440. At 3 months was 17, 3, p<0.001. At 6 months was 17, 4, p<0.001.	PRP is a superior treatment option for longer duration efficacy."	
Civelek 2012 (score=6.0)	Facet Joint Injections	RCT	No mention of industry sponsorship or COI.	N = 100 with chronic LBP and diagnosis of lumbar facet syndrome, not responding to 6-weeks of conservative treatment.	Mean age= 54.1 years; 30 males, 70 females.	Facet joint injections (FJI) with medial branch block of posterior primary ramus with 1 cc methylprednisolone acetate (40mg) diluted with 1cc SF combined with 2cc bupivacaine hydrochloride diluted with 2 cc SF (n = 50) vs. (n = 50) facet joint radiofrequency denervation (FJRF) at 80ºC for 120 seconds (n = 50).	Follow-up for 2 years.	No significant differences between comparison groups 1st month (p = 0.17), 6th month (p = 0.22), 12th month (p = 0.11) post-procedure follow-up in Euro-Quality of Life Dimensions (EQ-5D). FJRF group had significant effect for North American Spine Society (NASS) patient satisfaction (p = 0.05) vs. FJ (p = 0.912).	"Both procedures are effective, easy, and safe treatment modalities for the treatment of facet syndrome."	No placebo control. Results suggest the FJRF is slightly better in some outcome measures.
Pneumaticos 2006 (score=5.0)	Facet Joint Injections	RCT	Supported by Roderick Duncan MacDonald Research Fund of St Luke's Episcopal Hospital and Institute of Orthopaedic Research and Education, but no mention of COI.	N = 47 with facet joint syndrome scheduled for injections; LBP duration ≥6 months	23 males, 24 females.	SPECT with positive scans before facet joint injection (Group A1, n = 15) vs. bone scanning with SPECT with negative scans before injection (Group A2, n= 16) vs. injection decided by referring	Follow-up 1, 3, and 6 months	A1 only group with significant difference at 1 month (p <0.008). Change in pain scores at 3 months significantly higher in Group A1 (p <0.001) than other 2 groups, but	"[B]one scanning with SPECT helps in the identification of patients who would benefit from a facet joint injection."	No placebo group. Trial included facet joint abnormalities in 100%, making limited utility for diagnostic purposes or specificity or positive predictive value. Trial needs

						physician (Group B, n = 16). Facet injections with 0.5ml, 6mg/mL betamethasone sodium phosphate and betamethasone acetate injectable suspension plus bupivacaine 0.5%, 2.5mL.		Group B significantly higher (p = 0.015) than A2. No significant differences found at 6 months.		replication with larger sample sizes and higher quality studies. Data suggest better short-term response to injection if SPECT positive and used to target injection. However, no differences at 6 months suggest no intermediate or longer term benefits.
Chronic Pain – Facet Joint Syndrome										
Kawu 2011 (score=2.0)	Facet Joint Injections	Prospective randomized	No industry sponsorship or COI.	N= 18 with non-radicular chronic LBP lasting >3 months no response to conservative treatment. Excluded nerve root compression, infection, neoplastic disease. Mean age 44.7±10.4	Mean age= 44.3 years; no mention of patients' sex.	Facet joint injections (FJI) (n = 10) 0.5ml of 0.25% bupivacaine and 0.5ml (20mg) of methylprednisolone acetate vs. physiotherapy (n = 8).	Follow-up for 6 months.	Oswestry Disability Index (ODI) mean score consistently lower in FJi group compared to physiotherapy at 6-weeks, 3-months, and 6-months (p = 0.013). VAS pain scores significantly lower in FJI group compared to physiotherapy (p = 0.032) by post-treatment. Clinical success achieved in 90% of FJI and 75% of physiotherapy.	"There were two statistically significant findings, the patients in FJI group fared better and feel satisfied with the treatment than those in the physiotherapy group."	Small sample size.

Manchikanti 2001 (score=2.0)	Facet Joint Injections	RCT	No mention of COI or sponsorship.	N = 73 LBP with or without lower extremity pain.	Mean age= 46.8 years; 37 males, 63 females.	Group I: therapeutic injections with local anesthetic and Sarapin®, (n = 32) vs. Group II: therapeutic injections with mixture of local anesthetic, Sarapin, and methyl prednisolone. (n = 41).	No mention of follow up.	Mean±SEM average pain Group I: Pre vs. Post 7.6±0.13 vs. 3.5±0.26. Group II: 7.7±0.12 vs. 3.3±0.15. Author states significant change but no p-value given.	"[W]ith or without steroids, are a cost effective modality of treatment, resulting in improvement in pain status, physical status, psychological status, functional status and return to work."	Methodological details sparse.
Manchikanti 2008 (score=NA)	Facet Joint Injections	RCT, Follow-up of Manchikanti 2001	No industry sponsorship or COI.	N = 120 with lumbar facet joint pain, chronic function-limiting LBP for ≥6 months, with no disc related pain	Mean age= 47 years; 48 males, 72 females.	Group I: lumbar facet joint nerve blocks with injections of local anesthetic: bupivacaine 0.25% (n = 60) vs. Group II: lumbar facet joint nerve blocks with mixture bupivacaine and Sarapin (mixed equal volumes), and 0.15mg betamethasone (n = 60). Each nerve injected with 0.5-1.0mL of assigned mixture.	Follow up at baseline, 3 months, and 6 months,	Mean±SD for average relief per procedure for Group I vs. Group II: 15±9.9 vs.15±9.2. Mean±SD of Oswestry Disability Index at baseline and at 12 months of Group I compared to Group II: 26.6±4.6 and 12.3±4.8 vs. 25.9±5.0 and 12.0±5.4.	"The results of this randomized, double-blind controlled evaluation of lumbar facet joint nerve blocks in chronic function-limiting low back pain demonstrate the effectiveness in over 82% of the patients with improvement in functional status."	At 1 year, data suggest no differences in interventions. Lack of control or placebo group limits conclusions.
Manchikanti 2010 (score=NA)	Facet Joint Injections	RCT, 2 year follow-up report of Manchikanti 2001	No industry sponsorship or COI.	N = 120 with chronic function-limiting LBP for ≥6 months	Mean age= 47 years; 48 males, 72 females.	Group IA: Lumbar facet joint injections with bupivacaine (n = 30) vs Group IB: lumbar facet joint injections with bupivacaine and sarapin (n = 30)	Follow up at baseline, 3, 6, 12, 18, and 24 months.	Mean±SD average of pain scores at Baseline and 24 months for Group I vs. Group II: 8.2±0.8 and 3.5±1.5 vs. 7.9±	"The evidence in this report demonstrates lumbar facet joint pain diagnosed by controlled, comparative local anesthetic	At 1 year, data suggest no differences in interventions. Lack of control or placebo group limits conclusions.

						vs. Group IIA: lumbar facet joint injections with bupivacaine and steroid (n = 30) vs. Group IIB: lumbar facet joint injections with bupivacaine, Sarapin and steroids (n = 30). All underwent controlled comparative local anesthetic blocks 0.5mL 1% preservative-free lidocaine, followed by 0.5mL 0.25% bupivacaine 3-4 weeks after first injection if lidocaine block results positive.		1.0 and 3.2±0.9. Mean±SD average relief per procedure for Group I vs. Group II: 19±19.9 vs. 19±18.2. Mean±SD average total relief with sequential procedure for Group I vs. Group II: 82±31.8 vs. 84±27.5. Mean±SD average for ODI at baseline and 24 months for Group I vs. Group II: 26.6±4.6 and 12.0±4.9 vs. 25.9±5.0 and 11.0±4.8. Mean±SD average total opioid intake at baseline and 24 months for Group I vs. Group II: 31±25.2 vs.37±40.4 (p = 0.294) and 27 ± 23.8 vs. 30±27.1 (p = 0.549).	blocks may be treated with lumbar facet joint nerve blocks either with or without steroid."	

FACET JOINT HYALURONIC ACID INJECTIONS

Facet joint injections with hyaluronic acid are being attempted for treatment of facet degenerative joint disease. These injections are analogous to similar injections in the knee and other arthritic joints.

Recommendation: Facet Joint Injections with Hyaluronic Acid for Treatment of Facet Degenerative Joint Disease

Facet joint injections with hyaluronic acid are not recommended for treatment of facet degenerative joint disease.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are no placebo- or sham-controlled trials. Weekly injections of hyaluronic acid have been studied in one moderate-quality study and appear to be largely ineffective compared to facet steroid injections that appear no more effective than placebo.(1743) As studied, this intervention is invasive, requiring a series of 18 injections performed at 3 levels, likely has some side effects, and is high cost. While the comparative pain and disability score reductions could be interpreted as somewhat promising, additional studies are needed prior to recommending this fairly invasive intervention and would need to show superiority of these injections.

Evidence for use of Facet Joint Hyaluronic Acid Injections

There is 1 moderate-quality RCT incorporated into this analysis.(1743)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: Facet, joint, hyaluronic, acid, injections, subacute, radicular, syndromes, sciatica, Spinal, stenosis, chronic, low, back, and pain to find 24,887 articles. Of the 24,887 articles, we reviewed one articles and included one articles.

Author/Year Study Type	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Fuchs 2005 RCT Authors declare no COI. No mention of industry sponsorship.	7.0	N = 60 with chronic LBP at least 3 months duration and x-ray evidence of facet joint degenerative joint disease	Weekly, tri-level, bilateral injections of hyaluronic acid 10mg (n = 30) vs. Triamcinolone acetonide 10mg (n = 30) under CT guidance with follow-up at 3 and 6 months.	VAS scores decreased 69.2±14.2mm to 38.0±26.5mm at 6 months (45.1%) with hyaluronic acid, but not significant. With triamcinolone, decreased from 68.7±11.5 to 33.4±20.7 (56.2%). Oswestry scores decreased with hyaluronic acid (20.7±8.5 to 12.6±9.7 at 6 months) and triamcinolone (18.4±6.2 to 13.0±7.1).	"Intraarticular sodium hyaluronate is a promising new option for treating patients with chronic nonradicular lumbar symptoms. Graphic representations suggest there are no meaningful differences in efficacy between the two injections."	Article states patients received 6 injections, however 3 bilateral levels with weekly injections for 3 weeks is 18 injections per subject. Data do not support efficacy.

SACROILIAC JOINT INJECTIONS

The sacroiliac joints (SIJs) are believed to cause a minority of chronic LBP cases, with estimates ranging from 10 to 26.6%. The most commonly performed interventions are sacroiliac joint injections either with or without fluoroscopic or other imaging guidance.(1715, 1744) The injection targets the tenderest area and generally consists of a glucocorticosteroid combined with a local anesthetic agent. The combination of agents is frequently designed to attempt to be both diagnostic and therapeutic. However, the diagnostic precision of these injections is likely limited by factors that include the inability to inject the joint directly without fluoroscopic or other imaging, as well as the infiltration and diffusion of medication into surrounding tissues that could be potential pain generators.(1745) The use of fluoroscopically guided, CT guided, or unguided SI joint corticosteroid injections have been suggested by some to be effective for low back pain and spondyloarthropathy.(1746-1748) Other resources have found the evidence to be limited or poor.(1749, 1750)

1. *Recommendation: Sacroiliac Joint Corticosteroid Injections for Treatment of Sacroiliitis*
   Sacroiliac joint corticosteroid injections are recommended as a treatment option for patients with a specific known cause of sacroiliitis, i.e., proven rheumatologic inflammatory arthritis involving the sacroiliac joints.
   Indications – Symptoms of sacroiliitis of at least 1 to 2 months duration with prior treatment that has included NSAIDs.

   Frequency/Duration – Each injection should be evaluated before additional injections are scheduled, rather than scheduling a series of injections.

   Indications for Discontinuation – Resolution of the symptoms of sacroiliitis or decrease in symptoms to a tolerable level.
   Benefits – Short to intermediate term reduction in pain.
   Harms – Rare complications of paralysis, infections; medicalization.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence – Low

2. *Recommendation: Sacroiliac Joint Injections for Treatment of Acute Low Back Pain*
   Sacroiliac joint injections are not recommended for treatment of acute low back pain including low back pain thought to be sacroiliac joint related; subacute or chronic non-specific low back pain, including pain attributed to the sacroiliac joints, but without evidence of inflammatory sacroiliitis (rheumatologic disease); or any radicular pain syndrome.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations

Some patients appear to have SIJ pain that is not due to spondyloarthropathies. In one quality study, a short-term response to glucocorticoid injection into the soft tissue above the joint was demonstrated.(1751) In limb joints, injection outside a joint has not been demonstrated to improve pain coming from a joint, so the mechanism for this finding is puzzling. The other two quality studies were both of populations of spondyloarthropathy patients, thus applicability to working populations is unclear. Whether fluoroscopic guidance is needed is unclear and controversial.(1752) Without fluoroscopic guidance, the joint itself is usually not injected as this is a difficult joint on which to perform arthrocentesis without imaging guidance. It is not clear if actual joint injection results in appreciably lower success rates as an injection in the local proximity may be just as effective. Injection in the local proximity should perhaps be classified as a tender point injection, and not as a sacroiliac joint injection. There is no surgical procedure of proven efficacy to help patients tentatively identified as having "sacroiliac joint pain" by diagnostic injection. There are no quality studies showing a long-

term improvement in pain or function in those receiving sacroiliac joint injections for chronic non-specific LBP.

For patients with proven rheumatologic inflammatory disease of the sacroiliac joints (e.g., ankylosing spondylitis), SIJ injection has evidence of efficacy and the same sort of disease in extremity joints is commonly managed successfully with corticosteroid injection therapy. Sacroiliac joint diagnostic injections with topical anesthetic are not recommended. If an injection is felt to be necessary, then it is recommended that it be combined with a glucocorticosteroid injection and it should be performed with imaging guidance to insure the arthritic joint is successfully injected.

SIJ injections are minimally invasive, have low adverse effects, and are moderate cost if performed with fluoroscopy. They are recommended for treatment of proven inflammatory arthritis of the sacroiliac joints.

Evidence for the Use of Sacroiliac Joint Injections
We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates then an updated search was done in PubMed for publication between 1/1/2013 and 11/15/2017., We used the following search terms: sacroiliac joint corticosteroid injections, sacroiliitis, subacute low back pain, chronic low back pain, and low back pain to find 373 articles. Of the 675 articles, we reviewed 21 articles and included 21 articles (15 randomized controlled trials, 2 systematic reviews, and 4 Case-Series).

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Jee 2014 (score=6.0)	Sacroiliac Joint Pain	RCT	Sponsored by a research grant from Inje University, Gimhae, Korea. No COI.	N = 120 patients with non-inflammatory sacroiliac arthritis	Mean age: 60.8 years; 31 males, 79 females.	US-guided approach (n=55) – patients received sacroiliac joint (SIJ) intraarticular injections using an ultrasound (US) approach vs. FL-guided approach (n=55) – patients received SIJ injections using a fluoroscopy (FL) guided approach.	2 and 12 weeks	Verbal numeric pain scale (VNS) score at baseline, 2 weeks after injection, and 12 weeks after injection for the US-guided approach were 6.45, 3.14 ($p<0.025$), and 2.56 ($p<0.025$) and for the FL-guided approach were 6.53, 3.14 ($p<0.025$), 2.59 ($p<0.025$). The Oswestry Disability Index (ODI) score at baseline, 2 weeks after injection, and 12 weeks after injection for the US-guided approach were 46.74, 26.26 ($p<0.025$), 21.30 ($p<0.025$) and for the FL-guided approach were 45.78, 25.41 ($p<0.025$), 21.30 ($p<0.025$).	"The US-guided approach may facilitate the identification and avoidance of the critical vessels around or within the SIJ. Function and pain relief significantly improved in both groups without significant differences between groups. The US-guided approach was shown to be as effective as the FL-guided approach in treatment effects. However, diagnostic application in the SIJ may be limited because of the significantly lower accuracy rate (87.3%)."	Single injection intervention – 12 week follow up. Data suggest similar efficacy although US guided approach has less radiation exposure.
Cohen 2014 (score=5.0)	Injections	RCT	Sponsored by the Centers for Rehabilitation and Sciences Research, Uniformed Services University of the Health Sciences. No COI.	N = 119 patients with suspected sacroillac joint pain or complex regional pain syndrome.	Mean age: 49.9 years; 31 males, 42 females.	Sacroiliac Joint block (n = 57): patient received 3.5 mL solution containing 2 mL of bupivacaine 0.5% and 1.5 mL of 40 mg/mL of depo-methylprednisolone vs sympathetic block (n = 16): contrast dye was injected to ensure correct placement, after which 8 mL of 0.25% bupivacaine was given. Both were then broken into group 1 with 1st block sedation 2nd block no	Follow up at 1 month after each block.	Diagnostic pain diary change from baseline after block for sedation was -3.9 vs -2.7 for no sedation ($p=0.003$).	"The use of sedation during diagnostic injections may increase the rate of false-positive blocks and lead to misdiagnoses and unnecessary procedures, but has no effect on satisfaction or outcomes at 1-month."	Randomized crossover study. Data suggest sedation likely affects the outcome of diagnostic blocks and may increase numbers of false postures leading to misdiagnoses.

						sedation or group 2 1st block sedation second block sedation.				
Whang 2006 (score= NA)	Sacroiliac Joint Pain	Nonsurgical management analysis of Polly et al 2015.	No mention of sponsorship or COI.	N = 148 patients with SI joint dysfunction due to degenerative sacroiliitis or sacroiliac joint disruptions.	Mean age: 51 years; 45 males, 103 females.	Non-surgical management (n=46) – patients received either steroid injections, radiofrequency ablation of the SI joint, and/or received pain medication for 6 months vs. SI Joint Fusion (n=102) – patients underwent surgery using the SIJ fusion method.	6 months	The 6-month overall success rates (95% posterior credible interval) by group are 83/102 (81.4%, 72.4-88.4%) in SI Joint Fusion group and 11/46 (23.9%, 12.6-38.8%). The rate difference is 56.6% (41.5-70.0%). The VAS SIJ change from baseline in the NSM and SIJ groups are -13.0 and -49.2 at month 1 (p<0.0001), -18.7 and -56.5 at Mo 3 (p<0.0001), and -12.1 and -52.6 at Mo 6 (p<0.0001), respectively. The Oswestry Disability Index change in ODI score for the NSM and SIJ fusion group are -3.7 and -17.4 at Mo 1 (p<0.0001), -10.3 and -29.5 at Mo 3 (p<0.0001), and -4.9 and -30.3 at Mo 6 (p<0.001).	"Six-month follow-up from this level 1 study showed that minimally invasive SI joint fusion using triangular titanium implants was more effective than non-surgical management in relieving pain, improving function and improving quality of life in patients with SI joint dysfunction due to degenerative sacroiliitis or SI joint disruptions."	Data suggest SIJ fusion group experienced improved function, pain and quality of life at 6 months compared with non-surgical management. Non-surgical management did not consist of quality rehab program of active exercise plus CBT.
Polly 2016 (score= NA)	Sacroiliac Joint Pain	Follow up at 2 years from Polly et al 2015	Sponsored by SI-BONE. David Polly has no financial interest in SIBONE. Peter Whang is a paid SI-BONE consultant participating primarily in educational events. Clay Frank is an SI-BONE consultant participating primarily in educational events, but receives only	N = 148 patients with SIJ dysfunction.	Mean age: 51.3 years; 45 males, 103 females.	SIJ fusion group (n=102) – patients received SIJF with triangular titanium implants. Vs. Non-surgical management (n=46) – patients received intraarticular steroid injections and radiofrequency ablation.	1, 3, 6, 12, 18, and 24 months.	By month 6, 84 of 102 SIJF subjects (82%, 95% posterior credible interval [CI] 74-89%) and 12 of 46 NSM subjects (26%, 14-41%) met the study's primary success endpoint. In the SIJF group, the mean SIJ pain score improved from 82.3 at baseline to 30.1 at 6 month follow-up, 28.6 at 12 months and 26.7 at 24 months, corresponding to improvements from baseline of 52.3, 53.7and 55.4 points, respectively (all p<.0001). In the NSM group, mean SIJ pain improved from 82.2 to 70.3 at 6 months.	"In this Level 1 multicenter prospective randomized controlled trial, minimally invasive SIJF with triangular titanium implants provided larger improvements in pain, disability and quality of life compared to NSM. Improvements after SIJF persisted to 24 months."	Suggests sustained benefit from minimally invasive SIJ fusion. However, non-surgical management did not include progressive aerobic exercise, strengthening exercise plus CBT.

			reasonable expense reimbursement as compensation. Daniel Cher and Kathryn Wine are SI-BONE employees.							
Dengler 2017 (score= NA)	Sacroiliac Joint Pain	Pooled analysis of 3 SIJF implants (SIFI, INSITE, and iMIA).	SI-BONE Inc. is funding the iMIA trial in support of this work. Relevant financial activities outside the submitted work.	N = 423 patients from the INSITE (n=148), iMIA (N=103), and SIFI (N=172) studies with SIJ dysfunction.	Mean age: 50.4 years; 125 males, 298 females.	Non-surgical management (n=97) – patients received anti-inflammatory and opioid pain medications, physical therapy, intra-articular SIJ steroid injections, and radiofrequency neurotomy. vs. SIJF (n=326) – patients received sacroiliac joint fusion surgery.	2-year follow-up data from 2 US completed studies, and 1 year follow up from European RCT.	The adjusted reduction at month 6 in SIJ pain was 37.9 points larger (95% CI 32.5-43.4, p<0.0001) in the SIJF group vs. the NSM groups. Similarly, the improvement in ODI was 18.3 larger (95% CI 14.3-22.4, p<0.0001) and the improvement in E1-5D TTO index was 0.24 points larger (95% CI 0.17-0.30, p<0.0001).	"Our results support the view that SIJF lead to better treatment outcome than conservative management of SIJ pain and that higher margin of improvement can be predicted in non-smokers, non-opioid users, and patients of increased age and with longer pain duration."	Data from 3 trials (2 RCTS and 1 prospective cohort) suggests pain, function, and quality of life improvements were large compared to conservative management. However, non-operative management did not include progressive aerobic exercise, strengthening exercise plus CBT.
Periarticular Injection										
Luukkainen 1999 (score=7.0)	Sacroiliac Joint Injection	RCT	No mention of industry sponsorship or COI.	N = 20 with seronegative spondyloarthropathy and clinical sacroiliitis	Mean age: 41 years; 11 males, 9 females	Periarticular injection of 1.5ml (40mg/ml) methylprednisolone acetate 60mg (1.5mL of 40mg/mL) plus lignocaine 1.5mL or MP group (n = 10) vs. 1.5ml NS plus lignocaine or non-MP (n = 10). Follow-up at 0 and 2 months.	2 months	At 2 months, VAS (median change – MP -26.5 vs. non-MP -1.5) and pain index (mean change – MP -4.5 vs. non-MP -1.4 both favored MP group significantly (p = 0.02, p = 0.01 respectively).	"[T]he periarticular injection of methylprednisolone may be effective in the treatment of clinical sacroiliitis in patients with seronegative spondyloarthropathy. However, because the number of patients in our study was low, these results must be regarded as preliminary."	Small numbers. Significant differences in pain scores at baseline, suggesting randomization failure. Changes in scores favored steroid.
Maugars 1996 (score=6.5)	Sacroiliac Joint	RCT	No mention of industry sponsorship or COI.	N = 10 (13 articulations)	Mean age: 34.3 ± 10.3 years; 6	Sacroiliac corticosteroid injections (1.5ml cortivazol,	1, 3, 6 months	Corticosteroid favored at 1 month (p <0.05), dolorimetry (p <0.005), limping (p <0.002), sacroiliac pain on uni-podal	"This technique is safe and very efficient, and it has to be considered more widely in patients	Very small sample sizes. Randomization, allocation, control of

	Injections			with painful sacroiliitis and spondyl arthropathy	males, 4 females	equivalent to 62.5mg prednisone) (n = 6 articulations) vs. Isotonic saline solution placebo (n = 7 articulations). Follow-up at 1, 3, and 6 months.		jump (p <0.05), and pain with buttock pressure (p <0.05). At 6 months, 7/12 sacroiliac joints remained improved in steroid group; dolorimetry decreased 33% (p <0.05).	with contraindications or complications with NSAID, or if the medical treatment is unable to control sufficiently the active sacroiliitis."	co-interventions, compliance, and withdrawal details sparse. Suggests benefit of steroid injections in SI joint for spondyl-arthropathies, but small sample size limits conclusion.
Kim 2010 (score=5.5)	Sacroiliac Joint Injection	RCT	No industry sponsorship or COI.	N = 50 with pain in buttock, groin, or thigh at least 2 months.	Mean age: 60.2 years; 14 males, 34 females	Prolotherapy which consisted of an injection 2.5mL of 25% dextrose solution into the sacroiliac joint (SI joint) every other week and repeated up to 3 weeks (n = 24) vs. SI joint intra-articular injection which consisted of an injection of 40 mg of triamcinolone acetonide in 0.125% levobupivacaine 2.5 mL (n = 26).	2 weeks, 1 month, 6, 10, 15 months	Significant difference number of injections required for treatment 2.7 vs. 1.5 for prolotherapy vs. steroid (p <0.01); percentage of positive responses at 6/10/15 months: 63.6/58.7/58.7 (in respective months) for prolotherapy and 27.2/10.2/10.2 for steroid group (p <0.01). Numerical rating scale for pain 6.3±1.1 to 1.4±1.1 for prolotherapy, 6.7±1.0 to 1.9±0.9 steroid group (p <0.001) at 2 weeks, both significant changes. ODI also significant change in both groups, from 33.9±15.5 to 11.1±20.0 for prolotherapy and 35.7±20.4 to 15.5±10.7 in steroid group. All had reduced pain at least 50% at 2 weeks.	"Intra-articular prolotherapy with 5% dextrose water may be useful for the long-term relief of SI joint pain."	High opioids use in steroid group (24 v 14%). Data suggest prolotherapy superior to steroid injection, but study may be fatally confounded.
Luukkainen 2002 (score=4.5)	Sacroiliac Joint Injection	RCT	No mention of industry sponsorship or COI.	N = 24 with chronic LBP in SI joint region, pain for 3 plus months (median pain durations 4.4 and 5.4 years)	Mean age: 49.8 years; 7 males, 17 females	Periarticular injection of 1.5ml (40mg/ml) methylprednisolone (MP) acetate (60mg prednisolone acetate) and lidocaine (1.5mL) (n = 13) vs. Isotonic sodium chloride 1.5ml and lidocaine 1.5ml (20mg/ml) (n = 11). Follow-ups at 0, 1 month.	1 month	Median VAS change -40 in MP vs. -13 for controls (p = 0.046). Median change for pain index -3 for MP vs. 0 for non-MP group (p = 0.017). Multivariate test between changes significant (p = 0.045).	"[P]eriarticular injection of methylprednisolone may be effective in the treatment of low back pain in the region of the SIJ also in non-spondylarthropathic patients. However… [f]urther studies are needed with larger patient series and also with longer follow up times.	Duration of symptoms different at baseline. Small numbers. Lack of co-interventions discussion. Injections not fluoroscopically guided. Study reports benefit with methylprednisolone but, difficult to conclude with small numbers and no intermediate to long-term results.

INTRATHECAL DRUGS

The use of intrathecal drug delivery systems (aka, "pain pumps") for acute pain is common and frequently effective utilizing morphine, fentanyl and other agents for perioperative and post-operative pain control. Those uses are reviewed in other chapters (e.g., see Hip and Groin Disorders guideline).(1757-1760) Occasionally, treatment of severe pain has been attempted using opioids administered parenterally by these devices.(1757-1764)

Recommendation: Intrathecal Drug Delivery Systems for Chronic Non-malignant Pain Conditions
Intrathecal drug delivery systems are not recommended for treatment of chronic nonmalignant pain conditions.

Harms – Device complications, fatalities.
Benefits – Less debility, reduced accidents risks, risks of dependency or addiction.

Strength of Evidence − **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – High

Rationale for Recommendation
Intrathecal drug delivery systems have not been evaluated in quality studies to determine whether treatment with these systems is superior to oral medication(s) or other treatment options for chronic nonmalignant pain patients. A placebo-controlled trial for gabapentin was negative (2418). Administrations via pain pumps for chronic non-malignant and malignant pain are limited, but there are studies evaluating parenteral opioids for pain in chronic cervicothoracic patients that while suggesting short-term relief of pain, do not demonstrate long-term benefits. A quality cost-benefit analysis in an RCT is not available (2419). The medications used were potent and not intended for chronic use.(1763, 1765) Deaths have been associated with intrathecal opioid use, including one-day post-implantation.(1761) Granulomas appear to frequently develop;(1766) the expected "permanency" of neurologic abnormalities associated with their formation has not been established.(1767)

Ziconotide has been used in intrathecal delivery systems, but with only several days duration; thus, there was insufficient time to ascertain efficacy commensurate with the invasiveness of this delivery system.(1768) It is not known whether there is a reduced incidence of intrathecal granuloma formation with this drug since its use has not been widely applied over the long term. Ziconotide has a narrow therapeutic margin and has been associated with severe neuropsychiatric adverse effects. Since it does not share pharmacologic actions with narcotics, there is no known method to determine prospectively whether a patient will respond favorably to this drug.(1769)

Intrathecal opioid delivery systems are invasive and costly, with possible significant adverse effects including elevated mortality (2420) and potential long-term sequelae from both implantation/ retention of the devices, including granuloma formation, and those associated with the concurrent use of intrathecal opioids.(1770) Thus, with a lack of documented efficacy, invasiveness, serious adverse effects and marked costs, these devices are not recommended. For new patients, there are few barriers for implementing this guideline. For existing patients, this guideline should not be interpreted as requiring device removal.

Evidence for the Use of Intrathecal Drugs
We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates and then an updated search was conducted using PubMed for publications between 1/1/2013 and 11/15/2017. We used the following search terms: Intrathecal Pain Pumps, Intrathecal, drug, delivery, system, chronic, low, back, pain, and random to find 67,313 articles. Of the 67,313 articles, we reviewed 14 articles and 14 articles were included (12 randomized controlled trials and 2 systematic reviews).*

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Rauck, 2013 (Score=8.5)	Intrathecal Pain Pumps	RCT	No mention of sponsorship or COI.	N = 170 patients received SynchroMed intrathecal drug implantation.	Mean age: 49.6 years; 72 males, 98 females.	Placebo group: received 0 mg intrathecal gabapentin per day (n=44) vs. 1 mg group: received 1 mg intrathecal gabapentin per day (n=42) vs. 6 mg group: received 6 mg intrathecal gabapentin per day (n=41) vs. 30 mg group: received 30 mg intrathecal gabapentin per day (n=43).	No mention of follow-up.	No significant difference in pain scores change was found among the treatment groups and placebo group. (95% CI= -0.46 to 0.61 in 1 mg group, -0.17 to 0.92 in 6 mg group, -0.05 to 1.04 in 30 mg group. P=0.799 for 1 mg group, 0.871 for 6 mg group, 0.899 for 30 mg group.	"Twenty-two days of intrathecal gabapentin did not demonstrate statistically significant or clinically meaningful analgesic effects."	Placebo controlled. Data suggest lack of efficacy.
Eldabe, 2017 (Score=7.5)	Intrathecal Pain Pumps	RCT cross over study	Supported by Medtronic Europe Sarl. One or more of the authors have received or will receive benefits for personal or professional use.	N=32 patients were implanted with intrathecal drug delivery to manage non-cancer pain.	Mean age: 55.3 ±9.9 years; 18 males, 14 females.	Continuous group: received dose (48 mcl/day) administered as continuous flow (n=16) vs. bolus group: received daily dose (48 mcl/day) separated to 6 intermittent boluses (n=16).	No mention of follow-up.	Difference in continuous and bolus proportions was 1.1% (p=0.93; 95% CI=-21.8 to 24). Patients' Global Impression of Change scale in continuous group was 3.8 and 3.9 in bolus group, indicated no significant difference (p=0.72; 95% CI=-0.6 to -0.4).	"The mean PGIC and proportion of positive responders was not substantially different after intermittent bolus vs continuous administration."	Data suggest comparable (in)efficacy.
Corticosteroids										
Dureja, 2010 (score=6.5)	Prednisolone and Benzodiazepams and Midazolam	RCT	No COI or sponsorship.	N=150 patients with pain and allodynia	Mean age: 57.4 years; 79 males, 66 females	M-O (n=49): received methylprednisolone (60mg) suspended in 10 mL of	12 weeks	Groups M-1 and M-2 patients reported better pain relief compared	"The combination of intrathecal midazolam with epidural	Data suggest combining epidural methyl prednisolone with intrathecal midazolam

						normal saline in the epidural space and preservative free normal saline 2 mL in the intrathecal space vs M-1 (n=48): received normal saline 10 mL in the epidural space and midazolam 2 mL (1 mg/mL) in the intrathecal space vs M-2 (n=48): received methylprednisolone (60mg) suspended in 10 mL normal saline in the epidural space plus midazolam 2 mL (1mg/mL) in the intrathecal space		to M-O group. M-2 Group showed better scores of pain and allodynia compared with patients M-O and M-1.	methylprednisolone resulted in prolonged duration of analgesia in patients with post herpetic neuralgia of lumbosacral dermatomes due to the complementary anti nociceptive action of intrathecal midazolam with epidural methylprednisolone on spinal nerve roots."	prolonged the analgesic effect in post herpetic neuralgia and decreased other analgesic use.
Van Wijck, 2006 (score=4.5)	Epidural Steroids	RCT	Sponsored by a grant from the Netherlands Organisation for Scientific Research (NOW number 945-02-009). No COI.	N=598 patients with acute herpes zoster	Mean age: 66 years; 234 males, 364 females	Epidural group (n=301): received standard therapy with one additional epidural injection of 80 mg methylprednisolone acetate and 10 mg bupivacaine vs Standard Group (n=297): received oral antivirals and analgesics	1, 3, 6 months	After 1 month of treatment, 137 patients in epidural group reported pain and 164 patients in standard group reported pain (p=0.02). After 3 months of treatment epidural group had 58 patients with reported	"We conclude that one epidural injection of methylprednisolone and bupivacaine, applied in the acute phase of herpes zoster, has a modest effect in reducing zoster-associated pain for 1 month."	Standard care bias, data suggest only a modest effect from a single epidural injection of methylprednisolone plus bupivacaine vs standard care.

								pain and standard group with 63 patients (p=0.47). After 6 months, epidural group reported pain by 39 patients and standard group reported 44 patients (p=0.43).		
Keczkes, 1980 (score=3.0)	Prednisolone									Data suggest prednisolone reduced the length and incidence of PHN.
Intrathecal/Epidural Drugs										
Rijsdijk 2012 (Score = 6.0)	Intrathecal	RCT	No mention of Sponsorship or COI.	N = 10 with postherpetic neuralgia.	Mean age; 73.6 years; 4 males, 6 females.	MPA + lidocaine. 4 intrathecal injections with 60 mg MPA + 60 mg lidocaine. (N = 6) vs Lidocaine 60 mg Lidocaine alone. (N = 4)	1, 4, 8 weeks.	Treatment group at 8 weeks Global pain increase by 0.6 on VAS. Vas control vs treatment. Higher vas in treatment group (P = 0.002).	"Considering the absence of clinical benefits and the potential risks of the treatment, intrathecal administration of MPA is not recommended."	Small sample data suggest each of clinical efficacy and is not recommended due to concerns over safely and treatment
Kikuchi 1999 (Score = 6.5)	Intrathecal & Epidural	RCT	Sponsorship by grants for scientific research from department of education. No mention of COI.	N = 25 patients with postherpetic neuralgia (PHN).	Mean age: 65 years; 11 males, 14 females.	All premedicated with 10 mg Diazepam orally and 75 mg roxatidine 2 hours before treatment. Intrathecal methylprednisolone acetate (MPA). 3 mL of 2% lidocaine	24 weeks	Epidural vs Intrathecal at end for excellent global pain relief. 3 vs 12 (p < 0.01).	"Our results suggest the effectiveness of intrathecal as compared to epidural MPA for relieving the pain and allodynia associated with	Data suggest intrathecal MPA appears to be a better analgesic than epidural MPA in patients with retractable PHN.

						containing 60 mg MPA into intrathercal space. 60 mg contained 43.5 mg polyethylene glycol, 0.3 mg myristyl-y-pi-colinium chloride. (N = 14) vs Epidural MPA. 5 mL of 2 % lidocaine containing 60 mg MPA. (N = 15)			PHN. Also, our findings, together with the decrease in IL-8, may indicate that intrathecal MPA improves analgesia by decreasing an ongoing inflammatory reaction in the CSF."	
Eisenach 2003 (score=4.0)	Intrathecal	RCT	Sponsorship by grants from National Institutes of Health. No mention of COI.	N = 7 patients with chronic neuropathic pain.	Mean age: 37 ± 6; 3 males, 4 females.	Intrathecal adenosine (2 mg diluted in preservative free saline) and intravenous saline (100 mg) vs. intrathecal saline and intravenous adenosine (2 mg). Intravenous injections were performed over 4 h by infusion pump. Intrathecal injection was performed at a mid- or low lumbar interspace using sterile technique and #27 Whitacre spinal needle.	24 hours	Intrathecal adenosine statistically significant reduced the area of allodynia to testing with a cotton wisp. Intrathecal adenosine also reduced elicited pain from von Frey filament probing (p=0.04, by one way ANOVA). No effects were seen for intravenous adenosine or for intrathecal adenosine with a	"[I]intrathecal, but not intravenous adenosine produced a modest reduction in some aspects of hypersensitivity, including pain from stimulation in the area of hyperalgesia and reduced area of allodynia in patients with neuropathic pain."	Double blind crossover study. Small sample. Data suggest intrathecal adenosine improves pain and reduces allodynia from NP pain but intravenous adenosine in the same does not.

								two way ANOVA.		
Pasqualucci 2000 (Score = 3.0)	Intrathecal & Epidural	RCT								Data suggest methylprednisolone plus local anesthesia better than IV acyclovir and oral prednisolone at 12 months. Cross to Iv acyclovir after putting in epidermal section.
Epidural Methylprednisolone										
Van Wijck 2006 (score = 4.5)	Intrathecal & Epidural	RCT	No COI	598 patients with acute herpes zoster rash	All 50 years of age or older, mean age of 66. 61% females and 39% males.	A single epidural injection of 80 mg of methylprednisolone plus 10 mg bupivicaine compared to standard care of oral antivirals and analgesics.	1, 3 and 6 months	At one month, 48% of epidural reported pain compared to 58% in control group.	"One epidural injection of methylprednisolone and bupivicane applied in the acute phase of herpes zoster has a modest effect at reducibng zoster-associated pain for 1 month. However, because this treatment did not prevent long-term postherpetic neuralgia, we suggest that an epidural injection of corticosteroid and bupivicaine only be considered for patients with	Standard care bias. Data suggest only a modest effect for reduction of zoster associated pain from a single epidural injection of methylprednisolone plus bupivicaine plus standard care for up to one month.

									severe acute pain from herpes zoster who are not respondin g to standard analgesic therapy."	
Dureja, 2010 (score=6. 5)	Benzodia zepams Midazola m And Prednisol one	RCT	No COI or sponsorsh ip.	N=150 patients with pain and allodynia	Mean age: 57.4 years; 79 males, 66 females	M-O (n=49): received methylpred nisolone (60mg) suspended in 10 mL of normal saline in the epidural space and preservative free normal saline 2 mL in the intrathecal space vs M-1 (n=48): received normal saline 10 mL in the epidural space and midazolam 2 mL (1 mg/mL) in the intrathecal space vs M-2 (n=48): received methylpred nisolone (60mg) suspended in 10 mL normal saline in the epidural space plus midazolam 2 mL (1mg/mL) in the intrathecal space	12 weeks	Groups M-1 and M-2 patients reported better pain relief compared to M-O group. M-2 Group showed better scores of pain and allodynia compared with patients M-O and M-1.	"The combinati on of intratheca l midazola m with epidural methylpre dnisolone resulted in prolonged duration of analgesia in patients with post herpetic neuralgia of lumbosacr al dermatom es due to the compleme ntary anti nociceptiv e action of intratheca l midazola m with epidural methylpre dnisolone on spinal nerve roots."	Data suggest combining epidural methyl prednisolone with intrathecal midazolam prolonged the analgesic effect in post herpetic neuralgia and decreased other analgesic use.
Ziconotide										
Wallace, 2006	Ziconotid e	RCT	Sponsore d by Elan Pharmace	N = 264 patients with	Mean age: 52 years, 143	Ziconotide (n=170) vs	6 days	Ziconotid e group	"Ziconoti de provided	Trial of 6 days. Data suggest

(score=6.5)			uticals, Inc. COI: M.M., D.M., and D.E. were employees of Elan Pharmaceuticals during the conduct of this trial.	severe chronic nonmalignant pain	males, 112 females	Placebo (n=87)		showed a higher percent change in VASPI score compared to placebo ($p \leq 0.001$). VASPI score for ziconotide group improved by 31.2% (95% CI 24.6-37.9) compared to placebo of 6% (95% CI 0-11.9).	significant analgesia in patients for whom conventional therapy failed. However, there was a considerable incidence of ziconotide-associated AEs due to the rapid titration and high doses administered."	intrathecal use may provide short-term relief where intrathecal opioids have failed.

PROLOTHERAPY INJECTIONS

Prolotherapy injections attempt to address a theoretical cause or mechanism for chronic LBP.(103, 1771-1776) This purported therapy involves repeated injections of irritating, osmotic, and chemotactic agents (e.g., dextrose, glucose, glycerin, zinc sulphate, phenol, guaiacol, tannic acid, pumice flour, sodium morrhuate), combined with an injectable anesthetic agent to reduce pain, into back structures, especially ligaments, with the theoretical construct that they will strengthen these tissues.(1777, 1778) Prolotherapy injections alone have been mostly found to not be more effective than control injections for patients with chronic LBP.(1772, 1779, 1780)

Recommendation: Prolotherapy Injections for Treatment of Acute, Subacute, or Chronic Low Back Pain or Radicular Pain Syndromes

Prolotherapy injections are strongly not recommended for treatment of acute, subacute, or chronic low back pain or any radicular pain syndrome.

Strength of Evidence – **Strongly Not Recommended, Evidence (A)**
Level of Confidence – High

Rationale for Recommendation

Although there is considerable heterogeneity in the available literature, the highest quality studies showed no benefit of prolotherapy injections.(690, 1771, 1781-1783)

Prolotherapy injections are invasive and have a stated purpose of causing irritation. There are reports of deaths from accidental intrathecal injections,(1771) post-procedure "lumbar puncture headaches,"(1783, 1784) and increased LBP (88%).(690) The intravenous injections (e.g., diazepam, midazolam) given to tolerate the procedure and large volumes of lidocaine used may increase the risks from these procedures. These injections are costly. As the highest quality studies fail to show benefits, these injections are not recommended for the treatment of LBP.

Table 10. Outcomes from Prolotherapy Injections vs. Saline Injections and Exercise vs. Normal Activity among 110 Chronic LBP Patients

	VAS Baseline (0-100)	VAS at 1 year Follow up	Roland-Morris Disability Score at Baseline (0-23)	Roland-Morris Disability Score at 1 year Follow up
Injection glucose and lignocaine	51.9	18.6	13.7	5.5
Injection of saline	55.0	18.4	14.3	4.5
Exercise	54.6	20.5	13.0	4.8
Normal activity	52.3	16.5	15.0	5.1
	VAS baseline	VAS at 2-year follow-up	Roland-Morris disability score at baseline	Roland-Morris disability score at 2-year follow-up
Injection glucose and lignocaine	51.9	18.4	13.7	4.9
Injection of saline	55.0	16.4	14.3	4.2
Exercise	54.6	18.0	13.0	3.9
Normal activity	52.3	16.6	15.0	5.2

Adapted from Yelland MJ, Glasziou PP, Bogduk N, Schluter PJ, McKernon M. *Spine*. 2003.

Evidence for the Use of Prolotherapy Injections

There is 2 high-(1781, 1782) and 5 moderate-quality(1328, 1413, 1753, 1771, 1783) RCTs incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: prolotherapy injections, proliferation therapy, regenerative injection therapy, subacute low back pain, chronic low back pain, radicular pain, and sciatica to find 465 articles. Of the 465 articles, we reviewed 16 articles, and included 12 (6 RCTs and 6 systematic reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Prolotherapy Injections vs. Saline						
Yelland 2003 RCT No industry sponsorship or COI.	10.0	N = 110 with chronic LBP mean durations 13.8 to 14.8 years	2 arms: prolotherapy injections (20% glucose/0.2% lignocaine with 4ml 50% glucose, 1ml 2% lignocaine, 5ml water) (n = 54) vs. NS injections (n = 56). 2 sagittal loading exercises (10 reps, 4x a day for 6 months) vs. normal activity. Follow-up at 6 months.	Only difference found at months with group proportions, with 0 disability 0.15 for glucose-lignocaine and 0.02 for saline.	"In chronic nonspecific low-back pain, significant and sustained reductions in pain and disability occur with ligament injections, irrespective of the solution injected or the concurrent use of exercises."	Study suggests no differences in placebo, prolotherapy, or described exercises for chronic LBP. Data suggest prolotherapy ineffective.
Ongley 1987 RCT No mention of industry sponsorship or COI.	7.5	N = 81 with chronic LBP mean duration 10 years	Dextrose 25%, glycerine 25%, phenol 2-5%, and pyrogen-free water to 100% and diluted in 0-5% plain lignocaine hydrochloride (n = 40) vs. 0-9% saline (n = 41). Each patient received 6 injections of 20ml of same solution weekly. Follow-up at 0, 1, 3, 6 months.	At 6-months, 15 in experiment group 0 disability vs. 4 controls (p <0.003). Disability scores (entry/6 months): placebo (11.82±0.92/8.29± 1.10) vs. experimental (11.45±0.83/3.43 ±0.72), p <0.001. VAS pain scores: placebo (3.99± 0.19/ 3.08±0.28) vs. experimental (3.78±0.19/ 1.50±0.21), p <0.001. Pain (grid): (10.27± 1.6/8.24± 1.20) vs. (10.1±1.24/ 3.6± 0.37), p <0.001.	"[T]he experimental regimen is a safe and effective treatment for chronic low back pain."	Treatment groups differed by more than injections, differences cannot be ascribed to 1 intervention. States prolotherapy group also injected with triamcinolone, although methods section does not note that, thus appears to be another difference between groups. Too many flaws to be usable for guidance.
Klein 1993 RCT Supported by Santa Barbara Cottage Hospital, Sansum Medical Research Foundation, Sansum Medical Clinic, Max and Amy Klein, Dr. and Mrs. Farouk Akhadar, Mr. and Mrs. Bernard Fauber, K-mart corporation, additional donations from patients/friends.	7.5	N = 79 with chronic LBP duration ≥6 months who failed to respond to prior conservative treatment	Dextrose 25%, glycerine 25%, and phenol 2.4% made up to 100% with pyrogen-free water; 15ml mixed with 15ml of 0.5% lidocaine (n = 39) vs. 15ml 0.5% lidocaine with 15ml of normal saline (n = 40). All given flexion and extension exercises and prescribed brisk walking (at least 1 mile 5 days a week). Follow-up at 6 months.	Both groups improved (p <0.001) for VAS, pain grid, and disability scores. At 6 months, proliferant group favored for pain grid scores (p = 0.025), VAS (p = 0.056), and disability score improvements (p = 0.068).	"Injections into these tissues of a solution of dextrose-glycerine-phenol known to induce collagen proliferation appear to be a useful form of treatment in appropriately selected cases. Multicenter studies utilizing longer follow-up periods and larger groups of patients are needed to clarify the safety and efficacy of this treatment approach."	Data suggest prolotherapy group had lower pain and less disability. Data suggest lack of efficacy.

No mention of COI.						
Dechow 1999 RCT Study founded by South and West Region Research and Development Programme. No mention of COI.	6.5	N = 74 with chronic LBP of at least 6 months	Three once weekly injections 5ml dextrose 25%, glycerine 25%, phenol 2,4% made up to 100ml with sterile water with 5ml of 1% lignocaine (n = 36) vs. once weekly injection of 5ml saline plus 5ml 1% lignocaine (n = 38). Injections to L4-5 and L5-S1. Follow-up 0, 1, 3, and 6 months.	No significant difference in any measure over a 6-month follow-up period.	"[F]ollowing three, weekly sclerosant injections to the lumbar spinal ligaments we have been unable to demonstrate improvement in pain, self-reported function, somatization, depression or spinal flexion in patients with undifferentiated chronic pain…"	Data suggest lack of efficacy.
Pach 2011 Double-blind RCT Supported by grant from WALA Heilmittel GmbH. No mention of COI.	8.0	N = 150 with chronic LBP for ≥12 months, average intensity ≥40mm on VAS, no other therapy than NSAIDs and muscle relaxants.	(Verum)Treatment group 10ml of solution injected in 5-10 small dosages SQ with 0.4mm needle into painful sites on lower back + Disci/Rhus toxicodendron compositum 12 treatments, 4 weeks 2x/week + 1 treatment a week for 2nd 4 weeks (n = 51) vs. Placebo group injection with NS + hydrogen carbonate + water (n = 48) vs. No treatment received no additional intervention (n = 51).	Average pain and VAS: 37.0, 97.5% CI (25.3-48.8) in the verum group vs. 53.0 (41.8-64.2) in no-treatment vs. 41.8 (30.1-53.6) in placebo and VAS lower in no-treat group, p = 0.001, and no difference between verum and placebo, p = 0.350. At 26 weeks pain sensitivity/reported ad verse events: (did not differ significantly)/(15.7% verum vs. 15.7% placebo, p = 0.546, cold 17.6^ vs. 10.4%, pain 33.3% vs. 35.4%, p = 0.814).	"The homeopathic preparation was not superior to placebo."	Some baseline differences. Blinding not well described. Includes no treatment arm (non-attention bias). Data suggest lack of efficacy for injections.
Mathews 1987 RCT Study received financial help from Department of Health and Social Security and Special Trustees of St. Thomas' Hospital. No mention of COI.	4.0	N = 22 with low backache and local tenderness	Phenol 2.5%, dextrose 25%, glycerine 30% in distilled water (PDG), each injection 4ml PDG, 6ml 0.5% procaine, injected with 1ml each into L4-S1 levels left and right iliolumbar ligaments at posterior superior iliac spine, 1.5ml into deep posterior sacroiliac ligaments, 1.5ml into superficial posterior sacroiliac ligaments along iliac crest, 1.5ml into right and left sacroiliac ligaments (n = 16) vs 10ml 0.5% procaine into tender spot (n = 6). Follow-up 3, 6, 12 months.	No differences. At 3 months, 10/16 in treatment group vs. 2/6 placebo had recovered.	"It seems possible that sclerosant injection may have a worthwhile clinical effect, but a large study would be needed to confirm this."	Small numbers, especially in controls. Traction patients more likely to require surgery. Study population does not clearly distinguish clinical sciatica, rather may include thigh pain.
Prolotherapy for Sacroiliac Joint						
Kim 2010 RCT	5.5	N = 50 with pain in buttock, groin, or thigh	Prolotherapy which consisted of injection 2.5mL of 25% dextrose solution into sacroiliac joint (SI joint) every other week repeated	Significant difference in number of injections required for treatment 2.7 vs. 1.5 for prolotherapy and steroid	"Intra-articular prolotherapy with 5% dextrose water may be useful for the long-term relief of SI joint pain."	High opioids use in steroid group (24 v 14%). Data suggest prolotherapy superior to steroid

No industry sponsorship or COI.		at least 2 months.	up to 3 weeks, (n = 24) vs. SI joint intra-articular injection which consisted of injection of 40mg triamcinolone acetonide in 0.125% levobupivacaine 2.5mL, (n = 26).	respectively ($p < 0.01$) and percentage of positive responses at 6/10/15 months: 63.6/58.7/58.7 (in respective months) for prolotherapy and 27.2/10.2/10.2 for steroid group ($p < 0.01$). Numerical rating scale for pain went from 6.3±1.1 to 1.4±1.1 for prolotherapy group and 6.7±1.0 to 1.9±0.9 for steroid group ($p < 0.001$) at 2 weeks, both significant changes. Oswestry disability index also made significant change in both groups with scores going from 33.9±15.5 to 11.1±20.0 for prolotherapy and 35.7±20.4 to 15.5±10.7 in steroid group. All patients had reduced pain by at least 50% at 2 weeks.		injection, but study may be fatally confounded.

BOTULINUM INJECTIONS

Botulinum injections have been used to produce muscle paresis and have anti-nociceptive properties.(1785) Adherents beliefs include that this "rest through weakness" is useful as a treatment for a number of musculoskeletal disorders including LBP.(1786, 1787) It has been used for upper back and myofascial pain,(690, 1788, 1789) LBP,(1787, 1790-1792) and piriformis syndrome.(1715, 1786, 1793-1798)

Recommendation: Botulinum Injections for Treatment of Chronic Low Back Pain

There is no recommendation for or against the use of botulinum injections for treatment of acute, subacute, or chronic low back pain or radicular pain syndromes or other low back-related problems.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**

Level of Confidence – Low

Rationale for Recommendation

Two high-quality studies directly conflict, with one suggesting benefits(1799) while the other suggesting no benefits.(1794) One moderate-quality trial suggested benefits.(1796) Thus, the quality data conflict and there are no sizable quality studies with long-term follow-up. It is concerning that these injections induce weakness, yet many of the most successful interventions identified in systematic reviews in other sections of this guideline build strength and/or endurance. Botulinum injections are invasive, have adverse effects that include fatalities,(1799) and are costly and with conflicting data have no recommendation.

Evidence for the Use of Botulinum Injections

There are 2 high-(1794, 1799) and 2 moderate-quality(1796, 1800) RCTs incorporated into this analysis. There are 2 low-quality RCTs in Appendix 1.(1795, 1801)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms: botulinum injections, botulinum toxin A, subacute low back pain, chronic low back pain, spinal stenosis, spinal fractures, sacroiliitis or spondylolisthesis to find 1,898 articles. Of the 1,898 articles, we reviewed 5 articles and included all 5 articles (4 RCTs, 1 prospective study).

Author/Year Study Type COI	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Foster 2001 RCT No mention of industry support or COI.	10.5	N = 31 with chronic LBP lasting 6 plus months, pain between L-1 and S-1, and pain either unilateral or on one side showing predominance	Botulinum injections 200 units, 40 units/site (n = 15) vs. normal saline (n = 16) with follow-up 3 and 8 weeks. All injections 40 units at L-1 to L-5 or L-2 to S-1, injected only once unilaterally.	At 3 weeks, degree of pain relief exceeded 50% in 11/15 (73.3%) vs. 4/16 (25%) (p = 0.012). At 8 weeks, 9/15 (60%) for Botox vs. 2/16 (12.5%) for saline (p = 0.009). At 8 weeks 10/15 Botox group vs. 3/14 saline reported improvement (p = 0.011).	"Paravertebral administration of botulinum toxin A in patients with chronic low back pain relieved pain and improved function at 3 and 8 weeks after treatment."	Small numbers excluded workers' comp, litigation or "secondary groups." No mention co-interventions. Lack of details, difficult to assess validity of results. Needs replication.
De Andrès 2010 RCT No mention of industry support or COI.	8.5	N = 27 with LBP >6 months duration, age 20-70, with bilateral TrPs, intense pain resulting from applying moderate pressure to TrP, and/or failure of medical/PT to alleviate pain.	5mL BTX-A IM injection (in affected back muscles only) with NaCl 0.9% (n = 14) vs. with bupivacaine 0.25% (n = 13) contralaterally. Follow-up at 15, 30, 90 days. Ease of daily life activities and psychologic status assessed via Lattinen, Oswestry, STAI, HAD-A, HAD-D, and VAS scales.	Baseline to 90 days, post-inj: Lattinen- 13.3±2.3& 12.2±2.5; p = 0.078, Oswestry- 27.6±8.2& 26.0±9.1; p = 0.085, STAI- 75.1±22.3& 67.0±17.8; P=0.022, HADA- 9.6±5.4 & 9.2±4.1; P= 0.673, HADD- 7.41±4.5 and 8.0±4.2; p = 0.484. Reduction of VAS scores: 20% at 15 days (95% CI 0.46-2.43, p = 0.006), 20% at 30 days,(95% CI, 0.58-2.24, p = 0.002), 22% at 90 days (95%CI, 0.67--2.52; p = 0.002)	"Although BTX-A seems to provide significant pain relief at 15, 30, and 90 days after intervention, this trial has not been powered to detect small, non-clinically relevant differences among the studied treatments. Considering the high cost of BTX, it seems reasonable to reserve its use only when conventional medical and interventional procedures fail."	Data suggest no benefit.
Jabbari 2007 RCT No mention of industry support or COI.	5.0	N = 106 divided into 2 separate studies: study 1: n = 31 age 20-73, unilateral or primarily lateralized LBP >6 months, MRI of lumbosacral area, LBP unrepsonsive to conventional pharmaceutical treatment. Study2: n = 75 age 21-75 met Study 1inclusion criteria. Most diagnosed bilateral LBP.	Study 1: (n = 15) 200 U of BTX-A 40U in 5 INJ sites (L1-L5) vs NS control (n = 16) in 5 sites. Pain assessed via VAS, PIQ, OLPBQ at 3, 8 weeks. Study 2: open label (n = 75): A 40-50U dose into L1-S1 uni or bilaterally with extra injected laterally into erector muscles at level of most discomfort (total dose per session 200-500U). Pain assessed via VAS, PIQ, OLBPQ at baseline, 3 weeks, 2, 4, 6, 8, 10, 12, 14 months with BTX-A re-injections if pain returned post 4 months.	Study 1: baseline to 3 weeks 73.3% of BTX-A patients reported >50% pain relief, 25% of controls >50% relief (p = 0.012). 8 weeks, 66.67% of BTX-A and 12.5% of controls (p = 0.011) showed improvement. Study 2: In mean VAS and mean Oswestry scores compared with baseline at 2 months after injection (p <0.005) yielded significant improvement. 91% continued to improve over length of study.	"The novel protocol used in our clinical trials provided pain relief in 50% of the patients with refractory LBP… Botulinum neurotoxin therapy is a reasonable alternative to medications with high side effect profiles."	Population not well described and few data provided suggest differences between groups. Many details sparse. Limited data suggest Botox superior to placebo.
Moghtaderi 2011 RCT No mention of COI or industry sponsorship.	5.0	N = 50 with chronic LBP for ≥6 months	Group I (n = 25) treated with BoNT-A (5 injections of 40 Ipsen Unites each) vs. Group II (n = 25) treated with saline.	Week 8, 64% in BoNT-A group pain relief vs. 20% in saline (p <0.005); 68% BoNT-A group showed clinical improvement vs. 12% in saline group. (p <0.005).	"BoNT-A improves CLBP with a low incidence of side effects and can be used as a therapeutic tool in the management of these patients."	Sparse details with baseline data.

RADIOFREQUENCY NEUROTOMY, NEUROTOMY, AND FACET RHIZOTOMY

Facet joints (aka zygapophysial joints) have been thought to be the source of pain for some patients with chronic LBP.(1802-1807) Patients who experience pain relief from the injection of anesthetic along the nerve roots innervating the joints ("diagnostic blocks") have been considered candidates for various neurotomy procedures.(1808) Surgical neurotomy involves the transecting or cutting of the nerves supplying the facet joints. Less invasive procedures involving electrodes to create nerve lesions (denervation) have largely replaced this surgical procedure.(1804)

Radiofrequency neurotomy involves the use of a radiofrequency electrode to create a heat lesion to coagulate the nerve supplying the joint. If the theory is correct and the patient is correctly diagnosed, the procedure will result in complete relief of LBP. If there are other sources of pain that have other nerves for conduction of pain impulses or the radiofrequency (RF) lesion does not encompass the nerve due to either anatomic variants or technical errors, the procedure is thought to be less successful or not at all successful.(1712, 1809)

1. *Recommendation: Radiofrequency Neurotomy, Neurotomy, or Facet Rhizotomy for Treatment of Chronic Low Back Pain*

   Radiofrequency neurotomy, neurotomy, or facet rhizotomy are not recommended for treatment of patients with chronic LBP confirmed with diagnostic blocks, but who do not have radiculopathy and who have failed conservative treatment. (64% panel agreement; 36% of panel agreed with limited indications as indicated below.)

   Indications – Patients with chronic LBP without radiculopathy who failed conservative treatments and who have had a confirmed diagnosis by medial branch blocks.(1810)

   Frequency/Duration – One procedure might be tried as an option after failure of non-invasive treatments including NSAIDs and a quality exercise program or as a means to help with participation in an active rehabilitation program. There is no recommendation for repeated procedures. It is reasonable to attempt a second lesion after 26 weeks in patients who had greater than 80% improvement in pain from first procedure for the first 8 weeks with a late return of pain.(1811) There is no recommendation for a third or for additional procedures. There is logically a limit as to how many times it is possible to permanently destroy the same nerve.

   Indications for Discontinuation – Resolution of symptoms. If there is no response to the first procedure, there is no evidence that a second lesion will be beneficial.

   Benefits – Possible pain reduction
   Harms – Medicalization, procedural complications. Successful denervation of joints should increase risk of Charcot joints.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence –Low

2. *Recommendation: Radiofrequency Neurotomy, Neurotomy, or Facet Rhizotomy for Treatment of Other Lumbar Spinal Conditions*

   Radiofrequency neurotomy, neurotomy, or facet rhizotomy are not recommended for treatment of all other lumbar spinal conditions.

   Strength of Evidence – **Not Recommended, Evidence (C)**
   Level of Confidence – Low

Rationale for Recommendations

High-quality studies supporting surgical neurotomy using sham were not found. The highest quality, sham-controlled studies are largely negative.(1812, 1813) Another moderate quality study of RF added to steroid injection also found nearly all measures (e.g., ODI, NRS, MQS) were negative between groups (2421). The largest sized trial found neurotomy ineffective compared with an exercise program

for treatment of LBP, or SI joint pain or intervertebral disc pain (2422). The next lower quality study is more favorable, but used unconventional statistical testing with 90% confidence intervals, rendering it unusable(1814) and the next study suffered an apparent randomization failure.(1815) Two comparative trials found comparable (in)efficacy with intraarticular glucocorticoid injections which also appear ineffective, which suggests the procedure may have no significant benefit (see above) (2416, 2417).The lowest quality study had worrisome results in the placebo.(1816) There is a poor correlation between pain relief from a block and relief from radiofrequency neurotomy (2423). Available systematic reviews also discuss additional significant methodological concerns.(60) These concerns further limit the robustness of conclusions. As results are permanent, there should be good evidence of long-term benefit prior to recommending this procedure. Permanently denervated joints in the appendicular skeleton are called Charcot joints, and over long-term follow-up they do not do well; there are no long-term results reported for those potential adverse effects. All studies suggested the need for further research.

The theoretical basis of cutting or ablating nerve fibers seems sound as procedures that eliminate the pathway to conduct sensations of pain should be effective for the treatment of chronic pain syndromes. However, the history of cutting or otherwise ablating nerves to treat numerous pain conditions throughout the body is suboptimal, with a not infrequent increased risk for developing additional chronic pain problems(1817) that were only widely recognized after long-term follow-up studies were reported. There have been many attempts at this type of procedure over several decades. However, perhaps due to pain fiber regeneration, alternate pathways for conduction, phantom pain, ongoing neurological stimulation, and/or conduction from the transected or ablated nerve fibers, no procedure to date has been shown to be effective for the treatment of pain that involves cutting or ablating nerve fibers. An interesting finding in two of these studies is the possibility that patients with higher degree of successful blocks, (e.g., >80%) as opposed to the 50% threshold that is more widely employed, have better outcomes.(1814, 1816) However, as this has not been proven, it cannot be adopted as guidance at this time.

It is noteworthy how few patients thought to be candidates for the procedure actually have successful blocks (43.5%[679] to 54.3%(1813)). This suggests that the number of patients who could be successfully treated with this therapy, especially if the supposition in the prior paragraph proves true and the procedure is proven effective, would likely be quite small.

Radiofrequency lesioning is invasive, has adverse effects, and is costly. With the highest quality studies mostly suggesting a lack of efficacy, the overall evidence base does not support this treatment. Additional quality research is needed in this area as outlined above, as it is currently an experimental procedure for purposes of treating acute, subacute, and chronic LBP, and radicular pain syndromes and/or "discogenic" LBP. There are no quality studies identified to support surgical neurotomy or rhizotomy and thus they are not recommended.

Evidence for the Use of Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy
We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates then an updated search was done in PubMed for publication between 1/1/2013 and 11/15/2017. We used the following terms: radiofrequency neurotomy, neurotomy, facet rhizotomy, subacute low back pain, chronic low back pain, low back pain, back, random. Of the 389 articles, we reviewed 58 articles and included 58 articles (31 are randomized controlled trials and 29 systematic reviews).*

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Leclaire 2001 (score= 10.0)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	Sponsored by Institut de recherché en sante et securite du travail du Quebec. COI, industry COI (category: 14).	N = 70 with LBP >3 months duration	Mean age: 46.6 years; 25 male, 45 female.	Neurotomy sites anesthetized then RRE electrode introduced to medial branch of distal portion of spinal posterior rami nerve, set at 5 Hz with 0.5msec pulse duration. Temperature raised to 80°C for 90 seconds. For each nerve, 2 neurotomies performed, 1 at proximal portion, other distal portion of articular facet nerve, usually at L4-L5 and L5-S1 unilaterally (n = 36) vs. same procedure but electrode temperature 37°C (n = 34).	Follow-up 4 and 12 weeks.	No significant differences found.	"Radiofrequency facet joint denervation in the treatment of chronic low back pain has not proved to be effective, as determined by the functional disability at 12 weeks, the principal outcome measure of this study. However, before excluding this therapeutic approach to low back pain, other studies with stricter inclusion criteria regarding the face origin of the pain must be conducted."	Baseline characteristics did not include duration of LBP. Data suggest no intermediate or long term (>4 weeks) benefit to radiofrequency facet denervation for LBP in patients with positive response to diagnostic facet joint injections.
Jena 2016 (score= 8.0)	Radiofrequency	RCT	Sponsored by Nil. No COI.	N = 40 patients with chronic discogenic low back pain.	Mean age: 40.3 years; 22 male, 18 female	CRF plus intradiscal triamcinolone 40 mg (group 1) (n = 20) vs PRF plus intradiscal triamcinolone 40 mg (n = 20)	Follow up at baseline, 1 day, 2, 3, and 4 weeks and 6 months.	Visual analog scale at baseline was 8.7 for group 1 vs 1.9 at month 6 for group 1.	"CRF with steroid seems to be better for treatment of chronic discogenic low back pain than PRF with steroid."	Small sample. Data suggest at 6 months VAS scores improved with CRF group.
van Wijk 2005 (score= 8.5)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	Sponsored by Dutch Health Insurance Council. No mention of COI.	N = 81 with continuous LBP with or without radiating pain into upper leg for >6 months with focal tenderness over facet joints	Mean age: 47.5 years; 23 male, 58 female.	Radiofrequency (RF) facet joint denervation, 10cm electrodes, 3 each site of dorsal ramus medial branches of relevant facet joints. Stimulation 50 and 2 Hz. Sensory and motor stimulation required <0.5V to at least 2V. 0.5mL mepivacaine 2% injected through each electrode, treated with 80°C, 60 seconds (n = 40) vs. sham (same treatment no current, n = 41).	Follow-up 1 year, blinding ended at 3 months.	Global perceived effect showed difference favoring RF group for female patients (p = 0.018), older patients (p = 0.022), patients with longer pain history (p = 0.019), patients with employment (p = 0.008), and patients without back surgery (p = 0.032).	"[RF] lumbar facet joint denervation appears to have a better effect compared with sham treatment in a selected group of patients. Future research should be directed toward improvement of RF technique and psychologic profile evaluation as part of a selection procedure for RF treatment."	Successful blockade of lumbar facet joints required (50+% decrease in pain). Non-significant differences at baseline suggesting RF group less severely affected than control population. Some results, particularly gender, not explained.

Patel 2012 (score= 8.0)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	No sponsorship or COI.	N = 51 with chronic sacroiliac joint, or axial back, pain >6 months with positive responses to dual lateral branch blocks , age 18-88.	Mean age: 58.7 years; 14 male, 37 female.	Treatment group receiving radio frequency energy while under local anesthetic and moderate sedation (n = 34) vs. Placebo group: local anesthetic and moderate sedation with sham treatment (n = 17).	Follow-up analysis of treatment success at 1, 3, 6, and 9 months.	Changes in pain, disability, quality of life, physical function statistically significant at 3-month follow-up for lateral branch neurotomy treatment group while sham group was not. At measurement point, 47% treated patients and 12% sham showed treatment success. At 6 and 9 months follow-up, 38% and 59% of treated subjects exhibited treatment success.	"The treatment group showed significant improvements in pain, disability, physical function, and quality of life as compared with the sham group. The duration and magnitude of relief was consistent with previous studies, with current results showing benefits extending beyond 9 months."	Required 75% relief of index pain between 4 hours and 7 days to consider neurotomy. Data suggest short-to-intermediate-term efficacy that diminishes over time.
van Kleef 1999 (score= 7.0)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	Sponsored by Nederlandse Organisatie voor Wetenschappelijk Onderzock (NWO). No mention of COI.	N = 31 with chronic LBP at least 1 year duration and reported ≥50% pain relief with diagnostic dorsal rami nerve blocks	Mean age: 43.9 years; 11 male, 20 female.	Sixty second radiofrequency lesion of 80°C of medial branch of posterior primary ramus of segmental nerves L3-L5 on one or both sides (N = 15) vs. Electrodes placed, but no RF lesion (n = 16).	Follow-up at 3, 6, and 12 months.	Rate of successes higher in RF group. For all secondary outcomes, lesion group had better results (p = 0.003). At 3, 6, and 12 months, number of successes in RF lesion and sham groups was 9 and 4, 7 and 3, and 7 and 2, respectively (p = 0.02).	"Radiofrequency lumbar zygapophysial joint denervation results in a significant alleviation of pain and functional disability in a select group of patients with chronic low back pain, both on a short-term and a long-term basis."	Of initially eligible 40/92 (43.5%) had positive responses on diagnostic blocks, but 90% CIs selected for reporting. Appears data would have been statistically negative for additional measures with 95% CIs. Confidence bounds on point estimates expansive (even with 90% bounds) suggests confidence in accuracy of point estimate is low.
Koh 2015 (score= 7.0)	Radiofrequency	RCT	No sponsorship or COI.	N = 62 patients with pain intensity of 4 or moure out of 10 on the numerical rating scale, chronic LRP lasting 12 weeks or more, dominant leg pain with less	Mean age: 65.6 years; 21 male, 41 female	Pulsed radiofrequency (PRF) group (n = 31) vs control group (n = 31)	Follow up at 1, 2, 3 and 6 months.	Percentage of patients with successful treatment results at 3 months was 38.7% [95% CI; 23.7–56.2] for the PRF group and 9.7% [95% CI; 2.6–25.7] for the control group.	"The TFEI provided significant short-term pain relief and PRF can be applied in conjunction with TFEI to achieve higher treatment efficacy compared with TFEI."	Baseline differences in weight and pain duration between groups. Data suggest more patients reported treatment success in the PRF group at 6 months versus control.

				intense back pain, and the previous failure of conservative management.						
Kapural 2013 (score= 7.0)	Radiofrequency	RCT	Sponsored by Baylis Medical. No COI.	N = 57 patients with a history of chronic low back pain unresponsive to nonoperation care for longer than 6 months.	Mean age: 39.3 years; 27 male, 30 female	Intradiscal biacuplasty group (n = 27) vs sham group (n = 30)	Follow up at 1, 3, and 6 months.	Mean 6 month change in SF-36 physical functioning for IDB was 15.00 vs 2.63 for sham (p=0.012). Mean 6 month change NRS for pain for IDB was -2.19 vs -0.64 for sham (p=0.014). Mean 6 month change Oswestry disability scale for IDB was -7.43 vs 0.53 for sham (p=0.005).	"The results suggest that the clinical benefits observed in this study are the result of non-placebo treatment effects afforded by IDB. IDB should be recommended to select the patients with chronic discogenic low back pain."	Data suggest IDB better than placebo for improving discogenic LBP.
Kapural 2015 (score= NA)	Radiofrequency	Secondary Analysis	Sponsored by Baylis Medical. No COI.	N = 57 patients with a history of chronic low back pain unresponsive to nonoperation care for longer than 6 months.	Mean age: 39.3 years; 27 male, 30 female	Intradiscal biacuplasty group (n = 27) vs sham group (n = 30)	Follow up at 1, 3, 6, 9 and 12 months.	Mean NRS change at 12 months from baseline was -2.90 (p<0.01).	"Clinically significant improvements after IDB initially reported at 6 months were maintained at 9 and 12 months. The cross-over subjects had similar improvement in all outcome measures at all observed time points."	Secondary analysis of Kapural 2013. Data suggest treatment gains more maintained in the IDB group at 9 and 12 months.
Nath 2008 (score= 7.0)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT/double-blind	No sponsorship or COI.	N = 40 able to notice portion of their pain consistently relieved by medial branch blocks, with even longer lasting relief upon bupivacaine administration, age 36-79 with an average	Mean age: 56 years; 15 male, 25 female.	Active treatment group receiving the radiofrequency neurotomy (n = 20) vs. Placebo group receiving identical treatment, but with a sham electrode (n = 20). After 6 months, the same orthopedic surgeon conducting study re-examined the patients.	Follow up at baseline and 6 months	Active treatment group had baseline VAS score of 6.03 which changed to 4.10 at follow up. This difference of -1.93 has a p-value of 0.002. Placebo group had a baseline VAS score of 4.35 which changed to 3.98 at follow up. This difference of -0.38 has p-value of 0.29.	"Our study indicates that radiofrequency facet denervation is not a placebo and could be used in the treatment of carefully selected patients with chronic low back pain."	Patient demographics not well described but measure of generalized pain (6.03 vs. 4.35), LBP (5.98 vs. 4.38), leg pain (4.33 vs. 2.68) all worse in active group at baseline suggesting randomization failure.

				pain duration of 12 years.				Treatment group demonstrated significant improvements statistically and clinically in categories of "back movement and hip movement, quality of life variables, the sacroiliac joint test, paravertebral tenderness, and tactile sensory deficit."		
Gallagher 1994 (score= 6.5)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	No mention of sponsorship or COI.	N = 41 with chronic LBP suggestive of facet joint origin	No mention of mean age, age 25-55 years; No mention of gender.	Radiofrequency facet joint denervation (anaesthetized with lignocaine 2% 0.5ml) lesion at 80°C for 90 seconds (n = 24) vs. placebo procedure without lesion (n = 17). Patients divided based on results of diagnostic local anaesthetic injections. Group A had good responses to diagnostic blocks and received RF (N = 18), Group B had equivocal responses and received RF (n = 6), Group C had a good response and received placebo (n = 12), and Group D had equivocal responses and received placebo (n = 5).	Follow-up at 1 and 6 months.	Only significant difference was between group A with group C favoring A and based on VAS at 1 (34±6.9 vs. 60±9.8) and 6 months (44±7.2 vs. 70±8.5), p<0.05 for both. McGill Pain Questionnaire scores favored A over C with a significant difference at 1 month (9±2.3 vs. 16±2.8), p <0.05.	"[T]his study has demonstrated improvement in pain scores following facet joint denervation when compared with controls and confirms its place as a useful tool in the management of mechanical low back pain."	Baseline data scant. Those with "good response" to local injection had benefits in pain scores after treatment (30% of original 60 thought to have facet joint pain). Positive response of those who had an equivocal response to block and in placebo group not noted in table to be statistically significant, but data as recorded are statistically significant and concerning. McGill pain scores not significant at 6 months and do not support conclusions.
Lakemeier 2013 (score= 6.5)	Radiofrequency	RCT	No sponsorship or COI.	N = 52 patients suffering from LFJ-related pain at the L3/L4-L5/S1 segments.	Mean age: 57.0 years; 33 male, 19 female	LFJ steroid injection group (n = 26) vs RF denervation group (n = 26)	Follow up at 6 months	Reduction of VAS after 6 months was 5.4 for LFJ group and 4.7 for RF group (p=0.6)	"Intraarticular steroid infiltration or radiofrequency denervation appear to be a managing option for chronic function-limiting low back pain of facet origin with favorable shortand midterm results in terms of pain relief	Baseline differences in VAS scores. Data suggest comparable efficacy.

									and function improvement, but improvements were similar in both groups."	
Arsanious 2016 (score= 6.5)	Radiofrequency	RCT	No sponsorship or COI.	N = 55 with previously diagnosed back pain from facet joint disease, pain for 6 months or greater, with an average pain level of 4 or greater on a numerical pain scale.	Mean age: 51.3 years; 15 male, 40 female	Thermal radiofrequency ablation alone group (n = 26) vs pulsed dose radiofrequency (PDRF) followed by thermal radiofrequency ablation(n = 29)	Follow up at 1 and 2 days.	Pain level of PDRF group on day 1 in the morning was 2.38 followed by 3.08 Day 1 in the evening, then 2.31 day 2 in the morning and 2.6 on day 2 in the evening.	"Treating patients with pulsed dose radiofrequency prior to continuous thermal radiofrequency ablation can provide patients with less post-procedural pain during the first 24 hours and also reduce analgesic requirements. Furthermore, the addition of PDRF to standard thermal RFA did not prolong the time of standard thermal radiofrequency ablation procedures, as it was performed during the typically allotted time for local anesthetic action."	Predominantly female participants. Data suggest PDRF pre-ablation may improve pain and decrease analgesic requirements for the first 24 hours.
Hashemi 2014 (score= 6.0)	Radiofrequency	RCT	No mention of sponsorship or COI.	N = 80 patients screened with use of ultrasound-guided MBB who had pain relieved after ultrasound MBB injection of lidocaine.	Mean age: 64.1 years; 45 male, 35 female	PRF group (n = 40) vs 1 ml triamcinolone (steroid) group (n = 40)	Follow up at 3 6 and 12 months.	Mean NRS for low back pain for PRF group was 7.4 pretreatment vs 2.4 at 6 months (p=0.035). NRS at 6 months was superior in the PRF vs the steroid group (p=0.02)	"Our results demonstrated that the application of PRF might be more effective than steroid and bupivacaine injection in decreasing back pain due to degenerative facet pain and improvement in function of patients."	Claims treat or blinding. Data suggest PRF better for facet pain vs steroid at 6 months.
van Tilburg (score= 6.0)	Radiofrequency	RCT	No mention of sponsorship. No COI.	N = 60 patients with a history and physical examination suggestive of facet joint pain and a decrease of greater than	Mean age: 61.5 years; 26 male, 34 female	Percutaneous radiofrequency group (n = 30) vs sham group (n = 30)	Follow up at 1, 3, 6, and 12 months	Group x period for NRS for treatment vs Sham was F(1,58) = 0.393; p=0.53. The same for GPE satisfaction F(1,58)=1.23; p=0.27. And for GPE	"The null hypothesis of no difference in the decrease in pain and in GPE between the treatment and sham groups cannot be rejected. Post hoc analysis revealed that	Baseline differences in age between groups. Sham group allowed to crossover after 3 months if no improvement in pain. Data suggest apparent lack of efficacy.

				or equal to 2 on a numerical rating scale after a diagnostic facet joint test block.				recovery F(1,58)=0.09;p=0.77.	the age of the patients and the severity of the initial pain significantly predicted a positive outcome."	
Manchikanti 2010 (score= 6.0)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT/Double-blinded	No mention of sponsorship. No COI.	N = 120 with history of function limiting, chronic LBP at least 6 months with positive results to controlled diagnostic lumbar facet join nerve blocks with at least 80% concordant pain relief and ability to perform previously painful movements	Mean age: 47 years; 48 male, 72 female.	Treatment group received bupivacaine with steroids and subcategorized with half receiving Sarapin as well (n = 60) vs. lacebo group bupivacaine without steroids and subcategorized with half receiving Sarapin as well (n = 60).	Follow-up at 3, 6, 12, 18, and 24 months after treatment.	Average pain scores (Mean ±SD) for placebo group: baseline 8.2±0.8, 3 months 3.8±1.3, 6 months 3.6±0.5, 12 months 3.7±1.7, 18 months 3.5±1.5, 24 months 2.5±1.5. Average pain scores (Mean±SD) treatment group: baseline 7.9±1.0, 3 months 3.5±1.1, 6 months 3.3±0.8, 12 months 3.5±1.1, 18 months 3.3±1.0, 24 months 3.2±0.9. Functional assessment Oswestry Disability Index Scores (Mean±SD) placebo group: baseline 26.6±4.6, 3 months 12.7± 4.7, 12 months 12.3±4.8, and 24 months 12.0±4.9. Functional assessment value Oswestry Disability Index Scores (Mean±SD) treatment group: baseline 25.9±5.0, 3 months 13.5±5.6, 12 months 12.0± 5.4, 24 months 11.0±4.8.	"Therapeutic lumbar facet joint nerve blocks, with or without steroids, may provide a management option for chronic function-limiting low back pain of facet joint origin."	2nd year follow up of same study participants.
Dobrogowski 2005	Radiofrequency Neurot	RCT	No mention of sponsorship or COI.	N = 45 with chronic LBP >6 months, age 18-85.	Mean age: 66.4 years; 23	Group 1 (n = 15) 1ml with 10mg methylprednisolone vs. Group 2 (n = 15) with 1ml 10mg pentoxifylline	Follow-up at 1 week, 1 month, 3	No differences in pain relief between 3 groups. Patients (n = 36) reported >50%	"Our study confirmed previous results and demonstrated that radiofrequency medial	Small groups. Data suggest lack of efficacy of either medicine.

(score= 5.5)	omy, Neurotomy, and Facet Rhizotomy			Required clinical features consistent with possible lumbar zygapophysical joint pain >2 lumbar segments unilaterally, and significant pain relief after 2 controlled diagnostic blocks.	male, 22 female.	vs Group 3 (n = 15) with 1ml of 10mg NS.	months, and 6 months.	pain reduction after procedure, and (n = 27) >50% pain reduction after 6 months.	branch neurotomy was an effective method to treat low back pain originating from the zygapophysial joints. Intraoperative local injection of both methylprednisolone and pentoxifylline did not significantly influence the outcomes of the procedure, however, it tended to decrease the frequency of postoperative pain that manifested as local tenderness and soreness."	
Sanders 1999 (score= 5.5)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	No mention of sponsorship or COI.	N = 34 with at least 50% pain reductions on diagnostic facet block for LBP	Mean age: 62.3 years; 25 male, 9 female.	Percutaneous intra-articular facet denervation (PIFD) with electrical stimulation at 50Hz (n = 17) vs. Percutaneous extra-articular facet denervation (PEFD) with injection of lidocaine 2% 1mL, 3RF lesions (60 s, 22 volts) made (n = 17).	Follow-up 4 days before and 3 months	Result for PIFD with total mean VAS scores, COOP/WONCA and OLQ were significantly better than PEFD ($p < 0.01$).	"[O]n theoretical and clinical grounds in patients suffering from chronic low back pain, positively responding to a diagnostic blockade, the percutaneous intra-articular facet denervation RF technique is superior to the percutaneous extra-articular facet denervation."	Numbers of facet joints diagnostically blocked not noted. Short-term follow-ups. Given data suggest intra-articular facet denervation superior.
Chang 2017 (score= 5.5)	Radiofrequency	RCT	Sponsored by 2016 Yeungnam University Research Grant. COI not mention.	N= 50 patients with chronic lumbosacral radicular pain.	Mean age= 60.6 years; 26 males, 24 females.	Bipolar pulsed radiofrequency group (n=25): Procedure included patients put in prone position for C arm fluoroscopy and two 22 gauge curved-tip cannulae placed bilaterally around the DRG. When a tingling sensation is detected at less than 0.3 V then treatment is administered at 5Hz and a 5-ms pulsed width for 360 secs. At	Follow up at 1, 2, and 3 months.	Bipolar PRF Mean NRS score: 1 month (2.5± 1.5), 2 months (2.6±1.6), 3 months (2.6±1.7). vs Monopolar PRF Mean NRS score: Pretreatment (4.6±0.8) 1 month (3.0±1.5), 2 months (3.0±1.5), 3 months (3.0±1.5)	"The use of bipolar PRF on the DRG can be an effective and safe interventional technique for chronic refractory lumbosacral radiculopathy, particularly in patients whose pain are refractory to epidural steroid injection or monopolar PRF stimulation."	Sparse methods. Data suggest bipolar PRF better than monopolar PRF at 3 months.

						45V with a limit of 42°C for the electric tip Vs. Monopolar pulsed radiofrequency group (n=25): Procedure preparation the same as group bipolar PRF. A 22 gauge curved-tip cannula was placed around the DRG. Treatment is the same as bipolar PRF.				
Patel 2016 (score= 5.0)	Radiofrequency	RCT	Sponsored by Baylis Medical, COI not mention.	N= 51 patients with sacroiliac region pain.	Mean age= 58.6 years; 14 males, 37 females.	Cooled Radiofrequency denervation and Lateral branch neurotomy (LBN) group(CRF/LBN) (n=34): receive radiofrequency(RF) at 60°C during procedure Vs Sham group (n=17): Did not receive radiofrequency during procedure (RF). Sham group is offered CFR/LBN treatments after 3 months. All patients received fluoroscopy (c-arm) and received local anesthetic (0.5 mL of 2% lidocaine and 0.5 mL of 0.75% bupivacaine) and moderate sedation post-operatively.	Follow up at 1, 3, 6, 9, and 12 months.	LBN group at 12 months ODI score (mean score change -13.9) which is less than at baseline, SF36-PF score (mean score change = 17.4), and AQoL score mean score change (0.07) Sham group at 6 moths ODI score change = -8.8, SF36-BP (change = 11.9), and SF36-PF (change = 11.3), AQoL was favorable (change =0.11)	"These favorable 12-month results illustrate the durability of effective CRF/LBN-mediated treatment of SI region pain for selected patients. Furthermore, successful"	Data suggest at 12months CRF/LBN may be effective in treating sacroiliac region pain.
Juch 2017 (score= 6.0)	Radiofrequency	RCT	Sponsored by the Netherlands Organization for Health Research and Development, the Dutch Society of Anesthesiology, and the Dutch health Insurance companies. COI, one or	Facet joint trial: N = 251 patients who received a diagnostic facet joint block Sacroiliac joint trial: N = 228 patients who received a diagnostic sacroiliac joint block	Mean age: 52.2 years; 260 male, 421 female	Facet joint trial: Radiofrequency denervation group (n = 125) vs control group (n = 126) Sacroiliac joint trial: Radiofrequency denervation group (n = 116) vs control group (n = 112) Combination trial: Radiofrequency denervation group	Follow up at 3 and 6 weeks, 3, 6, 9, and 12 months.	Facet joint trial: Mean difference for primary outcome pain intensity at 3 months was -0.18 (95% CI, -0.76,0.40) Mean difference for functional status at 3 months was -2.45 (95% CI, -5.53,1.03) RR for global perceived recovery at 3 months was 1.35 (95% CI, 0.81,2.05)	"In 3 randomized clinical trials of participants with chronic low back pain originating in the facet joints, sacroiliac joints, or a combination of facet joints, sacroiliac joints, or intervertebral disks, radiofrequency denervation combined with a standardized exercise program resulted in either no improvement or no	Mint trials. Data suggest lack of efficacy at 12 months for all 3 RCTs.

			more of the authors have received or will receive benefits for personal or professional use.	Combination trial: N = 202 patients who received a combination of a diagnostic facet joint block and a diagnostic sacroiliac block.		(n = 103) vs control group (n = 99)		Sacroiliac joint trial: Mean difference for primary outcome pain intensity at 3 months was -0.71 (95% CI, -1.35,-0.06) Mean difference for functional status at 3 months was -4.20 (95% CI, -8.39,-0.002) RR for global perceived recovery at 3 months was 1.87 (95% CI, 1.13,2.71) Combination trial: Mean difference for primary outcome pain intensity at 3 months was -0.99 (95% CI, -1.73,-0.25) Mean difference for functional status at 3 months was -4.66 (95% CI, -10.21,0.89) RR for global perceived recovery at 3 months was 1.99 (95% CI, 0.99,3.36)	clinically important improvement in chronic low back pain compared with a standardized exercise program alone. The findings do not support the use of radiofrequency denervation to treat chronic low back pain from these sources."	
Patel 2016 (score= 5.0)	Radiofrequency	RCT	Sponsored by Baylis Medical. COI, Dr. Patel is a consultant to Kimberly Clark Corp.	N = 51 patients with SI region derived chronic low back pain.	No mention of mean age, ages 18 to 88 years; No mention of gender.	CRF/LBN treatment group (n = 34) vs sham treatment group (n = 17)	Follow up at 12 months.	Mean NRS score change from baseline to 12 months was -2.7 ($p<0.0001$) in the CRF/LBN group and during the same time mean SF36-BP increased by 15.8 ($p=0.006$) in the CRF/LBN group.	"These favorable 12-month results illustrate the durability of effective CRF/LBN mediated treatment of SI region pain for selected patients. Furthermore, successful CRF/LBN treatments in unblinded crossover study subjects demonstrate the unlikelihood that such positive outcomes are attributable to a	Secondary analysis of Patel. Data suggest at 12 months CRF/LBN may be effective in treating sacroiliac region pain.

									"placebo" effect, and suggest that CRF/LBN is an effective therapeutic option for alleviating pain, and improving physical function and quality of life, with few complications"	
Birkenmaier 2007 (score= 5.0)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	No mention of sponsorship or COI.	N = 26 thought to have facet joint mediated chronic LBP, non-sciatic LBP, localized paraspinal pain and localized tenderness to pressure	Mean age: 55.4 years; No mention of gender.	Medial branch blocks 1ml bupivacaine 0.5% (n = 13) vs. Pericapsular blocks 2.0ml bupivacaine 0.5% (N = 13).	Follow up at 6 months.	At 6 weeks and 3 months, LBP pain in medial branch block groups dropped to VAS of 2.2 and 2.3, while capsular group both averaged 4.2. These were only significant differences.	"[U]ncontrolled medial branch blocks are superior to pericapsular blocks in selecting patients for facet joint cryodenervation, but both blocks work." They also noted that if serial controlled blocks cannot be used, "lumbar facet joint pain remains a diagnostic dilemma."	No placebo/control group. Data suggest MBB superior to pericapsular blocks to select for cryodenervation. Small numbers. Overall medial branch blocks and periscapular blocks had similar results.
Joo 2013 (score= 4.5)	Radiofrequency	RCT	No mention of sponsorship, no COI.	N = 40 patients with recurrent thoracolumbar facet joint pain after successful thermal RFA defined as a numeric rating scale score of 7 or more or a revised Oswestry disability index of 22% or more.	Mean age: 68.3 years; 17 male, 23 female	Repeated RFA group (n = 20) vs alcohol ablation(AA) group (n = 20)	Follow up at baseline, 1, 6, 9, 12, 15, 18, 21, and 24 months.	Recurrence ratios during the 23 months following were 19/20 for RFA and 3/20 for AA. Median effective period in RFA was 10.7 vs 24 in the AA group ($p<0.001$)	"In our patient cohort, alcohol ablation in medial branch neurotomy provided a longer period of pain relief and better quality of life than repeated radiofrequency medial branch neurotomy in the treatment of recurrent thoracolumbar facet joint pain syndrome after successful thermal RFA without significant complications during the 24-month follow up."	Data suggest alcohol ablation better than repeated radiofrequency in treating recurrent thoracolumbar facet joint pain.
Moon 2013 (score= 4.5)	Radiofrequency	RCT	No sponsorship or COI.	N = 68 patients with predominantly axial lower	Mean age: 65.4 years; 23	Distal approach group (n = 34) vs tunnel vision approach group (n = 34)	Follow up at 6 months.	NRS at baseline for distal approach was 6.9 vs 4.5 at 6 months ($p<0.00001$).	"Patients who underwent LMBRFD by the tunnel vision or distal approaches	Data suggest at 6 months comparable efficacy.

				back pain for 3 or more noths, paraspinal tenderness overlying the L2-L4 lumbar facet joints, failure to respond to conservative therapy, and concordant pain relief of greater than 50% after a comparative local anesthetic block of .5 mL lidocaine and levobupivacaine hydrochloride.	male, 45 female			NRS at baseline for tunnel vision approach was 6.6 vs 4.5 at 6 months (p<0.00001)	showed significant pain relief at the 6-month follow-up. Less periprocedural pain was reported in the distal approach group. We consider that the distal approach provides an improved option for LMBRFD."	
Moussa 2016 (score= 4.5)	Radiofrequency	RCT	No sponsorship or COI.	N = 120 patients diagnosed with CLBP of a confirmed facet origin.	Mean age: 56.8 years; 33 male, 87 female	RF denervation of the facet joint capsule group (n = 40) vs RF denervation of the medial dorsal branch supplying the facet joint group (n = 40) vs sham group (n = 40)	Follow up at 3, 6, 12, 24, and 36 months.	At 3 year follow up, Mean change in VAS of the back for the joint capsule group was 5.9 vs 2.2 for the medial dorsal branch group vs 0.4 for the sham group.	"In CLBP of facet origin, shifting the target of percutaneous radiofrequency to the facet jointcapsule provides an easier technique with an extended period of pain relief compared to the medialdorsal branch of the facet joint."	Data suggest targeting the facet joint capsule during percutaneous radiofrequency provides extension of pain relief to medial dorsal branch of facet joint.
Do 2017 (score= 5.5)	Radiofrequency	RCT	No mention of sponsorship. No COI.	N = 60 patients with LFJ pain.	Mean age: 65.0±10.4 years; 24 male, 36 female	Intra-articular lumbar facet joint pulsed radiofrequency (IA PRF) group (n = 30) vs intra-articular corticosteroid injection (ICI) group (n = 30)	Follow up at baseline, 2 weeks, 1, 3 and 6 months.	Successful pain relief at 6 months was 50.0% for the PRF group and 46.7% for the ICI group (p=0.796)	"In the current study, both IA PRF stimulation and ICI into the LFJ significantly relieved LFJ pain. Their effects persisted for at least 6 months after the procedure. Thus, IA PRF is a useful therapeutic option for the management of LFJ pain."	Single treatment trial. Data suggest comparable long-term efficacy between groups.

Oh 2004 (score= 4.5)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	No mention of sponsorship or COI.	N = 49 with chronic discogenic LBP and history of failed conservative treatment of several months duration, IDET performed only after confirming discogenic pain with provocative discography at low pressurization	Mean age: 42.1 years; 21 male, 28 female.	1% lidocaine injection followed by radiofrequency (RF) thermocoagulation at 65°C for 60 seconds, then injection of 2mL of preservative free 1% lidocaine with 40mg sterile triamcinolone acetonide (n = 26) vs Injection of 2ml of preservative-free 1% lidocaine (n = 23).	Average follow-up period 4 months.	At 4 months, VAS pain scores improved at 46.5% change (p = 0.001), scores in bodily pain subscale improved by mean increase of 14.5 a change of 49.7% (p = 0.005) scores on SF-36 physical function subscale improved by mean increase of 15.2 points a change of 34.8% (p = 0.002). No statistically significant differences found in control group.	"[P]atients experienced satisfactory pain relief after RF neurotomy of the ramus communicans nerve, which is a safe, uncomplicated procedure for the treatment of intractable chronic discogenic pain. Radiofrequency neurotomy of the ramus communicans nerve is a desirable main or auxiliary treatment option for cases of chronic discogenic pain that do not respond to other forms of treatment."	Methods discuss sham treatment, but no significant discussion of blinding. Procedure chosen to blind at least the patient, does not appear to be optimal.
Buijs 2004 (score= 4.5)	Radiofrequency Neurotomy, Neurotomy, and Facet Rhizotomy	RCT	No mention of sponsorship or COI.	N = 33 with continuous LBP >6 months	Mean age: 52 years; No mention of gender.	Temperature-controlled lumbar radiofrequency facet denervation (80°C) (n = 17 and 55 lesions) vs. Voltage-controlled lumbar radiofrequency facet denervation (20 V) (n = 16 and 63 lesions).	No follow up.	All lesions in TC group considered adequate, while 44 (69.8%) in VC group considered inadequate.	"[T]his study shows that there is no consistent relationship between voltage and the obtained temperature during lumbar RF-facet denervation….. Thus, for reasons of reproducibility of lesion size, a TC setting is preferable."	No placebo or control group. Data suggest temperature control superior to voltage control for lesion size. Clinical applicability is inferred.

Desai 2017 (score= 3.5)										Cross-over open label RCT. Usual care bias. Data suggest long term (12 month) clinical effectiveness of IDB and CMM for treating chronic, lumbar discogenic pain. Crossovers also reported improved pain, function, and satisfaction.

DORSAL ROOT GANGLIA RADIOFREQUENCY LESIONING

Radiofrequency lesioning of the dorsal root ganglia has been attempted for treatment of chronic sciatica and some other pain syndromes.(1802, 1806, 1822)

Recommendation: Radiofrequency Lesioning for Treatment of Chronic Sciatica
Radiofrequency lesioning of the dorsal root ganglia is moderately not recommended for treatment of chronic sciatica.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation
Radiofrequency lesioning is invasive, has adverse effects, and is costly. It has been shown to not be efficacious in a high-quality study.(1823)

Evidence for the Use of Dorsal Root Ganglia Radiofrequency Lesioning
There is 1 high-quality RCT incorporated into this analysis.(1823)

We searched PubMed, EBSCO, Cochrane review and Google Scholar without any limits on publication dates. We used the following search terms "Radiofrequency lessoning of the dorsal root ganglia for chronic sciatica, radicular pain syndromes (including 'sciatica')" to find 8414 articles. Of those, we reviewed 5 articles and included 3 (1 RCT and 2 reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Geurts 2003 RCT No mention of industry sponsorship or COI.	10.0	N = 83 with chronic lumbosacral radicular pain mostly leg pain and positive Lasègue's sign (30-60°)	Radiofrequency lesion (an injection, to confirm location of dorsal root ganglion, of 1mL iohexol, followed by 3-5mL mepivacaine 2% then 90 seconds of lesioning at 67°C) (n = 45) vs. same procedure with no lesioning (n = 38). Follow-up at 0, 3 months.	No differences found. At 3 months, more controls treatment successes than RF group successes (25% vs. 16%).	"[O]ur trial did not show a significant difference in treatment effect between lumbosacral radiofrequency treatment of dorsal root ganglia and control treatment. Consequently, the use of this type of radiofrequency lesioning as routine treatment in lumbosacral radicular pain should not be advocated."	Measured depression symptoms. Radiofrequency lesioning of dorsal root ganglia did not have improved outcomes over sham. Sham treatment had greater improvement in leg symptoms.

INTRADISCAL ELECTROTHERMAL THERAPY (IDET)

Intradiscal electrothermal therapy (IDET) involves the heating of an intradiscal probe through electrical current. The goal is to coagulate tissue and theoretically result in improvement in pain thought to be derived from the disc or surrounding structures.(1824-1826) As this is a relatively new intervention, techniques have not been standardized.

Recommendation: Intradiscal Electrothermal Therapy (IDET) for Treatment of Low Back Pain
IDET is not recommended for treatment of acute, subacute, or chronic low back pain or any other back-related disorder.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are two high-quality RCTs(1827, 1828) that conflict regarding whether IDET has any value in treating chronic LBP. It is unclear whether heterogeneity of patients' clinical findings may in part explain these differences. Another problem is the reliance on discography as the primary diagnostic requirement for IDET, as it has low diagnostic value (see Discography). IDET has not been clearly shown to be beneficial. It is costly and invasive although it may have a relatively low complication rate.(1829) Thus, there is not adequate evidence to recommend this procedure.

Evidence for the Use of IDET

There are 2 high-quality RCTs incorporated into this analysis.(1827, 1828)

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following terms: IDET, intradiscal electrothermal therapy, and low back pain to find 1174 articles. Of the 1174 articles we reviewed two articles and included two articles.

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Pauza 2004 RCT No mention of COI or industry sponsorship	8.5	N = 64 with chronic LBP and disc degeneration identified with discography	IDET with electrode heated to 90°C, if pain produced 50-100µg fentanyl, when electrode removed 1cc bupivacaine 0.75% mixed with antibiotic inserted into disc (n = 37) vs. Sham treatment placing needle but no electrode (n = 27). Follow-up 0 and 6 months.	Both groups improved, but IDET significantly greater than sham group (p = 0.045). In Oswestry Disability Scale, IDET had better outcomes (p = 0.050). Differences favored IDET group for absolute change and for relative changes in pain scores measured by VAS.	"[T]he present study shows that nonspecific factors are a major determinant of the efficacy of IDET but that its effects cannot be wholly attributed to nonspecific factors. A needed-to-treat value of 5, for achieving 75% relief of pain, indicates that it is worthwhile intervention for some highly select patients."	Of IDET treated patients, 50 % had no benefit. Lack of no-treatment arm. Study suggests IDET benefits may be small, highly select group of patients, although benefit may be clinically small, with mean change of 2.4 points on 1-6 VAS scale at 6 months.
Freeman 2005 RCT Industry sponsored (Oratec Interventions, Menlo Park, CA; DePuy AcroMed, Raynham, MA; and Smith and Nephew Inc., Andover MA). Industry COI (one or more authorss received or will receive benefits for personal or professional use from commercial party related directly or indirectly to subject of this manuscript, benefits will be directed solely to research fund, foundation, educational institution or other nonprofit organization which author(s) has/have been associated.	8.5	N = 57 with chronic LBP and disc degeneration identified with discography	Intradiscal catheter with either 65°C rising over 12.5 minutes to 90°C held for 4 minutes (n = 38) vs. same sham without lesioning (n = 19). All had common rehab program including Pilates. Crossover therapy offered after 6 months to placebo group and follow-up at 0 and 6 months.	No subject reached clinically important differences previously defined. No differences between treatments.	"The IDET procedure appeared safe with no permanent complications. No subject in either arm met criteria for successful outcome. Further detailed analyses showed no significant change in outcome measures in either group at 6 months. This study demonstrates no significant benefit from IDET over placebo."	Included a mental health component. IDET no more effective than sham.

PERCUTANEOUS INTRADISCAL RADIOFREQUENCY THERMOCOAGULATION (PIRFT)

Percutaneous intradiscal radiofrequency thermocoagulation involves the same principle as that of IDET. However, the heating of an intradiscal probe is through radiofrequency instead of electrical current. The theoretical mechanisms of efficacy are essentially the same as for IDET.(1830-1832)

Recommendation: Percutaneous Intradiscal Radiofrequency Thermocoagulation for Treatment of Acute, Subacute, or Chronic Low Back Pain

Percutaneous intradiscal radiofrequency thermocoagulation is moderately not recommended for treatment of acute, subacute, or chronic low back pain particularly including discogenic low back pain.

Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
Level of Confidence – Moderate

Rationale for Recommendation

There is no evidence of efficacy in two quality studies, including one high quality study.(1830, 1833) A third moderate-quality trial is not a purely sham-controlled trial and has problems with interpretation. Thus, the procedure is not recommended.

Evidence for the Use of Percutaneous Intradiscal Radiofrequency Thermocoagulation

There is 1 high-(1830) and 2 moderate-quality(1832, 1833) RCTs incorporated into this analysis.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates. We used the following search terms "(Percutaneous intradiscal radiofrequency thermocoagulation) AND (subacute OR chronic OR low OR back OR pain)" to find 611 articles. Of the articles, we reviewed 5 articles and included 5 articles (3 RCTs and 2 reviews).

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Chronic LBP						
Barendse 2001 RCT Author mentions "Conflict of interest category: 12."	10.0	N = 28 with chronic discogenic LBP 1 plus year duration; only patients with 1 putative painful level accepted	PIRFT (RF probe with electrical stimulation to confirm not positioned near nerve structures, 90 second 70°C lesion) (n = 13) vs same without true lesioning (n = 15). Follow-up at 8 weeks.	No significant differences found.	"[A] 90 second 70°C monopolar RF intradiscal lesion was not sufficient to treat discogenic pain."	Required at least 50% pain relief on analgesic discography to be eligible (45.7% positive). Small numbers. Data suggest lack of efficacy.
Gautam 2011 RCT No mention of industrial sponsorship or COI.	7.0	N = 91 with LBP secondary to contained lumbar disc herniation	Ozone group received intradiscal oxygen-ozone therapy (4-7mL oxygen ozone mixture) (n = 45) vs. Ozone-PIRFT group received same oxygen-ozone therapy with PIRFT (radiofrequency lesioning at 80° C and 360 seconds) (n = 46). Follow-up at 2 weeks and 1, 3, 6, 12 months.	Ozone-PIRFT significantly favored in VAS/ODI scores ≥50% pain relief. At 2 weeks, 1, 3, 6, 12 months VAS scores ozone group 63.2 ±10.6/40.9±10.8/42.6± 13.3/35.8±14.7/33.1± 12.9; ozone-PIRFT group 57.9±11.9/35.3± 11.3/35.6±12.3/28.7± 14.3/26.4±12.4. ODI ozone 36.5±10.9/33.3± 12.8/28.8±11.6/25.2± 11.1/25.5±11.3; ozone-	"Ozone-PIRFT is more efficacious than ozone alone in reducing pain scores, analgesic consumption, improving functional outcome, and satisfaction of patients with contained lumbar disc herniation."	Unclear how MD blinded. Also unclear how control did not receive PRFT when design states PRFT performed to non-symptomatic side, precluding conclusions.

				PIRFT 30.8±9.6/28.3± 8.8/23.4±8.4/20.6±7.5/ 21.4±6.6.		
Erçelen 2003 RCT No funds received to support this work. No mention of COI.	5.5	N = 60 receiving conservative treatment for 2 plus years for chronic LBP	Radiofrequency (20-gauge RFK C 15 cannula with 10mm active tip with stylet of cannula replaced by RF probe an injection of radiological dye plus bupivacaine 0.05%), 80°C lesioning for 120 seconds in Group A (n = 19) vs 360 seconds in Group B (n = 18). Follow-up pre/post, 1/2 weeks, 1, 3, 6 months.	No significance between groups, but at 1 month both groups had significant decrease in VAS and ODS scores. However, at 6 months these changes were lost.	"[T]here is no significant difference between applying two different lesioning methods…. Because the response to pain relief decreased gradually after 1 month, this method is unacceptable as a long-term modality."	No placebo or sham arm. Trial compared shorter vs. longer duration of RF lesioning. No differences and data suggest no long-term benefits.

Surgical Considerations. . . . . .

This guideline will address only the non-emergent surgical treatment of the most common acute, subacute, and chronic back problems. The indications for emergent surgery for red flag conditions including spinal cord compression, cauda equina syndrome, unstable fractures, epidural abscess, or hematoma, etc., will not be discussed, as treatment of these conditions is outside the scope of these guidelines, as are other indications for surgery (e.g., neoplasms). This guideline does discuss recognition of red flag conditions that require expedited referral to a surgeon qualified to deal with spine emergencies (see Red Flags).

Within the first 3 months after onset of acute low back symptoms, surgery is considered only for serious spinal pathology or nerve root compression not responsive to an adequate trial of conservative therapy. Disc herniation may impinge on a nerve root typically causing mostly lower extremity and sometimes lumbosacral symptoms accompanied by nerve root dysfunction. However, the presence of a herniated disc on an imaging study does not necessarily imply nerve root dysfunction. Studies of asymptomatic adults commonly demonstrate intervertebral disc herniations that apparently do not cause symptoms.

Some studies show spontaneous disc resorption without surgery. Many patients with strong clinical findings of nerve root compression due to disc herniation and/or spinal stenosis recover activity tolerance within 1 month. There is no quality evidence that delaying surgery for this period worsens outcomes in the absence of progressive nerve root compromise.(1834) With or without surgery, more than 70% of patients with apparent surgical indications eventually recover to their pre-morbid activity level, including those with severe initial presenting signs of neurological compromise.(1835, 1836) Spine surgery for patients with clear indications appears to speed short- to mid-term recovery. However, surgery results in pain improvements in fewer than 40% of patients with questionable physiologic findings, which is the rate of response of pain to placebo surgery.(1209, 1837) Surgery generally increases the risk for future spine procedures with higher complication rates especially associated with more invasive procedures such as fusion.(1838-1841) Yet, reoperation rates are reportedy lower after fusion compared with decompressive surgery for spinal spondylolisthesis.(1840) In older patients and repeat procedures, the rate of complications is higher.(1842, 1843) Patients with comorbid conditions such as cardiac or respiratory disease, diabetes, or mental illness, may be poor candidates for surgery. Comorbidity should be weighed and discussed carefully with the patient.

If surgery is a consideration, counseling regarding likely outcomes, risks, and benefits and especially expectations is important. Patients with acute LBP alone, without findings of serious spinal pathology (such as tumor, fracture, infection, hematoma), rarely benefit from surgery, although a second opinion from a spine surgeon to the effect that surgery is not recommended and is unlikely to be helpful may be reassuring to the patient.

Before surgery, physicians may consider referral for psychological screening to improve surgical outcomes, possibly including standard tests such as the second edition of the Minnesota Multiphasic Personality Inventory (MMPI-2).(1844) In addition, physicians may look for non-organic signs (e.g., Waddell) during the physical exam as these have been shown to correlate with poorer surgical outcome.

LUMBOSACRAL NERVE ROOT DECOMPRESSION

Nerve root decompression is performed for symptomatic nerve root compression by disc herniation and/or spinal stenosis. Direct methods of nerve root decompression include standard open discectomy, laminotomy, foraminotomy, facetectomy, and laminectomy. Indirect methods of nerve root decompression potentially include chemonucleolysis with chymopapain, intradiscal electrothermal annuloplasty (IDET), and percutaneous discectomy (either by mechanical, electrical, or laser methods).

Endoscopic removal of a herniated disc fragment, while performed percutaneously, is a similar operation to standard open discectomy and is considered below. Standard open discectomy can be done with or without the use of an operating microscope or loop magnification and with or without endoscopic "tubes" to minimize the size of the skin incision and muscle dissection.

DISCECTOMY, MICRODISCECTOMY, SEQUESTRECTOMY, ENDOSCOPIC DECOMPRESSION

There are multiple surgical techniques that have been used to surgically relieve pressure on lumbosacral nerve roots causing radicular pain syndromes.(1845-1849, 2424) These include open discectomy (with or without microscope),(1850-1855) automated percutaneous discectomy,(1856-1858) epidural percutaneous discectomy,(1859) sequestrectomy, and endoscopic procedures.(1860-1864) More recent techniques include percutaneous laser disc decompression,(1865) automated percutaneous discectomies (also known as nucleoplasty),(1866, 1867) disc coblation, and endoscopic approaches.(1868) The same surgical approaches are also sometimes used to address less common spinal pathology (e.g., facet joint arthropathy with consequent nerve root impingement). This section reviews the indications for discectomy for a herniated lumbar disc.

1. *Recommendation: Lumbar Discectomy for Radiculopathy*
   Lumbar discectomy is moderately recommended to speed recovery in patients with radiculopathy due to ongoing nerve root compression who continue to have significant pain and functional limitation after 4 to 6 weeks of time and appropriate conservative therapy. For patients who are candidates for discectomy (other than for cauda equina syndrome and the rare progressive major neurologic deficit), there is evidence that there is no need to rush surgical decisions as there is no difference in long-term functional recovery whether the surgery is performed early or delayed. Open discectomy, microdiscectomy, and endoscopic discectomy are all potentially appropriate ways to perform discectomy. The decision as to which of these procedures to choose should be left to the surgeon and the patient until quality evidence becomes available to provide evidence-based guidance. Other procedures such as laser discectomy and/or PERC involve indirect procedures with limited access to the disc contents.

   Indications – All of the following should be present: 1) radicular pain syndrome with current dermatomal pain and/or numbness, or myotomal muscle weakness all consistent with a herniated disc; 2) imaging

findings by MRI, or CT with or without myelography that confirm persisting nerve root compression at the level and on the side predicted by the history and clinical examination; and 3) continued significant pain and functional limitation after 4 to 6 weeks of time and appropriate non-operative therapy that usually includes NSAID(s). Progressive neurological deficits are considered a separate indication.

Benefits – Earlier pain relief
Harms – Operative complications that very rarely include severe adverse effects or fatality comparable with other moderate surgical procedures.

Strength of Evidence – **Moderately Recommended, Evidence (B)**
Level of Confidence – High

2. *Recommendation: Discectomy for Treatment of Acute, Subacute, or Chronic Low Back Pain without Radiculopathy*
   Discectomy is moderately not recommended for treatment of acute, subacute, or chronic low back pain without radiculopathy.

   Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
   Level of Confidence – High

3. *Recommendation: Discectomy for Back or Radicular Pain Syndrome*
   Percutaneous discectomy (nucleoplasty), laser discectomy, and disc coblation therapy are not recommended for treatment for any back or radicular pain syndrome.

   Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations
There are no sham-controlled surgical trials. All moderate-quality comparative trials demonstrate short- to intermediate-benefits, but not long-term benefits from nerve root decompression surgery compared with conservative treatment for patients with radicular symptoms from disc herniation unresponsive to 4 to 6 or more weeks of prior non-operative treatment.(1834, 1869-1871) However, as up to 75% of patients with radicular symptoms from herniated discs may become minimally symptomatic or asymptomatic without surgery,(1834, 1869-1872) sufficient time should pass prior to consideration of surgery. Also, there is no need to rush patients into surgery as there is consistent evidence of a lack of differences in long-term functional recovery.(1834, 1869-1871)

Quality literature is insufficient on the comparative values of open discectomy, microdiscectomy, or endoscopic discectomy. There are no quality trails of endoscopic decompression identified or percutaneous lumbar laser disc decompression.(1873) Also, there is no quality evidence that automated percutaneous discectomy, laser discectomy, or coblation therapy is an effective treatment for any back or radicular pain problem. There are trials on techniques to minimize postoperative epidural fibrosis, but surgical technique is beyond the scope of this guideline.(1874)

Discectomy is invasive, costly and has adverse effects. However, there is consistent, moderate-quality evidence that lumbar discectomy is an effective operation to speed recovery in patients with radiculopathy due to ongoing nerve root compression who have not improved significantly after 4 to 6 weeks of time and appropriate conservative therapy and it is thus recommended.

Evidence for the Use of Discectomy

We searched PubMed, EBSCO, Cochrane Review, and Google scholar without limits on publication dates and then an updated search was done in PubMed for publication between 1/1/2013 and 11/15/2017. We used the following search terms: percutaneous discectomy, nucleoplasty, laser discectomy, disc coblation therapy, discectomy, microdiscectomy, sequestrectomy, chemonucleolysis,

endoscopic, decompression, subacute, low back pain, chronic low back pain, radicular pain, radiculopathy, sciatica, clinical trial, randomized controlled trial, random, systematic review, population study, epidemiological study, and prospective cohort to find 5,829 articles. Of the 5,829 articles, we reviewed 39 articles and 39 articles were included (28 randomized controlled trials and 11 systematic reviews).

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Peul 2007 (score=6.5)	Discectomy	RCT	Supported by a grant from the Netherlands Organization for Health Research and Development (ZonMW) and Hoelen Foundation, The Hague. No COIs.	N = 283 with 6-12 weeks sciatica and radiological confirmation of disc herniation	Mean age: 42.6 years; 186 males, 97 females	Early surgery (8-14 weeks after onset of symptoms) (n = 141) vs, continued conservative treatment with surgery if needed and offered at 6 months (n = 142).	26 week, 52 weeks	Area under curve for mean scores on Roland Disability Questionnaire did not differ (p = 0.13). Mean VAS pain scores for leg favored early surgery (p <0.001). Early surgery showed effect on recovery in 1st 36 weeks (p <0.001). Recovery as end point HR = 1.97 (95% CI, 1.72 to 2.22) favoring early surgery. At 1-year follow-up, perceived recovery 95% both groups.	"The 1-year outcomes were similar for patients assigned to early surgery and those assigned to conservative treatment with eventual surgery if needed, but the rates of pain relief and of perceived recovery were faster for those assigned to early surgery."	89% assigned to early surgery underwent surgery, 39% of those assigned to conservative care underwent surgery. Majority either recovered completely or sufficiently without surgery. Data suggest surgery improves early symptoms and recovery, but not long-term outcomes.
Österman 2006 (score=6.5)	Discectomy	RCT	Supported by Finnish Office for Health Technology Assessment at National Research and Development Centre for Welfare and Health; Jorvi Hospital, Helsinki and Uusimaa Hospital District, Espoo, Finland. No COIs.	N = 56 without clear neurological indications	Mean age: 37.5 years; 34 males, 22 females	Microdiscectomy for lumbar disc herniation (n = 28) vs. Continued conservative treatment (n = 28). Follow-up at 6 weeks, 3 months, 1 year, and 2 years.	6 weeks, 3 months, 6 months, 1 year, 2 years	Leg pain at 6 weeks favored surgery (p <0.01). Patients reporting a full recovery at 6 weeks favor surgery (p <0.05) and more satisfaction with treatment (p <0.01). Satisfaction favored surgery at 6 months (p <0.001), and 2 years (p <0.05).	"Lumbar microdiscectomy may be associated with a more rapid initial recovery in patients with sciatica due to disc extrusion or sequester and a history of less than 12 weeks… benefit from surgery is rather modest during the first 2 years and conservative therapy is a reasonable option for these patients."	Data suggest surgery superior for early relief of lower extremity pain. No differences in longer term outcomes.
Weinstein 2006 (score=5.5)	Discectomy	RCT	Supported by grant from NIAMS and by NIH Office of Research on Women's Health,	N = 501 with imaging-confirmed lumbar intervertebral disc	Mean age: 41.4±11.2 years; 406 males, 313 females	Open discectomy (n = 245) vs Conservative management (:at least active physical therapy," education,	6 weeks, 3 months, 6 months,	Utilization in conservative group: education/counseling (93%), NSAIDs (61%), opiates (46%), injections (50%), activity restrictions (29%). Both groups	"Because of the large numbers of patients who crossed over in both directions, conclusions about the superiority or equivalence of the treatments are not	Non-operative management not well described. Data suggest short-term benefits of surgery vs. non-

			National Institutes of Health, and National Institute for Occupational Safety and Health, the Centers for Disease Control and Prevention. The Multidisciplinary Clinical Research Center in Musculoskeletal Diseases funded by grant from NIAMS. One or more of the authors have received or will receive benefits for personal or professional use.	herniation and persistent radiculopathy at least 6 weeks		counseling plus HEP and NSAIDs (n = 256). Nearly all (97%) had MRI.	1 year, 2 years	improved. Surgical group had greater improvements. Other than peri-op, work status showed small benefit at 1 year, but not at 2. Intra-operative (5%) and post-op (5%) complications; 10% re-operation within 2 years.	warranted based on the intent-to-treat analysis." The authors concluded that "patients who underwent discectomy had significantly better self-reported outcomes than those who had usual care."	operative management, although lack of description of non-operative management is limiting. No long- term benefits demonstrated.
Weber 1983 (score=4.5)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 126 without clear indications for discectomy admitted to hospital for acute symptoms with sciatica as inclusion criteria	Mean age: 41.6 years; 165 males, 115 females	Conservative treatment with continued physiotherapy (n = 66) vs. surgery (n = 60). Follow-up at 3, 6 and 9 months; 10 year follow-up.	1, 4, 10 years	Complex report as also non-randomized cohorts. Patients randomized to conservative treatment and surgery. Controlled trial showed statistically significant better result in surgically treated group at 1-year follow-up.	"After 4 years, the operated patients still showed better results, but the difference was no longer statistically significant."	3 trial groups, 1 randomized; 35% conservative group surgery 1st year, but considered in conservative analysis. Data suggest fair/ good results majority of both groups (91% surgery vs. 81% conservative) at 1 year. Suggest no long-term differences.

Johnsen 2013 (score=4.0)	Discectomy	RCT		N = 120 with degenerative disc disease (DDD) and low back pain for more than a year	Mean age: 41.6 years; 55 males, 65 females	Originally 173 participants were randomized but only 120 were included in the analysis due to either drop out or incomplete radiographs. Total disc replacement (TDR) group, ProDisc II prosthesis inserted at L4/5, L5/S1, or both (n = 74) vs. Multidisciplinary Rehabilitation (MDR), consisting of cognitive intervention – lecture about understanding original activity would not harm the disc with recommendation to use and bend the back, also included physical exercise sessions, three daily sessions for three weeks (n = 46)	Follow up at 2 years	No significant mean difference between groups in Oswestry Disability Index (ODI) (mean difference = 1, 95% CI (-2.5 to 4), p = 0.654), in Physical Function-10 (PF-10) scores (mean difference = 6, 95% CI (-13 to 2), p = 0.172) or EuroQul-5D (EQ-5D) scores (mean difference = 0.047, 95% CI (-0.158 to 0.065), p = 0.407). At 2 year follow up, significant mean difference between groups for ODI scores (6.8, 95% CI (0.85 to 12.74), p = 0.025), PF-10 scores (-13, 95% CI (-23 to -4), p = 0.005), and pain (13, 95% CI (2 to 24), p = 0.022), all in favor of TDR. No significant difference in EQ-5D (-0.088, 95% CI (-0.088 to 0.061), p = 0.155)	"In this study, insertion of an intervertebral disc prosthesis TDR did not increase movement in the sagittal plane and segmental movement did not correlate with patient reported outcomes. This suggests that in the lumbar spine the movement preserving properties of TDR are not major determinants of clinical outcomes."	Baseline differences in low pain scores (higher in rehabilitation group). Data suggest slight trend in favor of total disc replacement over multidisciplinary rehabilitation.
Furunes 2017 (score=NA)	Discectomy	Post hoc analysis of Johnsen 2013		N = 152 with degenerative disc disease (DDD) and low back pain for more than a year	Mean age: 41.0 years; 61 males, 91 females	TDR surgery group (n = 86) vs. Multidisciplinary rehabilitation (n = 86). See Johnsen 2013 above for treatment details.	Follow-up at 8 years	Mean improvement in Oswestry Disability Index: surgery group – 20 points (95% CI (16.4–23.6), p ≤ 0.0001), rehabilitation group – 14.4 points (95% CI (10.7–18.1), p ≤ 0.0001). 8 year follow-up mean difference between groups – 6.1 points (95% CI (1.2–11.0), p = 0.02), in favor of surgery	"Substantial long-term improvement can be expected after both disc replacement and MDR. The difference between groups is statistically significant in favor of surgery, but smaller than the prespecified clinically important difference of 10 ODI points that the study was designed to detect. …"	Baseline differences as low back pain higher in rehabilitation group. Data suggest slight trend in favor of surgery versus rehabilitation at 8 years.

Thomé 2005 (score=5.5)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 84 with herniated lumbar discs refractory to conservative treatment	Mean age: 41 years; 47 males, 37 females	Sequestrectomy (n = 42) vs. Microdiscectomy (n = 42). Follow-ups at discharge, 4-6 months after surgery, and telephone at 12-18 months after surgery.	4-6 months, 12-18 months	Shorter operative time sequestrectomy vs. microdiscectomy (32.6±13.8 vs. 38.2±10.3 minutes, p <0.05). Free fragments found in 26% microdiscectomy vs. 41% sequestrectomy (NS). Re-operations in 4 (10%) microdiscectomy vs. 2 (5%) sequestrectomy. Pain scores 4-6 months favored sequestrectomy (1.6±2.5 vs. 0.9±1.4) and benefits through 12 to 18 months (NS).	"[S]equestrectomy does not yield a higher incidence of symptomatic recurrences compared with microdiscectomy in patients with free subligamentary, or transannular lumbar disc herniations. Analysis of early outcome demonstrates a trend toward superior results after sequestrectomy."	Somewhat variable follow-ups. Data suggest weak trends in favor of sequestrectomy.
Henriksen 1996 (score=5.5)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 79 with lumbar disc herniations.	Mean age: 41.3 years; 50 males, 29 females	Microsurgical discectomy (n = 39) vs. Standard discectomy (n = 40). Final follow-up at Week 6 post-op.	2, 4, 6 days, 2, 4, 6 weeks	Operation time longer for microdiscectomy vs. standard discectomy (48 vs. 35 minutes, p <0.0001). Comparable results.	"We think the only advantages the microscope can offer beside that magnification, are a smaller skin incision and better deep illumination. The use of the microscope therefore depends largely on the preference of the surgeon and whether the patient needs a small scar."	Lack of baseline characteristics. Data suggest no differences, although modestly longer OR time for microdiscectomy.

Bailey 2013 (score=5.5)	Discectomy	RCT	Funded by Anulex Technologies Inc., Minnetonka, MN (Anulex). No mention of COI.	N = 750 treated for herniated lumbar discs.	Mean age: 42.2 years; 424 males, 303 females	Control (n=249) - Disectomy without anular repair. vs.Xclose (n=478) - Discectomy with Xclose Tissue Repair System for anular repair.	2 weeks, 6 months, 1 year, 2 years	VAS leg pain improved (P < 0.001) by 6.3 points from a baseline mean of 7.8 (95% CI: 7.7–8.0) to 1.5 (95% CI: 1.2–1.7) at 2 years for Xclose, and by 6.3 points from a baseline average of 8.0 (95% CI: 7.8–8.2) to 1.7 (95% CI: 1.3–2.1) for control patients. At 2 years VAS back pain improved (P < 0.001) by 2.7 points from a baseline mean of 4.9 (95% CI: 4.6–5.1) to 2.2 (95% CI: 2.0–2.5) for Xclose, and by 2.5 points from an average of 4.8 (95% CI: 4.5–5.2) to 2.3 (95% CI: 1.9–2.7) for control patients.	"Without a safe and effective method for closing the anulus fibrosus after discectomy, current practice has been to leave the anulus in a compromised state. This multicenter randomized study demonstrated that, while not statistically significant, anular repair reduced the need for subsequent reherniation surgery while retaining the benefits of discectomy with no increased risk for patients."	Study failed to demonstrate efficacy.
MacKay 1995 (score=5.0)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 190 with radiologically confirmed single-level lumbar disc herniation	Mean age: 39 years; 106 males, 48 females	Fat graft (n = 40) vs. Gelfoam graft (n = 38) vs. no additional treatment (n = 50). Study evaluated how use of interposition materials affected post-op symptoms after lumbar discectomy. Final follow-up at 1 year.	1 year	Clinical outcomes unaffected by 3 treatment arms; 83% excellent or good outcomes overall (85% fat vs. 84% Gelfoam vs. 80% nothing, p = 0.67). Workers' comp patients had significantly lower success rates, 37% unsatisfactory vs. 8% for non-workers' comp.	"[P]lacing an interposition membrane over the nerve root has no beneficial effect on the outcome of lumbar disc surgery."	Study randomized, 190 patients, but reports data on 154 from 1-year follow up, dropout rate 19%. Data suggest grafts not effective.
Radcliff 2017 (score=4.5)	Fusion vs Discectomy	RCT		N = 229 patients with degenerative disk disease at 2 contiguous vertebral levels from L3 to	No mention of mean age, age range, or gender.	Lumbar total disk replacement (TDR) group (n = 161) – patients were managed with TDR at both levels. Vs. Circumferential fusion group (n = 68) – patients were managed	Follow up at 5 years.	Percent of subjects at 5 years undergoing secondary surgeries was 5.6% in the TDR group vs 19.1% for the fusion group (p=0.0027) Percent of subjects at 5 years with Index level secondary surgeries were 3.1% in the TDR group vs 16.2%	"There were significantly fewer reoperations in TDR Patients compared with fusion patients. However, most of the secondary surgeries were instrumentation removal in the fusion cohort. Discounting the instrumentation	Data suggest TDR non-inferior to fusion at 5 years.

				S1 with or without leg pain, a minimum of 6 months of unsuccessful nonoperation treatment, and had a minimum Oswestry Disability Index score of 40%.		with a 2-level anterior lumbar interbody arthrodesis with use of a commercially available femoral ring allograft.		in the fusion group (p=0.0009)	removals, there was no significant difference in reoperations between TDR and fusion. These results are indicative that lumbar TDR is noninferior to fusion."	
Wardlaw 2013 a (score=4.5)	Chemonucleolysis	RCT		N = 100 patients that had typical symptoms and signs of sciatica with a minimum period of 3 months conservative treatment.	Mean age: 51 years; 60 male, 40 female	Chemonucleolysis group (n = 48) vs standard discectomy (n = 52)	Follow up at 1 year, 10 to 13 years and 24 to 27 years.	93% of chemonucleolysis patients had a satisfactory outcome vs 96% of discectomy patients. 65% of chemonucleolysis patients considered themselves completely better vs 67% of discectomy patients (p=0.60)	"Chemonucleolysis is as effective as surgery when assessed according to intention-to treat analysis, with reduced complications, and age has no bearing on the outcome. The authors think that restoration of its availability would be beneficial to patients."	Data suggest comparable efficacy at 1 year, 10 years, 24-27 years.
Wardlaw 2013 b (score=4.5)	Chemonucleolysis	RCT		N = 100 patients that had typical symptoms and signs of sciatica with a minimum period of 3 months conservative treatment.	Mean age: 51 years; 60 male, 40 female	Chemonucleolysis group (n = 48) vs standard discectomy (n = 52)	Follow up at 1 year, 10 to 13 years and 24 to 27 years.	93% of chemonucleolysis patients had a satisfactory outcome vs 96% of discectomy patients. 65% of chemonucleolysis patients considered themselves completely better vs 67% of discectomy patients (p=0.60)	"Chemonucleolysis is as effective as surgery when assessed according to intention-to-treat analysis. The loss of disc height over time is the same in both groups. The authors think that restoration of its availability would be beneficial to patients.	Data suggest comparable efficacy at all time points.

Mayer 1993 (score=4.5)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 40 with contained lumbar disc herniations.	Mean age: 41.3 years; 26 males, 14 females	Percutaneous endoscopic discectomy (n = 20) – patients received the PED surgical treatment. vs. Microsurgical discectomy (n = 20) – patients received the MD surgical treatment.	2 years.	Suezawa and Schreiber scoring for percutaneous endoscopic discectomy (pre/2 years) 4.55±0.99/8.23±1.3 vs. microdiscectomy4.2±0.98/ 7.67±1.9, p <0.005.	"Percutaneous endoscopic discectomy appears to offer an alternative to microdiscectomy for patients with 'contained' and small subligamentous lumbar disc herniations."	Small sample size, lack of power, lack of control group limits conclusion. Most data suggest comparable results, although some suggest percutaneous discectomy superior to microdiscectomy.
Chatterjee 1995 (score=4.5)	Discectomy	RCT	Financed with a grant from The Department of Health, London, UK. No mention of COI.	N = 71 with contained lumbar disc herniation, excluded those primarily with LBP	No mention of age or gender.	Automated percutaneous lumbar discectomy (n = 31) – ALPD was performed with a 2-mm nonflexible automated suction nucleotome under local anesthesia and with biplanar radiologic control. vs. Microdiscectomy (n = 40) – was performe by standard technique via a 2-cm incision and a transligamentous approach with the removal of the herniated portion of the disc and all loose intradiscal material.	3 weeks, 2 months and 6 months.	Success rates combining excellent and good for automated percutaneous lumbar discectomy (APLD) 9/31 patients (29%) vs. microdiscectomy 32/40 patients (80%), p <0.001. Many underwent subsequent surgery and achieved lower overall success rate of 65%.	"APLD is ineffective as a method of treatment of patients with a small contained lumbar disc herniation."	A follow-up study on cost-effectiveness concluded that APLD was less cost effective than microdiscectomy. Outcomes data suggest microdiscectomy superior.
Tait 2009 (score=4.5)	Discectomy	RCT	Industry sponsored (Research Fellowship from the Royal College	N = 74 undergoing lumbar microdiscectomy (LMD) for	Mean age: 43.6 years; 37 males, 37 females	Experimental group (n = 38): LMD + patients given their removed disc fragments vs.	3-6 months	LMD reduced sciatica at >85% and back pain in ~80% patients in both groups. Giving patients removed disc fragments significantly increased	"Presentation of excised disc fragments is a cheap and effective way to improve outcome after LMD."	High dropouts. Data suggest better results when shown disc fragments.

			of Surgeons of England and the Neurosciences Research Foundation) and no COI.	radiculopathy due to prolapsed intervertebral disc.		Control group (n = 36): LMD + patients did not received removed fragments. Follow-up at 3 and 6 months after discharge.		probability of improvement in sciatica and back pain. 35/38 (92.1%) of experimental group showed alleviation in sciatica vs. 29/36 (80.6%) in control. 32/38 (84.2%) in experimental group reported improvement in back pain vs. 27/36 (77.1%) of controls.		
Revel 1993 (score=4.0)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 141 with sciatica caused by disc herniation unresponsive to conservative medical therapy	Mean age: 38.5 years; 94 males, 47 females	Chemonucleolysis (CN, n = 72) vs. Automated percutaneous lumbar discectomy (APLD, N = 69). Final follow-up at 1 year post-op.	1, 3, 6 months, 1 year	At 6-months, 44/72 (61.1%) chemonucleolysis vs. 30/69 (43.5%) in APLD very good or good, p <0.05. Subsequent open surgery required in 5/72 (6.9%) vs. 23/69 (33.3%). LBP baseline ratings 40.1±3.3 vs. 40.9±3.6 (CN vs. APLD) and sciatica ratings 63.4±2.9 vs. 68.1±2.6 (CN vs. APLD). At 6 months, LBP ratings 23.2±3.4 vs. 30.0±4.0 (CN vs. APLD) and sciatica 17.6±2.8 vs. 35.6±4.2 (CN vs. APLD, p <0.01).	"[C]ontrolled studies should be carried out before automated percutaneous discectomy can be considered a useful intervention." Authors also commented that results of both treatments "are generally disappointing."	Sparse study details for allocations, baseline comparability, co-interventions; 30% loss to follow-up. Suggests neither treatment particularly effective due to high failure (48%). Lack of control group limits conclusions on effectiveness of procedures vs. natural history. Data suggest discectomy inferior to chemonucleolysis.
Haines 2002 (score=4.0)	Discectomy	RCT	Sponsored by National Institutes of Health National Institute of Neurological Disorders	N = 34 with largely unilateral symptoms from herniated lumbar	Mean age: 39.6 years; 19 males, 15 females	Open discectomy (CD, N = 13) vs. Automated percutaneous discectomy (APD, N = 21). Follow-up at 1 week, 2, 6, and 12 months.	1 week, 2, 6, 12 months	Baseline differences favored conventional open discectomy over APD (age 35.4 for CD vs. 42.2 for APD; litigation status in follow-up 7.7% for CD vs. 38.1% for APD). At 6 months,	"No clinical trial of any percutaneous discectomy technique provides definitive evidence supporting the efficacy or effectiveness of the procedures."	Small groups. Data suggest comparable results and neither group strongly positive.

			and Stroke (R01-NS/HS30908) and the Agency for Health Care Research and Quality. No mention of COI.	discs (LA PDOG trial)				percentages of excellent or good results 7/17 (41.1%) for APD vs. 4/10 (40%) for CD.		
Katayama 2006 (Score=4.0)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 119 with herniated lumbar disc found	Mean age: 37.4 years; 76 males, 43 females	Macro discectomy (n = 62) vs. Microdiscectomy (n = 57). Mean study follow-up at 2.67 years.	12 months -4 years	Operation time for macro 40±12 minutes vs. 45±8 minutes for micro discectomy, p <0.0036. Bleeding amount macro 39±11g vs. 25±9g for micro, p <0.0001. VAS scores for lumbar pain improved 8.5±0.7 to 1.6±0.7 in macro, and 7.6±0.9 to 1.2±0.4 for micro, p = 0.0023.	"For herniotomy for lumbar disc herniation, both macro discectomy and microdiscectomy are appropriate, as long as surgeons have master of the procedures."	No blinding. Higher complication rate with microdiscectomy. Less bleeding intra-operatively with microdiscectomy. Baseline differences in VAS so difficult to conclude from VAS post-op. Both procedures appear comparable.
Gerszten 2003 (score=4.0)	Discectomy	RCT	Supported by grant from National Institute of Arthritis and Musculoskeletal and Skin Diseases (grant No. AR47121). No mention of industry sponsorship or COI.	N = 10 post-laminectomy patients	Mean age: 42 years; 5 males, 5 females	Re-exploration and decompressive treatment with 700-cGy external-beam irradiation (n = 5) vs. without irradiation (n = 5). Follow-up at 1 year.	6 weeks, 3 months, 1 year	ODI scores XRT (pre/1 year): 32.6/20.4 vs. 31.4/21.2 in controls. Trend towards better improvement in radiotherapy group with all 3 of those patients pain free in XRT group and all 2 of those without improvement in control group.	"Preoperative low-dose external-beam irradiation improved outcome at 1 year in patients who had undergone reexploration and decompression of nerve roots affected by post laminectomy peridural fibrosis causing radicular pain."	Tiny sample size. Baseline characteristics not well described. Co-interventions not well controlled. Unable to draw conclusions based on lack of study details and tiny size.
Franke 2009 (score=4.0)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 100 planned for disc prolapse surgery.	Mean age: 44 years; 60 males, 40 females	Microsurgical discotomy (MC) (n = 48) vs. Microscopic assisted	12 months	Significant improvement on sum VAS (F = 165, p <0.0001). Reduction of back pain in VAS score; statically significant at	"[The study] conclude that for both procedures the safety for disc removal procedure concerning the clinical	Data suggest mostly comparable results.

				Pathologic segment L5/S1 in 42%, L 4/5 in 51%, L3/4 in 6% and L2/3 in 1%.		percutaneous nucleotomy (MAPN) (n = 52). Follow-up at 8 weeks, 6 and 12 months.		discharge (p< 0.001), 8 weeks (p = 0.002), 6 (p = 0.003). MAPN group significantly shorter mean hospital stay: 3.8 days at index centre vs. 4.9 days MC group.	results and possible complications is given."	
Righesso 2007 (score=4.0)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 40 with sciatica caused by lumbar disc herniations nonresponsive to conservative treatment.	Mean age: 43.9 years; 23 males, 17 females	Group 1 (n = 19): open discectomy (OD) vs. Group 2 (n = 21): microendoscopic discectomy (MED). Follow-up at 1, 3, 6, 12, and 24 months after surgery.	Pre-operative, 12 hr post-op, 1, 3, 6, 12, 24 months	Significantly differences between group 1 vs. group 2 in the length of hospital stay [26 (16–72) vs. 24 (11 ± 72); p = 0.05], the surgical time [63.7 ± 15.5 vs. 82.6 ± 21; p <0.01], and immediate postoperative pain at the incision [1.2 (0–5) vs. 2 (1–4); p <0.01].	"The few parameters that were found to be statistically significant between the groups did not affect the overall outcome. In the current series, the final clinical and neurological results were similarly satisfactory in both the OD and the MED groups."	Data suggest comparable results.
Zigler 2012 (score=NA)	Discectomy	Secondary analysis of Zigler 2007		N = 166 with single-level lumbar degenerative disc disease (DDD)	Mean age: 38.9 years; 80 males, 86 females	Total disc replacement (TDR), ProDisc-L (n = 161) vs. Circumferential fusion (n = 75). Refer to Zigler 2007 for treatment details. Radiographic follow-up data at 5 years available for 123 TDR patients and 43 fusion patients.	Follow up at 5 years.	9.2% of TDR group and 28.6% of fusion group had changes in adjacent-level degeneration (ALD) (p = 0.004). New findings at 5 year follow-up for patients without ALD preoperatively present in 6.7% of TDR group and 23.8% fusion group (p = 0.008). 1.9% TDR patients and 4.0% of fusion patients reported adjacent-level surgery leading to secondary surgery (p = 0.6819)	"At 5 years after the index surgery, ProDisc-L maintained ROM and was associated with a significantly lower rate of ΔALDs than in the patients treated with circumferential fusion. In fact, the fusion patients were greater than 3 times more likely to experience ΔALDs than were the TDR patients."	Data suggest at 5 years, ProDisc-L had significantly fewer adjacent-level degeneration changes versus fusion (3 times fewer).
Sköld 2013 (score=NA)	Discectomy	Post hoc 5 year analysis of Sköld 2013		N = 152 with chronic low back pain and have not responded to	Mean age: 39.4 years; 62 males, 90 females	TDR (n = 80) vs. Fusion (n = 72). Reference Sköld 2013 for treatment descriptions	Follow up at 1,2, and 5 years	Both groups showed clinical improvement at 5-year follow-up. 1-year results: Pain free : 29% (23/80) in the TDR group vs. 10% (7/71) in fusion group (p = 0.003); VAS back pain: 25.5 ± 26.5 (TDR vs. 33.4 ± 26.8	"Global assessment of low back pain differed between the two surgical groups at all follow-up occasions. Significant differences between groups concerning back pain, pain improvement,	Data suggest at 5 years twice as many patients in total disc replacement group were pain free compared to fusion group.

				nonsurgical treatment				(fusion) (p = 0.030); difference pre-postop: 36.8 ± 30.0 (TDR) vs. 25.1 ± 34.2 (fusion) (p = 0.027); VAS leg pain: 13.2 ± 21.9 (TDR) vs. 20.6 ± 25.1 (fusion) (p = 0.007); EQ5D: 0.71 ± 0.28 (TDR) vs. 0.63 ± 0.27 (fusion) (p = 0.046); ODI: 19.5 ± 187 (TDR) vs. 24.9 ± 16.1 (fusion) (p = 0.023); difference pre-postop: 22.4 ± 17.8 (TDR vs. 16.3 ± 18.4 (fusion) (p = 0.036). 2-year results: Pain free: 30% (24/80) in TDR group vs. 15% (11/71) in fusion group (p = 0.031); VAS leg pain: 16.4 ± 24.5 (TDR) vs. 20.7 ± 24.3 (fusion) (p = 0.037). 5-year results: Pain free: 38% (30/80) in TDR group vs. 15% (11/71) in fusion group (p < 0.002); much better: 35% (28/80) in TDR group vs. 52% (37/71) in fusion group, (p = 0.034); VAS back pain 22.7 ± 29.2 (TDR) vs. 30.5 ± 26.9 (fusion) (p = 0.009); difference pre-postop: 39.6 ± 31.8 (TDR) vs. 27.5 ± 32.3 (fusion) (p = 0.037); EQ5D 0.76 ± 0.30 (TDR) vs. 0.68 ± 0.30 (fusion) (p = 0.026); ODI: 17.3 ± 19.0 (TDR vs. 22.5 ± 17.1 (fusion) (p = 0.015); difference pre-postop: 24.6 ± 18.1 (TDR) vs. 18.3 ± 18.6 (fusion) (p = 0.019)	and ODI were present at 1 year and disappeared at 2 years, but reappeared at the 5-year follow-up."	
Abrishamkar 2015 (score=2.5)	Discectomy									Sparse methods. Data suggest comparable efficacy but

										nucleoplasty is less invasive.
Arts 2011 (score=9.0)	Discectomy	RCT	Funded by Dutch Health Insurance Board (CVZ). No COI.	N = 328 in Netherlands age 18-70 with sciatica due to lumbar disk herniation lasting more than 6 to 8 weeks unresponsive to conservative treatment.	Mean age: 41.5 years; 172 males, 153 females	Tubular diskectomy (n = 167) vs. Conventional microdiskectomy (n = 161) with follow-up 2 years after surgery. Data available for 294 patients at 2 year follow-up.	2. 4, 6, 8, 12, 26, 38, 52, 104 weeks	Mean±SD 52 week Roland Disability Questionnaire score: NS. Mean 52 week VAS: leg pain, tubular 17.3±1.3 vs. conventional 14.0±1.3, p = 0.04; back pain, NS. Mean 52 week proportion of patients recovered: NS. Mean 52 week rate recovery, NS. Mean 52 week SF-36 bodily pain, NS. Mean 52 week SF-36 physical functioning, NS. Mean 52 week Sciatic Frequency and Bothersomeness index: frequency, NS; bothersomeness, NS.	"Although minimally invasive lumbar disk surgery was launched to be superior to conventional diskectomy in terms of speed of recovery and outcome, the present data do not support better results of tubular diskectomy compared with open microdiskectomy."	2 year results of Arts 2009 RCT. Data suggest comparable results. Weak trend toward better results with conventional microdiscectomy.
Arts 2009 (score=9.0)	Discectomy	RCT	Funded by Dutch Health Care Insurance Board. No COI.	N = 328 in Netherlands age 18-70 with sciatica due to lumbar disk herniation lasting more than 6-8 weeks unresponsive to conservative treatment	Mean age: 41.5 years; 172 males, 153 females	Tubular diskectomy (n = 167) vs. Conventional microdiskectomy (n = 161) with follow-up at 8 weeks and 1 year after surgery.	2. 4, 6, 8, 12, 26, 38, 52 weeks	Mean±SD 52 week Roland-Morris Disability Questionnaire score: NS. Mean±SD score on horizontal VAS leg pain: tubular 18.3±1.3 v. conventional 14.1± 1.2, p = 0.01. Mean 52 week score on horizontal VAS back pain: 23.2±1.2 v. 19.7±1.3, p = 0.04. Mean 52 week score on horizontal VAS general health: 71.9± vs. 75.6±1.1, p = 0.01. Proportion recovered at week 52: 0.69 v. 0.79, p = 0.05. Mean 52 week rate of recovery: NS. Mean 52 week Prolo scale functional score: NS; economic score: NS. Mean 52 week SF-36 score: bodily pain, NS; physical functioning, NS. Mean 52 week sciatica	"Although the minimally invasive technique of tubular diskectomy seemed to be an attractive surgical method for treating sciatica, our data do not support a higher rate of recovery when compared with conventional microdiskectomy."	1 year follow up.

								index: frequency score, NS; bothersomeness score, NS.		
el Barzouhi 2013 (score=8.0)	Discectomy	RCT	Sponsored by a grant from the Netherlands Organization for Health Research and Development and the Hoelen Foundation. One or more of the authors have received or will receive benefits for personal or professional use.	N = 267 with 6-12 weeks of sciatica and disc herniation as seen in MRI.	Mean age: 42.5 years; 155 males, 112 females	Surgery Group: underwent early surgery (n = 170) vs. No Surgery Group: underwent conservative care (n = 97).	1 year	Presence of herniated discs on Surgery group vs. No Surgery group: 21% vs. 60% (p <0.001). Disappearance of root compression compared to baseline on Surgery group vs. Non surgery group: 82% vs. 60% (p<0.001). At 1 year, disc herniation found on 35% patients with favorable outcome vs. 33% with unfavorable outcome (95%CI, -18.8 to 12.6, p = 0.70).	"In patients who had undergone repeated MRI 1 year after treatment for symptomatic lumbar-disk herniation, anatomical abnormalities that were visible on MRI did not distinguish patients with persistent or recurrent symptoms of sciatica from asymptomatic patients."	Data suggest MRI findings not correlated with function at 1 yr, as disk herniation at 1yr in 35% favorable vs. 33% unfavorable outcomes.
Mirzai 2002 (score=6.5)	Discectomy	RCT	No mention of industry sponsorship. COI category: 12.	N = 44 with lumbar disk surgery for relief of post-op back pain	Mean age: 39.3 years; 25 males, 19 females	Peri-operative administration of bupivacaine hydrochloride and corticosteroids (n = 22) vs. placebo (N = 22). Assessment at 1, 3, 6, and 12 hours post-op.	1, 3, 6, 12 hours post-operation	VAS scores not differing between groups (p > 0.05). Less post-op medication requested by treatment group (p <0.05).	"[T]he perioperative use of bupivacaine and corticosteroids during lumbar discectomy maintains effective postoperative analgesia and decreases postoperative opioid usage without complications."	Very short follow-up of 12 hours. Data suggest injection of paravertebral soft tissue with bupivacaine and corticosteroid may reduce use of post-op opioids, but no differences in VAS pain scores.
Teli 2010 (score=5.5)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 240 with diagnosis of single level posterior lumbar disc herniation	Mean age: 39.9 years; 139 males, 73 females	Microendoscopy discectomy (MED, group 1, n = 70) vs. Microsurgical discectomy (MD, group 2, n = 72) vs. Open discectomy (OD,	Post-operatively, 6, 12, and 24 months	Mean operative time: MED 56±12 minutes, p = 0.023 v. MD 43±8 minutes, p = 0.062 v. OD 36±10 minutes, p = 0.013. VAS for back and leg, ODI, and SF-36 scores not significant between	"[M]ED, MD and OD show similar clinical outcomes when randomly applied to the treatment of LDH, but severe complication (dural and root injuries, recurrences) are significantly more	Underpowered. More dual tears and root injuries in Group 1.

				(LDH) and n = 65 with pain unresponsive to at least 6 weeks of conservative treatment.		group 3, n = 70) with 24 month follow up.		groups throughout the study.	frequent and surgical costs are higher with MED."	
Garg 2011 (score=4.5)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 112 age 26-57 with single level disc herniation	Mean age: 37 years; 80 males, 32 females	Microendoscopic discectomy (MED, n = 55) vs. open (fenestration/ laminotomy) discectomy (n = 57) and assessed pre- and post-op at 6 weeks, 6 months, and 1 year.	12-18 months	Mean operative time: MED 84±36 minutes vs. open discectomy 56±33 minutes, p <0.001. Mean anaesthesia time: MED 217±76 minutes vs. open discectomy 170±38 minutes, p <0.001. Hospital stay: MED 3±1 days vs. open discectomy 12±3 days, p <0.001. Mean Oswestry score: post-op week 1 MED 13.02 v. open discectomy 14.05, p <0.005; all times, NS.	"Both methods are equally effective in relieving radicular pain."	Methods sparse.
Ruetten 2009 (score=4.0)	Discectomy	RCT	No mention of industry sponsorship or COI.	N = 100 with symptomatic recurrent disc herniation after conventional discectomies who underwent surgical treatment in 2004/2005, age 23-59 and pain	Mean age: 39 years; 56 males, 44 females	Conventional microsurgical (MI) revision discectomy (N = 50) vs. Full-endoscopic (FE) revision discectomy (N = 50) with follow-up at day 1 and months 3, 6, 12, and 24 post surgery.	Day 1, 3 months, 6 months, 12 months, 24 months	Mean surgery time: FE 24 minutes vs. MI 58 minutes, p <0.001. Rate of serious complications: FE 6% vs. MI 21%, p< 0.05. Re-recurrences: NS. Post-op pain and pain medication: significantly reduced in FE, p<0.01. Mean postoperative work disability: FE 28 days v. MI 52 days, p <0.01.	"The clinical results of the full-endoscopic technique are equal to those of the microsurgical technique."	2nd report. Patients not well described. 2 year follow up.

				duration 1 day to 13 months.						
Garcia 2015 (score=6.0)	Discectomy	RCT		N = 324 with reported lumbar pain due to radiographically confirmed degenerative disc disease (DDD) at L4-L5 or L5-S1, despite at least 6 months of nonsurgical management	Mean age: 39.3 years; 169 males, 155 females.	Investigational TDR device (activL), modular prosthesis with inferior cobalt-chromium plate anchored in end-plate of caudal vertebral body, with ultrahigh molecular weight polyethylene inlay (n=218) vs. Control, FDA-approved TDR devices (ProDisc-L or Charité, based on surgeon's preference) (n=106). All TDR implants placed via anterior retroperitoneal approach	Follow-up at 6 weeks and at 3, 6, 12, and 24 months	24 months follow-up compliance: active = 83%, control = 80%. Overall treatment success rate at 24 months: activL noninferior to control using margins of 10% and 15% (both $p < 0.001$). After sensitivity analyses, patients treated with activL disc had higher rates of radiographic success compared to controls (59%, 43%, respectively, $p < 0.01$) and Oswestry Disability Index (ODI) success (75%, 66%, $p = 0.08$)	"The single-level activL TDR is safe and effective for the treatment of symptomatic lumbar DDD through 2 years."	Data suggest at 2 years single level activL total disc replacement appears to benefit discogenic low back pain patients. ActivL TDR was non-inferior to control TDR with p-value < 0.001.
Guyer 2014 (score=5.0)	Discectomy	RCT	No mention of sponsorship. One or more authors received consulting fees or honorarium, traveling supporting, writing assistance, equipment or administrative support.	N = 394 with single-level symptomatic disc degeneration at either L4-L5 or L5-L1 who failed to respond to at least 6 months of nonoperation care	Mean age: 39.7 years; 186 males, 208 females	Kineflex-L Disc implant, modular metal-on-metal implant with cobalt chromium molybdenum endplates, articulating core (n = 204) vs. Control, Charité artificial disc, 3-piece device with 2 cobalt chromium alloy endplates, sliding ultra-high molecular weight polyethylene core (n = 190)	Follow-up at 6 weeks and at 3, 6, 12, and 24 months	No significant difference between groups when comparing composite success criteria at 24 months. Overall success: 76.5% for Kineflex-L, 74.7% for control ($p > 0.05$). FDA definition of success: 68.6% for Kineflex-L, 68.4% ($p > 0.05$). No significant difference between 2 treatment groups based on any individual success criteria components (all $p > 0.05$)	"This prospective, randomized, controlled study comparing 2 TDRs, the first to the authors' knowledge, found the devices produced very similar clinical outcomes. Both groups improved significantly by 6 weeks postoperatively and remained improved throughout follow-up with a high patient satisfaction rate."	Data suggest comparable efficacy at both 6 weeks and 2 years.

Guyer 2016 (score=NA)	Discectomy	Post hoc analysis of Guyer 2014	COI, one or more of the authors have received or will receive benefits for personal or professional use. No mention of sponsorship.	N = 394 with single-level symptomatic disc degeneration at either L4-L5 or L5-L1 who failed to respond to at least 6 months of nonoperation care	Mean age: 39.7 years; 186 males, 208 females	Kineflex-L Disc implant, modular metal-on-metal implant with cobalt chromium molybdenum endplates, articulating core (n = 204) vs. Control, Charité artificial disc, 3-piece device with 2 cobalt chromium alloy endplates, sliding ultra-high molecular weight polyethylene core (n = 190)	Follow-up at 5 years	Percentage of each group meeting composite success criteria at 5 year follow-up: 76.5% for KineFlex-L group, 69.5% for control group (p > 0.20)	"This prospective, randomized study comparing two TDRs found no significant differences in outcomes during 5-year follow-up. Both provided statistically significant improvements by 6 weeks that were maintained. This results support other studies. Serum ion levels in TDR patients were well below the recommended threshold levels to merit monitoring."	Data suggest comparable efficacy at both 6 weeks and 2 years.
Bono 2017 (score=4.5)	Discectomy	RCT	COI, one or more of the authors have received or will receive benefits for personal or professional use. No mention of sponsorship.	N = 108 with predominant radicular leg pain clinically correlated to single-level, central or posterolateral lumbar disk herniation	Mean age: 43.32 years; 61 males, 46 females	6-week restriction group (n=55) vs. 2-week restriction group (n=53). Restriction periods included telling the patient to refrain from bending forward at the weight, lifting more 5 to 10 pounds, or twisting	Follow-up at 2 and 6 weeks, 3 months, and 1 and 2 years post-surgery	Immediately post-operative period: 6% of patients in 2-week restriction group reherniated, 2% in 6-week restriction group (p = 0.36). VAS back pain, leg pain, and Oswestry Disability Index (ODI) score significantly improve for both groups when comparing baseline to follow-up times through 1 year (all p < 0.001). No significant differences detected in VAS back pain, leg pain or ODI scores between groups (all p > 0.01). Similar findings occurred at 2 years follow-up	"The results of this randomized trial suggest equivalent clinical outcomes irrespective of the length of post-operative restriction. From a clinical perspective, if patients are deemed at low risk for a reherniation event they may be confidence that early return to activity at 2 weeks will not compromise outcomes and may not adversely impact the risk of reherniation."	Data suggest comparable outcomes.

ADHESIOLYSIS

Epidural adhesiolysis attempts to use hypertonic saline and glucocorticoids with a catheter and/or endoscopy to address adhesions that particularly develop after surgery and are proposed by some to be related to post-operative pain and failed back surgery syndrome.(1903, 1904) Epidural adhesiolysis is also known as percutaneouslysis of epidural adhesions, epidural neurolysis, epidural decompressive neuroplasty, and Racz neurolysis.(1905-1909)

Recommendation: Adhesiolysis for Treatment of Low Back Pain

Adhesiolysis is not recommended for treatment of acute, subacute, or chronic low back pain, or spinal stenosis or radicular pain syndromes.

Strength of Evidence **– Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are no sham-controlled trials. All studies comparing different adhesiolysis techniques were conducted by the same research group. The only other trial was an unblinded comparison of adhesiolysis with physiotherapy.(1910) Independent replication of the suggested modest benefits is needed before a recommendation may be made.

Adhesiolysis has been reported to show encouraging results in relatively small case studies and other uncontrolled or poorly controlled studies.(1903) No large scale, controlled clinical trials involving adhesiolysis have been reported.

Adhesiolysis is a relatively new procedure, is invasive, and has complications including serious ones such as dural puncture, spinal cord compression, infection, catheter shearing, hematoma, cardiac dysrhythmias, myelopathy, paralysis, and blindness.(516, 520, 1908, 1911-1913) It is also costly. Large scale, high-quality, multi-center studies with long-term follow-up are needed prior to consideration of this intervention for recommendation.

Evidence for the Use of Adhesiolysis

There is 1 high-(1914) and 4 moderate-quality(520, 1910, 1915, 1916) RCTs incorporated into this analysis. There is 1 low-quality RCT in Appendix 1.(1912)

One of the studies (which suggested that approximately half of the relief was gone at 12 months)(1907) has been labeled by its authors with an incorrect study design which raises concerns about selection bias, spectrum bias, and a potential uncontrolled confounder due to enrolling subjects into multiple studies.

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar with no limits on publication dates. We used the following terms: medical food theramine, theramine, subacute low back pain, chronic low back pain and low back pain. Of the 444 articles, we reviewed 10 articles and included 6 articles.

Author/Title Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Chronic LBP						
Manchikanti 2004 RCT Industry sponsored (EPIMED International provided supplies) and no COI.	8.0	N = 75 with chronic LBP and or lower extremity pain of 2 plus years and VAS ≥6	Group 1 (n = 25) anesthetic injection, steroid, normal saline vs. Group 2 (n = 25) adhesiolysis with local anesthetic, steroid, normal saline vs. Group 3 (n = 25) adhesiolysis, hypertonic saline injection, local anesthetic with steroid. Final follow-up 1 year.	At 12 months, Groups 2 and 3 had significant improvements in range of motion compared to baseline (p <0.03). ODI improved in Groups 2 and 3 at 12 months vs. baseline and Group 1 (p <0.001, p <0.001).	"Percutaneous adhesiolysis, with or without hypertonic saline neurolysis, is an effective treatment for chronic low back pain and/or lower extremity."	Data suggest adhesiolysis superior; however, issues of unblinding occurred in trial.
Manchikanti 2003 RCT Industry spnosored (Clarus Medical Systems provided supplies) and no mention of COI.	7.5	N = 39 with chronic LBP lasting ≥6 months	Spinal endoscopy (n = 16) Vs endoscopy with adhesiolysis (n = 23) followed by injection of local anesthetic and steroid with control group. Final follow-up at 6 months post-op.	MRI impressions: epidural fibrosis (10.3% mild, 20.5% moderate, 35.9% severe), disc herniation (10.3%), bulging (5.1%), severe degeneration (5.1%), severe spinal stenosis (5.1%). ODI scores 3.5±0.7 vs. 3.6±0.5 at baseline, 2.9±0.8 vs. 2.5±1.0 at 1 month, 3.1±0.7 vs. 2.6±1.1 at 3 months.	"Spinal endoscopic adhesiolysis with targeted injection of local anesthetic and steroid is an effective treatment in a significant number of patients without major adverse effects at 6-month follow-up."	Patients unblinded if they requested (data suggest that 64.1% unblinded at 3 months), thus limiting blinding at most to 3 months and resulting in questions. Data suggest adhesiolysis of minimal benefit.
Manchikanti 2005 RCT Double-blind	7.0	N = 83 facing chronic refractory low back and lower extremity pain	Control group with endoscopy into sacral level without adhesiolysis, followed by injection of local anesthetic and steroid (n = 33) vs. spinal endoscopic adhesiolysis, followed by injection of local anesthetic and steroid (n = 50). Outcomes assessed at 3, 6, 12 month intervals following procedure.	One from control group lost to follow-up after 3 months; 2 withdrew from intervention group (first experienced no improvement and underwent further surgical intervention while second reported no significant relief, refused further follow-up). Considerable pain relief (≥ 50%) in months after treatment found for both groups. Control group 0.7±0.73 months relief. Intervention 7.6±4.7 months relief. Duration of significant relief (≥ 50%) (mean±SD) 9.3±3.6 months in patients considered as successful (40 of 50).	"Spinal endoscopic adhesiolysis with targeted delivery of local anesthetic and steroid is an effective treatment in a significant number of patients with chronic low back and lower extremity pain without major adverse effects."	Appears to be a preliminary analysis of 83 subjects. Meaningful differences at 12 months among this population, data favor intervention.
Manchikanti 2009 RCT Equivalence	6.0	N = 83 with chronic low back and lower extremity pain with lumbar central spinal stenosis for at	Control group receiving caudal epidural injections with catheterization up to S3 with local anesthetic, 0.9% sodium chloride solution, non-particulate betamethasone (n = 25) vs. receiving percutaneous	Average pain scores (mean±SD) followed for control group: Baseline value: 8.0±1.1, 3 months - 5.4#±1.6, 6 months - 6.0#±1.1, and 12 months - 6.2#±0.9. Intervention group values: Baseline - 7.8±0.9, 3 months - 3.6# ± 1.2, 6 months: 3.8# ± 1.2, 12 months - 3.9#±1.2. P-values calculated at	"With significant pain relief in 76% of patients, percutaneous adhesiolysis utilizing local anesthetic, steroids and hypertonic sodium chloride solution may be effective in patients with chronic function-	Study of multiple injections precludes assessment of which is efficacious. High dropouts as not completed. Data favor intervention. Opioid use did not.

		least 2 years duration	adhesiolysis with targeted delivery and injection of lidocaine, 10% hypertonic sodium chloride solution, non-particulate Betamethasone (n = 25). Outcomes assessed at 3, 6, and 12 month intervals following the procedure. 18 in control group dropped from study. (10 in last 6 months and 8 at 12 months. 1 died due to problems unrelated to the study)	.471 for baseline scores and 0.0 all other time frames. Average ODI scores (mean±SD) for control group: Baseline value - 30.2±4.9, 3 months - 23.3#±6.2, 6 months - 25.2#±4.5, and 12 months - 25.4#±4.4. Intervention group values: Baseline - 30.6±4.1, 3 months - 15.6#±5.3, 6 months - 15.8# ±4.4, and 12 months - 15.6#±4.7. P values calculated at .804 for baseline scores and 0.0 all other time frames. Results show change in significant pain relief (> 50%) in 76% at 1 year follow-up in adhesiolysis group vs. 4% in control group.	limiting low back and lower extremity pain with spinal stenosis."	
Veihelmann 2006 RCT No mention of industry spnosorship or COI.	5.0	N = 99 with chronic LBP and sciatica based on disc protrusion/prol apse or failed back surgery	Physiotherapy (n = 52) vs. epidural neuroplasty (n = 47). Final follow-up at 1 year post-op.	VAS leg pain scores 6.7±2.0 at baseline to 5.6±2.4 at 3 months to 5.9±2.3 at 12 months (although number of patients fell from 52 to 39 to 27). VAS leg pain scores in epidural neuroplasty group 7.2±2.0 to 2.4±2.2 to 2.8±2.8. VAS LBP and Oswestry scores showed similar trends.	"Taking into account that the results of open discectomy are not necessarily superior to conservative treatment often long-term follow-up, our data show for the first time that for patients with radicular pain due to disc protrusion and herniation or epidural fibrosis epidural neuroplasty seems to be an effective safe alternative treatment."	Authors note that "at least 3 months after neuroplasty it is superior in comparison to conservative treatment with physiotherapy," but that further studies should be performed to prove the effectiveness of epidural neuroplasty.

DECOMPRESSIVE SURGERY FOR SPINAL STENOSIS (LAMINOTOMY/FACETECTOMY, LAMINECTOMY)

Spinal stenosis means insufficient room for neural elements in the spinal canal and/or neural foramina. It can be congenital (e.g., short pedicles, narrow canal diameter) or acquired (degenerative enlargement of facets and ligaments and in addition the formation of osteophytes), or both. Stenosis can be in the central canal, in the lateral recess, or in the neural foramen. These degenerative changes are referred to as lumbar spondylosis. The typical symptom of lumbar spinal stenosis is neurogenic claudication, or leg pain that develops during walking and that is promptly relieved by rest. Standing may exacerbate the pain. Acquired lumbar spondylosis is a natural aging phenomenon with a strong genetic component that can become symptomatic.

Decompressive surgery for spinal stenosis involves techniques that remove bone from one or more structures to expand a narrowed spinal canal/neural foramen that impinges on neural structures.(16, 1917-1927) **Laminotomy** is removal of a portion of the lamina, usually to permit access to the central spinal canal to gain access to another structure such as a herniated disc or a neural foramen.**Laminectomy** refers to the complete removal of the lamina. It was traditionally performed as part of a discectomy, but is not performed any longer for that sole indication.(1928, 1929) **Hemilaminectomy** refers to removal of the left half or the right half of the lamina. **Facetectomy** is removal of part of or at times all of a facet joint. **Posterior decompression** is a term usually used to include any of the above surgeries for spinal stenosis. **Fusion** is sometimes recommended at the same time as a spinal stenosis decompression.(1930) The fusion section of these guidelines should be consulted for the indications for spine fusion performed simultaneously with decompression.

Recommendation: Decompression Surgery for Treatment of Spinal Stenosis

Decompression surgery is moderately recommended as an effective treatment for patients with symptomatic spinal stenosis (neurogenic claudication) that is intractable to conservative management. Caution is warranted among elderly with multiple comorbidities.(1931)

Indications – All of the following should be present: 1) radicular-type pain involving usually multiple dermatomes with pain and/or numbness, or myotomal muscle weakness all consistent with the nerve root levels affected; 2) imaging findings by MRI, or CT with or without myelography that confirm spinal stenosis and corroborate the dermatomal and myotomal findings predicted by the history and clinical examination; and 3) continued significant pain and functional limitation after at least 4 to 6 weeks of time and appropriate non-operative therapy that usually includes flexion exercises plus aerobic exercise (walking or cycling),(598) and NSAIDs. Progressive neurological deficits are considered a separate indication.

Benefits – Relief of spinal stenosis-related symptoms.

Harms – Rare, but serious complications include infection, paralysis and death.

Strength of Evidence – **Moderately Recommended, Evidence (B)**

Level of Confidence – Moderate

Rationale for Recommendation

The highest of the moderate-quality trials reported comparable results from physical therapy (PT) consisting of flexion exercises plus aerobic exercises versus decompressive surgery over 2 years,(598) although it is noteworthy that 57% of the PT group crossed over to surgery. One trial found no significant differences between a decompressive device and epidural steroid injection.(1338) One moderate-quality trial comparing decompressive surgery with non-operative management and found superiority of decompression surgery for patients with symptomatic spinal stenosis (neurogenic claudication) that is intractable despite conservative management.(1932, 1933) The few other trials compare various operative procedures. These procedures are commonly performed in settings of either central canal stenosis, lateral recess, or neuroforaminal stenosis. Decompressive surgery is invasive,

has significant adverse effects and is costly, but if there is insufficient improvement with non-operative management and/or progressive neurological deficits, it is recommended.
There is no quality evidence of benefit to adding lumbar fusion to decompression.(1934) Fusion has no role in the surgical treatment of spinal stenosis, rather the role of fusion is to treat instability if proven to be present (see Fusion).

Evidence for the Use of Decompressive Surgery

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates and then an updated search was done in PubMed for publication between 1/1/2013 and 11/15/2017. We used the following search terms: decompression surgery, decompression, back, microdiscectomy, lumbar laminectomy, open decompression, microdecompression, spinal stenosis, herniated disc and spondylolisthesis to find 8,102 articles. Of the 8,102 articles we reviewed 90 articles and 25 articles were included (6 randomized controlled trials and 19 systematic reviews).

Decompressive Surgery vs. Non-operative Treatment										
Malmivaara 2007 (score= 7.0)	Decompression	RCT	Sponsored by Finnish Office for Health Technology Assessment, and participating hospitals. No mention of COI.	N = 94 with lumbar spinal stenosis	Mean age: 47.0 years; 31 male, 63 female.	Segmental decompressive surgery and undercutting facetectomy of affected area n = 50) vs. conservative non-surgical treatment (including NSAIDs and physiotherapy) (n = 44).	Follow-up at 6, 12, 24 months.	Oswestry scores 0/6/12/24 months 34.7/28.3/30.2/29.0 non-operative, and 34.0/20.7/18.9/21.2 surgical, p = 0.01. Leg pain during walking and LBP during walking also different between groups (p = 0.02 and p = 0.0003, respectfully).	"Although patients improved over the 2-year follow up regardless of initial treatment, those undergoing decompressive surgery reported greater improvement regarding leg pain, back pain, and overall disability."	Results suggest modest benefits that appear to diminish over 2-year follow-up. Data suggest decompression superior to non-operative management.
Delitto 2015 (score= 6.5)	Decompression	RCT	Sponsored by National Institutes of Health. Dr. Delitto reports grants from NIH/NIAMS. Dr. Welch reports grants from NIH, Zimmer Spine, personal fees from ISTO, other from Transcendental Spine, outside submitted work and Dr. Piva reports grants from National Institute of Health. No mention of COI.	N = 169 with diagnosis of LSS identified by computed tomography.	Mean age: 68.15 years; 88 male, 81 female.	Surgery included decompressive laminectomies, partial facet resection, and neuroforaminotomies performed at the levels of radiographic stenosis (n = 87) vs. Physical therapy or PT emphasized lumbar flexion exercises, general conditioning exercises, and patient education for 6 weeks, 2 visits per week (n = 82).	Follow-up at 6, 12 and 24-month.	Mean changes in physical function for surgery and PT groups: 22.4 (95% CI, 16.9 - 27.9) and 19.2 (CI, 13.6 - 24. No difference between surgery and PT groups at all points of follow-up, (p > 0.50 8). Of 44 who crossed over from PT to surgery, 24 (55%) achieved successful outcome, and 29 in	"Surgical decompression yielded similar effects to a PT regimen among patients with LSS who were surgical candidates."	57% patients in PT group crossed over to receive surgery, through 2 years. Excluded, spondylolisthesis >5 mm of slippage, PT was flexion exercise plus cycle/treadmill.

								PT group who did cross over, 15 (52%) had successful outcome.		
Benyamin 2016 (score= 5.0)	Decompression for PDD	RCT	Sponsored by Vertos Medical. No COI.	N = 302 medicare beneficiaries that have had neurogenic claudication symptoms for at least 3 months that was refractory to physical therapy, home exercise programs, and oral analgesics.	Mean age: 75.3 years; 132 male, 170 female.	MILD group (n=149) vs active control (n=153)	Follow up at baseline, 6 months and 1 year.	Primary efficacy: ODI at 1 year was 58.0% for the MILD group vs 27.1% for the control (p<0.001).	"One-year results of this randomized controlled clinical trial demonstrate that MILD is statistically superior to ESIs in the treatment of LSS patients with neurogenic claudication and verified central stenosis due to ligamentum flavum hypertrophy."	At 1 year, MILD was statistically superior to ESI for improved function.
Comparison of Decompressive Surgeries										
Thomé 2005 (score= 6.0)	Decompression	RCT	No mention of sponsorship or COI.	N = 120 with lumbar spinal stenosis refractory to adequate conservative treatment.	Mean age: 68.7 years; 53 male, 67 female.	Bilateral laminotomy (N = 40) vs unilateral laminotomy for bilateral decompression (N= 40) vs laminectomy (N = 40).	Follow-ups at 3, 6, and 12 months.	Bilateral laminotomy group required longest operative time (mean 90 minute/level vs. 77 minute/level for unilateral laminotomy vs.73 minute/level for laminectomy, p <0.01). 12 months pain scores post-op 2.3±2.4 for bilateral group vs. 3.6±2.7 for	"Bilateral and unilateral laminotomy allowed adequate and safe decompression of lumbar stenosis, resulted in a highly significant reduction of symptoms and disability, and improved health-related quality of life…In most outcome parameters, bilateral laminotomy was associated with a significant benefit and thus constitutes a promising treatment alternative."	Data suggest bilateral laminotomy outperformed laminectomy results and trends toward favoring over unilateral laminotomy for bilateral disease.

								unilateral group vs. 4±1 for laminectomy group, p <0.05. Complications 5.0% vs. 17.5% vs. 22.5%.		
Wang 2011 (score= 5.5)	Decompression	RCT	No mention of sponsorship or COI.	N = 52 with failed discectomy and decompression by open posterior midline.	Mean age: 55.5 years; 28 male, 24 female.	Minimally invasive transforaminal lumbar fusion (MiTLIF) (n = 25) vs Open transforaminal lumbar interbody fusion (OTLIF) (n = 27).	Mean follow up 27.5 months.	During surgery, MiTLIF group lost significantly less blood vs. OTLIF (p <0.01). Post-op blood loss significantly less in MiTLIF group vs. OTLIF (p <0.01). Day after surgery, VAS pain scores for MiTLIF group went from 7.1 +/- 2.4 to 2.2 +/- 0.6 (p <0.05).	"…Due to less tissue trauma and structure damage, MiTLIF may reduce the amount of iatrogenic injury while still safely accomplishing the goals of the conventional open TLIF."	Data suggest faster short term recovery but not long term with less invasive procedure.
Gerszten 2010 (score= 5.0)	Decompression	Prospective RCT	Sponsored by ArthroCare Corp. COI: Ms. Crabtree, Dr. Bloch, Dr. Gerszten, and Dr. Smuck are consultants for ArthroCorp and Dr. Smuck also reports financial support from ArthroCare Corp. for a non-study related research effort	N = 90 with chronic LBP and radicular pain score of 50 or greater as measured using 0-100mm VAS (visual analog scale). All received epidural injection for same symptoms between 3 weeks	Mean age: 44.1 years; 42 male, 43 female.	PDD (Plasma disc decompression) (n = 46) vs. TFESI (transforaminal epidural steroid injection) (n = 44)	Follow up at 6 weeks, 3 and 6 months, 1 and 2 years.	Significantly greater percentage of patients in PDD group satisfied with care provided vs. TFESI group (p = 0.004). As well as significantly lowering back pain, PDD group also showed significant improvements in 4 SF-36	"Pain, function, and quality-of-life measures were significantly enhanced for patients in the PDD Group compared with those in the TFESI Group and significantly more patients in the PDD Group remained free from having a secondary procedure during the 2-year follow-up period."	Excluded WC. Criteria of failing 1 ESI may be biased against that arm and may be fatal flaw. Greater LBP in ESI group (VAS 53 v 44, p=0.10). Massive dropout rates (27/45 vs. 35/40 for ESI). 2yrs followup. Cointerventions not well controlled. <80% compliance with 2nd ESI in that group. Study reports more secondary procedures in ESI group but data provided suggest increase in PDD at

			overseen by him.	and 6 months previous to study				quality of life components vs. TFESI group. (PDD p-value, TFESI p-value) Physical Function (<0.0001, .0016), Bodily pain (<0.0001, 0.0039), Physical components summary (<0.0001, 0.0040) and social function (0.0028, 0.0312).		2yrs but not at 6mo.
Dai 2008 (score= 4.5)	Decompression	Prospective RCT	Sponsored by Shanghai Natural Science Foundation, No COI	N = 62 with symptomatic degenerative lumbar spinal stenosis.	No mention of mean age, age range 48-73 years; 25 male, 37 female.	β-TCP combined with local bone obtained from decompression used. Tricalcium Phosphate (Group A, n = 32) vs. Autogenous iliac crest bone graft plus decompression bone used. Autograft (Group B, n = 30). In both groups, pedicle screw instrumentation used. Subjects intravenously given prophylactic antibiotics peri-operatively	Follow-up after surgery at 6 weeks, 3 months, 6 months, 12 months, 24 months, and 36 months.	Duration surgery between groups: 156 minutes (range 80-210) group A Vs. 178 minutes (range 90-240) for group B (p >0.05). No difference between two groups when comparing Japanese Orthopedic Association (JOA) score and recovery rate at all-time interval (p >0.05)	"Instrumented posterolateral fusion with β-TCP combined with local autograft results in the same radiographic fusion rates and similar improvement of clinical outcomes and life quality compared with autograft alone. The authors therefore recommend the use of β-TCP as bone graft substitute for instrumented posterolateral fusion of lumbar spine to eliminate the need of bone grafting harvesting from the ilium."	Data suggest no difference in between treatment groups.

						and mobilized 3-5 days after surgery.				
Comparison of Decompressive Surgeries										
Komp 2015 (score= 5.0)	Decompression for PDD	RCT	No sponsorship or COI.	N=160 patients with microsurgical or full-endoscopic decompression	Mean age: 62 years; 69 males, 91 females	Conventional microsurgical group (MI) (n=80) vs full-endoscopic interlaminar (FI) decompression group (n=80)	Follow up at day 1, and months 3, 6, 12, and 24 months after surgery.	Mean operating time for the FI group was 42 mins vs 64 minutes for MI ($p<0.05$). Complications were as follows: 11 times transient postoperative dysesthia (7 MI, 4 FI), 4 times transient urinary retention (3 MI, 1 FI) and 5 times dura injuries (3 MI, 2 FI).	"The recorded results demonstrate that the full-endoscopic interlaminar bilateral decompression adopting a unilateral approach provides an adequate and safe supplement and alternative to the conventional microsurgical bilateral laminotomy technique when the indication criteria are fulfilled. At the same time, it offers the advantages of a minimally invasive intervention."	No placebo group. Sparse description of baseline characteristics of study population. No patient blinding. Data suggest FI technique required less operation time, fewer complications, and shortened rehab time.
Mobbs 2014 (score= 4.0)	Decompression for PDD	RCT	No mention of sponsorship. No COI.	N=54 patients with symptomatic LSS with radiculopathy, neurogenic claudication or urinary dysfunction and radiologically confirmed LSS caused by degenerative changes and canal stenosis at a max of 2 levels.	Mean age: 69.3 years; 18 male, 36 female.	ULBD Group (n=27) vs Open-surgery Group (n=27)	Follow up at a mean of 40.6 months.	Mean improvement in ODI was 17.8 for open surgery vs 28.6 for ULBD ($p=0.055$) Mean improvement in VAS for open-surgery was 3.9 vs 5.6 for the ULBD group ($p=0.013$)	"Based on short-term follow-up, microscopic ULBD is as effective as open decompression in improving function (ODI score), with the additional benefits of a significantly greater decrease in pain (VAS score), postoperative recovery time, time to mobilization, and opioid use."	Short term follow up. Age in ULBD group older than open surgery group. Data suggest comparable efficacy but shorter recovery time, and greater pain relief in ULBD group.

Musacchio (score= 4.0)	Decompression for PDD	RCT	No mention of sponsorship. COI: One or more of the authors have received or will receive benefits for personal or professional use.	N=322 patients with moderate to severe lumbar stenosis	No mention of mean age: range: 40-80 years; no mention of sex.	D+ILS Group: received decompression and interlaminar stabilization (n=215) vs D+PS Group: received decompression and fusion with pedicle screws (n=107)	Post-op, 6 weeks, 3, 6, 12, 18, 24, 36, 48, 60 months	At 60 month follow-up patients that received D+ILS showed greater success than D+PS group (55.1% vs 35.3%; 0.05<p<0.065). Reoperation/revision rates were similar between groups (p>0.9). Improved ODI scores were observed in 80.6% of D+ILS group and in 73.2% of D+PS group.	"Results of this 5-year follow-up study demonstrate that decompression and interlaminar stabilization with coflex is a viable alternative to traditional decompression and fusion in the treatment of patients with moderate to severe stenosis at one or two lumbar levels."	Data suggest comparable efficacy at 5 years, but early follow up showed a benefit of D-ILS. Also, two level D-ILS had fewer reoperations than did the fusion group.
Erginousakis 2011 (score= 3.0)	Decompression	Prospective RCT	No mention of sponsorship. No COI.	N = 31 with sciatica due to intervertebral disk herniation.		Control group (17 men and 14 women): conservative therapy (administration of analgesics, antiinflammatory drugs, muscle relaxants, and physiotherapy) for 6 weeks vs. Percutaneous disk decompression (PDD) (19 men and 12 women).	Follow-up at 3, 12, and 24 months.	Decompression group had significantly a greater reduction of pain in NVS units vs. control group at 12 (1.7±2.4 vs. 4.0±3.4; p = 0.005) and 24 (1.6±2.5 vs. 4.0±3.4; p = 0.004) months. Per statistically analysis, patients in either group that had large	"When compared with conservative therapy, PDD shows improved amelioration of symptoms at 12- and 24-month follow-up."	Quasirandomized. No neurological deficits. Patients not well described. Conservative outperformed surgery at 3 months, but surgery outperformed at 1 & 2 years.

								improvement (>4 NVS units) at 1-month follow-up maintained decreased symptoms (p <0.01).		
Grob 1995 (score= 2.5)	Decompression			N = 45 with degenerative lumbar spinal stenosis		Decompression with laminotomy and medial facetectomy (group I, n = 15) vs. decompression and arthrodesis most stenotic segment (group II, n = 15) vs. decompression and arthrodesis of all decompressed vertebral segments (group III, n = 15).	Mean follow up at 28 months.	No significant differences between groups for relief in pain. Group I vs. II vs. III had significant improvement in walking distance at baseline-follow up: p<0.001, p<0.002, p<0.005.	"[I]n the absence of segmental instability, arthrodesis is not necessary after decompression of the lumbar spine in patients who have degenerative lumbar spinal stenosis, provided that the stabilizing posterior elements of the spine are preserved during the operation."	Lack of study details such as baseline comparisons and co-interventions lowered score. Data suggest arthrodesis did not improve outcomes in surgical patients with stable spinal stenosis.
X-Stop										
Lønne, 2015 A (score=6.0)	Decompression, X-stop	RCT	No sponsorship, no COI.	N = 96 patients who exhibited symptoms of neurogenic intermittent claudication within 250-m walking distance for at least 6 months.	Mean age: 67 years. 54 males, 42 females.	Minimally invasive decompression (MID) (n = 41) vs X-stop (n = 40)	Follow up preoperative, at 6 weeks, 3 months, and 1 and 2 years.	ZCQ-symptom severity score for MID (3.37 preoperative vs 2.4 at 6-weeks, p<0.01) and X-stop (3.25 preoperative 3.25 to 2.2 at 6-weeks, p<0.01). There was 4.9% (2 patients) reoperations in the MID group	"Both MID and X-Stop led to significant symptom improvements. There were no significant clinical differences in effect between the methods at any of the follow-up time points. X-Stop had significant higher risk of secondary surgery. Complication was more severe for MID."	Data suggest comparable efficacy but higher reoperation rates in X-stop group and study was then terminated.

								vs 25% (10 patients) in the X-stop group.		
Lønne, 2015 B (score=6.0)	Decompression, X-stop	RCT	Sponsored by the South-East Regional Health Authority, Norway and the National Advisory Unit on Spinal Surgery, St. Olavs Hospital, Norway.sponsorship. No COI.	N = 96 patients who exhibited symptoms of neurogenic intermittent claudication within 250-m walking distance for at least 6 months.	Mean age: 67 years. 54 male, 42 female.	Minimally invasive decompression (MID) (n = 41) vs X-stop (n = 40)	Follow up preoperative, at 6 weeks, 3 months, and 1 and 2 years.	Mean total hospital cost of X-stop was €8247 for X-stop vs €5415 for MID. Incremental health gain was 0.11 QALY. The ICER was €25700	"The majority of the bootstrap samples displayed in the northeast corner of the cost-effectiveness plane, giving a 50% likelihood that X-stop is cost effective at the extra cost of €25,700 (incremental cost-effectiveness ratio) for a quality-adjusted life-year. The significantly higher cost of X-stop is mainly due to implant cost and the significantly higher reoperation rate."	Study termination midway through due to 33% reoperation rate.
Stromqvist, 2013 (score=4.5)	Decompression, X-stop	RCT	No sponsorship or COI.	N = 100 patients with MRI verified spinal stenosis on 1 or 2 levels in the lumbar spine.	Mean age: 69 years; 56 male, 44 female.	X-stop (n = 50) vs Decompression (n = 50)	Follow up at 6, 12 and 24 months.	ZCQ score between X-stop and decompression at 6, 12, and 24 months were not significantly different. Reoperation rates during follow up was 6% for decompression and 26% in X-Stop (p=0.04).	"For spinal stenosis with neurogenic claudication, decompressive surgery as well as X-Stop are appropriate procedures. Similar results were achieved in both groups, however, with a higher number of reoperations in the X-Stop group. Patients having X-Stop removal and decompression experienced results similar to those randomized to primary decompression."	Data suggest comparable efficacy but higher reoperation rate in X-stop group.
Puzzilli, 2014										Data suggest X-stop may be beneficial for individuals

(score=3.0)										suffering from persistent spinal stenosis vs conservative treatment in those with symptomatic NIC secondary to degenerative lumbar disease for up to 7 years.
Interspinous Process Device (IPD)										
Moojen, 2013 (score=7.5)	Back Decompression, IPD	RCT	Sponsored by Paradigm Spine. No COI.	N = 159 patients with intermittent neurogenic claudication due to lumbar spinal stenosis at 1 or 2 levels with an indication for surgery	Mean age: 67.3 years; 86 male, 73 female.	Patients receiving an interspinous process device (IPD) (n = 80) vs patients who underwent spinal body decompression (BD) (n = 79)	Follow up at 2, 4, 8, 12, 26, and 52 weeks.	ZCQ of IPD vs BD was 67 vs 57 (p=0.18) at 2 weeks, 63 vs 72 (p=0.44) at 8 weeks, 64 vs 63 (p=0.64) at 26 weeks, and 66 vs 69 at 52 (p=0.77) weeks. Reoperation rates during follow up were 29% for IPD vs 8% for BD (p<0.001).	"This double blinded study could not confirm the Hypothesized short term advantage of interspinous process device over conventional "simple" decompression and even showed a fairly high reoperation rate after interspinous process device implantation."	Data suggest IPD is not superior to standard decompression and reoperation rates were high.
Moojen, 2015 (score=NA)	Back Decompression, IPD	Secondary analysis of Moojen, 2013	Sponsored by Paradigm spine. No COI.	N = 145 patients with intermittent neurogenic claudication due to lumbar spinal stenosis at 1 or 2 levels with an indication for surgery	No mention of mean age or gender for this subset of data	Patients receiving an interspinous process device (IPD) (n = 70) vs patients who underwent spinal body decompression (BD) (n = 75)	2 year follow up	At 2 years IPD group did not show significant difference in success rates (69%, 95% CI (57-78%)) compared to standard bony decompression (60%, 95% CI (48-71%), p = 0.2).	"This double-blinded study could not confirm advantage of IPD without body decompression over conventional 'simple' decompression."	2 year analysis of Moojen 2013. Data suggest long term VAS pain scores in addition to reoperation rates were high in IPD.
Meyer, 2017 (score=6.0)	Back Decompression, IPD	RCT	Sponsored by Medtronic Spinal and Biologics.	N = 163 patients with at least 6 weeks of	Mean age: 65 years; 80 male,	Patients receiving an interspinous process device(IPD)	Follow up at 2 and 6 week	Mean ZCQ baseline to 24 months was 2.6 vs 1.5	"Confirming 3 recent RCTs, we could show that IPD as well as open	Open label RCT. Although comparable efficacy between IPD and SDS was

			COI: BM has been a consultant for Medtronic, Depuy/Synthes, Ulrich Medical, Spine Art, Relievant, and Brainlab for relevant financial activities outside the submitted work.	intermittent NIC due to DLSS at 1 or 2 levels, with symptoms relieved by flexion.	83 female.	(n = 82) vs patients receiving standalone decompression surgery (SDS) (n = 81)	s, 6, 12, and 24 months.	(p<0.001) for IPD and 2.7 vs 1.7 (p<0.001) for SDS. Reoperation rates at 12 months were 29% for IPD vs 6% for SDS.	decompression achieve similar results in relieving symptoms of NIC in highly selected patients. However, despite some advantages in secondary outcomes, a higher reoperation rate for IPD is confirmed."	shown, the IPD group resulted in more reoperations.
Percutaneous Laser Disc Decompression (PLDD)										
Brouwer, 2015 (score=6.5)	Back Decompression, PLDD	RCT	Sponsored by the Healthcare Insurance Board of the Netherlands. COI, one or more of the authors have received or will receive benefits for personal or professional use.	N = 115 patients with sciatica that was refractory to conservative management for more than 6 weeks and were candidates for surgery.	Mean age: 43.5 years; 72 male, 43 female.	Percutaneous laser disc decompression (n = 57) vs. conventional surgery (n = 58)	Follow up at 8 and 52 weeks	RDQ showed noninferiority of PLDD at 8 (-0.1; 95% CI, -2.3 to 2.1) and 52 weeks (-1.1; 95% CI, -3.4 to 1.1) vs conventional surgery. Additional surgery for PLDD vs conventional surgery was 44% vs 16%	"At one year, a strategy of PLDD, followed by surgery if needed, resulted in non-inferior outcomes compared with surgery."	Baseline differences between groups for duration of sciatica. Data suggest the primary outcome measure of a clinical outcome score no worse than compared to conventional surgery was met. However, 24 patients in the PLDD group (44%) required additional surgery vs 9 patients (16%) in the conventional surgery group.
Superior IPS										
Patel, 2015 (score=4.0)	Back decompression Superior IPS	RCT	Sponsored by VertiFlex Inc. No COI.	N = 391 patients with intermittent neurogenic claudication secondary to moderate LSS who failed at least 6 months of nonsurgical	Mean age: 66.5 years. 239 male, 152 female.	Superion spacer group (n = 190) vs X-stop spacer group (n = 191)	Follow up at 6 weeks, 3, 6, 12, 18, and 24 months.	The posterior probability that the composite treatment success outcome through 2 years with Superion vs X-Stop was no less than the 10% noninferiority margin was 0.993.	"The Superion and X-Stop interspinous process spacers both relieve symptoms of intermittent neurogenic claudication secondary to moderate LSS. In addition, the safety profiles of these devices were comparable. The Superion device may represent a	No sham or placebo group. Baseline physical function different between groups. Data suggest superion spacer not inferior to X-stop spacer for relief of neurogenic claudication symptoms.

				management.					reasonable treatment option for this patient population."	
Nunley, 2017 (score=NA)	Back decompression Superior IPS	Secondary analysis of Patel 2015.	Sponsored by VertiFlex Inc. No COI.	N = 391 patients with intermittent neurogenic claudication secondary to moderate LSS who failed at least 6 months of nonsurgical management.	Mean age: 66.5 years. 239 male, 152 female.	Superion spacer group (n = 190) vs X-stop spacer group (n = 191)	Follow up at 4 years.	At 4 years, 75/89 (84.3%) patients had clinical success on 2 or more ZCQ domains.	"Minimally invasive implantation of the Superion device provides long-term, durable relief of symptoms of intermittent neurogenic claudication for patients with moderate lumbar spinal stenosis."	4 year outcome analysis of Patel 2015. Data suggest at 4 years, 75.8% of superion group did not require reoperation and 84.3% reported clinical success on at least 2 of 3 ZCQ domains.
Nunley, 2017 (score=NA)	Back decompression Superior IPS	Secondary analysis of Patel 2015.	Sponsored by VertiFlex Inc. No COI.	N = 391 patients with intermittent neurogenic claudication secondary to moderate LSS who failed at least 6 months of nonsurgical management.	Mean age: 66.5 years. 239 male, 152 female.	Superion (IPD) spacer group (n = 190) vs X-stop spacer group (n = 191)	Follow up at 5 years.	At 5 years 74/88 (84%) patients had clinical success on 2 or more ZCQ domains. 142/190 (74%) of patients randomized to the IPD group did not have any reoperation, revision, or supplemental fixation at 5 years.	"After 5 years of follow-up, IPD with a stand-alone spacer provides sustained clinical benefit."	5 year analysis of Patel 2015. Data suggest sustained results at 5 years post IPD.
Decompression for PDD										
Nikoobakht 2016 (score=6.0)	Decompression for PDD	RCT	Sponsored by Qazvin University Medical Sciences. No COI.	N=177 patients with primarily radicular pain associated with disc herniation	Mean age: 34.8 years; 79 male, 98 female.	PDD Group: (n =89) vs Conservative Group: (n =88)	Follow up at baseline, 1, 3, and 12 months.	Baseline VAS score for PDD was 7.60 vs 4.68 at 12 months (p=0.04). Present pain intensity at baseline for PDD was 3.56	"Patient selection for PDD over physiotherapy favored younger patients who presented with a shorter period of pain symptoms and who had a more favorable body habitus."	Data suggests at 12 months the PDD group had improved VAS scores and decreased leg pain.

								vs 2.49 at 12 month follow up (p<0.001).		
Delitto 2015 (score=6.5)	Decompression for PDD	RCT	Sponsored by National Institutes of Health and National Institute of Arthritis and Musculoskeletal and Skin Diseases. No COI.	N=169 patients with lumbar spinal stenosis	Mean age: 68.1 years; 88 males, 81 females	Surgical decompression group (n=74) vs physical therapy group (n=73)	Follow up at 10 weeks, 6, 12, and 24 months.	47 of 82 (57%) patients in the PT group crossed over to surgery during the 24 month study.	"Surgical decompression yielded similar effects to a PT regimen among patients with LSS who were surgical candidates. Patients and health care providers should engage in shared decision-making conversations that include full disclosure of evidence involving surgical and nonsurgical treatments for LSS."	Results are difficult to interpret since 57% of PT group crossed over to surgery.
Post-operative Treatment										
Chen 2015 (score=3.5)										Data suggest rehab group (PG) had less pain intensity but functional gains were limited at 6 months.

SPINAL FUSION

Lumbar fusion involves the surgical fusion of one or more vertebral segments by inserting bone grafts (with or without instrumentation) so that the previously mobile involved segments heal together to form a single bone mass. A spinal motion segment consists of two adjacent vertebra, the connecting ligaments, two facet joints, and the interposed disc. The proposed goal of lumbar fusion is similar to that in fusing other joints in the body – that instability and pain will be significantly improved, if not resolved.(563, 1938-1971)

The U.S. has the highest rate of lumbar fusion surgery in the world (twice that of Norway, 5-fold that of England). There has been a 55% increase in spine surgery rates in the 1980s, a 6-fold variation in spine surgery rates among U.S. cities, and 10-fold variation in spine fusion rates(1972) without evidence of beneficial outcomes.

There are some diagnoses for which fusion is either non-controversial or less controversial. These include unstable vertebral fractures or where surgery is being done for tumor, infection (osteomyelitis and/or discitis), or other disease processes that have led to spinal motion segment instability. Treatment of these conditions is outside the scope of these guidelines.

1. *Recommendation: Lumbar Fusion for Treatment of Chronic Non-specific Low Back Pain*
   Lumbar fusion is moderately not recommended as a treatment for chronic non-specific low back pain.(1973-1978)

   Strength of Evidence – **Moderately Not Recommended, Evidence (B)**
   Level of Confidence –Moderate

2. *Recommendation: Lumbar Fusion for Treatment of Isthmic Spondylolisthesis*
   Lumbar fusion is recommended as an effective treatment for isthmic spondylolisthesis.(1979)
   Indications – LBP with documented instability. Either i) ≥5mm of translation of the superior vertebral body on the inferior body from the full extension film to the full flexion films, and/or ii) a total angular movement during flexion and extension at the unstable level that is at least 20 degrees greater than the motion present at an adjacent disc. Lumbar fusion is also indicated for grades 3, 4, and 5 spondylolisthesis; 2) a decompressive laminectomy at an area of degenerative instability as in the case of a coexisting spondylolisthesis or scoliosis when a discectomy is performed at the same level; 3) a decompressive laminectomy performed at an area of degenerative instability, as in the case of a coexisting spondylolisthesis or scoliosis where there is gross movement on flexion-extension radiographs; and 4) a decompressive laminectomy at an area of degenerative instability as in the case of a coexisting spondylolisthesis or scoliosis where an adequate decompression requires the removal of greater than 50% of both facets or the complete removal of a unilateral facet complex.(1980)
   Benefits – Reduction in back pain and neurological compromise if present.
   Harms – Operative complications, rare severe outcomes (e.g., paralysis, fatalities), increased further re-operative risk, cost, increased risk of disability.

   Strength of Evidence – **Recommended, Evidence (C)**
   Level of Confidence –Moderate

3. *Recommendation: Lumbar Fusion for Treatment of Degenerative Spondylolisthesis*
   Lumbar fusion is recommended as an effective treatment for degenerative spondylolisthesis.
   Indications – LBP with documented instability. Either i) ≥5mm of translation of the superior vertebral body on the inferior body from the full extension film to the full flexion films, and/or ii) a total angular movement during flexion and extension at the unstable level that is at least 20 degrees greater than the motion present at an adjacent disc. Lumbar fusion is also indicated for grades 3, 4,

and 5 spondylolisthesis; 2) a decompressive laminectomy at an area of degenerative instability as in the case of a coexisting spondylolisthesis or scoliosis when a discectomy is performed at the same level; 3) a decompressive laminectomy performed at an area of degenerative instability, as in the case of a coexisting spondylolisthesis or scoliosis where there is gross movement on flexion-extension radiographs; and 4) a decompressive laminectomy at an area of degenerative instability as in the case of a coexisting spondylolisthesis or scoliosis where an adequate decompression requires the removal of greater than 50% of both facets or the complete removal of a unilateral facet complex.(1980)
Benefits – Reduction in back pain and neurological compromise if present.
Harms – Operative complications, rare severe outcomes (e.g., paralysis, fatalities), increased further re-operative risk, cost, increased risk of disability.

Strength of Evidence – **Recommended, Evidence (C)**
Level of Confidence – Moderate

4. *Recommendation: Lumbar Fusion for Treatment of Radiculopathy from Disc Herniation or Chronic Low Back Pain*
Lumbar fusion is not recommended to treat radiculopathy from disc herniation or for most patients with chronic low back pain after lumbar discectomy. Exceptions are rare but include large foraminal herniations with need to remove the facet joint to access the disc.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Moderate

5. *Recommendation: Spinal Fusion with Third Discectomy*
Spinal fusion is recommended as an option at the time of discectomy if a patient is having the third lumbar discectomy on the same disc.
Indications – Meeting indications for a third discectomy on the same disc.
Benefits – Theoretical reduced risk of 4th surgery on the same disc.
Harms – Longer recovery, greater rate of complications, higher costs.

Strength of Evidence – **Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

6. *Recommendation: Spinal Fusion for Treatment of Spinal Stenosis without Concomitant Instability or Deformity*
Lumbar fusion is not recommended for treatment of spinal stenosis unless concomitant instability or deformity has been proven.(1932, 1933)

Strength of Evidence – **Not Recommended, Evidence (C)**
Level of Confidence – Moderate

Rationale for Recommendations: General Issues Regarding Fusion
There are many quality studies on fusion, although most are somewhat handicapped as they have heterogenous populations of patients and insufficient sample sizes with which to assess differences between diagnostic entities. There are no RCTs on patients with what are widely considered as unequivocal indications for lumbar fusion surgery such as unstable fracture, spinal infections, or tumors. There are many trials showing equivalent outcomes in non-operatively managed, neurologically-intact patients with thoracolumbar burst fractures compared with various surgeries.(1935, 1981-1983) Treatment of these conditions is outside the scope of this guideline. This guideline also does not address human bone morphogenetic protein-2(1935, 1981-2000) or osteoconductive bone graft extenders.(1935, 2001-2007)

There are no RCTs using lumbar fusion for either acute or subacute non-specific LBP. Lumbar fusion has been proposed as treatment for spondylolisthesis,(2008) disc herniation, spinal stenosis, and chronic non-specific LBP (also referred to as degenerative disc disease, discogenic LBP, micro instability, black disc disease, and lumbar spondylosis).

There are numerous methodological issues affecting the quality of the literature on this subject and these methodological issues impair the ability to draw robust evidence-based conclusions. These difficulties have been widely noted(35, 1955, 1961, 1966, 2009-2013) and these quality problems in the underlying original research are underscored by the sharply differing conclusions in the systematic reviews. Many of these conflicts likely originate from the problem that case series tend to show benefits while subsequent RCTs may or may not support the original impressions from the uncontrolled or less well designed studies.

Chronic LBP patients can be extremely difficult to manage, particularly when the pain is severe, narcotics and other drug issues are present, adherence to exercise regimens is weak, psychosocial stressors are present, and coping skills are poor (2425). Patients without indications often come to view these surgical procedures as potential cures. Lumbar fusion is the most invasive of the commonly performed lumbar surgeries. It is high cost and has significant risks of complications. However, for a select few chronic LBP patients with specific indications, it may be recommended.

Rationale for Recommendations: Fusion Complication Rates
Compared with matched non-surgical controls, patients on worker's compensation reportedly have worse outcomes with over 5.5-fold greater permanent disability status, greater opioid use, greater than 3.6-fold days of work lost and 26% of surgical patients underwent a second surgery.(1962) Risks of increased opioids use among those with prior use and 13% without pre-operative use becoming chronic users after fusion surgery suggest risks are considerable (2426). Following lumbar fusion, reoperation rates within 2 years have been estimated to range from 5.4 to 22% in the recent well-designed RCTs.(2014, 2015) A 1990s population-based study found the reoperation rate following lumbar fusion was 17 to 21% when assessed at 11-year follow up.(2016) There appears to be increased risk of reoperation if the initial diagnosis is herniated disc, degenerative disc disease, or spinal stenosis. Patients subjected to more invasive procedures have increased blood loss, longer operative times, and/or poorer outcomes in all higher quality studies where such data have been reported.(2014, 2017-2023) Overall, reported complication rates range from 1.4 to 40% (excluding scoliosis).(2009, 2014, 2020, 2024)

Rationale for Recommendations: Instability Issues
There is controversy in the medical literature about the definition of proven spinal instability. The Evidence-based Practice Spine Panel recognizes the controversy(2025) and recommends the following definition be used with flexion-extension bending films done standing with a 72 inch tube to film distance: These films should be taken digitally, and a CD with the films and the software to permit viewing and computer measurement of the translation distance should be retained and kept available for review. The first criterion is ≥5mm of translation of the superior vertebral body on the inferior body from the full extension film to the full flexion films. The other criterion is having a total angular movement during flexion and extension at the unstable level that is at least 20 degrees greater than the motion present at an adjacent disc.

Rationale for Recommendations: Fusion for Chronic Non-Specific Low Back Pain
The terms "degenerative disc disease," "discogenic back pain," "black disc disease," "micro instability," and "lumbar spondylosis" are used interchangeably to describe the same group of patients with chronic LBP in whom the pain generating structure is not defined. Discography has been used to

attempt to define the lower back disc structures as the pain source, but has been largely unsuccessful in so doing (see Discography above). Chronic back pain thought to arise from degenerative disc disease is complex and can be difficult to treat. Current surgical treatment modalities are controversial. Since there is no reliable method to identify the source of a patient's pain, surgery for pain would presumably be unlikely to be helpful. Nevertheless, this theory has been attempted to be tested.

There are 3 moderate-quality comparative trials of fusion vs. rehabilitation programs for treatment of chronic LBP and two of them suggest fusion is inferior to rehabilitation.(1973-1978, 2014, 2019, 2020, 2026, 2027) The third study reported surgical fusion improved upon standard conservative care,(2019, 2026) however, the wait-listed control group's treatment consisted of "more of the same" that previously failed,(2028) while anticipating surgery and thus likely biasing the design. In addition, Fritzell's patients were highly selected (each surgeon did on average 2 fusions for chronic back pain each year). They had a much lower incidence of depressive symptoms than is seen in typical chronic LBP populations. Benefits from fusion were on average small (on average 30% improvement), and about 1 in 6 patients became pain free. The study was not blinded and improvement in outcomes from fusion over non-operative treatment decreased over time.(2029) These studies demonstrate that if there is a benefit from fusion, it is not much.(1973-1975) A meta-analysis of RCTs found that at an average 11 years after surgery/randomization, there is no demonstrable benefit for fusion surgery among these patients and there was more adjacent segment disease among those undergoing fusion surgery although it was not clinical significant (2393-2398).

In a pooled study, the surgical group incurred reoperations (23%), worse disability (53% vs. 32% disability pensions) and greater fear avoidant beliefs.(2030) There are no published RCTs of lumbar fusion in a US workers' compensation population. There are four retrospective cohort studies in worker's compensation systems, and these show the results of fusion are significantly worse than in a non-workers' compensation population.(485, 1962, 2031, 2032) Thus, there is not quality evidence to support fusion for chronic non-specific LBP in any population, and evidence of considerably worse outcomes in workers.

Rationale for Recommendation: Fusion for Isthmic Spondylolisthesis
For isthmic spondylolisthesis, there is one moderate-quality trial comparing fusion with non-operative care that reported benefits of surgery.(1979) Thus, fusion is recommended for this indication. The literature available pertains to lumbar fusion for treatment of Grade 1 and Grade 2 spondylolisthesis. There is no quality evidence on Grade 3, Grade 4, and Grade 5 spondylolisthesis, but these are rare conditions, and when nerve roots are compromised, fusion is widely viewed as indicated.

Rationale for Recommendation: Lumbar Fusion for Treatment of Degenerative Spondylolisthesis
There is one moderate quality trial comparing fusion with non-operative care for degenerative spondylolisthesis. This trial reported negative results, however the trial reported approximately 40% crossovers and so it may have inadvertently negated the value of the trial as there were no differences in the "intension to treat" analysis, but better outcomes for fusion in the "as treated" analysis.(2024) One comparative trial of spinal fusion with spinal fusion plus decompressive surgery for treatment of adult spondylolisthesis found no additive benefits of the decompressive surgery.(123) Another trial of unilateral compared with bilateral fusion found no significant differences.(2033) Thus, the highest quality evidence suggests there may be a beneficial effect of fusion surgery for treatment of isthmic spondylolisthesis and it is also believed to be true for degenerative spondylolisthesis and thus it is recommended. The literature available pertains to lumbar fusion for treatment of Grade 1 and Grade 2 spondylolisthesis. There is no quality evidence on Grade 3, Grade 4, and Grade 5 spondylolisthesis, but these are rare conditions, and when nerve roots are compromised, fusion is widely viewed as indicated.

Rationale for Recommendation: Lumbar Fusion for Treatment of Radiculopathy from Disc Herniation or Chronic Low Back Pain
There are no quality trials in these patients. Without other indications for more extensive surgery, far less invasive surgical options (e.g., non-operative management, discectomy etc.) than fusion are available and are recommended for treatment. Thus, fusion for these patients is not recommended.

Rationale for Recommendation: Spinal Fusion with Third Discectomy
There are no quality trials on these patients. If there is a second herniation of the same disc, repeat discectomy results in comparable outcomes and is recommended.(2034-2037) However, among those having undergone two prior discectomies, it is believed to be a reasonable option to attempt fusion to avoid the theoretical need for a 4th discectomy.

Rationale for Recommendation: Spinal Fusion for Treatment of Spinal Stenosis without Concomitant Instability or Deformity
Decompressive surgery (reviewed above), is a less extensive surgical approach that resolves these issues. Additionally, one moderate-quality trial reported no advantage of fusion over decompression for foraminal stenosis.(2038) In the absence of proven instability or deformity, fusion is not recommended.

Rationale for Recommendations: Other
There are many other comparative trials with different approaches and techniques. One pattern present is quality evidence of higher rates of fusion from use of an electromagnetic device compared with sham in all three high- and moderate-quality trials.(2039-2041)

Evidence for the Use of Spinal Fusion
We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without limits on publication dates and then an updated search was conducted using PubMed for publications between 1/1/2013 and 11/15/2017. We used the following search terms: fusion, spinal fusion, spondylodesis, spondylosyndesis, back, chronic low back pain, and random to find 47,070 articles. Of the 47,070 articles we reviewed 270 articles and included 270 articles (109 randomized controlled trials and 161 systematic reviews).*

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Non-specific Low Back Pain: Spinal Fusion: Surgical vs. Non-operative Management										
Brox 2003 (score= 7.5)	Fusion	RCT	No sponsors hip or COI	N = 64 with chronic LBP lasting a year or longer	Mean age: 43.4 years; 25 males, 39 females.	Fusion: (posterolateral fusion with transpedicular screws of L4-L5 and/or L5-S1 with autologous bone with physical activity first 3 months post-surgery) (n = 37) vs. Cognitive intervention plus exercises (endurance and coordination for co-contraction of deep abdominal muscles with multifidus) (n = 27).	Follow-up at 3 and 6 months.	NS between groups for Oswestry and general function score, back pain, medication use, emotional distress, life satisfaction, baseline-1 year. Low limb pain (baseline/1 year): lumbar fusion (43.5±27.7/26.6 ±28.1) vs. cognitive/ exercises (34.0±19.3/35.5 ±30.6), p = 0.002. Fear avoidance work: (26.8±9.8/27.9± 12.0) vs. (27.1±12.4/21.5 ±14.4), p = 0.002. Fear avoidance physical activity: (13.7±4.8/11.5± 6.3) vs. (16.4±5.3/6.5±6. 0), p <0.001. Fingertip-floor distance: (15.1±17.5/13.4 ±13.5) vs. (22.5±24.5/7.1± 14.7), p = 0.009.	"The main outcome measure showed equal improvement in patients with chronic low back pain and disc degeneration randomized to cognitive intervention and exercises, or lumbar fusion."	Surgery group had greater complication rate and greater fear-avoidance beliefs at 1 year. Data suggest comparable results.
Keller 2004, 2003, Brox 2006 (score= 7.5)	Fusion	RCT	No sponsors hip or CIO	N = 124 with chronic LBP and disc degeneration or post-laminectomy syndrome	Mean age: 43 years; 56 male, 68 female.	As above.	Follow up at 1 year.	NS between groups for cross-sectional area, density at T12-L1, and Oswestry Disability Index Score. Muscle strength extension 60°/sec (before/after 1 year): fusion (433±348/360±358) vs. cognitive/exercise (376±295/477±3	"Patients with chronic low back pain who followed cognitive intervention and exercise programs improved significantly in muscle strength compared with patients who underwent lumbar fusion. In the lumbar fusion group, density decreased significantly at L3–L4 compared with the exercise group."	Study raises concerns about longer term fusion complications and post-operative adjacent segment issues.

								78), p <0.05. Biering-Sorensen test: (68±45/48±40) vs. (63±41/65±43), p <0.05. Density at L3-L4: 55.1±13.6/49.4± 15.4) vs. (53.9±9.6/53.3± 9.1), p <0.05.		
Fritzell 2001 (score= 7.5)	Fusion	RCT	No mention of sponsorship or COI.	N = 294 with chronic LBP	Mean age: 43.2 years; 144 male, 150 female.	Surgical group: (autologous bone from iliac crest for posterolateral fusion (PLF) or PLF and internal fixation device with pedicle screws and plates or PLF and internal fixation plus interbody bone graft either anterior or posterior) (n = 222) vs. Nonsurgical group treated mainly with PT. Treatment could vary individually. (n = 72). Follow-up at 6 and 12 months, and 2 years.	Follow up after 6, 12 and 24 months.	VAS back pain (baseline/2 years): surgery (64.2±14.3/43.2 ±25.2) vs. no surgery (62.6±14.3/58.3 ±18.8), p = 0.0002. VAS leg pain: surgery (35.3±25.4/29.0 ±27.0) vs. no surgery (35.6±25.2/42.6 ±24.8), p = 0.005. General function scale: (49.1±15.9/34.1 ±22.4) vs. (47.6±16.3/45.5 ±20.3), p = 0.005. NS between groups for Zung scores.	"Lumbar fusion in a well-informed and selected group of patients with severe CLBP can diminish pain and decrease disability more efficiently than commonly used nonsurgical treatment."	Baseline characteristics sparse. Patients failed at least 1 year of "conservative" " management before entry to study, thus trial appears to be comparison of 'more of the same' and biased against non-operative management. Data suggest surgery superior to continuing various PT and exercises if these fail after at least 1 year.
Fritzell 2002 (score= 7.5)	Fusion	RCT	Sponsored by Acromed Corporation, Cleveland, Ohio and Ossano Scandinavica AB, Stockholm, Sweden. COI, Industry	N = 294 patients who underwent lumbar fusion due to chronic LBP	Mean age: 43.2 years; 144 male, 150 female.	See above.	Follow up after 6, 12 and 24 months.	No differences between groups after 2 years.	"All the fusion techniques used in the study could reduce pain and improve function in this selected group of patients with severe chronic low back pain. There was no obvious disadvantage in using the least demanding surgical technique of posterolateral fusion without internal fixation."	Complication rates lower in least invasive group (complication rates 6% vs. 16% vs. 31%). Radiographic evidence of fusion trended in opposite direction (72%, 87%, and 91%). No differences in return-to-work

			COIs (category 16)							status (35% vs. 35% vs. 37%).
Fritzell 2003 (score= 7.5)	Fusion	RCT	Sponsored by Acromed Corporation, Raynham, Massachusetts, USA and Ossano Scandinavica AB, Stockholm, Sweden. No mention of COI.	N = 294 with chronic LBP	Mean age: 43.2 years; 144 male, 150 female.	See above.	Follow up after 6, 12 and 24 months.	Early complications: Group 1 (6%) vs. Group 2 (18%) vs. Group 3 (30%), p = 0.001. Late complications: NS between groups. Total percent of complications: Group 1 (12%) vs. Group 2 (22%) vs. Group 3 (40%), p = 0.003.	"[C]omplications increased significantly with increasing technicality of the surgical procedure."	No association between clinical outcomes and complications after 2 years. Data suggest PLF has similar clinical outcomes to VSP and 360 but significantly fewer post-op complications. 4-fold risk of re-operation if instrumented fusion.
Hägg 2003 (score= 7.5)	Fusion	RCT	Sponsored by DePuyAcromed Corporation, Raynham, Massachusetts, USA and the Gothenburg Medical Society, Gothenburg, Sweden). No mention of COI.	N = 294 with chronic LBP without radicular involvement for at least 2 years on sick leave for at least 1 year	Mean age: 43.2 years; 144 male, 150 female.	See above.	Follow up after 6, 12 and 24 months.	No significant differences between pain drawings and outcome, work status, or personality traits at follow-up.	"[T]he pain drawing has no predictive value in the treatment of CLBP."	Baseline characteristics lacking. Data suggest pain drawing does not correlate well with outcomes in either group. Pain drawing associated with depression at time of drawing.
Fritzell 2004 (score= 7.5)	Fusion	RCT	Sponsored by Acromed Corporation, Raynham, MA, USA and Ossano Scandinavica AB, Stockholm, Sweden. No mention of COI.	N = 294 with chronic LBP	Mean age: 43.2 years; 144 male, 150 female.	See above.	Follow up after 6, 12 and 24 months.	Cost for other hospital services: fusion 31,800±34,400 vs. control 43,300±19,700 (95% CI -16,200 to -6,800). Total hospital cost/patient: fusion 112,000±57,000 vs. control 51,800±37,700 (95% CI 49,500 to 70,300). Production losses (indirect costs): 445,900±172,40	"For both the society and the health care sectors, the 2-year costs for lumbar fusion were significantly higher compared with nonsurgical treatment but all treatment effects were significantly in favor of surgery. The probability of lumbar fusion being cost-effective increased with the value put on extra effect units gained by using surgery."	No significant differences between surgical procedures. Analyses impaired by inability of patients on disability to return to work, thus net potential benefits may be underestimated relative to what would be expected if patients

								0 vs. 460,200±183,200 (95% CI -61,800 to 35,900). Direct/indirect costs: 704,000±254,000 vs. 636,000±208,000 (95% CI 10,200 to 125,700). Costs for fusion groups. Primary/private care, back related drugs, family support/housekeeping, production losses (indirect costs), and societal perspective (direct and indirect costs): NS between groups.		returned to work.
Brox 2006 (score= 7.0)	Fusion	RCT	Sponsored by Norwegian Back Association and Foundation for Health and Rehabilitation. No mention of COI.	N = 60 with LBP lasting longer than 1 year after previous surgery for disc herniation	Mean age: 42.5 years; 31 male, 29 female.	Posterolateral fusion with pedicle fixation (n = 29) vs. Cognitive intervention and exercises (n = 31) 25 hours a week for 3 weeks (described in Brox 1999 and 2003).	Follow-up at 1 year.	No difference between groups for ODI, general function score, back pain, lower limb pain, medication, emotion distress, fear avoidance, or working full time at 1 year. Fear-avoidance physical activity (baseline/1 year): fusion 12.8±5.1/ 11.9±5.4 vs. cognitive/exercise 14.2±4.4/7.9±5.4, p = 0.003. Fingertip-floor distance (cm): 25.9±20.2/19.8±21.8 vs. 28.7±17.1/11.7±18.7, p = 0.009.	"For patients with chronic low back pain after previous surgery for disc herniation, lumbar fusion failed to show any benefit over cognitive intervention and exercises."	Data suggest no improvements in those with prior spinal surgery over cognitive and exercises. Fear-avoidance behavior worse in surgical group.
Brox 2010 (score= 6.5)	Fusion	RCT, see also Brox 2003 and Brox 2006	No sponsorship or COI.	N = 124 with CLBP at least 1 year, disability >30, L4-L5,	Mean age: 42.6 years; 56 male, 68 female.	Posterolateral fusion with transpedicular screws of L4-L5 and/or L5-S1 segments (n = 66) vs.	Follow up at 4 years	Primary outcome; adjusted treatment effect −1.6; 95% CI −8.9 to 5.6. Secondary outcome; only	"[P]atients did not have a better long-term improvement after instrumented fusion compared with cognitive	Pooled Study. 4-year followup of vast majorities (92% and 86%). 23% reoperation rate. More

				and/or L5-S1		Non-surgical exercise cognitive intervention group (n = 58) for 3 weeks followed with 2 weeks at home.		treatment effect observed was physical activity fear avoidance compared to ITT; -3.5, 95% CI –5.8 to –1.1 vs. –2.8; 95% CI –5.3 to –0.4. Last analysis & medication taken was; –4.3; 95% CI –8.3 to –0.2 vs. –4.8; 95% CI –8.9 to –0.7 & 58% vs. 35%, p = 0.14. 24% crossed over to surgery.	intervention and exercises."	disability pensions if surgery (53% vs. 32%). Only other differences: reduced fear avoidant beliefs in CBT group.
Fairbank 2005 (score= 6.5)	Fusion	RCT	Sponsored by Medical Research Council and NHS). COI, Industry COIs (Synthes).	N = 349 with more than 1 year of chronic LBP	No mean age provided, ages 18-55 years; 172 male, 177 female.	Spinal stabilization surgery (n = 176): (surgeon picked surgery best for patient) vs. Intensive rehab program (n = 173): (outpatient daily education and exercise tailored to patient baseline ability and included stretching of major muscle groups, spinal flexibility exercises, general muscle strengthening, spine stabilization exercises, and cardiovascular endurance exercise using any mode of aerobic exercise) 5 days a week for 3 weeks.	Follow up baseline, 6, 12, and 24 months.	Oswestry disability index at 24 months: surgery (34.0±21.1) vs. rehabilitation (36.1±20.6), p = 0.045. NS between groups at 24 months for shuttle walking test, SF-36 physical component score, SF-36 mental component score, domains of SF-36 (general health perception, physical function, role limitation physical and emotional), pain, social function, mental health, and energy and vitality.	"The statistical difference between treatment groups in one of the two primary outcome measures was marginal and only just reached the predefined minimal clinical difference, and the potential risk and additional cost of surgery also need to be considered. No clear evidence emerged that primary spinal fusion surgery was any more beneficial than intensive rehabilitation."	Lack of well-defined patient criteria on entry and lack of control over surgical interventions, limiting strength of some conclusions. Data suggest no long term differences.
Rolving 2015 (Score= 5.5)	Fusion	RCT	Supported by the Health Research Fund of	N=90 Danish patients with grade1	Mean age: 50.1 years; 39 males,	CBT group: received 6 cognitive behavioral therapy	Follow-up at 1 year.	Primary outcome Oswestry Disability Index (ODI) score	"Participating in a preoperative CBT intervention in addition to usual care did not produce	Baseline differences between groups for DJD,

			Central Denmark Region, the Danish Rheumatism Association, Danish Council for Strategic Research, and Health Foundation funds.	to 2 spondylolisthesis and maximum of 3 adjacent vertebrae fusion.	51 females.	sessions with 3 hours for each session (n=59) vs. control group: received standard course treatment involving preoperative information and 8 weeks of postoperative exercise (n=31)		indicated no differences in the two groups (p=0.082). CBT group showed better results with median 15 points significant reduction (-26 to -4), and control group showed no significant clinical reduction.	better outcomes at 1-year follow-up for patients undergoing LSF."	spondylolisthesis is surgeries. Data suggest at one year CBT did not prove superior to fusion at 1 year although disability was reduced at a faster rate.
Spondylolisthesis: Fusion vs. Non-operative Care										
Möller 2000 (score= 5.5)	Fusion	RCT	Sponsored by Karolinska Institutet and the King Oscar II and Queen Sofia's Golden Anniversary Foundation. COI, Industry COIs (category 14).	N = 111 with adult spondylolisthesis	Mean age: 39 years; 57 male, 51 female.	Surgery (n = 77): either posterolateral fusion in situ or posterolateral fusion in situ with transpedicular Cotrel-Dubousset instrumentation (CDI) vs. Exercise (n = 34): strength and postural training with emphasis on back and abdominal muscle exercises 3x week for 6 months then 2x a week for 6 months..	Follow up at baseline, 1 and 2 years.	DRI score (before/1 year/2 year): surgery 48/29/29 vs. exercise 44/45/44, p = 0.004. Pain index: 63/35/37 vs. 65/54/56, p = 0.002.	"Surgical management of adult isthmic spondylolisthesis improves function and relieves pain more efficiently than an exercise program."	No mention of prior treatments, trial may be biased in favor of surgery. Data suggest fusion results in lower DRI and pain index.
Weinstein 2007 (score= 5.0)	Fusion	RCT	Sponsored by National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) and Office of Research on	N = 304 with lumbar degenerative spondylolisthesis	Mean age: 66.1 years; 88 male, 212 female.	Posterior decompressive laminectomy with or without bilateral single-level fusion (n = 159) vs. Non-surgical protocol of usual care including active PT, education or	Follow up at 6 weeks, 3 and 6 months, 1 and 2 years.	No differences between groups for randomized cohort in SF-36 bodily pain, physical function, and Oswestry Disability Index.	"In nonrandomized as-treated comparisons with careful control for potentially confounding baseline factors, patients with degenerative spondylolisthesis and spinal stenosis treated surgically showed substantially greater improvement in pain and function during a period of 2 years than	High crossover rates (approximately 40%) in each direction. between the 2 arms and substantially weaken the strengths of the conclusions. High crossovers may have led to negative results.

			Women's Health; by National Institutes of Health; by National Institute of Occupational Safety and Health and Centers for Disease Control and Prevention; and by grant and Research Career Award from NIAMS COI, Industry COIs (Consulting fees received from United Healthcare, Blue Cross/ Blue Shield)			counseling with instructions for exercising at home and NSAIDs (n = 145).			patients treated nonsurgically."	
Spondylolisthesis: Fusion vs. Decompression and Fusion										
Carragee 1997 (score= 7.0)	Fusion	RCT	Sponsored by Division of Orthopaedic Surgery, Stanford University School of Medicine. No mention of COI	N = 42 with Grade I or II isthmic spondylolisthesis at most caudad mobile lumbar segment, persistent LBP, lower extremity pain	Mean age: 32.1 years; 26 male, 16 female.	Posterolateral arthrodesis only (n = 24) vs. Posterolateral arthrodesis and decompression (n = 18). All smokers assigned to management with instrumentation and all non-smokers assigned to arthrodesis	Follow up at 2, 6, 12, and 24 weeks, 1 and 2 years.	All arthrodesis patients without decompression had successful fusion vs. 14 of arthrodesis and decompression group, p = 0.02.	"The addition of decompression to arthrodesis, performed with or without instrumentation, for the treatment of low-grade isthmic spondylolisthesis in patients who do not have a serious neurological deficit does not appear to improve the result and may significantly increase the rates of pseudarthrosis and unsatisfactory results."	Small numbers for each group. No description of co-interventions. Data suggest decompression with arthrodesis for grade 1 or 2 isthmic spondylolisthesis does not improve results.

				despite non-operative treatment for 6 plus months		management only.				
Försth 2016 (Score= 6.5)	Fusion	RCT	Supported by Uppsala University, Stockholm Spine Center, Uppsala Country Council, and Johnson & Johnson. Two of the authors have received or will receive benefits for personal or professional use.	N = 247 patients had lumbar spinal stenosis.	Mean age: 67 years; 78 males, 155 females.	Fusion group: received decompression surgery and fusion surgery (n =123) vs. decompression-alone group: received decompression surgery alone (n= 124).	Follow-up at 2 years.	Primary outcome Oswestry Disability Index (ODI) scores in two groups indicated no significant difference (p=0.24). Fusion group indicated 15 ODI scores decreased from baseline. Decompression-alone group indicated 17 decrease. No improvement was found between spondylolisthesis and treatment according to primary outcome (p=0.33).	"Among patients with lumbar spinal stenosis, with or without degenerative spondylolisthesis, decompression surgery plus fusion surgery did not result in better clinical outcomes at 2 years and 5 years than did decompression surgery alone."	Data support fusion plus decompression not superior to decompression alone at both 2 and 5 years.
Fernandez Fairen 2007 (score= 4.0)	Fusion	RCT	No sponsorship or COI	N = 82 with degenerative spondylolisthesis	Mean age: 61.1 years; 31 male, 51 female.	Posterolateral arthrodesis performed bilaterally (Group 1, n = 42) vs. Arthrodesis performed unilaterally (Group 2, n = 40) In all cases, Morselized autologous corticocancellous and cancellous bone, from iliac crest placed bilaterally onto and between decorticated transverse process and facet joints and implemented	Follow-up 3 years	No differences between both groups in regards to demographic (P>0.5), blood loss, need of transfusion and the duration of hospital stay, complications and clinical results. There was a difference between the two groups in relation to operating time; Group 2 having a mean±SD: 168±37 minutes compared to mean±SD: 203±35 minutes in group 1 (P<0.001)	"Unilateral instrumentation used for the treatment of degenerative lumbar spondylolisthesis is as effective as bilateral instrumentation in when performed in addition to 1- or 2 level posterolateral fusion."	Both treatment arms improved significantly over the study period but there were minimal differences between groups.

						with granulated of bicalcium phosphate.				
Decompression vs. Decompression vs. Decompression and Fusion with Cage										
Hallett 2007 (score= 5.0) RCT	Fusion	RCT	Sponsored by (DePuy Ltd). No mention of COI.	N = 44 with bilateral or unilateral leg pain	Mean age: 57 years; 24 male, 20 female.	Group 1 (n = 14) received nerve root decompression by single or bilateral foraminotomy vs. Group 2 (n = 16) received spinal decompression and instrumented posterolateral fusion vs. Group 3 (n = 14) received decompression and instrumented posterolateral fusion plus transforaminal interbody fusion (TLIF) using titanium interbody cages.	Follow up at 2 and 5 years.	LBOS/RM/DPQ /Daily activity/Work/Anxiety/ Social interest at pre-op, 2 and 5 years; (18±9, 31±18*, and 36±18*) / (15±5, 11±7*, and 11±7*)/(71±14, 53±25*, and 52±25*)/(73±17, 57±31*, and 56±32*) / (48±23, 38±29, and 36±27*)/(45±22, 36±29, and 34±29*). No improvement in Farfan index in any group or differences in the disc height ($p < 0.05$).	"Patients with foraminal stenosis and single-level degenerative disease universally improved with surgery, and this improvement was maintained at 5 years."	Lack of blinding, baseline comparison. No control group. Data suggest no benefit from fusion over decompression. Study lacks control group limiting conclusion of decompression effect. Patient population was narrow (single, white) which may limit generalizability further.
Andersen (Part 1) 2009 (score= 4.5)	Fusion	RCT	No sponsorship or COI	N = 107 with chronic LBP	Mean age: 70.2 years; 35 male, 63 female.	Posterolateral Spinal Fusion (n = 43) vs. Posterolateral Spinal Fusion +40 µA (n = 44) vs. Posterolateral Spinal Fusion +100 µA (n = 11). Posterolateral spinal fusion with or without DC-electric stimulation (fresh frozen allograft used). 2 year follow up.	Follow up at 1 and 2 years.	PLF vs. PLF+40 µA vs. PLF+100 µA; daily activity at 1-year/work-leisure at 1 and 2/ depression at 2/social interest at 2; ($p = 0.0175$)/($p = 0.0032$ and $p = 0.0110$)/($p = 0.0296$)/($p = 0.0367$), baseline 1 and 2 years. Walking distance; control vs. 40 µA vs. 100 µA; 1250 to 1500m vs. 4000 to 2000 vs. 2000 to 3000, at 1-year to 2-years.	"[S]urgery led to an improvement in functional outcome and that the achievement in functional outcome and that the achievement of a good functional outcome after spinal fusion in older patients is heavily dependent on obtaining a good walking distance."	Data suggest no clinically significant differences for stimulation vs no stimulation. High dropouts and lack of Intention to treat analysis.
Andersen (Part 2) 2009 (score= 4.5)	Fusion	RCT	No sponsorship or COI.	See above.	Mean age: 70.2 years; 33 male, 62 female.	After 2-year follow-up using CT Siemens or Phillips 0.8mm	Follow up at 1 and 2 years.	Fusion rates/DPQ and LBPRS and SF-36/ satisfaction / walking distance; (21%	"[T]his study demonstrated very low fusion rates after uninstrumented fusion using fresh frozen allograft in	See Andersen Part 1.

						thickness and 0.4mm overlap scanners; radiation dose 120 Kv & 150mA, between control, 40 and 100µA.		for smokers vs. 41% in non-smokers) / (50% better in fused patients, SF-36 shows some difference)/(93% fused group vs. 80% and 82% in doubtful and nonunion group)/(3000m fused group compared to 1500m in doubtful and nonunion group).	patients older than 60 years."	
Experimental Instrumentation vs. Standard Posterolateral Fusion										
Korsgaard 2002 (score= 7.0)	Fusion	RCT	No mention of sponsorship or COI	N = 130 with lumbar or lumbosacral instability.	Mean age: 44.7 years; 60 males, 69 females.	Cotrel-Dubousset pedicle screw supplemented fusion (instrumented group, n = 63) vs. Posterolateral intertransverse fusion (non-instrumented group, n = 64).	Follow-up at 1- and 2-year.	No difference between the two groups in relation to lumbar lordosis with a median of 43.6 degrees (range, 0 to 83 degrees); p<0.002.	"[U]se of Instrumentation did not influence lumbar spinal alignment compared with non-instrumented fusions. The sagittal alignment was stable both 1 and 2 years after solid fusion. The failure mode of instrumented fusions was a reduced degree of lordosis in contrast to lordosis in patients with non-instrumented"	1 patient from the instrument group and 2 patients from the non-instrument group were excluded after randomization. No meaningful differences between treatment arms.
Thomsen 1997 (score= 6.0)	Fusion	RCT	Industry support (Danish Rheumatism Association and Arosia Spine Research Foundation). No mention of COIs.	N = 130 with chronic LBP from spondylolisthesis Grades 1 and 2 or from primary or secondary degenerative segmental instability	Mean age: 44.7 years; 60 males, 69 females.	Non Cotrel-Dubousset supplemented fusion, posterolateral intertransverse fusion (non-CD group, n = 66) vs. Cotrel-Dubousset instrumentation fusion (CD group, n = 64).	Follow-up at 2 years.	No differences between groups for fusion rate, occupational status, or Dallas Pain Questionnaire. Re-operations 19% in CD group vs. 6% in non-CD group, p <0.01.	"The results of this study do not justify the general use of pedicle screw fixation alone as an adjunct to posterolateral lumbar fusion."	Data on occupational status misleading as represented. Main outcome was increased numbers on disability pensions. Data do not support general use of pedicle screw fixation alone as an adjunct to posterolateral lumbar fusion.
Christensen 2002 (score= 6.0)	Fusion	RCT	No COIs or industry sponsorship.	N = 129 with chronic LBP from localized lumbar	Mean age: 44.7 years; 60 males, 69 females.	Cotrel-Dubousset supplemented fusion (instrumented group, n = 64) vs. Noninstrume	Follow-up at 5 years.	28% of instrumented group vs. 14% non-instrumented group required a second operation, p	"The long-term functional outcome of posterolateral spinal fusion improved significantly for both those with and without pedicle screw	Five year report. Lack of details on co-interventions. Work status was not improved in either group at

				or lumbosacral segmental instability caused by isthmic spondylolisthesis Grades 1 and 2		nted posterolateral intertransverse fusion (noninstrumented group, n = 66).		<0.03. 23% of instrumented group vs. 12% in non-instrumented group sick listed; 52% instrumented group and 43% noninstrumented group received pension because of back pain. No other differences.	instrumentation, with a global 70% satisfaction reported by the patients."	5 years. Data suggest overall non-instrumented had superior outcomes except for patients with primary degeneration at 5 years.
Davis 2013 (Score= 5.0)	Fusion	RCT	Supported by Paradigm Spine, LLC in New York, NY. No mention of COI.	N = 322 patients with low back pain and moderate spinal stenosis.	Mean age: 62.8 years; no mention of sex.	Coflex group: received Coflex and laminectomy interlaminar stabilization (n=215) vs. fusions group: received posterolateral spinal fusion and laminectomy with spinal instrumentation (n=107).	Follow-up at 2 years.	Oswestry Disability Index (ODI) scores in Coflex group indicated better outcomes, compared with fusions group (ODI in Coflex= 22.0, ODI in fusion=26.7; P=0.075). ODI change in Coflex group at 6 weeks and 3 months after the intervention were significant (p=0.001; p=0.033).	"Coflex interlaminar stabilization is a safe and efficacious alternative, with certain advantages compared with lumbar spinal fusion in the treatment of spinal stenosis and low grade spondylolisthesis."	Data suggest Coflex group had decreased operative time, blood loss, length of stay with higher reoperation rates but at 2 years Coflex group maintained originate surgical positions.
Bae 2016 (No score)	Fusion	Secondary analysis of 3-year follow-up of Davis 2013 RCT.	Sponsored by Paradigm Spine. COI, one or more authors have received or will receive financial benefits from working on this publication.	N = 290 patients with low back pain and moderate spinal stenosis.	No mention of mean age or gender for this specific subset	Coflex group: received Coflex and laminectomy interlaminar stabilization (n=196) vs. fusions group: received posterolateral spinal fusion and laminectomy with spinal instrumentation (n=94).	Three year follow up	Composite clinical success at three years – 62.2% in Coflex group, 48.9% in fusion group (difference – 13.3%, 95% CI (1.1-25.5%), p = 0.03).	"Coflex Interlaminar Stabilization for stenosis is proven to be effective and durable at improving overall composite clinical success without altering normal spinal kinematic motion at the index level of decompression or adjacent levels."	Data suggest at 3 years, Coflex appears beneficial for treating lumbar stenosis without changing normal motion.

Davis 2013 (score= 5.0)	Fusion	RCT	Sponsored by Paradigm Spine, LLC. COI, Dr. Davis is a consultant for and received clinical or research support for this study from Paradigm Spine, LDR, and Zimmer. Dr. Auerbach is a consultant for Paradigm Spine, Synthes Spine, Zyga Technology, Simpirica Spine, Medical Metrics Inc., and Medacta International. Dr Errico received clinical or research support for this study from Paradigm Spine. Authors are consultants to Paradigm Spine, LLC.	Investigational device exemption (IDE) trial (n = 322) and Spondylolisthesis Cohort (n = 150)	Mean age: 64 years; 60 males, 90 females.	IDE trial Coflex device Treatment (n = 232) vs. Fusion Treatment (n = 114) received posterolateral spinal fusion with spinal instrumentation. Spondylolisthesis Cohort Coflex Treatment (n = 99) vs. Fusion Treatment (n = 51).	Follow-up at 24 months.	No group difference at baseline. No differences among groups except greater ZCQ satisfaction with coflex at 2 years. 62.5% of subjects yielded p = 1.000 but reoperation rate of coflex cohort 14.1% vs. 53.9% of fusion p = 0.18. Mean+-SD, P Value Symptom Severity Coflex: Preop: 3.54+-0.63; Month 24: 1.90+-0.70. Fusion Control Preop: 3.54+-0.56, p = 0.987; Month 24: 2.14+-1.00, p = 0.144. Physical Function Coflex: Preop: 2.79+-0.45; Month 24: 1.55+-0.60. Fusion Control Preop: 2.76+-0.47, p = 0.637; Month 24: 1.66+-.69, p = 0.352	"Low-grade spondylolisthesis was effectively stabilized by coflex and led to similar clinical outcomes, with improved perioperative outcomes, compared with PSF at 2 years. Patients in the fusion cohort experienced significantly increased superior and inferior level angulation and translation, while those in the coflex cohort experienced no significant adjacent or index level radiographic changes from baseline."	High non-compliance rate. Study methods not well described. No comparison with non-surgery group. No meaningful difference between groups.
Fusion vs. Non-fusion for Burst Fracture										

Wang 2006 (score= 5.5)	Fusion	RCT	No COIs or industry sponsorship.	N = 58, with neurogically intact spine with kyphotic angle ≥20°, decreased vertebral body height or canal compromise ≥50%	Mean age: 40 years; 42 males; 16 females.	Fusion with bone graft (n = 30) vs. non-fusion no graft group (n = 28).	Follow-up at 24 to 71 months, average 41 months.	At final follow-up compared to pre-op % body vertebral height loss/average segmental motion and low back outcome scale (19.1%, 22.3% vs. 8.3% vs. 15.6% vs. 3.6%) / (1.0° vs. 4.8°, p <0.001 and 31.9, 47.1, 62.7, and 66.3 at 3 & 6 months, 1 and 2 years, fusion group for same period 30.7, 46.7, 62.7, & 65.6 vs. 33.3, 47.8, 62.8, & 66.9.	"[Short-term] results of short-segmental fixation without fusion for surgically treated burst fractures of the thoracolumbar spine were satisfactory…"	Randomization by roll of dice…Data suggest no clinical differences at 3 to 4 years….complications in non-fusion group related to no donor site.
Fusion with Instrumentation vs. Fusion without Instrumentation										
Fischgrund 1997 (score= 5.5)	Fusion	RCT	No COIs or industry sponsorship.	N = 68 with degenerative lumbar spondylolisthesis with spinal stenosis	Mean age: 68 years; 13 males, 55 females.	Decompressive laminectomy and single level autogenous bilateral lateral intertransverse process arthrodesis (n = 33) vs. Decompressive laminectomy and single level bilateral lateral autogenous intertransverse process arthrodesis with transpedicular instrumentation (n = 35). Surgery mostly L4-L5. Same post-op rehab program for all.	Follow-up at 2 years.	Arthrodesis in 83% of instrumented vs. 45% non-instrumented, p = 0.0015. No other differences.	"In patients undergoing single-level posterolateral fusion for degenerative spondylolisthesis with spinal stenosis, the use of pedicle screws may lead to a higher fusion rate, but clinical outcome shows no improvement in pain in the back and lower limbs."	No blinding. Mean follow-up period was 28 months. Data suggest higher fusion rates with instrumentation but no clinical outcome differences between groups
Posterolateral (PLF) vs. Posterior Lumbar Interbody (PLIF) vs. PLF + PLIF										

Etemadifar 2016 (Score= 5.5)	Fusion	RCT	No sponsorship or COI.	N= 50 patients with isthmic spondylolisthesis.	Mean age: 52.6 years; 20 males, 30 females.	PLF group: received only posterior lumbar interbody fusion (n=25) vs. PLF+TLIF group: received posterior lumbar interbody fusion and unilateral transforaminal lumbar interbody fusion (n=25).	Follow-up at 2 years.	Pain in back and leg both decreased in the two groups ($p<0.05$). Patients in PLF+TLIF indicated lower pain, compared with PLF group ($p<0.05$). Oswestry Disability Index (ODI) score significantly decreased in the two groups ($p<0.05$).	"[A]ccompanying TLIF with PLF might lead to better functional improvement and pain reduction in patients with spondylolisthesis."	Data suggest at 6 months, one year and 2-year post surgery back and leg pain were significantly lower in PLF + TLIF group.
Høy 2013 (Score= 5.0)	Fusion	RCT	No mention of sponsorship. The authors declared no COI.	N=100 patients with radicular pain and severe low back pain.	Mean age: 49.8 years; 41 males, 59 females.	TLIF group: received transforminal fusion in tantalum cage form from Zimmer and Implex by lateral to the facet joint approach replacement (n=51) vs. control group: received posterolateral fusion with Medtronic's titanium pedicle instrumentation (n=49).	Follow-up at 2 years.	Oswestry Disability Index (ODI) scores in both groups indicated no significant difference: TLIF group=25.8±6.9, control group=26.7±4.5 ($p=0.698$). Low back pain index indicated no significant differences between the two groups: TLIF group=23.6±7.2, control group=18.1±4.5 ($p=0.728$).	"Transforaminal interbody fusion did not improve functional outcome in patients compared to posterolateral fusion. Both groups improved significantly in all categories compared to preoperatively."	Baseline differences in groups as more patients had spondylolisthesis in control group. Data suggest comparable outcomes between groups but surgical time and EBL significantly higher in TLIF group.
Høy 2017 (No score)	Fusion	Secondary analysis of Høy 2013 RCT.	No COI. No mention of sponsorship.	N = 88 patients with radicular pain and severe low back pain.	Mean age: 50.0 years; 38 males, 50 females.	TLIF group: received transforminal fusion in tantalum cage form from Zimmer and Implex by lateral to the facet joint approach replacement (n=44) vs. control group: received posterolateral fusion with Medtronic's	5 to 10 year follow up	93% of participants included in follow up. Long-term reoperation rate equal among groups ($p=0.24$). Mean differences – back pain: 3.8, TLIF: 3.65, PLF: 3.97 ($p = 0.62$); leg pain: 2.68, TLIF – 2.90, PLF – 0.34 ($p = 0.34$). No difference in functional	"In a long-term perspective, patients with TLIF's did not experience better outcome scores."	Data suggest at 5-10 years post-surgery TLIF did not produce better outcomes over PLF.

						titanium pedicle instrumentation (n=44).		outcome between groups (p = 0.93)		
Serban 2017 (Score= 4.5)	Fusion	RCT	No mention of sponsorship. The authors declared no COI.	N=80 patients with low back pain and radicular pain or neurogenic claudication.	Mean age: 50.71 years; 33 males, 47 females.	S-TLIF group: received standard transforaminal lumbar interbody fusion with an opening in fascia (n=40) vs. MI-TLIF group: received 2 paramedian incisions with minimally invasive transforaminal lumbar interbody fusion (n=40).	Follow-up at 3, 6 and 12 months.	Oswestry Disability Index (ODI) improved in both groups with no significant differences between groups (p=0.96). ODI in S-TLIF group changed from 38±7 to 11±6 (p<0.0001); ODI in MI-TLIF group changed from 37±6 to 11±6 (p<0.0001)	"In this prospective randomized study comparing S and MI TLIF in patients with symptomatic spondylolisthesis, the MI TLIF group patients had significantly shorter hospitalization than the S TLIF group patients."	Data suggest that at 1 year both groups exhibited similar outcomes although the minimally invasive group initially had shortened hospitalization time.
Jalalpour 2015 (Score= 4.5)	Fusion	RCT	No mention of sponsorship or COI.	N=135 patients with postdiskectomy syndrome or degenerative disk disease.	Mean age: 44.5 years; 74 males, 61 females.	PLF group: received standard uninstrumented posterolateral fusion using autograft (n=67) vs. TLIF group: received trasforaminal lumbar interbody fusion with porous tantalum interbody spacer posterolateral autograft pedicle titanium screw fixation (n=68).	Follow-up at 1 and 2 years.	Pain index (PI) and disability rating index (DRI) indicated significant differences between the two groups (PI: p=0.007; DRI: p=0.003). No differences in Oswestry Disability Index (ODI) was found between the groups (p=0.110). ODI in PLF group improved 18.5 points, and ODI in TLIF group improved 22.9 points.	"The results of the current study support the use of TLIF rather than PLF in the surgical treatment of chronic low back pain."	Data suggest at 2 years follow-up, TLIF group reported less pain & disability and had fewer reoperation.
Challier 2017 (Score= 4.5)	Fusion	Monocentric open-label RCT	No sponsorship. No mention of COI.	N=60 patients suffered one-level lumbar degenerative spondylolisthes	Mean age: 64.5 years; 18 males, 42 females.	PLF group: received isolated instrumented posterior fusion with intertransverse autologuous graft and	Follow-up at 2 years.	Significant difference was found among 43.3% patients in PLF group and 93.3% in PLF+TLIF group indicated less than 5° movement in	"Posterior decompression and instrumented fusion is an efficient technique that proved its significant clinical benefit in the surgical treatment of DS."	Open label RCT with relatively small sample size. Data suggest comparable efficacy between techniques,

				is with low back or leg pain, or both.		posterior pedicle screws (n=30) vs. PLF+TLIF group: received instrumented posterior fusion and interbody fusion with transforminal approach (n=30).		flexion or extension radiographs (p<0.05). PLF+TLIF group indicated superior change in segmental lordosis level (SL) over PLF group (36.7% vs. 13.3%), but the difference was not significant (p>0.05).		
Kim 2006 (score= 4.0)	Fusion	RCT	No COIs or industry sponsorship.	N = 167 with chronic LBP	Mean age: 55.9 years; 45 males, 122 females.	Posterolateral fusion (PLF, Group 1, n = 62) vs. Posterior lumbar interbody fusion (PLIF, Group 2, n = 57) vs. PLF+PLIF (Group 3, n = 48).	Follow-ups at 6 months, and years 1-3.	No differences in back pain, leg pain, or Oswestry scores at any time. Blood loss: Group 1 (1082ml) vs. Group 2 (738) vs. Group 3 (1490), p <0.05.	"No significant differences in clinical results and union rates were found among the 3 fusion methods. PLIF had better sagittal balance than PLF. PLIF without PLF had advantages of the elimination of donor site pain, shorter operating time, and less blood loss."	Single surgeon performed all procedures. Baseline characteristics sparse. Data suggest no clinically significant difference between the 3 procedures.
Electromagnetic Field Stimulation vs. Placebo										
Linovitz 2002 (score= 9.5)	Fusion	RCT	No COIs or industry sponsorship.	N = 243 with primary intertransverse fusion without internal fixation; randomization within 30 days of fusion	Mean age: 57 years; 81 males, 120 females.	Combined magnetic field stimulation device (n = 125) vs. Placebo (n = 118). Treatments through single posterior coil, centered over fusion site, 30 minutes a day for 9 months.	Follow-up at 9 months	Differences in fusion success at 9 months for all patients, and females: p = 0.003, p = 0.001. Improvement in magnetic device vs. placebo for Level 1 fusion, p = 0.009. Magnetic device favored over placebo in ITT for fused, not fused, and LVCF: p = 0.006, p = 0.015, p = 0.007.	"[T]he adjunctive use of the combined magnetic field device for posterolateral fusions was shown to be beneficial in this study."	Healing rates differed (64% vs. 43% for placebo devices). Effects present only in females (males: 55% vs. 61%) number they state completed all aspects of study and thus analyzed. But enrolled 337 and individuals dropped from analysis due to missing documents, withdrawals, non-compliance, adverse reactions, wound infection, etc.
Goodwin 1999 (score= 7.5)	Fusion	RCT	Industry Sponsored (Biolectron, Inc., Hackens	N = 179 undergoing primary lumbar fusions	Mean age: 42 years; 97 males, 82 females.	Direct current plus electromagnetic field stimulation (n = 85) vs.	Follow-up at 12 months.	Differences in clinical and radiographic success (%), and stratification by posterolateral	"Capacitively coupled stimulation is an effective adjunct to primary spine fusion, especially for patients	Clinical outcome scores (good or excellent) and radiographic fusion were

			ack, New Jersey). No mention of COIs.	for degenerative disc disease		Placebo (n = 94). Randomization 3 weeks post-fusion. Devices worn 24 hours a day until healing occurred or for 9 months if delayed healing (average use 15.7 vs. 16.5 hours a day).		fusion at final evaluation: p = 0.0043, p = 0.006. Electromagnetic stimulation vs. placebo no internal fixation success (%) at level 1 fusion, and level 2 fusion: 100%/83%, 75%/100%. Internal fixation: 79%/84%, 64%/58%.	with posterolateral fusion and those with internal fixation."	84.7% vs. 64.9% suggesting efficacy. However, authors stated that 220 patients completed final status documents but only 179 completed independent radiographic review.
Mooney 1990 (score= 6.5)	Fusion	RCT	No mention of industry sponsorship or COIs.	N = 195 who underwent interbody lumbar fusions	Mean age: 37.8 years; 111 males, 95 females.	Brace with electromagnetic field (n = 98) vs. Sham brace (n = 97). .	Follow-up at 12 months.	Electromagnetic field vs. placebo success rate based upon autogenous graft, cadaverous graft, autogenous/cadaverous graft, and total: 92.0%/73.7%, 92.6%/72.7%, 91.7%/50.0%, 92.2%/67.9%. Success rate for no fixation, fixation, total: 93.8%/57.1%, 91.7%/71.8%, 92.2%/67.9%. Success rate for single-level fusion, double level fusion, and 3 or more fusion: 93.5%/72.5%, 88.9%/53.8%, 0/0, 92.2%/67.9%.	"In the active group there was 92% success rate, while the control group had a 65% success rate (P>0.005). The effectiveness of bone graft stimulation with the device is thus established."	Data suggest better radiological fusion with electromagnetic field.
Bone Morphogenetic Protein-1 (rhBMP-7) vs. Iliac Crest Autograft										
Delawi 2016 (Score= 6.5)	Fusion	RCT	No mention of sponsorship. One or more pf the authors have received or will receive benefits for personal	N=119 patients with isthmic or degenerative spondylolisthesis with neurological compression	Mean age: 54.5 years; 52 males, 67 females.	OP-1 group: received an Osigraft unit with 1 a carrer of type-I collagen of 3.5 mg lyophilized recombinant human OP-1 (n=60) vs. Autograft group: received	Follow-up at 1 year.	Overall success rate in OP-1 group was 40%, and autograft group for 54% (95%CI= -28.6 to 2.1).Significantly lower fusion rate in OP-1 group's CT result indicated the overall success difference	"OP-1 with a collagen carrier was not as effective as autologous iliac crest bone for achieving fusion and cannot be recommended in instrumented posterolateral lumbar fusion procedures."	OP-1 demonstrated lack of efficacy. At 1 year post surgery the fusion rate was lower as seem on CT.

			or professional use.	symptoms.		autologous bone graft from local bone and iliac crest (n=59).		(p=0.03; 95%CI= -40.1 to -2.98). Treatment group influenced fusion rate seen on CT significantly (p=0.02).		
Vaccaro 2005 (score= 6.0)	Fusion	RCT	No mention of industry sponsorship or COIs mentioned.	N = 36 with grade I or II degenerative spondylolisthesis of L3-L4, L-4-L5 segments.	Mean age: 68±8.5 years; 3 males, 9 females.	Osteogenic Protein 1 or OP-1 (rhBMP-7) (n = 24) vs. Autograft group (n = 12).	Follow-up at 3, 6, 9, 12, and 24 months.	Oswestry score 24-36 months; 85% OP-1 vs. 64% patients achieved at least 20% improvement; 58% autograft patients rated as clinical success & 33% rated as radiographic success vs. OP-1 71% clinical and 46% radiographic success.	"This study represents the first clinical trial to demonstrate the safety and similarity of OP-1 Putty as a replacement for autogenous bone graft in the posterolateral fusion environment with a minimum of 2-year follow-up."	Data suggest similar outcomes with …treatment. Small study population limits generalizability.
Delawi 2010 (score= 5.0)	Fusion	Prospective RCT	Sponsored by Corporate /Industry and institutional funds. No COI.	N = 36 who required 1-level instrument posterolateral fusion of lumbar spine (mean± SD age 53±18 years.	Mean age: 54 years; 16 males, 18 females.	Osteogenic protein (OP-1) combined with locally obtained bone form laminectomy (OP-1 group, n = 18) vs. Autologous bone graft combined with locally obtained bone (Autograft group, n = 18) Subjects observed before surgery and 6 weeks, 3 months, 6 months, 1 year after surgery. Prophylactic cephalosporin given for 24 hours starting at 15 minutes before incision.	Follow-up at 6 weeks, 6 and 12 months.	No difference between groups in regards to fusion rates (p = 0.95); 10 (63%) of 16 patients in OP-1 group compared with 10 (67%) of 15 Autograph group were classified as fused. No difference between both groups in the mean scores (P=0.52)	"The results demonstrate that OP-1 combined with locally obtained autograft is a safe and effective alternative for iliac crest autograft in instrumented single-level posterolateral fusions of the lumbar spine. The main advantage of OP-1 is that it avoids morbidity associated with the harvesting of autogenous bone grafts from the iliac crest".	There were no statistically significant differences between the groups.
Vaccaro 2008 (score= 4.5)	Fusion	Prospective RCT	No mention of sponsors	N = 36 with degenerative lumbar	Mean age: 64 years; 16 males,	In 23 subjects (96%), surgery performed at	Follow-up at 6 weeks, and 3, 6, 9, 12,	At 48-month time, radiographic and clinical results were available	"Despite the challenges associated with obtaining a solid uninstrumented fusion in patients	Data suggest that OP-1 is more efficacious than autograft

			hip or COI	spondylolisthesis, within the age range of 43-80 years and the average age of 63 years.	20 females.	L4-L5 level and L3-L4 in 1 subject (4%). 3.5 mg of lyophilized rhOP-1 formulated with 200mg of carboxymethylcellulose and 1g of type 1 collagen from bovine bone (OP-1 Putty, n = 24) vs. In 9 subjects (75%), surgery was performed at L4-L5 level and L3-L4 in 3 subjects (25%). Treated with Morselized corticocancellous bone (Autogenous iliac crest bone graft, n = 12).	and 24 months, then on a yearly basis.	for 22 of 36 patients (19 OP-1 Putty and 6 autograft) and 26 of 36 patients (19 OP-1 Putty and 7 autograft). No difference between the two groups in relation to the average operative time, estimated blood loss, duration of hospital stays, post-op neurological status or prevalence of a positive straight let tension sign. No P-value reported.	with degenerative spondylolisthesis, the rates of radiographic fusion, clinical improvement, and overall success associated with the use of OP-1 Putty were at least comparable to that of the autograft controls for at least 48 months after surgery. These results appear to validate the short-term results previously reported for OP-1 Putty and suggest that this material may potentially represent a viable bone graft substitute for certain fusion applications."	group. However results were generally not significant.
Vaccaro 2004 (score= 4.0)	Fusion	RCT	Sponsored by Corporate/Industry funds. No COI	N = 36 with degenerative lumbar spondylolisthesis is within the age43-80 (average age 63)	Mean age: 44.3 years; 16 males, 20 females.	23 (96%) had surgery at L4-L5 and 1 had surgery at L3-L4. One OP-1 Putty implant placed between transverse processes on each side of spine (7.0mg of rhOP-1 per patient) (OP-1 Putty, n = 24) vs. 9 (75%) had surgery at L4-L5, and 3 had surgery at L3-L4. Morselized iliac crest bone graft placed on each side of spine to span space	Follow-up at 1 year.	No difference between the two groups in regards to the rate of adverse events (P=1.00), fusion rate (P=0.675), clinical success (P=0.39) and the operative times, hospital stays, or the presence of a postoperative straight legs tension sign. Both treatment groups improved in physical and mental well-being. No p-values reported.	"Although the posterolateral spine is a challenging fusion environment in patients with degenerative spondylolisthesis, successful radiographic fusion was obtained using OP-1 Putty at a rate that was similar to autograft given the number of patients in this study. Importantly, there were no apparent adverse consequences related to the use of the OP-1 Putty implant in this patient population".	Few methodological details. No significant differences between groups.

						between transverse process (Iliac crest autograft, n = 12). In both groups, each subject fitted with lumbosacral brace and instructed to wear it for 3 months. Physical therapy was begun at the 6-8 weeks after surgery. Subjects observed at 6 weeks, and 3, 6, 9 and 12 months after surgery.				
Bone Morphogenetic Protein-2 (rhBMP-2) vs. Iliac Crest Autograft										
Dimar 2009 (score= 5.0)	Fusion	RCT	No mention of COIs or industry sponsorship.	N = 463 with single-level degenerative disc disease from L2-L3 to L5-S1 and no succeed in non-operative treatment at least 6 months	Mean age: 52.8 years; 203 males, 260 females.	Investigational group: rhBMP-2 matrix (n = 239) vs. Control group: iliac crest bone graft or ICBG (n = 224). Patients observed 6 weeks and 3, 6, 12 and 24 months after surgery.	Follow-up at 24 months.	Operative time ($p < 0.001$), and blood loss ($p < 0.001$) were significantly less in rhBMP-2 matrix group 2.5±0.09, and 343.1±264.5 respectively vs. 2.9±1.0, and 448.6±301.7 in ICBG group. Fusion success rates for rhBMP-2 matrix group at 6, 12, and 24 months vs. ICBG group: 79% (155/196), 88% (182/208), and 96% (186/194) vs. 65% (115/176), 83% (151/183), and 89% (151/169), p = 0.002, 0.107, 0.014. Patients requiring second surgery higher in ICBG group (36 patients) vs. rhBMP-2 matrix group (20	"[I]n posterolateral lumbar arthrodesis, rhBMP-2 matrix decreases operative time and blood loss and has earlier, higher fusion rates and similar clinical outcomes as iliac crest bone graft, and its use can eliminate the need for harvesting iliac crest bone in this procedure."	Reported data suggest comparable clinical outcomes.

								patients), p = 0.015.		
Burkus 2006 (score= 4.5)	Fusion	RCT	No COIs or industry sponsorship	N= 131 with symptomatic degenerative disc disease at L4-L5 or L5- S1 and disabling LBP at least 6 months and no response to nonoperative treatment	Mean age: 41.5 years; 51 males, 80 females.	Investigational group: rhBMP-2 on an absorbable collagen sponge in conjution with MD-II (n = 79) vs. control group: iliac crest bone graft (n = 52).	Follow-up at 6, 12, and 24 months.	Allograft incorporation: at 12 months, 96% of rhBMP-2 group showed complete incorporation. This compares with the control group who demonstrated a 66%. At 24 months, 100% of rhBMP-2 showed complete incorporation in contrast with the 79% iliac crest bone graft group. New bone formation occurred in both groups; however, the incidence of new bone formation was always higher in the rhBMP-2 in all time intervals. Fusion rates were statistically superior in rhBMP-2 to those in iliac crest bone graft at all time intervals (p < 0.05).	"The interbody healing patterns associated with rhBMP-2in conjunction with allograft bone dowels are considerably different from those observed with metallic interbody cages. These differences are best observed using thin-slice CT scans because plain radiographs lack the imaging resolution and sensitivity to detect these differences. Interestingly, while the healing patterns are different, the fusion success and clinical success are not affected."	Details sparse.
Glassman 2008 (score= 4.5)	Fusion	RCT	Industry sponsored (Medtronic Sofamor Danek). Industry COI's (Medtronic Sofamor Danek).	N = 102 over age 60 with frequent diagnoses of spinal stenosis, spondylolisthesis, and adjacent level degeneration.	Mean age: 69.6 years; 32 males, 70 females.	Investigational group: rhBMP-2/ACS (n = 50) vs. Control group: iliac crest bone graft or ICBG (n = 52).	Follow-up at 2 years.	Mean OR time was shorter in rhBMP-2 group vs. ICBG (248± 58.8 vs. 270± 33.6 min), p = 0.024. 20 pre-op complications in ICBG group vs. 8 complications in rhBMP-2 group (p= 0.014). At 2 years, mean change in ODI score 15.8± 17.7 in rhBMP-2 group vs. 13.0±15.5 in ICBG group.	"RhBMP-2/ACS is a viable ICBG replacement in older patients in terms of safety, clinical efficacy, and cost-effectiveness."	Details sparse.

								Mean change in SF-36 PCS 6.6±9.3 in rhBMP-2 group vs. 7.5±8.4 in ICBG group. Average postoperative CT grade 4.3 ± 1.3 in rhBMP-2 group vs. 3.8±0.9 in ICBG group (p = 0.030). Fusion rate 70.8% in ICBG group vs. 86.3% in rhBMP-2 group. No statistically significant differences in NRS back and leg pain and costs between 2 groups.		
Haid 2004 (score= 4.5)	Fusion	RCT	No industry sponsorship. Industry COI (Medtronic Sofamor Dan).	N = 67 with symptomatic, single-level degenerative lumbar disc disease. Disabling LBP with or leg pain, or both >6 months and no response to nonoperative treatment	Mean age: 46.2 years; 32 males, 35 females.	Investigational group: rhBMP-2 on an absorbable collagen sponge (n = 34) vs. Control group: autogenous iliac crest bone graft (n = 33).	Follow-up at 24 months.	At 24 months, average improvement in back pain higher in rhBMP-2 group (9 points) vs. iliac crest bone group (4.5 points), p = 0.009. 24 patients in rhBMP-2 group had new bone formation outside of disc space and into spinal canal vs. 4 patients iliac crest bone group, (p <0.0001, Fisher). Posterior bone formation unrelated to leg pain. ODI, SF-36, leg pain score, and fusion rate not statistically significant differences.	"This small multicenter, randomized, nonblinded trial showed few statistically significant differences between the study groups."	Details sparse.
Burkus 2002 (score= 4.0)	Fusion	RCT	No mention of COIs or industry sponsorship.	N = 279 with symptomatic, single level degenerative	Mean age: 42.8 years; 146 males, 133 females.	Investigational group: rhBMP-2 on an absorbable collagen sponge (n = 143) vs.	Follow-up at 12 and 24 months.	Oswestry scores within the rhBMP-2 group at pre/6 weeks/3 months/6 months/12 months/24 months were:	"RhBMP-2 is a promising method of facilitating anterior intervertebral spinal fusion and of decreasing pain and improving clinical outcomes after anterior	Details sparse. Possible randomization failure based on proportion of participants working difference

				lumbar disc disease and symptoms of disabling low back or leg pain or both, and no success in nonoperative treatment at least 6 months.		Control group: iliac crest bone graft (n = 136).		12.5/5.1/5.6/6.4/6.4/6.5, p< 0.001 in all times intervals. Within the ICBG group at pre/6 weeks/3 months/6 months/12 months/24 months were: 12.5/4.1/5.6/6.3/5.6/6.3/5.9, p< 0.001 in all times intervals.	lumbar fusion when used with the LT-CAGE device. The use of rh-BMP-2 is associated with high fusion rates without the need for harvesting bone from the iliac crest and exposing the patient to the adverse effects associated with that procedure."	between 2 groups.
Dawson 2009 (score= 4.0)	Fusion	RCT	Industry sponsored (Medtronic Sofamor Danek). Industry COI (Medtronic Sofamor Danek).	N = 46 with single-level degenerative disc disease from L1 to S1 and had not responded to conservative care for 6+ months; clinical symptoms included LBP, radicular leg pain, or both	Mean age: 56.4 years; 19 males, 27 females.	Investigational group: rhBMP-2 on an absorbable collagen sponge combined with ceramic granules (n = 25) vs. Control group: iliac crest bone graft (n = 21).	Follow-up at 24 months.	RhBMP-2 group evidence of bridging trabecular bone 91% (20 of 22) [71%, 99%] at 6 months vs. iliac crest bone graft with 58% (11 of 19) [33%, 80%], p = 0.032. At 24 months, the overall success rate, ODI, and fusion rate did not have statistically significant. However, improvement in rhBMP-2 group 81% (17/21) vs. 55% (11/20) in the iliac crest bone graft, (p = 0.345). ODI scores of rhBMP-2 group 96% (22/23) vs. 75% (15/20) in the iliac crest bone graft, p = 0.240. Lastly, the fusion rate of rhBMP-2 group 16% higher than iliac crest bone graft.	"Compared with an iliac crest bone graft, the combination of an absorbable collagen sponge soaked with rhBMP-2 and ceramic granules resulted in trends toward improvements in clinical outcomes and toward a higher rate of radiographic fusion. This combination of an osteoinductive agent with an osteoconductive matrix may be an effective replacement for autograft in single-level posterolateral lumbar arthrodeses with instrumentation."	No functional differences at 2 yrs.
Gornet 2002 (score= 4.0)	Fusion	RCT	No mention of COIs or industry sponsorship.	N = 281 single-level degenerative lumbar disc	Mean age: 42.8 years; 146 males, 133 females.	Investigational group: rhBMP-2 on an absorbable collagen sponge (n =	Follow-up at 6, 12, and 24 months.	Mean operative time in rhBMP-2 group was 1.7 hours vs. 2.0 hours in iliac crest bone graft group. Blood	"The combination of rhBMP-2 with a tapered cage has demonstrated itself as a promising alternative of facilitating anterior	Data suggest modestly faster surgery with BMP.

				disease, disabling LBP with leg pain, or both of at least 6 months, no response to non-operative treatment.		145) vs. control group: autogenous iliac crest bone graft (n = 136).		loss in rhBMP-2 group 109.3cc vs. 153.8cc in iliac crest bone graft group, p< 0.05.	intervertebral spinal fusion, decreasing pain and improving clinical outcomes."	
Author Year (Score):	**Category:**	**Study type:**	**Conflict of Interest:**	**Sample size:**	**Age/Sex:**	**Comparison:**	**Follow-up:**	**Results:**	**Conclusion:**	**Comments:**
Autograft vs. Allograft										
Putzier 2009 (score= 5.5)	Fusion	RCT	No mention of COIs or industry sponsorship.	N = 44 with bilateral or unilateral leg pain, age 34-47	Mean age: 45.5 years; 22 males, 22 females	Autogenous iliac crest cancellous bone (n = 22) vs. Freeze-dried, human allogenic cancellous bone (n = 22).	3, 6, 9, 12 months	After 3 & 6 & 9 & 12 months; fusion rates 5.0% vs. 10.0%, & 15.0% vs. 35.0%, & 45.0% vs. 55.0%, & 65.0% vs. 70.0%, k = 0.86. Bone density 0-3 months p = 0.034	"The results of our study show freeze-dried allogenic cancellous bone can be used for nonsegmental spondy-lodeses."	Allocations, baseline comparability details missing. Data suggest similar fusion results at 1 year.
Posterolateral vs. Circumferential Fusion										
Christensen 2002 (score= 6.5)	Fusion	RCT	No mention of industry sponsorship or COIs.	N = 146 with chronic LBP and leg pain, static or dynamic	Mean age: 45.5 years; 58 males, 88 females	Posterolateral spinal fusion with titanium Cotrel-Dubousset instrumentation (CDI) (posterolateral group, n = 73) vs. Circumferential spinal fusion (anterior lumbar interbody fusion with radiolucent Brantigan cage plus posterolateral fusion, circumferential group, n = 75).	1 year, 2 years	22% of patients in posterolateral group had second surgery vs. 5 in circumferential group, p <0.009. No other between-group differences.	"Circumferential lumbar fusion restored lordosis, provided a higher union rate with significantly fewer repeat operations, showed a tendency toward better functional outcome, and resulted in less peak back pain and leg pain than instrumented posterolateral fusion."	Lack of details on co-interventions. Full-time work increased 24-37% after surgery. Data suggest no difference between groups on DPQ and LBPR. Grade 1 or 2 isthmic spondylolisthesis did not benefit more from circumferential fusion. Smokers had overall poorer outcomes measured by DPQ and non-union of posterolateral fusion mass.

Soegaard 2007 (score= 5.5)	Fusion	RCT	No mention of COIs or industry sponsorship.	N = 148 with severe chronic LBP, age 20-65	Mean age: 46 years; 57 males, 89 females	Posterolateral fusion using titanium Cotrel-Dubousset (n = 73) vs. Circumferential fusion, using intervertebral support (n = 73).	4, 8 years	EQ-5D net utility gains / Cost / Return to work; 0.13 (0.07-0.18) vs. 0.24 (0.19-0.29) / (p=0.012) / (8 of 18 vs. 2 of 18).	"Circumferential fusion is dominant over instrumented posterolateral fusion, that is, both being significantly cheaper and significantly better in a long-term, societal perspective."	Follow-up to 2006 report (Videbaek). Data suggest improved outcomes in total cost, return to work rates and health related quality of life. These differences did not become significant until after year 2 of follow up.
Videbaek 2006 (score= 5.5)	Fusion	RCT	No COIs or industry sponsorship.	N = 148, with severe chronic LBP, mean age 45	Mean age: 45 years; 60 males, 88 females	Posterolateral lumber Fusion with titanium Cotrel-Dubousset (n = 75) vs. Combined anterior lumber interbody fusion, Brantigan cage, lumbar disc + posterolateral fusion (n = 75).	2 years, 5 years, 9 years	Apparent higher statistical difference for lumber interbody fusion group with DPQ daily activity, work-leisure, anxiety and social concerns / ODI / SF-36; (p = 0.002, p = 0.005, p = 0.007 and p =0.019)/(p = 0.004)/(p = 0.005).	"These first long-term results of circumferential fusion in comparison with PLF demonstrate an improved outcome in terms of functional disability, back pain, and general health."	Timing of assessments range 5-9 years. No data on how groups compared… Data suggest long term subjective outcomes favor circumferential fusion in this population.
Schofferman 2001 (score= 5.0)	Fusion	RCT	No COIs or industry sponsorship.	N = 48 with chronic LBP from variable causes	Mean age: 42 years; 27 males, 21 females	Fusion 270° (n = 24) received anterior lumbar interbody fusion (ALIF) without posterolateral fusion (PLF) vs. 360° fusion (n = 29) received ALIF with PLF.	24, 45 months	No differences in pain and function outcomes. Blood loss (ml): 360 combined 1225 vs. 270 combined 908, p <0.05; 360 PLF only 965 vs. 270 PLF only 620, p <0.02. Hospital stay: 360 8.1 days vs. 270 6.9 day, p <0.05. Professional charges: 360 $26,113 vs. 270 $16, 990, p <0.001.	"Both the 360° and 270° fusions significantly reduce pain and improve function, and there are no significant clinical differences between them. However, there were shorter operating times, less blood loss, lower costs, and less utilization of health care resources associated with the 270° fusions."	Heterogeneity of baseline patient population and significant degree of and differences between groups in surgical variability limits conclusions. Data suggest comparable results.
Radcliff 2017 (score= 4.5)	Fusion vs Discectomy	RCT	Sponsored by Synthes USA products LLC. COI, one or more of the authors have	N = 229 patients with degenerative disk disease at 2 contiguous vertebra	No mention of mean age, age range, or gender.	Lumbar total disk replacement (TDR) group (n = 161) – patients were managed with TDR at both levels. Vs.	Follow up at 5 years.	Percent of subjects at 5 years undergoing secondary surgeries was 5.6% in the TDR group vs 19.1% for the fusion group (p=0.0027)	"There were significantly fewer reoperations in TDR Patients compared with fusion patients. However, most of the secondary surgeries were instrumentation removal in the fusion cohort. Discounting the instrumentation	Data suggest TDR non-inferior to fusion at 5 years.

			received or will receive benefits for personal or professional use.	l levels from L3 to S1 with or without leg pain, a minimum of 6 months of unsuccessful nonoperation treatment, and had a minimum Oswestry Disability Index score of 40%.		Circumferential fusion group (n = 68) – patients were managed with a 2-level anterior lumbar interbody arthrodesis with use of a commercially available femoral ring allograft.		Percent of subjects at 5 years with Index level secondary surgeries were 3.1% in the TDR group vs 16.2% in the fusion group (p=0.0009)	removals, there was no significant difference in reoperations between TDR and fusion. These results are indicative that lumbar TDR is noninferior to fusion."	
Hoff 2016 (Score= 4.0)	Fusion	RCT	Sponsored by the German Research Foundation. The authors declared no COI.	N=50 patients	Mean age: 46.5 years; 24 males, 26 females.	Hybrid group: received total disc replacement at L4/5 and anterior lumbar interbody fusion at L5/S1 (n=26) vs. fusion group: received 2-level circumferential fusion with transforaminal lateral interbody fusion and transpedicular stabilization at L4-S1 (n=24).	Follow-up at 12, 24, and 37 months.	Visual analog scale (VAS) and Oswestry Disability Index (ODI) improved in the two groups (p_{time}<0.001). Significant reduction of pain level was found in hybrid group (p<0.05).	"Hybrid surgery is a viable surgical alternative for the presented indication. Approach-related inferior trauma and the balanced restoration of lumbar lordosis resulted in superior clinical outcomes compared to two level circumferential fusion with TLIF."	Data suggest hybrid surgery may be a reasonable option for DDD.
Fusion with Coralline Hydroxyapatite vs. Iliac Autograft										
Korovessis 2005 (score= 4.0)	Fusion	RCT	No mention of COI or industry sponsorship.	N = 60 with symptomatic degenerative lumber	Mean age: 61 years; no mention of sex.	IBG or iliac bone graft over decorticated laminae (n =19) vs. CH or	Follow-up at 3 and 4 years.	ODI/R-M/VAS; (41±27% vs. 47±39% vs. 43±28%) / (47±43% vs. 60±46% vs. 55±28%) /	"This prospective randomized study showed that autologous iliac bone graft remains the gold standard for achieving solid	Lack of study details, randomization, allocation, baseline comparability. Data suggest

				spine stenosis with instability		hydroxyapatite granules, 15 cc per level mixed with local bone chips, 5-10 cc bone chips per segment (n = 18) vs. CH granules, 15cc per level mixed with local bone chips 5-10c bone chips per segment (n = 20).		(8±1.2 vs. 8±1.7 vs. 7±2).	posterior instrumented lumber fusion, to which each new graft should be compared."	no differences in fusion rates or clinical outcomes.
Comparison of Fusion Cages										
Diedrich 2001 (score=4.5)	Fusion	RCT	No industry sponsorship. Industry COI (categories 12 and 14).	N = 40 with single-level PLIF with polyetherether-ketone (PEEK) cages, treated with degenerative or post-op monosegmental instabilities and stabilized either vertebral segment L4-L5 or L5-S1. Follow up at 6 and 12 months.	Mean age: 54.5 years; 14 males, 26 females.	In-group I (n = 20): nonwedged standard cages (rectangular, 0°) vs. Group II (n = 20): wedged cages with 4° inclination.	Follow-up at 1 year.	6 weeks and 12 months after surgical reposition, vertebral slip and disc high improved compared to preoperative measurements for both groups (p<0.01). There was an increase of lumbar lordosis at the 12 months control compared with the status at 6 weeks after surgery on both groups (p=0.01).	"These results show that normal sagittal alignment after single-level lumbar fusion can be achieved with rectangular and 4° wedged cages."	Biomechanical study. No meaningful health outcome measures.
Zhao 2002 (score=4.0)	Fusion	RCT	No COIs or industry sponsorship.	N = 25 posterior lumbar interbody fusion at L4-L5 for degenerative	Mean age: 49 years; 12 males, 13 females.	Group 1 (n = 13) received a single BAK fusion cage inserted posterolaterally with unilateral facetectomy and hemilaminec	Follow-up at 2 years.	Blood loss (ml): 1 BAK 661±171 vs. 2 BAK 1033±206, p <0.01. Operative time (minutes): 173±29 vs. 258±51, p <0.01. Stay in hospital, hospital fees,	"Posterior lumbar interbody fusion using diagonal insertion of a single threaded cage by a posterior approach with unilateral facetectomy enables sufficient decompression and solid interbody	Small numbers. Lack of baseline characteristics. Cost analysis included. Data suggest 1 BAK fusion cage in posterior lumbar interbody

				spondylolisthesis		tomy vs. Group 2 (n = 12) received 2 BAK fusion cages inserted posteriorly with bilateral facetectomy and laminectomy.		and operation fees: not significant between groups. Implants fees: 824±0 vs. 1578±238, p <0.01.	arthrodesis to be achieved while maintaining a majority of the posterior elements."	fusion at L4-L5 similar fusion rate as 2 BAK cages.
Fusion vs. Disc Replacement										
Guyer 2009 (score= 6.5)	Fusion	RCT, See also Blumenthal 2005	No COIs or industry sponsorship.	N = 133 enrolled in CHARITÈ IDE trial	Mean age: 39.6 years; 71 males, 62 females.	Investigational group (n = 90) implanted with CHARITÈ Artificial Disk vs. Control group (n = 43) treated by anterior lumbar interbody fusion (ALIF) with BAK threaded fusion cages packed with iliac crest autograft.	Follow up at 5 years.	Mean estimated blood loss (ml) comparing CHARITÈ group vs. BAK group: 212.1 vs. 204.3 (p = 0.8644). 15 point improvement in ODI comparing CHARITÈ group vs. the BAK group: 68% vs. 65% (p=0.8443). Mean preoperative L4-L5 range of motion comparing CHARITÈ vs. BAK: 8.7° vs. 9.2° (p = 0.8162). Mean preoperative L5-S1 ROM comparing CHARITÈ vs. BAK: 7.6° vs. 8.2° (p = 0.6793).	"Results of this five-year, prospective, randomized multicenter study are consistent with the two-year reports of noninferiority of CHARITÈ artificial disc vs. ALIF with BAK and iliac crest autograft."	Follow-up of Blumenthal 2005. Data suggest comparable results.
Zigler 2007 (score= 5.5)	Fusion	RCT	No COIs or industry sponsorship.	N = 286 with single-level degenerative disc disease	Mean age: 39.2 years; 116 males, 120 females.	ProDisc-L total disc replacement (investigational, n = 161) vs. Circumferential fusion receiving anterior lumbar interbody fusion (control, n = 75).	Follow-up at 2 years.	At 6 weeks, 3 and 6 months, the disc group had greater improvement vs. fusion, p <0.05. Also trended toward significance at 2 years, p = 0.0551. ODI success >15% improvement: Week 6 (fusion 49.3% vs. ProDisc-L 72.1%, p = 0.0007), Month	"In properly chosen patients, ProDisc®-L has been shown to be superior to circumferential fusion by multiple clinical criteria."	Included somewhat diverse patients with varying disorders. Data suggest disc replacement superior to fusion at 2 years.

								3 (60.6% vs. 80.5%, p = 0.0016), Month 6 (69.6% vs. 81.8%, p = 0.0346), Month 12 (NS), Month 18 (65.4% vs. 81.4%, p = 0.0189), Month 24 (64.8% vs. 77.2%, p = 0.0390). VAS patient satisfaction at 24 months: disc 76.7±29.2 vs. fusion 67.3±31.5, p = 0.015. At 2 years, 92.4% disc group vs. 85.1% fusion employed, p = 0.0485.		
Zigler 2012 (score =NA)	Discectomy	Secondary analysis of Zigler 2007	COI, one or more of the authors have received or will receive benefits for personal or professional use. No mention of sponsorship.	N = 166 with single-level lumbar degenerative disc disease (DDD)	Mean age: 38.9 years; 80 males, 86 females	Total disc replacement (TDR), ProDisc-L (n = 161) vs. Circumferential fusion (n = 75). Refer to Zigler 2007 for treatment details. Radiographic follow-up data at 5 years available for 123 TDR patients and 43 fusion patients.	Follow up at 5 years.	9.2% of TDR group and 28.6% of fusion group had changes in adjacent-level degeneration (ALD) (p = 0.004). New findings at 5 year follow-up for patients without ALD preoperatively present in 6.7% of TDR group and 23.8% fusion group (p = 0.008). 1.9% TDR patients and 4.0% of fusion patients reported adjacent-level surgery leading to secondary surgery (p = 0.6819)	"At 5 years after the index surgery, ProDisc-L maintained ROM and was associated with a significantly lower rate of ΔALDs than in the patients treated with circumferential fusion. In fact, the fusion patients were greater than 3 times more likely to experience ΔALDs than were the TDR patients."	Data suggest at 5 years, ProDisc-L had significantly fewer adjacent-level degeneration changes versus fusion (3 times fewer).
Gornet 2011 (score= 5.5)	Fusion	RCT	No industry sponsorship or COIs.	N = 577 with discogenic degenerative disease; discogenic	Mean age: 40 years; 291 males, 286 females.	Investigational treatment (n = 405) received lumbar disc arthroplasty vs. Control treatment (n = 172)	Follow-up at 2-year.	At 12 and 24 months after surgery, Investigational group showed ODI scores of 33.9 and 33.8 (respectively) vs. Control	"The investigational group consistently demonstrated statistical superiority versus fusion on key clinical outcomes including improved physical function, reduced pain, and	Data suggest greater RTW, Oswestry success rates and global effects with disc arthroplasty.

				back pain with/without leg pain documented in plain films, CT and MRI (with Modic changes, or high-intensity zones in the annulus or loss of disc height or decreased hydration of disc) and single-level symptomatic involvement L4-S1 requiring surgery, pre-op Oswestry ≥30, and back pain of ≥20.		received anterior interbody fusion with rhBMP-2 on an absorbable collagen sponge and tapered fusion cages.		group with scores of 29.0 and 29.4 ($p<0.001$ and $p=0.004$, respectively). Investigational group mean improvement was 53.4 for back pain (at 24 months), and 28.4 for leg pain (at 12 months) vs. Control group with scores of 49.0 for back pain, and 23.1 for leg pain ($p=0.022$ and $p=0.011$ respectively).	earlier return to work."	
Sköld 2013 (score= 5.0)	Fusion	RCT	No COIs or industry sponsorship.	N = 152 with chronic LBP not responding to nonsurgical treatment	Mean age: 39.4±8.0 years; 62 males, 90 females.	Total disc replacement (TDR) (n = 80) vs. Lumbar fusion (n = 72).	Follow-up at 1, 2 and 5 years.	Both groups clinical improvement at 5-year follow-up. 1-year results: Pain free 29% (23/80) in TDR group vs. 10% (7/71) in fusion group, p = 0.003; VAS back pain: 25.5 ± 26.5 (TDR vs. 33.4 ± 26.8 (fusion), p = 0.030; difference pre-post-op:	"Global assessment of low back pain differed between the two surgical groups at all follow-up occasions. Significant differences between groups concerning back pain, pain improvement, and ODI were present a 1 yea and disappeared at 2 years, but reappeared at the 5 year follow-up."	2nd report Berg 2009. Data suggest better pain and ODI with disc replacement at 5 years.

								36.8±30.0 (TDR) vs. 25.1 ± 34.2 (fusion), p = 0.027; VAS leg pain: 13.2±21.9 (TDR) vs. 20.6 ± 25.1 (fusion), p = 0.007; EQ5D: 0.71 ± 0.28 (TDR) vs. 0.63 ± 0.27 (fusion), p = 0.046; ODI: 19.5 ± 187 (TDR) vs. 24.9 ± 16.1 (fusion), p = 0.023; difference pre-postop: 22.4 ± 17.8 (TDR vs. 16.3 ± 18.4 (fusion), p = 0.036. 2-year results: Pain free: 30% (24/80) in TDR group vs. 15% (11/71) in fusion group, p = 0.031; VAS leg pain: 16.4 ± 24.5 (TDR) vs. 20.7 ± 24.3 (fusion), p = 0.037. 5-year results: Pain free: 38% (30/80) in TDR group vs. 15% (11/71) in fusion group (p < 0.002); much better: 35% (28/80) in TDR group vs. 52% (37/71) in fusion group, p = 0.034; VAS back pain 22.7 ± 29.2 (TDR) vs. 30.5 ± 26.9 (fusion), p = 0.009; difference pre-post-op: 39.6 ± 31.8 (TDR) vs. 27.5 ± 32.3 (fusion), p = 0.037; EQ5D 0.76 ± 0.30 (TDR) vs. 0.68 ± 0.30 (fusion), p = 0.026; ODI: 17.3 ± 19.0 (TDR vs. 22.5 ±		

								17.1 (fusion), p = 0.015; difference pre-postop: 24.6 ± 18.1 (TDR) vs. 18.3 ± 18.6 (fusion), p = 0.019.		
Sköld 2013 (score =NA)	Discectomy	Post hoc 5 year analysis of Sköld 2013	No COI or sponsorship.	N = 152 with chronic low back pain and have not responded to nonsurgical treatment	Mean age: 39.4 years; 62 males, 90 females	TDR (n = 80) vs. Fusion (n = 72). Reference Sköld 2013 for treatment descriptions	Follow up at 1,2, and 5 years	Both groups showed clinical improvement at 5-year follow-up. 1-year results: Pain free : 29% (23/80) in the TDR group vs. 10% (7/71) in fusion group (p = 0.003); VAS back pain: 25.5 ± 26.5 (TDR vs. 33.4 ± 26.8 (fusion) (p = 0.030); difference pre-postop: 36.8 ± 30.0 (TDR) vs. 25.1 ± 34.2 (fusion) (p = 0.027); VAS leg pain: 13.2 ± 21.9 (TDR) vs. 20.6 ± 25.1 (fusion) (p = 0.007); EQ5D: 0.71 ± 0.28 (TDR) vs. 0.63 ± 0.27 (fusion) (p = 0.046); ODI: 19.5 ± 187 (TDR) vs. 24.9 ± 16.1 (fusion) (p = 0.023); difference pre-postop: 22.4 ± 17.8 (TDR vs. 16.3 ± 18.4 (fusion) (p = 0.036). 2-year results: Pain free: 30% (24/80) in TDR group vs. 15% (11/71) in fusion group (p = 0.031); VAS leg pain: 16.4 ±	"Global assessment of low back pain differed between the two surgical groups at all follow-up occasions. Significant differences between groups concerning back pain, pain improvement, and ODI were present at 1 year and disappeared at 2 years, but reappeared at the 5-year follow-up."	Data suggest at 5 years twice as many patients in total disc replacement group were pain free compared to fusion group.

								24.5 (TDR) vs. 20.7 ± 24.3 (fusion) (p = 0.037). 5-year results: Pain free: 38% (30/80) in TDR group vs. 15% (11/71) in fusion group (p < 0.002); much better: 35% (28/80) in TDR group vs. 52% (37/71) in fusion group, (p = 0.034); VAS back pain 22.7 ± 29.2 (TDR) vs. 30.5 ± 26.9 (fusion) (p = 0.009); difference pre-postop: 39.6 ± 31.8 (TDR) vs. 27.5 ± 32.3 (fusion) (p = 0.037); EQ5D 0.76 ± 0.30 (TDR) vs. 0.68 ± 0.30 (fusion) (p = 0.026); ODI: 17.3 ± 19.0 (TDR vs. 22.5 ± 17.1 (fusion) (p = 0.015); difference pre-postop: 24.6 ± 18.1 (TDR) vs. 18.3 ± 18.6 (fusion) (p = 0.019)		
Allograft vs. Cage										
McKenna 2005 (score= 5.5)	Fusion	RCT	No mention of COIs or industry sponsorship.	N = 83 degenerative disc disease (L3-S1) with ≤2 consecutives motion segments to instrumented, pain or	Mean age: 40.3 years; 35 males, 43 females.	N = 45 received Titanium cages (TC) vs. n = 38 received femoral ring allograft (FRA).	Follow-up at 2-year.	Mean±SD improvement postoperatively in ODI comparing FRA vs. TC: 15±20 vs. 6±15 (p = 0.027). VAS score for back pain (SD) improvement comparing FRA vs. TC: 2.0 (2.8) vs. 1.1 (2.2), p = 0.188. VAS	"[W]e have found the clinical results of FRA to be superior to TCs when used as a interbody spacers in circumferential fusion of the lumbar spine 2 years after surgery."	Some trends in outcome measures at baseline. Data suggest FRA superior.

				functional deficit (preoperatively) for ≥6 months and failure to respond conservative modality for ≥3 months, with radiographic evidence of sclerosis, osteophyte formation, degenerative changes of facet joints or >50% collapse of interspace and ≥3.5mm movement on flexion/extension.				score (SD) for leg pain improvement comparing FRA vs. TC: 1.1 (2.5) vs. 0.4 (3.1), p = 0.029		
Engineered Tissue Material vs. Traditional Iliac Autograft										
Putzier 2008 (score= 4.0)	Fusion	RCT	No mention of COIs or industry sponsorship.	N = 24 history of persistent lumbosacral and/or pseudoradicular symptoms in whom conservative treatment of ≥6 months failed. Presenc	Mean age: 47.8 years; 10 males, 11 females.	Both groups underwent single-level circumferential lumbar fusion with cages. In Group 1 (n = 11) cage filling was autologous iliac crest cancellous bone vs. In Group 2 (n = 13) cage filling was autologous periosteal cells in	Follow-up at 3, 6, 9, and 12 months.	Improvement at 3, 6, 9 and 12 months in group one p = 0.007, p = 0.008, and p = 0.022 respectively vs. Group 2: p = 0.037, p = 0.023, p = 0.018, p = 0.016 respectively. After 12 months, average VAS score in Group 1 33.7mm vs. Group 2 with 32.2mm.	"The use of autologous periosteal cells on carrier material with osteoinductive and osteoconductive properties showed comparable results with autologous cancellous bone and better results with regard to consolidation at 6–9 months postoperatively."	Sparse details. Data suggest faster fusion with periosteal cells.

				e of Modic Grade 2 or higher osteochondropathy, resulting from idiopathic intervertebral disc degeneration, or spondylolisthesis up to Meyerding Grade 1 verified by MRI.		fibrin/polyglactin-poly-p-dioxanone fleece.				
Comparison of Autograft Surgical Techniques										
Høy 2013 (score= 7.0)	Fusion	RCT	No COI's. No mention of industry sponsorship.	N = 100 with severe chronic LBP and/or leg pain	Mean age: 47 years; 40 males, 58 females.	Transforaminal lumbar interbody fusion (TLIF) (n = 51) vs. Instrumental posterolateral fusion (PLF) (n = 49).	Follow-up at 2 years.	No statistically significant differences between groups.	"Transforaminal interbody fusion did not improve functional outcome in patients compared to posterolateral fusion. Both groups improved significantly in all categories compared to preoperatively. Operation time and blood loss were significantly higher in the TLIF group."	Data suggest comparable outcomes at 2 years.
Sys 2011 (score= 5.5)	Fusion	RCT	No COIs. No mention of industry sponsorship.	N = 40 single level disc degeneration no response to conservative treatment, and sciatica despite epidural steroid injections, and ilytic and degenerative spondyl	No mention of participants' age. 24 males, 14 females.	Study group (n = 20) received autograft plus platelet-rich plasma (PRP) vs. Control group (n = 20) receiving autograft.	Follow-up at 2 years.	Improvement on the VAS score after 2 years comparing Study group vs. Control group: 4.92 vs. 4.0 (p = 0.166). Improvement for ODI after 2 years for study group 30.0 vs 32.1 in Control group (p = 0.201). No difference between groups on interbody healing at 3, 6, and 12 months (p = 0.741, p = 0.663, p =	"Using PRP provided no substantial improvement or deterioration in clinical and radiographical outcomes in posterior lumbar interbody fusion."	Data suggests lack of efficacy.

				olisthesis as indication of surgery				0.951), respectively.		
Farrokhi 2012 (score= 5.5)	Fusion	RCT	Industry sponsored (Vince-Chancellor for Research Affairs of Shiraz University of Medical Sciences and Apadana Tajhizgostar Co.). No mention of COI's.	N = 80 age 18-65 September 2008 to March 2010 and 1-year follow-up from March 2010 to March 2011. Participants randomly assigned to two groups by opening sealed envelopes.	Mean age: 50 years; 18 males, 62 females.	N = 40 (operated on with posterolateral fusion (PLF) with posterior instrumentation, group 1) vs. n = 40 (operated with posterior lumbar interbody fusion (PLIF) with posterior instrumentation, group 2). Pre-op radiological evaluation included static and functional lumbar spine plain x-rays, 4 views: anteroposterior (AP), lateral, right, and left obliques, Complete discectomy and total disc resection performed with preservation of both endplates only in group 2. All 10 completed questionnaire regarding pain and LBP-related disability.	Follow-up at 1 year.	Pre-op MRI scans showed no statistically significant difference for presence of intervertebral foraminal stenosis, improvement in radicular pain (p = 0.242), and LBP (p = 0.416) in two groups. Over 3-day hospitalization period, group 2 received more narcotic doses than group 1 and this was statistically significant. Other clinical parameter measured 1 year after surgery. Percentage of participants who had complaints of neurogenic claudication 1 year after operation significantly higher in group 2 than group 1 (33.3% vs. 7.3%; p = 0.004)	"Our data showed that PLF with posterior instrumentation provides better clinical outcomes and more improvement in low back pain compared to PLIF with posterior instrumentation despite the low fusion rate."	Data suggests better fusion and less pain in posterolateral fusion with instrumentation.
Rodriguez-Vela 2009 (score= 4.5)	Fusion	RCT	No COIs. No mention of industry	N = 30 with degenerative discopathy (with	Mean age: 38.1 years; 20 males, 10 females.	Classic Approach (CL) group (n = 15) underwent a 360°circumferential	Follow-up at 3 months.	Mean±SD improvement in ODI comparing CL group vs. MO group: 31.5±14.2 vs. 16.0±12.1 (p =	"[A]lthough we cannot predict comparable clinical results in both groups in the long term, we have confirmed that the hospitalary	Small groups. Quasi-randomized. Less EBL, shorter hospital stays and less post-operative

			sponsorship.	acute neurological deficit or pain exacerbation) with/without disc herniation (no lumbar spine surgery), after ≥6 months back lumbar pain (with unsuccessful conservative treatments)		arthrodesis with the classic posterior approach vs. Mini-open (MO) group (n = 15) underwent same arthrodesis as CL group, but using mini-open approach.		0.005). Difference on estimated blood loss of CL group vs. MO group: 757±255 vs. 318±215 (p = 0.002).	parameters (operative bleeding, haemoglobin and haematocrit decrease and hospital stay) are significantly better in the ‘‘mini-open’’ approach patients than in the classic approach ones.”	medications with minimally invasive approach.
Comparison of Allograft Preparation Methods										
Thalgott 2009 (score= 4.0)	Fusion	RCT	No COIs or industry sponsorship.	N = 40 with IDD diagnosed via discography, DDD, or herniated nucleus pulposus at 1-2 consecutive levels between L3-S1	Mean age: 43.5 years; 19 males, 21 females.	N = 21 received frozen (FZ) femoral ring allograft vs. n = 19 Frozen dried (FD) femoral ring allograft.	Follow-up at 2-year.	Average change in ODI 17.33 (FD:15.68±20.50, FZ: 18.8±20.24, p = 0.635). Average PCS 36.77 (FD: 33.47±10.12, FZ: 39.76±11.50, p = 0.074). Radiographic fusion detected in 17 FD levels (65.38%) vs. 23 FZ levels (76.67%), p = 0.388.	“[T]he 2 methods of preservation of FRA seem to perform without significant differences when the results are considered in terms of clinical outcomes.”	IDD/DDD via discography. Mostly comparable clinical results. 2 year follow up.
Minimally Invasive vs. Open Fusion Techniques										
Wang 2011 (score= 5.5)	Fusion	RCT	No COIs or industry sponsorship.	N = 79 with single-level degenerative lumbar spine disease	Mean age: 54.2 years; 47 males, 32 females.	Minimally invasive surgery (MIS) group (n = 41) underwent modified transforaminal lumbar interbody fusion (TLIF) via MAST Quadrant	Follow-up at 3, 6, 12, and 24 months.	Mean±SD average operation time comparing MIS group vs. Open surgery group: 168.7±36.4 vs. 145.0±26.8 (p = 0.190). ODI score at 3 and 6 months better in MIS group vs. Surgery group (p <0.01).	“[T]his study found that minimally invasive TLIF can effectively reduce sacrospinalis muscle injury compared with open surgery, which is conducive to early functional recovery.”	Data suggest faster short term recovery (esp. 3-6mo) but no long-term advantages.

						retractor vs. Open surgery group (n = 38) underwent improved open TLIF.				
Fusion with vs. without Cage										
Videbaek 2010 (score= 5.5)	Fusion	RCT	Industry sponsored (Danish Rheumatism Association). No COIs.	N = 148 with severe chronic LBP with leg pain from lumbar or lumbosacral segmental instability caused by spondylolisthesis (grades 1 or 2) or disc degeneration.	Mean age: 56.5 years; 34 males, 61 females.	Fusion with anterior support (n = 48) vs. Fusion with no anterior support (n = 47).	Follow-up At 12-month.	At 12-month follow-up there were (n = 48) in anterior support and (n = 44) in the no anterior support (n = 92/148 total). ODI scores were not statistically significant between groups (p = 0.18), SF-36 physical scores (p = 0.92) and SF-36 mental (p = 0.08) not significant. Anxiety/depression scores and social interest were significantly greater in the anterior support group (p<0.01 and p <0.05) compared to no anterior support.	"[T]here was no difference in the sagittal spinal balance parameters investigated in patients in whom anterior lumbar interbody fusion with posterolateral fusion was carried out compared with patients in whom a posterolateral fusion alone was done. Overall, lumbar lordosis and the type of lordosis correlated with outcome but do not play a significant role in explaining the superior outcome in the group with anterior column support."	Follow up report Videbaek 2006.
Madan 2003 (score= 5.5)	Fusion	RCT	No COIs or industry sponsorship.	N = 45 with single level disc degeneration	Mean age: 44.5 years; 29 males, 26 females.	Graf ligamentoplasty (n = 28) vs. Anterior lumbar interbody fusion (ALIF) with Hartshill horseshoe cage (n = 27)	Follow-up at 2 years.	Graf group better than ALIF group, p = 0.0477 for outcomes.	"Retaining mobility in the lumbar segments gives better results after stabilisation with Graf ligaments than rigid fixation and fusion with the Hartshill horseshoe cage in the short term."	Lack of details on baseline characteristics and co-interventions. Data suggest Graf ligamentoplasty has superior outcomes compared to Hartshill horseshoe cage.
Sasso 2004 (score= 4.0)	Fusion	RCT	No COIs or industry sponsorship.	N = 140 with many different indications/diagnoses related to LBP	Mean age: 41.1 years; 63 males, 76 females.	INTER FIX device filled with autogenous bone derived from iliac crest (n = 78) vs. Controls (n = 62) treated with femoral ring allograft	Follow-up at 3, 6, 12, 24 months.	INTER FIX device fusion rates superior to controls at 6, 12, and 24 months, p <0.001. No differences for Oswestry Scores. Rates of implant breakage, implant	"Intraoperative complications were higher in the cylindrical threaded cage group compared with the trapezoidal femoral ring control cohort but did not reach statistical significance."	No blinding. Included workers' comp patients. Adverse events trended differently depending on the device. Data suggest threaded interbody

						also filled with iliac crest-derived autogenous bone. All underwent anterior surgical approach for single-level interbody fusion.		loosening/displacement, back pain, and other pain for controls higher vs. INTER FIX, p <0.05. INTER FIX had fewer supplemental fixations vs. controls, p = 0.003.		fusion cages have higher fusion rate, but not clinical outcomes.
Local Bone Fusion vs. Iliac Crest Graft Fusion										
Ohtori 2011 (score= 5.5)	Fusion	RCT	No mention of COIs or industry sponsorship.	N = 82 with chronic LBP and leg pain. Diagnosis with lumbar degeneration at level L4 with spinal stenosis between L4 and L5 levels.	Mean age: 66.5 years; 40 males, 42 females.	Fusion with local bone graft (n = 42) vs. Fusion with iliac crest bone graft (ICBG; n = 40) for L4-L5 decompression laminotomy with posterolateral fusion surgery. Local bone graft from spinal processes of L4-L5.	Follow up at 24 months.	Postoperatively, VAS pain scores, Japanese orthopedic association score (JOAS), and ODI scores in LBP not significantly different between groups. Similarly, VAS and JOAS scores for leg pain not statistically significant between groups. ICBG group had significantly more complications from surgery in sensory loss (p = 0.01) and pain (p = 0.025) around iliac crest.	"…Rate and average duration of bone union were not significantly different in the local bone and ICBG groups. However, prolonged surgical time and complications such as donor site pain were observed in the ICBG group."	Lack of randomization, allocation details. Data suggest no clinical benefit, Higher risk of complications of ICBG vs. local bone graft.
Comparison of Postoperative External Corset vs. No Corset										
Yee 2008 (score= 5.5)	Fusion	RCT	Industry sponsored (Medtronic Sofamor Danek). Industry COI (Medtronic Sofamor Danek)	N = 90 with degenerative disc disease and/or neurologic symptoms related to spinal stenosis, spondylolisthesis and/or degener	Mean age: 52.5 years; 35 males, 37 females.	Experimental group (n=37) treated with Non-brace Therapy vs. Control group (n=35) treated with Brace (corset) Therapy.	Follow-up at 2 years.	Surgical complications comparing Experimental group vs. Control group: 22% vs. 27 (p = 0.8). No difference on postoperative SF-36 domain and component scores between group: p = 0.38 for physical functioning domain; p = 0.28 for bodily pain; p = 0.23 for general health.	"[T]his study did not demonstrate a significant advantage or disadvantage to the use of a postoperative lumbar canvas corset with two molded posterior metallic supports by patients treated with posterior lumbar spinal arthrodesis with instrumentation for degenerative conditions."	Data suggest equal (in)efficacy.

				ative scoliosis with failed nonoperative therapy for 2 years				Subsequent spinal operations in 19% vs. 14%.		
Low Quality										
Sembrano 2016 (Score=3.5)										Baseline differences between groups for DM and back pain via VAS scores small sample. Data support comparable efficacy between groups both in short term and at 2 years.
Ghogawala 2016 (Score=3.5)										High dropout rate at 4 years follow-up. Data suggest laminectomy plus fusion group had a trend towards improved quality of life fusion group had fewer reoperation.
France 1999 (score=3.5)										Military personnel. Lack of baseline characteristics. Co-interventions unclear. Data suggest no benefit from additional instrumentation.
Amundsen 2000 (score=3.5)										Randomization not completely random for all participants. Lack of baseline characteristics. Conservative management hospitalized 1 month. Data suggest surgical treatment

										superior, but some responses to non-operative treatment.
Zdeblick 1993 (score= 3.5)										Many details sparse. Study primarily reports anatomic fusion rate rather than clinical outcomes.
McGuire 1993 (score= 3.5)										Small numbers. No statistical comparisons on baseline characteristics. Lack of reporting on co-interventions. Data suggest no clinical differences.
Cheng 2009 (score= 3.5)										Methodological methods sparse.
Jiya 2011 (score= 3.5)										Small sample size. Some baseline differences. Data suggest PEEK superior.
Ohtori 2011 (score= 3.5)										>2 year LBP. Excluded WC and MVA's.
Müslüman 2011 (score= 3.5)										Lack of randomization, allocation, control of cointervention details. Loss to follow-up. No blinding.
Geisler 2004 (score= 3.5)										Lack of randomization allocation, co-interventions details. No blinding. Device trial for FDA exemption. Suggests no difference between interventions. Populations limited to single level DDD. No control-group

										limits conclusion of efficacy for CLBP.
Korovessis 2004 (score=3.5)										Lack of study details for randomization, allocation, baseline comparability, assessor blinding. Data suggest no advantages of one device over the others.
Boden 2002 (score=3.5)										Small sample size, failed randomization.
Gibson 2002 (score=3.0)										Lack of details for randomization, allocation, blinding, follow-up. Data suggest similar clinical outcomes 1 and 6 years. At 6 years, high percentage had same or poor outcome.
Ekman 2005 (score=3.0)										Follow-up report of Moller 2000. 9-year follow-up study. Data suggest no significant differences in surgical fusion groups compared with non surgical group except in global assessment.
Bridwell 1993 (score=3.0)										Randomization not completely random. Methods sparse. Patients not well described. Co-interventions unclear. Data suggest fusion with autologous bone and instrumentation has better fusion rate but

										lack of details makes conclusions difficult.
Burkus 2003 (score= 3.0)										Details sparse.
Boden 2000 (score= 3.0)										Small sample size, failed randomization.
Glassman 2005 (score= 3.0)										Details sparse, preliminary report of partial study participants
Inamdar 2006 (score= 3.0)										Small groups. Sparse details.
Niu 2009 (score= 3.0)										Title indicates randomization but actually not randomized.
Ohtori 2009 (score= 3.0)										Many method details lacking. No control group. Study assumes non-specific LBP discogenic. Data suggest modestly better outcomes in Discoblock group. Small sample size.
Tezeren 2009 (score= 2.5)										Pseudo randomization, lack of details for baseline characteristics, timing of assessments, completion rates. Suggests no clinical differences in outcomes at 36 months.
Wilson-MacDonald 2008 (score= 2.5)										Follow-up report of Fairbank 2005. Reported data from surgical arm. Data suggest similar clinical outcomes of 3 suggesting

										compliance is favorable.
Dimar 2006 (score= 2.5)										Details sparse.
Burkus 2009 (score= 2.5)										6 year follow up of pooled data from two prior RCTs evaluating surgical approach.
Jenis 2000 (score= 1.5)										Lack of details lowered score. No baseline characteristics; co-interventions not reported. Data suggest no benefit from DC or PEMF on bone healing after posterior spinal surgery.
Frohold t 2011 (score= 1.5)										8-year follow-up to Brox 2003/2006. Data suggest no long-term differences in extension/flexi on strength. Most dropped out (55.6%), thus validity of comparative data in significant doubt. Data suggest no meaningful differences.
Burkus 2005 (score= 0.0)										Near duplicate report of 2006 article.
Burkus 2004 (score= 0.0)										Abstract only.
Bae 2007 (score= 0.0)										Abstract only.
Burkus 2004 (score= 0.0)										Abstract only.

DISC REPLACEMENT

Artificial disc replacement was devised as an alternative to fusion for the patient with chronic non-specific LBP thought to be disc-related(1967, 2097-2100) as well as for focal lumbar stenosis.(2101) Its theoretical advantage is that it preserves motion in the involved vertebral segment thus purportedly decreasing the chances of degenerative changes developing at the adjacent motion segments. The term "adjacent segment disease" is used to describe patients with degenerative changes (that are presumed to be painful) at the spinal level above or below a spinal motion segment that has been treated, for example, by spinal fusion.(2102)

1. *Recommendation: Disc Replacement for Subacute or Chronic Lumbar Radiculopathy or Myelopathy*

There is no recommendation for artificial disc replacement as a treatment for subacute or chronic radiculopathy or myelopathy.

Strength of Evidence – **No Recommendation, Evidence (I)**
Level of Confidence – Low

Recommendation: Disc Replacement for Treatment of Chronic Non-specific Low Back Pain or Other Spinal Pain Syndrome

Artificial disc replacement is not recommended as a treatment for chronic non-specific low back pain or any other spinal pain syndrome.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There is one moderate-quality trial comparing disc replacement with only ~2 weeks of a rehabilitation program, showing some evidence of superiority over 2 years based on Oswestry Disability Index scores, however, the study reported actually worse adjacent segment disease and facet degeneration in the surgical arm(2103-2105, 2427) and no significant advantage in range of motion.(2106) The rehabilitation was so short that it may likely be susceptible to both undertreatment and attention biases. A few comparative RCTs suggest potential superiority of disc replacement to fusion over short to intermediate terms.(2015, 2054, 2056, 2057, 2069, 2107, 2108) Results from trials are not generalizable to those with multi-level degenerative disc disease. One trial has now been reported to 5 years of follow up, suggesting superiority over fusion(2069), but no longer-term quality studies have been reported.

Available RCTs compare disc replacement to fusion (2015, 2069, 2107, 2109, 2428, 2429) and as noted in the fusion section of this Guideline, fusion has not been shown to improve the outcomes over modern non-operative care. The follow-up in the published RCTs is now up to 5 years. Some may consider this too short to be considered standard treatment. There is evidence that higher volume surgical centers have shorter hospital stays and lower complication rates.(2110) Complication rates are not inconsiderable and surgical candidates should be fully apprised of these reported complications which include 2.8 adverse events per patient, 5% device failures, 5% neurological deteriorations at 24 months compared with baseline, and 33.3% failure to have at least a 25% decrease in the ODI at 24 months compared with baseline. Additional research including demonstrated long-term safety and efficacy would be needed prior to a recommendation in support.

Evidence for the Use of Disc Replacement

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without using any limitation on publication dates and then an updated search was done in PubMed for publication between 1/1/2013 and 11/15/2017. We used the following search terms: disc replacement, back, spinal fractures, randomized clinical trial or randomized controlled trial or random, systematic review or reviews, population study or epidemiological study or prospective cohort to find 3666 articles. Of the 3666 articles we reviewed 64 articles and included 31 articles (16 randomized controlled trials and 15 systematic reviews).

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow -up:	Results:	Conclusion:	Comments:
Disc replacement – Rehabilitation										
Hellum 2011 (score=7.5)	Disc Replacement	Prospective RCT	Industry sponsored by South Eastern Norway Regional Health Authority and EXTRA funds from Norwegian Foundation for Health and Rehabilitation, through Norwegian Back Pain Association. No COIs.	N = 173 with history of LBP for at least 1 year.	Mean age: 41.0 years; 81 males, 91 females	Surgery with disc prosthesis (n = 86) vs. outpatient multi-disciplinary rehab 12-15 days consisting of cognitive approach and supervised physical exercise (n = 87). Last follow-up 2 years after surgery.	3 weeks, 3 months, 6 months, 1 year	Differences between groups in mean change ODI with changes surgery 20.8 (95% CI 16.4 to 25.2) vs. rehab 12.4 (9.5 to 16.3), p< 0.001 at 1-year and p = 0.001 at 2 years. Mean difference between groups at 2 years -8.4 (-13.2 to -3.6) in ITT. Higher percentage of surgical patients had improved ODI of ≥15 points 70% vs. 47% (P < 0.006) (ITT).	"Surgical intervention with disc prosthesis for chronic low back pain resulted in a significantly greater improvement in the Oswestry score compared with rehabilitation, but this improvement did not clearly exceed the pre-specified minimally important clinical difference between groups of 10 points, and the data are consistent with a wide range of differences between the groups, including values well below 10 points."	Rehab arm is short (12-15 days), which raises questions of undertreatment in that arm. ODI favored surgery. Most results not different. 2 year follow up. 34% complications over 2 years.
Hellum 2012a (score=6.5)	Disc replacement	RCT	Industry sponsored (South Eastern Norway Regional Health Authority and EXTRA funds from Norwegian	N = 154 with chronic back pain at least 1 year and degenerative discs.	Mean age: 41.2 years; 73 males, 81 females	Surgery with disc prosthesis (n = 88) vs. rehab program (n = 66). Five did a cross-over from rehab to surgery. Last follow-up at 2 years.	2 years	For surgery: Long duration of back pain and high FABQ-W predicted having an ODI change <15 points in final model (OR = 1.0, confidence interval (CI) 1.2-	"Patients with low FABQW or Modic changes type I or II should be considered for surgery if rehabilitation fails. However, our findings need	Analyses of Hellum 2011. Data suggest disc replacement did not reduce adjacent segment disease. Study did not include significant health

			Foundation for Health and Rehabilitation, through Norwegian Back Pain Association). No COIs.					3.2 and OR = 1.7, CI 1.2-2.4). For rehabilitation: not using narcotics daily (OR = 23.6 CI 2.1-266.8), high ODI at baseline (OR = 2.5, CI 1.4-2.5 for every 5-point reduction) For merged cohorts: Working at baseline predicted working at follow-up (OR = 4.1, CI 1.2-13.2) and high FABQ-W was predictive for not working a 2 years (OR = 1.3, CI 1.0-1.5). For patients with high levels of ODI at baseline, there were no significant differences in outcome between treatment groups.	to be confirmed in future studies."	outcomes/functional status
Hellum 2012b (score=6.5)	Disc Replacement	RCT	Industry sponsored (South Eastern and Western Norway Regional Health Authorities, from Haakon and Sigrun Ødegaard`s Fund at Norwegian Society of Radiology, and Norwegian ExtraFoundatio	N = 116 with LBP history for 1+ year, ODI 30+ points and degenerative changes in 1 or 2 lower lumbar spine levels.	Mean age: 41.7 years; 54 males, 62 females	Surgery with disc prosthesis (n = 59) vs. rehab (n = 57). Last follow-up at 2 years.	2 years	Mean ODI decrease from baseline to 2yrs. surgery 23.1 (95% CI, 18.8-32.7) vs. rehab 15.8 (95% CI, 11.7-19.9); mean decrease in LBP (VAS) 33.3 (95% CI, 25.2-41.2) vs. 24.7 (95% CI, 16.8-32.7). At adjacent level L3-L4, mean disc height decreased 0.1 mm vs.	"The potential advantage of low risk of accelerated ALD with a disc prosthesis must be weighed against the increased risk of index level FA, particularly in L5–S1."	Second analysis. Data suggest no prevention of adjacent segment disease.

			n for Health and Rehabilitation, through Norwegian Back Pain Association). No COIs.					increased by 0.2 mm in rehab group (p = 0.01). No other adjacent level degeneration (ALD) measures significant between groups. Index level facet arthropathy (FA) appeared at a higher rate post-op vs. those rehabilitated (4%, p <0.001).		
Johnsen 2013 (score=4.0)	Disc replacement	RCT	Sponsored by the South East Norway Regional Health Authority and EXTRA funds from the Norwegian Foundation for Health and Rehabilitation via the Norwegian Back Pain Association. No COI.	N = 120 with degenerative disc disease (DDD) and low back pain for more than a year	Mean age: 41.6 years; 55 males, 65 females	Originally 173 participants were randomized but only 120 were included in the analysis due to either drop out or incomplete radiographs. Total disc replacement (TDR) group, ProDisc II prosthesis inserted at L4/5, L5/S1, or both (n = 74) vs. Multidisciplinary Rehabilitation (MDR), consisting of cognitive intervention – lecture about understanding original activity would not harm the disc with recommendation to use and bend the back,	Follow up at 2 years	No significant mean difference between groups in Oswestry Disability Index (ODI) (mean difference = 1, 95% CI (-2.5 to 4), p = 0.654), in Physical Function-10 (PF-10) scores (mean difference = 6, 95% CI (-13 to 2), p = 0.172) or EuroQul-5D (EQ-5D) scores (mean difference = 0.047, 95% CI (-0.158 to 0.065), p = 0.407). At 2 year follow up, significant mean difference between groups for ODI scores (6.8, 95% CI (0.85 to 12.74), p = 0.025), PF-10 scores (-13, 95% CI (-23 to -4), p = 0.005), and pain (13, 95% CI (2 to 24), p = 0.022), all	"In this study, insertion of an intervertebral disc prosthesis TDR did not increase movement in the sagittal plane and segmental movement did not correlate with patient reported outcomes. This suggests that in the lumbar spine the movement preserving properties of TDR are not major determinants of clinical outcomes."	Another report of Hellum 2011, 12. Baseline differences in low pain scores (higher in rehabilitation group). Data suggest slight trend in favor of total disc replacement over multidisciplinary rehabilitation.

						also included physical exercise sessions, three daily sessions for three weeks (n = 46)		in favor of TDR. No significant difference in EQ-5D (-0.088, 95% CI (-0.088 to 0.061), p = 0.155)		
Total Disc Replacement vs. Fusion										
Blumentha l 2005 (score=6.5)	Disc Replacement	RCT	McAfee 2005, 2003, 2006 Herkowitz 2006 Mirza 2005 Wong 2007 Chin 2007 No COIs or industry sponsorship.	N = 304 with single-level symptomati c DDD at L4-L5 or L5-L1	Mean age: 39.6 years; 157 males, 147 females	Total disc replacement with CHARITE artificial disc (investigational group, n = 205) vs. ALIF with BAK threaded fusion cages packed with iliac crest autograft (control, n = 99) with assessments at 6 weeks and at 3, 6, 12, and 24 months.	3, 6 weeks, 3, 6, 12, 24 months	Mean ODI Scores: baseline (disc 50.6 vs. fusion 52.1), 6 weeks (37.7 vs. 43.7, p = 0.0198), 3 months (29.9 vs. 37.4, p = 0.0014), 6 months (27.5 vs. 35.8, p = 0.0017), 12 months (26 vs. 31.8, p = 0.0393), 24 months (NS). Mean VAS scores: baseline (72 vs. 71.8), 6 weeks (36.4 vs. 44.1, p = 0.0222), 3 months (35.7 vs. 44.5, p = 0.0177), 6 months (33.1 vs. 43.9, p = 0.0044), 12 months (32.9 vs. 40.4, p = 0.0418), 24 months (NS). Overall success (117±57.1 vs. 46±46.5), p <0.0001.	"[Q]uantitative clinical outcome measures following lumbar total disc replacement with the CHARITÉ™ artificial disc are at least equivalent to clinical outcomes with anterior lumbar interbody fusion. These results support earlier reports in the literature that total disc replacement with the CHARITÉ™ artificial disc is a safe and effective alternative to fusion for the surgical treatment of symptomatic disc degeneration in properly indicated patients."	Baseline differences, especially in BMI and activity, favor disk replacement. No non-intervention control group. Data difficult to draw conclusions on because of study limitations, however data suggest disc replacement superior to fusion.
Guyer 2009 (score=6.5)	Disc replacement	RCT	See also Blumenthal 2005	N = 133 enrolled in CHARITÈ IDE trial	Mean age: 71 males, 62 females	Investigational group (n = 90) implanted with CHARITÈ Artificial Disk vs. Control	6 weeks, 3, 6 months , 1, 2, 5 years	Mean estimated blood loss (ml) comparing CHARITÈ group vs. BAK group: 212.1 vs. 204.3 (p	"Results of this five-year, prospective, randomized multicenter study are consistent	Followup of Blumenthal 2005. Data suggest comparable results.

			No COIs or industry sponsorship.			group (n = 43) treated by anterior lumbar interbody fusion (ALIF) with BAK threaded fusion cages packed with iliac crest autograft.		= 0.8644). 15 point improvement in ODI comparing the CHARITÈ group vs. the BAK group: 68% vs. 65% (p = 0.8443). Mean preoperative L4-L5 range of motion comparing CHARITÈ vs. BAK: 8.7° vs. 9.2° (p = 0.8162). Mean preoperative L5-S1 range of motion comparing CHARITÈ vs. BAK: 7.6° vs. 8.2° (p = 0.6793).	with the two-year reports of noninferiority of CHARITÈ artificial disc vs. ALIF with BAK and iliac crest autograft."	
Zigler 2007, 2003 (score=5.5)	Disc replacement	RCT	Delamarter 2003 No COIs or industry sponsorship	N = 286 with single-level degenerative disc disease	Mean age: 39.2 years; 116 males, 120 females	Investigational or ProDisc-L total disc replacement group (n = 161) vs. Circumferential fusion or control group receiving anterior lumbar interbody fusion (n = 75). Follow-up at 2 years.	6 weeks, 3, 6, 12, 18, and 24 months	At 6 weeks, 3 and 6 months, disc group greater improvement vs. fusion, p <0.05. Also trended toward significance at 2 years p = 0.0551. ODI success >15% improvement: Week 6 (fusion 49.3% vs. ProDisc-L 72.1%, p = 0.0007), Month 3 (60.6% vs. 80.5%, p = 0.0016), Month 6 (69.6% vs. 81.8%, p = 0.0346), Month 12 (NS), Month 18 (65.4% vs. 81.4%, p = 0.0189), Month	"In properly chosen patients, ProDisc®-L has been shown to be superior to circumferential fusion by multiple clinical criteria."	Included somewhat diverse patients with varying disorders. Data suggest disc replacement superior to fusion at 2 years.

								24 (64.8% vs. 77.2%, p = 0.0390). VAS patient satisfaction at 24 months: disc group 76.7±29.2 vs. fusion 67.3±31.5, p = 0.015. At 2 years, 92.4% disc group vs. 85.1% fusion employed, p = 0.0485.		
Zigler 2007 (score=5.5)	Fusion	RCT	No COIs or industry sponsorship.	N = 286 with single-level degenerative disc disease	Mean age: 39.2 years; 116 males, 120 females.	ProDisc-L total disc replacement (investigational, n = 161) vs. Circumferential fusion receiving anterior lumbar interbody fusion (control, n = 75).	Follow-up at 2 years.	At 6 weeks, 3 and 6 months, the disc group had greater improvement vs. fusion, p <0.05. Also trended toward significance at 2 years, p = 0.0551. ODI success >15% improvement: Week 6 (fusion 49.3% vs. ProDisc-L 72.1%, p = 0.0007), Month 3 (60.6% vs. 80.5%, p = 0.0016), Month 6 (69.6% vs. 81.8%, p = 0.0346), Month 12 (NS), Month 18 (65.4% vs. 81.4%, p = 0.0189), Month 24 (64.8% vs. 77.2%, p = 0.0390). VAS patient satisfaction at 24 months: disc 76.7±29.2 vs. fusion 67.3±31.5, p = 0.015. At 2 years, 92.4% disc	"In properly chosen patients, ProDisc®-L has been shown to be superior to circumferential fusion by multiple clinical criteria."	Included somewhat diverse patients with varying disorders. Data suggest disc replacement superior to fusion at 2 years.

								group vs. 85.1% fusion employed, p = 0.0485.		
Zigler 2012 (score=NA)	Discectomy	Secondary analysis of Zigler 2007	COI, one or more of the authors have received or will receive benefits for personal or professional use. No mention of sponsorship.	N = 166 with single-level lumbar degenerative disc disease (DDD)	Mean age: 38.9 years; 80 males, 86 females	Total disc replacement (TDR), ProDisc-L (n = 161) vs. Circumferential fusion (n = 75). Refer to Zigler 2007 for treatment details. Radiographic follow-up data at 5 years available for 123 TDR patients and 43 fusion patients.	Follow up at 5 years.	9.2% of TDR group and 28.6% of fusion group had changes in adjacent-level degeneration (ALD) (p = 0.004). New findings at 5 year follow-up for patients without ALD preoperatively present in 6.7% of TDR group and 23.8% fusion group (p = 0.008). 1.9% TDR patients and 4.0% of fusion patients reported adjacent-level surgery leading to secondary surgery (p = 0.6819)	"At 5 years after the index surgery, ProDisc-L maintained ROM and was associated with a significantly lower rate of ΔALDs than in the patients treated with circumferential fusion. In fact, the fusion patients were greater than 3 times more likely to experience ΔALDs than were the TDR patients."	Data suggest at 5 years, ProDisc-L had significantly fewer adjacent-level degeneration changes versus fusion (3 times fewer).
Gornet 2011 (score=5.5)	Disc replacement	RCT	No industry sponsorship or COIs	N = 577 discogenic degenerative disease; discogenic back pain with/without leg pain documented in plain films, CT and MRI (with Modic changes, or high-intensity zones in the annulus or	Mean age: 40.0 years; 291 males, 286 females	Investigational treatment (n = 405) received lumbar disc arthroplasty vs. Control treatment (n = 172) received anterior interbody fusion with rhBMP-2 on an absorbable collagen sponge and tapered fusion cages. 2 year follow-up.	1.5, 3, 6, 12, and 24 months	At 12 and 24 months after surgery, Investigational group showed ODI scores of 33.9 and 33.8 (respectively) vs. Control group with scores of 29.0 and 29.4 (p <0.001 and p = 0.004, respectively). Investigational group mean improvement 53.4 for back pain (at	"The investigational group consistently demonstrated statistical superiority versus fusion on key clinical outcomes including improved physical function, reduced pain, and earlier return to work."	Data suggest greater RTW, Oswestry success rates and global effects with disc arthroplasty.

				loss of disc height or decreased hydration of the disc) and single-level symptomatic involvement L4-S1 requiring surgery; pre-op Oswestry ≥30, and back pain of ≥20.				24 months), and 28.4 for leg pain(at 12 months) vs. Control group with scores of 49.0 for back pain, and 23.1 for leg pain (p = 0.022 and p = 0.011).		
Sköld 2013 (score=5.0)	Disc replacement	RCT	No COIs or industry sponsorship.	N = 152 with chronic LBP and had not responded to nonsurgical treatment	Mean age: 39.4 years; 62 males, 90 females	Total disc replacement (TDR) (n = 80) vs. Lumbar fusion (n = 72). Follow-up: 1, 2 and 5 years after surgery	1, 2, 5 years	Both groups showed clinical improvement at 5-year follow-up. 1-year results: Pain free : 29% (23/80) in the TDR group vs. 10% (7/71) in fusion group, p = 0.003; VAS back pain: 25.5 ± 26.5 (TDR vs. 33.4 ± 26.8 (fusion), p = 0.030; difference pre-postop: 36.8 ± 30.0 (TDR) vs. 25.1 ± 34.2 (fusion), p = 0.027; VAS leg pain: 13.2 ± 21.9 (TDR) vs. 20.6 ± 25.1 (fusion), p = 0.007; EQ5D: 0.71 ± 0.28 (TDR) vs. 0.63 ± 0.27 (fusion), p = 0.046; ODI: 19.5 ± 187 (TDR) vs. 24.9 ± 16.1	"Global assessment of low back pain differed between the two surgical groups at all follow-up occasions. Significant differences between groups concerning back pain, pain improvement, and ODI were present a 1 yea and disappeared at 2 years, but reappeared at the 5 year follow-up."	2nd report Berg 2009. Data suggest better pain and ODI with disc replacement at 5 years.

								(fusion), p = 0.023; difference pre-postop: 22.4 ± 17.8 (TDR vs. 16.3 ± 18.4 (fusion), p = 0.036. 2-year results: Pain free: 30% (24/80) in TDR group vs. 15% (11/71) in fusion group, p = 0.031; VAS leg pain: 16.4 ± 24.5 (TDR) vs. 20.7 ± 24.3 (fusion), p = 0.037. 5-year results: Pain free: 38% (30/80) in TDR group vs. 15% (11/71) in fusion group (p < 0.002); much better: 35% (28/80) in TDR group vs. 52% (37/71) in fusion group, p = 0.034; VAS back pain 22.7 ± 29.2 (TDR) vs. 30.5 ± 26.9 (fusion), p = 0.009; difference pre-postop: 39.6 ± 31.8 (TDR) vs. 27.5 ± 32.3 (fusion), p = 0.037; EQ5D 0.76 ± 0.30 (TDR) vs. 0.68 ± 0.30 (fusion), p = 0.026; ODI: 17.3 ± 19.0 (TDR vs. 22.5 ± 17.1 (fusion), p = 0.015; difference pre-postop: 24.6 ±		

								18.1 (TDR) vs. 18.3 ± 18.6 (fusion), p = 0.019.		
Sköld 2013 (score=5.0)	Fusion	RCT	No COIs or industry sponsorship.	N = 152 with chronic LBP not responding to nonsurgical treatment	Mean age: 39.4±8.0 years; 62 males, 90 females.	Total disc replacement (TDR) (n = 80) vs. Lumbar fusion (n = 72).	Follow-up at 1, 2 and 5 years.	Both groups clinical improvement at 5-year follow-up. 1-year results: Pain free 29% (23/80) in TDR group vs. 10% (7/71) in fusion group, p = 0.003; VAS back pain: 25.5 ± 26.5 (TDR vs. 33.4 ± 26.8 (fusion), p = 0.030; difference pre- post-op: 36.8±30.0 (TDR) vs. 25.1 ± 34.2 (fusion), p = 0.027; VAS leg pain: 13.2±21.9 (TDR) vs. 20.6 ± 25.1 (fusion), p = 0.007; EQ5D: 0.71 ± 0.28 (TDR) vs. 0.63 ± 0.27 (fusion), p = 0.046; ODI: 19.5 ± 187 (TDR) vs. 24.9 ± 16.1 (fusion), p = 0.023; difference pre-postop: 22.4 ± 17.8 (TDR vs. 16.3 ± 18.4 (fusion), p = 0.036. 2-year results: Pain free: 30% (24/80) in TDR group vs. 15% (11/71) in fusion group, p = 0.031; VAS leg pain: 16.4 ± 24.5	"Global assessment of low back pain differed between the two surgical groups at all follow-up occasions. Significant differences between groups concerning back pain, pain improvement, and ODI were present a 1 yea and disappeared at 2 years, but reappeared at the 5 year follow-up."	2nd report Berg 2009. Data suggest better pain and ODI with disc replacement at 5 years.

								(TDR) vs. 20.7 ± 24.3 (fusion), p = 0.037. 5-year results: Pain free: 38% (30/80) in TDR group vs. 15% (11/71) in fusion group (p < 0.002); much better: 35% (28/80) in TDR group vs. 52% (37/71) in fusion group, p = 0.034; VAS back pain 22.7 ± 29.2 (TDR) vs. 30.5 ± 26.9 (fusion), p = 0.009; difference pre-post-op: 39.6 ± 31.8 (TDR) vs. 27.5 ± 32.3 (fusion), p = 0.037; EQ5D 0.76 ± 0.30 (TDR) vs. 0.68 ± 0.30 (fusion), p = 0.026; ODI: 17.3 ± 19.0 (TDR vs. 22.5 ± 17.1 (fusion), p = 0.015; difference pre-postop: 24.6 ± 18.1 (TDR) vs. 18.3 ± 18.6 (fusion), p = 0.019.		
Sköld 2013 (score=NA)	Discectomy	Post hoc 5 year analysis of Sköld 2013	No COI or sponsorship.	N = 152 with chronic low back pain and have not responded to nonsurgical treatment	Mean age: 39.4 years; 62 males, 90 females	TDR (n = 80) vs. Fusion (n = 72). Reference Sköld 2013 for treatment descriptions	Follow up at 1,2, and 5 years	Both groups showed clinical improvement at 5-year follow-up. 1-year results: Pain free : 29% (23/80) in the TDR group vs. 10% (7/71) in fusion group (p = 0.003); VAS back	"Global assessment of low back pain differed between the two surgical groups at all follow-up occasions. Significant differences	Data suggest at 5 years twice as many patients in total disc replacement group were pain free compared to fusion group.

								pain: 25.5 ± 26.5 (TDR vs. 33.4 ± 26.8 (fusion) (p = 0.030); difference pre-postop: 36.8 ± 30.0 (TDR) vs. 25.1 ± 34.2 (fusion) (p = 0.027); VAS leg pain: 13.2 ± 21.9 (TDR) vs. 20.6 ± 25.1 (fusion) (p = 0.007); EQ5D: 0.71 ± 0.28 (TDR) vs. 0.63 ± 0.27 (fusion) (p = 0.046); ODI: 19.5 ± 187 (TDR) vs. 24.9 ± 16.1 (fusion) (p = 0.023); difference pre-postop: 22.4 ± 17.8 (TDR vs. 16.3 ± 18.4 (fusion) (p = 0.036). 2-year results: Pain free: 30% (24/80) in TDR group vs. 15% (11/71) in fusion group (p = 0.031); VAS leg pain: 16.4 ± 24.5 (TDR) vs. 20.7 ± 24.3 (fusion) (p = 0.037). 5-year results: Pain free: 38% (30/80) in TDR group vs. 15% (11/71) in fusion group (p < 0.002); much better: 35% (28/80) in TDR group vs. 52% (37/71) in fusion group, (p = 0.034);	between groups concerning back pain, pain improvement, and ODI were present at 1 year and disappeared at 2 years, but reappeared at the 5-year follow-up."	

								VAS back pain 22.7 ± 29.2 (TDR) vs. 30.5 ± 26.9 (fusion) (p = 0.009); difference pre-postop: 39.6 ± 31.8 (TDR) vs. 27.5 ± 32.3 (fusion) (p = 0.037); EQ5D 0.76 ± 0.30 (TDR) vs. 0.68 ± 0.30 (fusion) (p = 0.026); ODI: 17.3 ± 19.0 (TDR vs. 22.5 ± 17.1 (fusion) (p = 0.015); difference pre-postop: 24.6 ± 18.1 (TDR) vs. 18.3 ± 18.6 (fusion) (p = 0.019)		
Berg 2009 (score=5.0)	Disc replacement	RCT	No mention of COIs or industry sponsorship.	N = 152 chronic LBP, disc degeneration seen on MRI	Mean age: 40 years; 62 males, 90 females	Disc replacement (n = 80) vs. Posterior lumbar fusion (n = 72) 1 or 2 levels treated.	1, 2 years	Totally pain free at 1 year TDR 29% vs. PF 10% (p = 0.003) at 2 years TDR 30% vs. PF 15% (p = 0.031). NS difference in other levels of pain between groups.	"In this prospective randomized study comparing TDR to fusion in a carefully selected population, we found a better outcome for TDR in most parameters at 1-year follow-up. The fusion group improved during the second year. However, the TDR group had a larger number of pain-free patients at both 1 and 2 years."	Three different replacement discs used. Two different posterior fusion techniques. Lack of details on co-interventions other than surgery. Data suggest a benefit in pain rating with TDR vs. PF at 1 and 2 year follow-up.

Hoff 2016 (Score=4.0)	Fusion	RCT	Sponsored by the German Research Foundation. The authors declared no COI.	N=50 patients	Mean age: 46.5 years; 24 males, 26 females.	Hybrid group: received total disc replacement at L4/5 and anterior lumbar interbody fusion at L5/S1 (n=26) vs. fusion group: received 2-level circumferential fusion with transforaminal lateral interbody fusion and transpedicular stabilization at L4-S1 (n=24).	Follow-up at 12, 24, and 37 months.	Visual analog scale (VAS) and Oswestry Disability Index (ODI) improved in the two groups (ptime<0.001). Significant reduction of pain level was found in hybrid group (p<0.05).	"Hybrid surgery is a viable surgical alternative for the presented indication. Approach-related inferior trauma and the balanced restoration of lumbar lordosis resulted in superior clinical outcomes compared to two level circumferential fusion with TLIF."	Data suggest hybrid surgery may be a reasonable option for DDD.
Total Disc Replacement vs Other										
Garcia 2015 (score=6.0)	Discectomy	RCT	No mention of COI. Sponsored by Aesculap Implant Systems, Inc. grant funds.	N = 324 with reported lumbar pain due to radiographically confirmed degenerative disc disease (DDD) at L4-L5 or L5-S1, despite at least 6 months of nonsurgical management	Mean age: 39.3 years; 169 males, 155 females.	Investigational TDR device (activL), modular prosthesis with inferior cobalt-chromium plate anchored in end-plate of caudal vertebral body, with ultrahigh molecular weight polyethylene inlay (n=218) vs. Control, FDA-approved TDR devices (ProDisc-L or Charité,	Follow-up at 6 weeks and at 3, 6, 12, and 24 months	24 months follow-up compliance: activL = 83%, control = 80%. Overall treatment success rate at 24 months: activL noninferior to control using margins of 10% and 15% (both p < 0.001). After sensitivity analyses, patients treated with	"The single-level activL TDR is safe and effective for the treatment of symptomatic lumbar DDD through 2 years."	Data suggest at 2 years single level activL total disc replacement appears to benefit discogenic low back pain patients. ActivL TDR was non-inferior to control TDR with p-value < 0.001.

						based on surgeon's preference) (n=106). All TDR implants placed via anterior retroperitoneal approach		activL disc had higher rates of radiographic success compared to controls (59%, 43%, respectively, $p < 0.01$) and Oswestry Disability Index (ODI) success (75%, 66%, $p = 0.08$)		

VERTEBROPLASTY

Vertebroplasty, first reported in 1987,(2113) involves using image guidance to inject polymethylmethacrylate within the vertebral body, in order to stabilize vertebral fractures caused by osteoporosis,(2114-2120) vertebral osteonecrosis, or malignancies of the spinal column.(2121-2129) This procedure is most common among elderly osteoporotic patients who have delayed healing of compression fractures of the vertebral body(ies),(2130) but it is sometimes performed on younger patients with acute vertebral fractures due to osteoporosis. A work-related minor trauma may be the event that caused the osteoporotic pathologic fracture.

1. *Recommendation: Vertebroplasty for Treatment of Low Back or Thoracic Pain Due to Vertebral Compression Fractures*
   Vertebroplasty is strongly not recommended as a routine treatment for patients with low back or thoracic pain due to vertebral compression fractures.(2131, 2132)

   Strength of Evidence – **Strongly Not Recommended, Evidence (A) [Subacute, Chronic]**
   Level of Confidence – High
   Strength of Evidence – **Not Recommended, Evidence (C) [Acute]**
   Level of Confidence – Moderate

2. *Recommendation: Vertebroplasty for Treatment of Select Patients with Low Back or Thoracic Pain Due to Vertebral Compression Fractures*
   There is no recommendation for or against the use of vertebroplasty for treatment of highly select patients with low back or thoracic pain due to unusual vertebral compression fractures.

   Indications – Patients who are not included in the two available high-quality trials. These include patients who have had fractures despite bisphosphonate therapy, pathologic fractures due to neoplasms in the vertebral body, or multiple simultaneous compression fractures (three or more). Candidates for vertebroplasty should have these types of unusual vertebral body compression fractures, should generally have severe pain, passage of at least 2 months, and failure of other treatment options including medical management.

   Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
   Level of Confidence – Low

Rationale for Recommendations

There are multiple (2009, 2430) high-quality, sham-controlled RCTs that evaluated the efficacy of vertebroplasty and failed to find significant improvements in the patients who underwent vertebroplasty compared with a sham procedure. (2131, 2132) These results are in contrast with two moderate-quality RCTs(2133, 2134) and other low-quality studies that had reported pain relief and other functional improvements that had appeared promising.(2126, 2135-2143) There is one other quality trial which reported pain relief and increased mobility; however, that trial is of lower quality, was short term (2 weeks), and had a substantially lower sample size than both of the 2009 studies, and appears biased against pain treatment.(2144) In addition, substantial complications occur with this procedure including deaths (2126, 2132, 2145, 2146) and subsequent fractures (2399, 2400). The results of the two high-quality RCTs indicate that vertebroplasty is strongly not recommended for nearly all patients with vertebral compression fractures. It remains unclear whether there are highly selected unusual patients – such as severely affected patients, patients with 3 or more simultaneous compression fractures, or patients with pathologic fractures due to neoplasms(2147)– who were outside the scope of these two quality trials, who might still derive benefit from this procedure. This procedure is invasive, has complications,(2148, 2149) and is costly. Therefore, vertebroplasty is not recommended other than for highly select patients who have failed other interventions (including quality medical management) and for whom there are no

other options available, whose significant pain is not resolving, and especially those for whom bisphosphonate therapy has failed.

Evidence for the Use of Vertebroplasty

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without using any limitation on publication dates and then an updated search was done in PubMed for publication between 1/1/2013 and 11/15/2017. We used the following search terms: vertebroplasty,back, spinal fractures, randomized clinical trial or randomized controlled trial or random, systematic review or reviews, population study or epidemiological study or prospective cohort to find 5,167 articles. Of the 5,167 articles we reviewed 57 articles and included 30 articles (21 randomized controlled trials and 10 systematic reviews).

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Vertebroplasty vs. Sham										
Buchbinder 2009 (score=9.5)	Vertebroplasty	RCT	Supported by grants from National Health and Medical Research Council of Australia (284354), Arthritis Australia, Cabrini Education and Research Institute, and Cook Australia. Dr. Buchbinder reports receiving grant support from Cook Australia to perform this trial. No other potential COIs.	N = 78 with 1 to 2 painful compression fractures of up to 12 months old	Mean age: 76 years; 16 males, 62 females.	Vertebroplasty (n = 38) vs. Sham or blunt needle (n = 40).	Outcomes assessed at 1 week, 1, 3, and 6 months	Overall pain score changes (1 week/1 month/3 months/6 months): vertebroplasty (1.5±2.5/2.3±2.6/2.6±2.9/2.4±3.3) vs. placebo (2.1±2.8/1.7±3.3/1.9±3.3/2.1±3.3) all p >0.05. Perceived status at 1 week: vertebroplasty 6 (16%) better, 5 (14%) worse vs. placebo 13 (35%) better, 1 (3%) worse; 1 month vertebroplasty 12 (34%) better, 2 (6%) worse vs. placebo 9 (24%) better and 9 (24%) worse. At 6 months, vertebroplasty 16 (46%) better, 7 (20%) worse vs. sham 15 (42%) better and 5 (14%) worse.	"We found no beneficial effect of vertebroplasty as compared with a sham procedure in patients with painful osteoporotic vertebral fractures, at 1 week or at 1, 3, or 6 months after treatment."	Co-interventions unclear. Overall 141/468 declined to participate. Data suggest no benefit.
Kroon, 2014 (no score)	Vertebroplasty	Secondary analysis for Buchbinder 2009 RCT.	Osborne received a National Health and Medical Research Council Population Health Career Development Award and Buchbinder received a National Health and Medical	N = 57 with 1 to 2 painful compression fractures of up to 12 months old	Mean age: 77.19 years; 10 males, 47 females	Vertebroplasty (n = 29) vs. Sham or blunt needle (n = 28).	Two-year follow up	Complete data available for 73% of participants, respectively. 24 months those in active group improved by 3.0±3.1 units while those in sham group improved 1.9±3.0 (Mean difference = 1.1 units, (95% CI, –0.3 to 2.4)). No significant between- group differences observed for any secondary efficacy outcomes at 12 or 24 months. No between- group differences in incident clinical vertebral	"These results provide further evidence that the use of this treatment in routine care is unsupported."	Data suggest vertebroplasty is not supported for routine care of vertebral fractures.

			Research Council Practitioner Fellowship. No mention of sponsorship.					fractures up to 24 months (active: n=14, sham: n=13)		
Staples, 2015 (no score)	Vertebroplasty	Post-hoc secondary analysis for Buchbinder 2009 RCT.	Buchbinder is supported by an Australian National Health and Medical Research Council (NHMRC) Senior Principal Research Fellowship. The Mayo Clinic received funding from NIH (R01 AR49373) for the work submitted. No mention of sponsorship.	N = 78 with 1 to 2 painful compression fractures of up to 12 months old	No mention of age or sex of participants included in analysis	Vertebroplasty (n = 38) vs. Sham or blunt needle (n = 40).	Two-year follow up	Radiographs available for 60% of participants. No between-group differences for new or progressed fractures at 12 and 24 months: 32 and 40 for vertebroplasty group and 21 and 33 to sham group (Hazard Ratio = 1.8, 95% CI (0.82-3.94)). In vertebroplasy group, fracture risk was unrelated to total (HR = 0.91, 95% CI (0.71-1.17)) or relative (HR = 1.31, 95% CI (0.15-11.48)) cement volume, or cement leakage (HR = 1.2, 95% CI (0.63-2.31))	"For patients undergoing VP our study did not demonstrate significant increases in subsequent fracture risk beyond that experienced by those with vertebral fractures who did not undergo the procedure. However, because of the non-significant numerical increases observed, studies with adequate power are needed to draw definite conclusions about fracture risk."	Data suggest at 2 years post-surgery, new vertebral fractures were equal in both the surgical and placebo groups.
Kallmes 2009 (score=9.0)	vertebroplasty	RCT	Supported by a grant (R01-AR49373) from National Institute of Arthritis and Musculoskeletal and Skin Diseases. Each author received either a fee or a grant from a different institution, and no other	N = 131 with 1-3 painful compression fractures T4-L5 of up to 12 months old. Age ≥50 years.	Mean age: 73.8 years; 32 males, 99 females.	Vertebroplasty (n = 68) vs. Sham, no needle control group (n = 63); Outcomes were assessed at 3 days, 14 days, 1 month and 3 months.	Follow-up at 1 and 3 months.	At 14 days, 63% vertebroplasty vs. 51% controls correctly guessed assignment; 1 hospitalized with thecal sac injury. Rolland-Morris Disability scores (baseline/3 days/14 days/1 month): vertebroplasty (16.6±3.8/13.0±5.2/ 12.4±5.8/12.0±6.3) vs. sham (17.5±4.1/12.5±5.5/12.3±5.9 /13.0±6.4), p = 0.30, 0.35, 0.49. Pain intensity scores: vertebroplasty (6.9±2.0/4.2±2.8/4.3±2.9/3.9 ±2.9) vs. sham	"Improvements in pain and pain-related disability associated with osteoporotic compression fractures in patients treated with vertebroplasty were similar to the improvements in a control group."	Co-interventions not mentioned, but appear likely; 300 of 1682 exclusions were declinations. Allowed crossover after 1 month for both groups [8 (12%) of vertebroplasty group vs. 27 (43%) controls crossed over], precluding assessment of long-term effects. Data suggest no benefit.

			COIs declared.					(7.2±1.8/3.9±2.9/4.5± 2.8/4.6±3.0), p = 0.37, 0.77, 0.19. Post-hoc analyses no significant differences by pain duration (<13 weeks, 14-26 weeks, 27-52 weeks).		
Vertebroplasty vs. Pain Treatment										
Farrokhi 2011 (score=7.5)	Vertebroplasty	RCT	Grant from Shiraz University of Medical Sciences and Apadana Tajhizgostar Co. No COIs declared.	N = 82 with painful, osteoporotic compression fractures refractory to 4 plus weeks to 1 year of analgesics age 55-90	Mean age: 73 years; 22 males, 60 females.	Vertebroplasty (VP, n = 40) vs. Optimal medical therapy (OMT, n = 42).	Follow-up at 3 years.	VAS pain scores (baseline/1 week/2 months/6 months/1 year/2 years/3 years): PV 8.4/3.3/3.2/2.2/2.2/2.8/1.8 vs. OMT 7.2/6.4/6.1/4.1/4.1/3.7/3.7, (p <0.02 up to 6 months; p <0.11/0.37/0.81 for last 3 intervals). Oswestry LBP scores for quality of life: PV 52.2/30.1/15.0/10.0/ 8.0/8.0/8.0 vs. OMT 50.4/ 44.0/30.0/21.0/20.0/20.0/ 22.0 (p <0.04 all times).	"The PV group had statistically significant improvements in visual analog scale and QOL scores maintained over 24 months, improved VBH maintained over 36 months, and fewer adjacent-level fractures compared with the OMT group."	OMT may or may not be optimal. Baseline data reported with unusual statistics (e.g., p <0.11 and p=0.11). Somewhat more wedge fractures in VP (90 vs. 78%). 10/42 (23.8%) crossed over, raising questions about magnitude of potential benefit. Data suggest less pain and disability with vertebroplasty.
Voormolen 2007 (score=5.5)	Vertebroplasy	RCT	No mention of sponsorship or COIs.	N = 34 with compression fractures and "refractive to medical therapy for at least 6 weeks and no longer than 6 month." Age ≥50.	Mean age: 73 years; 6 males, 28 females.	Vertebroplasty (n = 18) vs. Pain management, NSAID or opioid (n = 16). Study terminated early as nearly all pain management patients asked to be treated with vertebroplasty after 2 weeks (suggests bias).	Follow-up at 2 weeks.	VAS pain scores (baseline/Day 1/2 weeks): PV 7.1/4.7/4.9 vs. OPM 7.6/7.1/6.4. Analgesic use: PV 1.9/1.1/1.2 vs. OPM 1.7/2.5/2.6.	"Pain relief and improvement of mobility, function, and stature after PV is immediate and significantly better in the short term compared with OPM treatment."	Short-term 2-week trial after which crossed over. Small sample size; some baseline differences. Requirement to have at least 6 weeks prior treatment (likely including pain management) appears to bias in favor of other intervention as pain management would then be "more of the same."
Percutaneous vertebroplasty vs. Kyphoplasty										
Klazen 2010 (score=6.5)	Vertebroplasty	RCT	Study sponsored by ZonMw (Dutch organisation for health care research and	N = 202 with compression fractures of T5 or lower, back pain ≤6 weeks and	Mean age: 75.3 years; 62 males, 140 females.	Vertebroplasty (n = 101) vs. Conservative treatment (n = 101).	Follow-up at 1 year.	VAS pain scores (1 day/1 week/1 month/3 months/6 months/1 year): VP 3.7/3.5/2.5/2.5/2.3/2.2 vs. conservative 6.7/5.6/4.9/3.9/3.9/3.8, p<0.025 all intervals.	"Pain relief after vertebroplasty is immediate, is sustained for at least a year, and is significantly greater than that achieved	Some baseline differences in outcomes measures with worse baseline disability in VP. Fewer wedge fractures in VP (66 vs. 81%). Data

			innovation of care), project number 945-06-351 and unrestricted grant from COOK Medical (Bloomington, IN, USA). No COIs declared.	VAS pain ≥5. Age ≥50.					with conservative treatment..."	suggest more pain relief with VP. Unclear if disability differed at 1 year (data not provided).
Rousing 2009 (score=5.0)	Vertebroplasty	RCT	Foundation and Danish government funds received in support of this work. No mention of COI.	N = 50 with either acute/ subacute (<2 weeks /between 2 and 8 weeks) osteoporotic fractures preventing the patient in taking care of oneself. Age less than 65.	Mean age: 80 years; 10 males, 40 females.	Percutaneous vertebroplasty or PVP group, under local anesthetics, 11-to 13-gauge needles placed using uni- or bilateral transpedicular approach (n = 26) vs. Conservative treatment group, offered brace treatment (n = 24).	Follow-up at 3 months.	VAS pain score/EQ5D; VAS pain lowered in PVP group from VAS 7.7, CI (6.7-8.7) before operation to VAS 2.0, CI (0.9-3.2), and at 12-24 hours after procedure, p = 0.00/EQ5D significantly different in both PVP group p = 0.00 and conservative group, p = 0.01, 3 months after inclusion.	"The majority of patients with acute or subacute painful osteoporotic compression fractures in the spine will recover after a few months of conservative treatment."	Only assessed at 3 months.

Rousing 2010 (score=5.0)	Vertebroplasty	RCT	Foundation and Danish Government funds received in support of this work. No mention of COI.	N = 49 with intractable pain because of acute/subacute (<2 weeks/2 and 8 weeks) osteoporotic vertebral fractures. Age less than 65.	Mean age: 80 years; 9 males, 40 females.	Percutaneous vertebroplasty or PVP group, under local anesthetics and operated as soon as possible after inclusion and mobilized within a day after the procedure (n = 25) vs Conservative treatment group, hospitalized and offered brace treatment, pain medication, and general mobilizing physiotherapy (n = 24).	Follow-up at 12 months.	Pain lowered in PVP group from 7.9 before to 2.0 after 12-24 hours post-op, p <0.00, but no difference in pain between groups after 3 and 12 months. EQ5D test, there was significant better health state in PVP group at 3-months follow-up vs. conservative group, p = 0.04. After 12 months, 4 new fractures in PVP group and 3 new fractures in conservative group detected.	"PVP is a good treatment for some patients with acute/subacute painful osteoporotic vertebral fractures, but the majority of fractures will heal after 8 to 12 weeks of conservative treatment with subsequent decline in pain."	Additional Report to Rousing 2009.
Blasco 2012 (score=4.0)	Vertebroplasty	Prospective RCT single-center controlled	Funded by grants from Fundacio´ La Marato´ de TV3, Spanish Society of Medical Radiology, and Catalan Society of Rheumatology. No COI.	N = 125 with painful osteoporotic vertebral fractures or VF.	Mean age: 73.3 years; 28 males, 97 females.	Conservative therapy with analgesics and nasal calcitonin (n = 48/61) vs VP group (strict bed rest for 6 hours after procedure, calcitonin and PRN analgesics (n = 47/64). Improving painful osteoporotic VF from T4-L5, over 1-yr. Clinical assessment at 2 weeks, and 2, 6 and 12 months.	Follow-up at 1 year.	At 2 months improvement in pain relief greater in with VP vs. conservative approach (1.59 ± 0.42 versus 3.07 ± 0.45, p = 0.0172) and main pain score reduction of 45% compared to 25% with conservative treatment.	"In conclusion, VP and conservative treatment are both associated with significant improvement in pain and quality of life in patients with painful osteoporotic VF over a 1-year follow-up period with no statistically significant differences in mortality between the two groups."	Study of osteoporotic fractures. Lack of study details for control of cointerventions, compliance.

Piazzolla 2011 (score=4.0)	Vertebroplasty	Prospective RCT	No mention of sponsorship. Authors declare that they have no conflict of interest concerning this article.	N = 50 with Magerl type A1.2 non-osteoporotic thoracolumbar or lumbar spinal compression fractures in patients aged over 18 years and free of neurologic compromise.	Mean age: 40 years; 32 males, 18 females.	Group 1 received conservative treatment by 4-6 weeks hyperextension cast (n = 26) vs. Group 2 treated using B-Twin intra-body expansion spacer with upright posture as of day following surgery, without corset (n = 24).	Follow-up for 12 months.	VAS pain scores between 3-12 months with greater pain reduction in group 2 vs. group 1, p <0.05. OID scores showed improvement in quality of life at 6 and 12 months in group 2, p <0.05. At 12-month follow-up; no implant migration, device rupture, infection or further bone fracture at same or an adjacent level observed.	"The vertebral body reconstruction technique provided anatomic vertebral body reconstruction and quick return to household activity without resort to a corset."	Details sparse.
Cortoss vs. Polymethylmethacrylate										
Bae 2012 (score=5.0)	Vertebroplasty	Prospective RCT	Corporate/industry funds received in support of this work. No mention of conflict of interest (COI).	N = 256 with painful osteoporotic VCFs, VAS pain score at least 50mm on 100mm scale and at least 30% disability as measured by ODI.	Mean age: 75.8±10.3 years; 67 males, 189 females.	Cortoss or coaxial catheter-based system with general anesthesia (n = 162) vs. Polymethylmethacrylate or PMMA with general anesthesia (n = 94).	Follow-up at 24 months.	Baseline mean score were comparable (80-mm Cortoss; 78-mm PMMA) and mean disability was at 60% for both groups. At week 1, 59% of patients experienced improvement of 15 points or more on the ODI or disability scale, and at 3 months, 75% or more of patients experienced this level of improvement.	"Vertebroplasty using either Cortoss or PMMA provides effective, immediate, and lasting pain relief and prevents further loss of function."	No meaningful differences at 24 months.
Percutaneous vertebroplasty vs. Chemotherapy										
Yang 2012 (score=4.0)	Vertebroplasty	RCT	No industry sponsorship or COI.	N = 76 with multiple myeloma (MM) associated spinal fracture	Mean age: 59.27 years; 39 males, 37 females.	Percutaneous vertebroplasty or PVP using needle diameters 2.5 and 3.2mm with length of 100-150mm (n = 38) vs. Chemotherapy treatment group (n = 38).	Follow-up at 5 year.	Overall response rate at 1 year; in ORR in combined treatment group significantly higher than in chemotherapy only treatment group, p = 0.001. At 3-years, VAS and KPS scores between groups significantly different, p = 0.000. At 5-years, survival rate in treatment group 68.4% and 42.1% in chemotherapy group.	"PVP had characteristics of minimal trauma, easy operation and less complication. PVP can achieve long-term analgesic effect, and enhance the spinal stability."	Details sparse.
Teriparatide vs. Antiresorptive										

Tseng 2012 (score=4.0)	Vertebroplasty	RCT	No funds received in support of this study. No mention of COIs.	N = 50 with risk of new vertebral compression fractures (VCFs). Mean age of patients in Teriparatide group vs. Antiresorptive: 75.59±6.28 vs. 70.55±4.10.	Mean age: 73.25 years; 4 males, 40 females.	Teriparatide Vit-D+Ca or injections of teriparatide (20µg) once daily plus daily supplementation with calcium (1,000-1,500mg) and vitamin D (800-1,000 IU) (n = 24) vs. Antiresorptive Vit-D+Ca group either Alendronate or Raloxifene combined with calcium supplementation (1,000-1,500 mg) and vitamin D (800-1,00 IU) for at least 20 months after occurrence of adjacent osteoporotic VCFs (n = 26).	Follow-up at 18 months.	Pre-existing VCFs significantly higher in group A or 3.01±0.87 compared to group B or 70.55 ± 4.10, p = 0.002. Vertebral body reduction ratio in group A 48.68% ± 11.94% compared to group B or 49.82%±12.19% p = 0.756. Baseline JOA / VAS scores; p = 0.115 and 0.888. At 6 months, VAS score significantly lower in group A compared to B p = 0.003. Mean T-score values at; baseline/6/12 and 18 months; -3.43±0.73/-3.36± 0.64/-3.15±0.63 and -3.12± 0.57 months.	"Treatment of post-vertebroplasty adjacent VCFs with teriparatide (no new vertebroplasty) was more effective than that of repeated vertebroplasties combined with and anti-resorber."	Algorithm allowed for switching between treatment groups based on outcomes. Quasi randomized. Baseline differences.
Chen 2012 (score=4.0)	Vertebroplasty	RCT	Supported by Startup Foundation for Research Program of Doctoral Degree of Guangzhou Medical College (grant # 2010c12). Author support no conflict of interest concerning this article.	N = 60 who had undergone percutaneous vertebroplasty and processed sufficient muscle strength to participate in training.	Mean age: 68.8 years; 5 males, 55 females.	Group A or general post-op therapy plus antiosteoporotic medications and education (n = 30) vs. Group B or symptomatic back muscle exercise in addition to antiosteoporotic education (n = 30).	Follow-up at 1 and 2 years.	There was statistical differences between Group A and B at six-month, one and two-year follow up; p < 0.05, overall ODI of group B, was lower p < 0.05. Post-op VAS and ODI scores for both groups lower than at pre-op. At one point at 1 and 2-year follow up, VAS score in group A significantly higher p < 0.05.	"[F]indings suggest that the benefit of the exercise required at least six months to be observed; however, the favorable effects could last for two years."	24 month FU. Data suggest exercise of little immediate benefits, but better performance at 1-2 years.
Percutaneous vertebroplasty vs. Kyphoplasty										
Endres 2012 (score=4.0)	Vertebroplasty	RCT	No mention of sponsorship. No COI.	N = 66 with osteoporosis proven on DXA scan, and fresh painful single-level osteoporosis with sintering	Mean age: 67.3 years; 18 males, 40 females.	Group A or Kyphoplasty using unipedicular approach (n = 20) vs. Group B or vertebroplasty using unipedicular transpedicular approach (n = 21) vs. Group C or Shield Kyphoplasty using unilateral working cannula and standard	Follow-up at 5.8 months.	Vertebral body height did not improve, p <0.05. Comparing surgery and fluoroscopy times and dosage area-product was significantly different in favor of vertebroplasty, p <0.01.	"Overall, apart from mostly asymptomatic cement leakage, vertebroplasty could be considered as the surgical procedure of choice."	Quasi Randomized. Six month FU. No sham/placebo control

				fractures in the middle and lower thoracic spine (TS) and lumbar spine (LS). Age 47-79.		Kyphoplasty equipment (n = 18).				
Percutaneous vertebroplasty vs. Control										
Brinjikji 2010 (score=9.0)	Vertebroplasty	RCT	One author (D.F.K.) received research support for augmentation trial from Arthrocare, Stryker, and Cook. No mention of COIs.	N = 131 who participated in investigational vertebroplasty efficacy and safety trial (INVEST): detailed analysis of blinding efficacy.	Mean age: 73.8 years; 28 males, 93 females.	Vertebroplasty with bone biopsy needle was advanced into the vertebral body (n = 68) vs. Controls had intermittent pressure placed to the patient's back, simulating needle placement (n = 63). Patients guessed multiple times their treatment allocation up to 1 month.	Follow-up at 30 days.	Effect of pain duration on patient guess approached significance, p = 0.09. At days 3 and 14 no statistical difference of guess between those guessing correctly compared to those guessing incorrectly, p = 0.40 and 0.59. Those in control intervention group showed a stronger association between pain relief and type of guess at day 14, and 30 p = 0.02 and p <0.001.	"A number of factors were associated with the ability of patients to guess their treatment allocation correctly— namely, treatment effect (in the control group only), study treatment site, and baseline pain duration."	2nd analysis of INVEST study. Trout 2005
Low Quality Studies										
Venmans 2012 (score=3.5)	Vertebroplasty	Open-label RCT	Study sponsored by ZonMW and grant from Cook Medical. No mention of COIs.	N = 95 with vertebral compression fractures.	Mean age: 78.9 years; 30 males, 65 females.	Following Vertebroplasty treated patients, until sufficient pain relief defined as VAS score > 3 (n = 38) vs. Conservative therapy treated patients until sufficient pain relief, defined as VAS score ≤3 (n = 57).	Follow-up at 1 year.	95 or 60% has sufficient pain relief with VAS score ≤3. 38 or 40% had pain with VAS score ≥4 at last follow-up interval of 12 months.	"In the VERTOS II trial, most conservatively treated patients with acute osteoporotic compression fractures had sufficient pain relief during the first 3 months."	Details sparse. Follow-up of Klazen 2010.
Liu 2010 (score=3.0)	Vertebroplasty	RCT	Study supported by grant from Chung-Shan Medical University Hospital (CW08110). No COI.	N = 100 with VCF at (T-L) junction (T12-L1). Age 57-88 years old.	Mean age: 73.3 years; 23 males, 67 females.	Vertebroplasty (n = 50) vs. Kyphoplasty (n = 50) Procedure: IV general anesthesia (Propofol) + 2% xylocaine injured locally, needle, PMMA, x-ray.	Follow-up at 6 months.	VAS V vs. K score prior/3days/6 months; (8.0±0.8) /(2.6±0.6,p<0.001)/(2.6±0.6, p = 0.001) vs. (7.9±0.7)/(2.3±0.5, p <0.001)/(2.6 ±0.6, p <0.001).	"[In] terms of clinical outcomes we found little difference between vertebroplasty and kyphoplasty treatment groups."	Lack of study details, randomization, allocation, blinding of assessor, cointerventions, follow-up rate, ITT. Data suggest no clinical differences in outcomes of pain. Lack of control group limits conclusion

										regarding invasive treatment of VCF vs. conservative care.
Yang, 2016 (Score= 3.5)										Data suggest PVP group reported less pain and improved quality of life up to 12 months versus CT group.
Leali, 2016 (Score= 3.0)										No long term follow-up. Data suggest short term pain relief with VP.

KYPHOPLASTY

Kyphoplasty, first introduced in 1998, has been used similarly to vertebroplasty to restore vertebral body height and improve sagittal alignment of the spine.(2124, 2145, 2162-2172) Kyphoplasty involves injection of polymethylmethacrylate within a cavity in the vertebral body that has been created by percutaneously insertion of a balloon through the involved pedicle(s).(2173) It has been suggested that kyphoplasty may be appropriate as a prophylactic procedure.(2174)

Recommendation: Kyphoplasty for Treatment of Low Back or Thoracic Pain Due to Vertebral Compression Fractures

There is no recommendation for or against the use of kyphoplasty for the treatment of low back or thoracic pain due to vertebral compression fractures.

Indications – Vertebral body compression fractures among patients with severe pain; patients who have had
fractures despite bisphosphonate therapy may also be candidates.

Strength of Evidence – **No Recommendation, Insufficient Evidence (I)**
Level of Confidence –Low

Rationale for Recommendation

There are no quality studies comparing kyphoplasty with a sham procedure. There is one moderate-quality study comparing kyphoplasty with an unstructured, unblinded, non-interventional control that included cancer patients.(2175) This study also differentially utilized passive treatments between the two groups, such as bed rest and braces that may have confounded the results. The other moderate-quality study compared two types of cement and found the calcium phosphate cement to be inferior for burst fractures.(2173) There are comparative clinical trials and other low-quality studies suggesting benefit.(2166, 2176, 2177) These have been compiled into meta-analyses with a conclusion of efficacy (as well as efficacy of vertebroplasty).(2178-2180) Yet, as kyphoplasty is similar to vertebroplasty, and two high-quality, sham-controlled trials for vertebroplasty are now reported documenting a lack of benefit,(2131, 2132) and despite the Wardlaw study which included patients with neoplasia, it appears reasonable to assume the same lack of benefit will eventually be shown for kyphoplasty for treatment of non-cancer patients. It remains unclear whether there are highly selected, unusual patients such as those severely affected, patients with 3 or more simultaneous compression fractures, or patients with pathologic fractures due to neoplasms,(2147) who may derive benefit from this procedure. Kyphoplasty has also been found to be associated with subsequent, adjacent vertebral compression fractures.(2160, 2181, 2182-2184, 2399-2402) Kyphoplasty is invasive, has complications, and is costly. There is no recommendation for or against kyphoplasty other than for highly selected patients who have failed other interventions (including quality medical management), and in whom there are no other options available, whose significant pain is not resolving, and especially those for whom bisphosphonate therapy has failed.

Evidence for the Use of Kyphoplasty

We searched PubMed, EBSCO, Cochrane Review, and Google Scholar without using any limitation on publication dates and then an updated search was done in PubMed for publication between 1/1/2013 and 11/15/2017. We used the following search terms: Kyphoplasty, Back, Spinal fractures, Randomized Controlled Trial, Random, Randomized, Systematic Review, Reviews, Population study, Epidemiological study, and Prospective cohort to find 5,213 articles. Of the 5,213 articles, we reviewed 39 articles and included 21 articles (17 randomized controlled trials and 4 systematic reviews).

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Comparison of 2 Methods of Kyphoplasty										
Bastian 2013 (score= 5.5)	Kyphoplasty	RCT, Non-blinded trial	Supported by Medtronic Spine LLC. No mention of COI.	N = 112 with osteoporosis and 1 acute vertebral compression fractures (VCF).	Mean age= 74.7 years; 24 males, 88 females.	Bilateral balloon kyphoplasty (BKP) in which curette used first or CF group (n = 57) vs. Using inflatable bone tamps (IBTFs) used first (n = 55). 1 lost to follow-up in BKP group.	Follow-up for 30 days.	Primary end point: Improvement observed not statistically significant, p = 0.4. Secondary Radiographic End Points: Anterior improvement or angle measured for treated vertebrae not statistically significant, p = 0.4 or 0.05. Mobile fractures: Pre/postop height change better in mobile fracture group, 3.46mm: 95%CI, 2.58-4.34mm, p <0.001 compared to non-mobile fractures 1.52mm: 95%CI, 0.84-2.21 mm, p <0.001. Pain/Mobility: At baseline (on 10-point scale) CF group pain score of 7.7 points, similar to IBTF group 7.5 points. On average, CF group had post-op improvement of 3.0 points; IBTF group improved to 3.3 points.	"Both techniques resulted in significant vertebral body height and pain improvement. Procedure and adverse event data demonstrated safe curette use in conjunction with balloon kyphoplasty procedures."	Data suggest comparable LBP and ambulation status but not sham or comparable controls.
Tutton 2015 (score =5.0)	Kyphoplasty	RCT	No sponsorship mention. COI, one or more of the authors have receive or will receive benefits for personal or professional use.	N=300 Osteoporotic Vertebral Compression Fractures (VCF).	Mean age: 75.6 years; 89 males, 211 females.	Treatment group KIVA (n=153): a small implant that is delivered through a single, small diameter incision to the vertebral body. PMMA cement is then injected through a small slots in the implants. The endpoint was at 12 month, including reduction in pain by 15 mm vs. Control	Follow up at 7 days, 30 days, 6 months, and 12 months.	VAS scores among the 284 Vertebral Augmentation treatment improved significantly over baseline in both groups after 12 months (Kiva: 70.8 ± 26.3; and BK: 71.8 ± 23.5). ODI scores also improved significantly at 12 months over baseline in both groups (Kiva: 38.1 ± 19.8; and BK: 42.2 ± 21.7).	"The KAST study successfully established that the Kiva system is noninferior to BK based on a composite primary endpoint assessment incorporating pain-, function-, and device-related serious adverse events for the treatment of VCFs due to osteoporosis."	Data suggest KIVA has comparable efficacy to BK

						group Balloon kyphoplasty (n=147): including bone tamps, bone filler devices, and cement. The endpoint is also 12 months, including reduction pain by 15 mm.				
Blattert 2009 (score =4.5)	Kyphoplasty	RCT	No industry sponsorship. No mention of COI.	N = 56 osteoporotic patients with 60 fractures; excluded those under age 65	Mean age=74 years; patients sex is not mention.	Kyphoplasty with polymethylmethacrylate (n = 30, PMMA) vs. calcium phosphate cement (n = 30, CaP).	Follow-up at 6 weeks, and 3, 9 and 12 months.	Mean VAS pain ratings (pre/1 year): A1.3 fractures CaP (7.9/2.1, p <0.05) vs. PMMA (8.2/2.3, p <0.05). A3 fractures CaP (8.2/7.4, p = NS) vs. PMMA (8.1/2.5, p <0.05).	"The routine use of the CaP tested is not currently recommended for kyphoplasty."	Baseline data not well described. Long-term dropout rate unclear. Results worse for CaP A3 fractures. Study does not compare kyphoplasty with sham procedure, non-interventional control, or control group with known success/failure rate.
Chen 2010 (score =4.5)	Kyphoplasty	RCT	No mention of industry sponsorship. None of the authors report any conflicts of interest that could bias nature of this study.	N = 58 females with osteoporotic vertebral compression fractures over 6 months. Also, Patients had chronic back pain over 6 months.	Mean age=69.3 years, 58 females.	Group I: unipedicular kyphoplasty or KP (n = 33) vs. group II: bipedicular KP (n = 25).	Follow up at baseline, and 2 weeks.	Average percentage of height restoration rate 25.84 ±13.79% in unipedicular KP vs. 32.32±10.33% in bipedicular KP. Mean surgery time for each vertebra in group I 33.84±4.02 min vs. 59.39±5.34 min in group II (p <0.001). No statistically significant differences between groups in VAS and ODI scores. Significant statistically scores within groups at pre/2 weeks: mean VAS score: 7.79± 1.27/2.28± 1.31 in group I (p< 0.001), and 7.36± 0.95/2.76 ±0.88 in group II (p< 0.001). The ODI scores 40.94± 4.98/19.85± 6.45 in group I (p <0.001), 39.32±3.08/ 21.32± 4.19 in group II (p< 0.001).	"[C]hronic painful OVCFs should be candidates for KP via both unipedicular and bipedicular approachment and the operation time is shorter via unipedicular approachment. Although the pain relief and physical abilities improvement for the two techniques were not so different in early stage, the bipedicular KP is more efficacious in vertebral height restoration."	Details sparse, older female population, short follow up duration of 2 weeks. Both treatment arms included kyphoplasty, precluding ability to determine efficacy of kyphoplasty.
Kyphoplasty Plus Non-operative Care vs. Non-operative Care Alone										

Wardlaw 2009 (score =6.0)	Kyphoplasty	RCT	Study sponsored and funded by Medtronic Spine LLC. DW received honoraria for consulting from Medtronic Spine LLC and Cryolife, and has received research funding from Medtronic Spine LLC, Zimmer, Apatec, and Cryolife.	N = 300 with 1-3 compression fractures T5-L5, less than 3 month fracture age; included malignancies	Mean age=73.1 years; 68 males, 232 females.	Kyphoplasty plus non-operative care (n = 149) vs Non-operative alone (n = 151). Non-operative care unstructured and included analgesics, bed rest, back braces, physiotherapy, rehab programs, walking aids, vitamin D, calcium, anti resorptive or anabolic agents.	3 and 12 month follow up	Mean improvement in SF-36 physical component improved at 1 month 5.2 points more than for non-operative group (p <0.0001). Differences decreased over time (4.0, 3.2, 1.5 at 3,6,12 months) and not different at 12 months. Roland Morris improved 4.0 pts at 1 moth and 2.6 at 12 months (p <0.0001 and p = 0.0012); 2.9 fewer days of restricted activity per 2 weeks than non-operative at 1 month (p = 0.0004).	"[C]ompared with non-surgical management, balloon kyphoplasty resulted in improvements in quality of life and disability measures and reduction of back pain in patients with acute painful vertebral fractures; however, differences in improvement…. diminished by 1 year."	No sham. Somewhat more multiple fractures in kyphoplasty group (32.9% vs. 23.8%). Heterogeneous and unstructured non-operative care precludes assessment of comparison with specific treatments. Some non-operative treatments more utilized in non-operative group and questionable [e.g., bed rest (42 vs 23%), back braces (20 vs 7%), walking aides (42 vs 24%)], possibly worsening clinical case, potentially confounding results.
Fritzell 2011 (score= 6.0)	Kyphoplasty	RCT, Multicenter Controlled Cost Effectiveness Analysis	Medtronic funds received in support of this work. No conflict of interest (COI).	N = 67 with severe thoracic and/or LBP due to acute or subacute <3 months vertebral compression fracture (VCF), confirmed on MRI. 1-3 fractured vertebrae (Th5–L5), adjacent or separate levels accepted. Above 21 years of age.	Mean age=73 years; 17 males, 50 females.	Balloon kyphoplasty (BKP) using radiographic assistance for all procedures, all fractured vertebrae were stabilized during the same procedure (n = 35) vs Control or standard medical treatment, same medical and functional treatment (n = 32). Primary non-clinical outcome aim was to assess the cost-effectiveness of BKP and primary clinical outcome was Quality-adjusted Life Years (QoL).	Follow up at 1, 3,6,12,18 ,and 24 months.	Mean costs per patient in BKP group was SD = 151,082, and in the control group $40,953. Difference significant, $75,198, 95% CI: 16,037–120,104. EQ-5D after 1, 3, 6, 12, and 24 months in the BKP group were 100%, 97%, 100%, 94%, and 88% and in the control 100%, 97%, 97%, 94%, and 91%.	"In this randomized controlled trial, it was not possible to demonstrate that BKP was cost-effective compared with standard medical treatment in patients treated for an acute/subacute vertebral fracture due to osteoporosis."	Economic analysis of RCT over 2 years. Cost efficacy not described.

Ransta m 2012 (score= 6.0)	Kyph oplast y	RCT	The FREE trial was sponsored and funded by Medtronic Spine LLC. No mention of COI.	N = not specified, at least 1 acute thoracic or lumbar (T5-L5) vertebral fracture with bone marrow signal changes on MRI, vertebral height reduction (>15% predicted vertebral height) vs. adjacent vertebrae.	No mention of patients mean age or sex.	BK performed with introducer tools, inflatable bone tamps, and polymethylmethacryl ate bone cement and delivery devices (n = unknown) vs Non-surgical care received analgesics, bed rest, bracing, physiotherapy, rehabilitation programmers and walking aids (n = unknown)	Follow up at 1 month, and 24 months.	Complete-case analyses were performed on 62%, 64%, 49%, 62%, 54% and 66% of patients for SF-36 PCS, EQ-5D, RMD score, number of days in bed, restricted activity and back pain. Missing response levels; 1 month, 14.5%, 24 months, 28%. 19% missing data during entire period.	"The FREE trial results are robust as the alternative methods used for substituting missing data produced similar results."	2nd report of Wardlaw 2009
Van Meirha eghe 2013 (score 5.0)	Kyph oplast y	RCT	No sponsorship mention. COI, one or more of the authors have received or will receive benefits for personal or professional use.	N=300 patients with 1-3 Vertebral Compressi on Fractures (VCF).	Mean age: 73.2 years; 68 males, 232 females.	Balloon Kyphoplasty (BKP) (n=149): BKP performed (7 days after randomization) by using introducer tools, inflatable bone tamps and polymethylmathacryl ate bone cement and delivery devices. Therapy includes analgesics, bed rest, bracing, and physiotherapy, rehabilitation programs, and walking aids vs. Non-surgical Management (NSM) (n=151): Therapy includes analgesics, bed rest, bracing, and physiotherapy, rehabilitation	Baseline, 1,3,6,12, 24 months. .	Kyphoplaty group on the PCS scale had 5.35 points (95% CI, 3.41–7.30; $P < 0.0001$) more than the non-surgical group at 1 month, and average 2.71 points more during the 2 year-follow up (95% CI, 1.34 − 4.09; $P = 0.0001$).	"Compared with NSM, BKP improves patient quality of life and pain averaged during 24 months and results in better improvement of index vertebral body kyphotic angulation. Perioperative complications may be reduced with more care in patient positioning."	Data suggest BKP decreased pain and improved function at 2 years compared to NSM. However, these were numerous AE's associated with BKP.

						programs, and walking aids. All patients were referred for treatment with calcium and vitamin D supplements and antiresorptive or anabolic agents				
Masoudi 2017 (score =4.5)	Kyphoplasty	RCT	Sponsored by Shiraz University or Medical Sciences. COI, Dr. Ghazal Ilami, Diba Negar for improving the style and English of the article, all patients and families.	N= 70 Paratroopers with stable thoracolumbar fractures presenting <60 days after trauma and hyper intensity in T2 weighted magnetic resonance imaging.	Mean age: 31.56 years; no mention of participants' sex.	Group 1 (n= 34): underwent percutaneous balloon kyphoplasty in the next day elective operating room vs. Group 2 (n= 36): Receive standard thoracolumbar orthosis for 3 months.	Follow up at baseline, 1 3, 6, and 12 months.	VAS score is significantly lower in kyphoplasty group compered to conservative therapy after intervention (P<0.001), 1 month (P<0.001), 3 months (P<0.001), 6 months (P<0.001), and 12 months (P<0.001). After 1 year, kyphoplasty group return to parachute jumping significantly higher than the conservative therapy group (29.4% vs. 5.6%; P=0.011).	"Early kyphoplasty in stable thoracolumbar fractures after parachute jumping is associated with less pain, better functional recovery, less days of absence from work, and shorter duration of returning to parachuting."	Data suggest improved pain and shorter recovery time with early kyphoplasty versus Conservative Management.
Berenson 2011 (score= 4.5)	4.5	RCT	JB and FV have received honoraria (LB), consulting fees (JZ, KS), and (RP) research funding from Medtronic Spine.	N = 134 with cancer and vertebral compression fractures (VCFs)..	Mean age=61.6 years; 59 males, 75 females.	Kyphoplasty with introducer tools, inflatable bone tamps, polymethylmethacrylate bone cement, delivery devices percutaneous, bilateral, transpedicular, or extrapedicular method (n = 68) vs. Control or non-surgical management group with analgesics, bed rest, radiation therapy, orthotic devices and antiresorptive therapy (n = 61).	Follow up at 1, 3, 6, and 12 months.	At 2 weeks: Kyphoplasty group had mean change from baseline in reduced activity caused by back pain of -6.3 days vs. control. For RDQ, 51/63 in kyphoplasty group improved by at least 2 points vs. 14/50 in non-surgical management. At 1 month, 41/63 patients in the kyphoplasty group improved 10 points or more in KPS compared to 13 of 49 improved in the non-surgical management group.	"For painful VCFs in patients with cancer, kyphoplasty is an effective and safe treatment that rapidly reduces pain and improves function."	High dropouts. Patients with cancer.

Boonen 2011 (score =4.0)	Kyphoplasty	RCT	Sponsored and funded by Medtronic Spine, LLC. No mention of COI.	N = 300 with at least one acute thoracic or lumbar (T5-L5) vertebral fracture.	Mean age: 73.156 years; 68 males, 232 females	Balloon kyphoplasty (n = 149) vs Nonsurgical management controls (n = 151).	Patients observed at 1, 3, 6, 12, and 24 months.	At 12 months, 32/121 (26.4%) kyphoplasty vs. 45/107 (42.1%) of controls used nonpharmacologic therapy. At 12 months, 61/118 (51.7%) kyphoplasty used less pain medication vs. 69/101 (68.3%) of controls, p = 0.013. SF-36 PCS score average at 3.24 points, 95% CI 1.47-5.01, p = 0.0004. 24 months, SF-36 bodily pain subscale 9.75 points, 95% CI 5.18-14.3, p< 0.0001. Back pain scored averaged at 24 months -1.49 points, 95% CI -1.88 to -1.10, p <0.0001. Differences significant at all follow-up (-0.80 points, 95% CI -1.39 to -0.20, p = 0.009). Roland-Morris scale with reduced disability -3.01 points, 95% CI -4.14 to -1.89, p <0.0001, (interaction p = 0.0008). Days of limited activity (within 2 weeks) decreased with average -2.04 days, 95% CI -3.57 to -0.51, p = 0.009, at 12 months, and -2.62 days, 95% CI -3.68 to -1.57, p <0.0001, at 24 months.	"[C]ompared with nonsurgical management, balloon kyphoplasty rapidly reduces pain and improves function, disability, and QOL over the course of 2 years without increasing the risk of additional vertebral fractures. Most outcomes are not statistically different at 24 months, but the reduction in pain remains statistically significant at all time points."	Many details sparse. Data suggest kyphoplasty superior to nonsurgical management.
Kyphoplasty vs. Vertebroplasty										
Liu 2010 (score =4.0)	Kyphoplasty	RCT	Supported by grant from Chung-Shan Medical University Hospital (CS08110). No COI.	N = 100 with osteoporotic vertebral compression fractures (T12-L1) over 6 months.	Mean age=73.3 years; 23 males, 77 females.	Balloon kyphoplasty (n = 50) vs Percutaneous vertebroplasty (n = 50).	Patients observed 3 days and 6 months after surgery	Operation time (min): 46.2±4.5 in vertebroplasty vs.44.0±4.4 in kyphoplasty, 1.05 fold, p <0.05. Amount of PMMA (mL): 5.56± 0.62 in vertebroplasty vs. 4.91± 0.65 in kyphoplasty, 1.13 fold, p <0.001. Pre-op vertebral body height (cm): 1.13±0.34 in kyphoplasty and 1.01±0.22 in	"In terms of clinical outcome there was little difference between the treatment groups. Thus, with the higher cost of the kyphotic balloon procedure, we recommend vertebroplasty over kyphoplasty for the	Details sparse, older population. Both arms interventional, precluding assessment of the value of either of them.

				Age 57-88.				vertebroplasty. Post-op (cm): 2.04±0.41 (p <0.001) in kyphoplasty and 1.32±0.26 (p< 0.001) in vertebroplasty. Pre-op kyphotic wedge angle: 17.0±.3 (p <0.001) in kyphoplasty and 15.5±4.2 (p <0.001) in vertebroplasty. Post-op angle: 9.0±5.7 (p <0.001) in kyphoplasty and 12.2±3.6 (p <0.001) in vertebroplasty.	treatment of osteoporotic VCFs."	
Evans, 2016 (Score =5.0)	Vertebroplasty/ kyphoplasty / vertebral compression fracture	RCT	Supported by Carefusion, Cardinal Health and Stryker, Johnson and Johnson DePuy Synthes Spine. One or more of the authors have received or will receive benefits for personal or professional use.	N = 115 patients with vertebral body compression fractures.	Mean age: 75.6±10.0 years; 33 males, 82 females.	Kyphoplasty group: received 16 to 17 weeks kyphoplasty intervention to conservatively treat pain and functional limitations (n = 59) vs. vertebroplasty group: received 16 to 17 weeks vertebroplasty intervention to conservatively treat pain and functional limitations (n = 56).	Follow-up at 3 days, 1, 6, and 12 months.	The overall mean score of pain was 7.7±2.0, no significant difference was found between the two treatment groups (p=0.25). For Roland-Morris Low Back Pain and Disability Questionnaire (RMDQ) score, effect size was -0.04 to 0.18, and no significant difference was found between the two treatment groups (p>0.05).	"[V]ertebroplasty and kyphoplasty appear to be equally effective in substantially reducing pain and disability in patients with vertebral body compression fractures."	Data suggest comparable efficacy.
Beall, 2017 (Score =4.0)	Polyetherethereketone implant/ ballon kyphoplasty	RCT	Supported by Benvenue Medical Inc. One or more of the authors have received or will receive benefits for personal or professional use.	N=285 patients with vertebral compression fractures	Mean age: 75.5 years; 74 males, 211 females.	Implant group: received polyetheretherketone implant included injected cement, sagittal alignment, enhance structural support to improve containment (n=144) vs. BK group: received balloon kyphoplasty with direct inflatable bone tamps to create cavity for bone cement injection (n=141)	Follow-up at 1 years.	Implant group indicated significantly lower risk of having serious adverse events (SAE) readmission, 34.4% lower than BK group (95%CI=11.1 to 51.7; p=0.007). BK group indicated higher proportion of cardiovascular disorder serious adverse event during follow-up, compared to implant group (p<0.041).	"The augmentation approaches compared here have similar pain relief and quality of life effects; the implant showed a lower risk of readmissions."	Data suggest both interventions resulted in improved pain but the risk for a readmission was lower in the vertebral implant groups at 12 month follow-up.

Dohm, 2014 (Score =3.5)										Data suggest comparable efficacy for pain relief and improvement in disability but vertebroplasty took less time and kyphoplasty had fewer cement leakages.
Kyphoplasty vs. Vertebral Augmentation										
Korovessis 2013 (score= 8.0)	Kyphoplasty	RCT, Prospective Parallel-group Controlled comparative trial	No industry sponsorship or COI.	N = 168 with osteoporotic fractures.	Mea age= 70.5 years; 49 males, 119 females.	KIVA (a novel vertebral augmentation technique), sterile, single-use device (n = 82) vs. BK (Balloon Kyphoplasty) K-wires of 2-mm diameter are inserted through both pedicles of the damaged vertebra (n = 86).	1 year follow up.	Significant (>5.5 points) back pain score (VAS) improvement in 44 (54%) and 37 (43%) patients in KIVA and BK groups, respectively. SF-36 improved in 51% and 59% in the patients of KIVA and BK groups, p = 0.95. ODI scores, improved significantly in both groups, p = 0.001.	"Both KIVA and BK restored in short-term similarly vertebral body height, but only KIVA restored vertebral body wedge deformity."	No placebo/sham control. Data suggest comparable (in) efficacy for functional outcome.
Low Quality										
Rebolledo 2013 (score= 3.5)	Kyphoplasty	RCT	No industry sponsorship or COI.	N = 44 with acute vertebral compression fracture causing pain and functional limitations in daily activities, age >50.		Unipedicular group a single dose of first-generation cephalosporin intravenously immediately before surgery (n = 23) vs. Bipedicular group a single dose of first-generation cephalosporin intravenously immediately (n = 21);	12 month follow-up	No differences between Uni- and Bi-pedicular kyphoplasty groups for pre-operative ODI, VAS, RDQ, p = 0.88, 0.95, 0.79. At 3 months post-op both groups improved significantly: ODI, VAS, RDQ; p = 0.85, 0.67, 0.17. Bi-pedicular group showed improvement from 3 months 10.6 points RDQ points, to 12 months 5.9 points, p = 0.008.	"In conclusion we would encourage the use of a unipedicular approach as the preferred surgical technique for treatment of osteoporotic vertebral compression fractures."	Many sparse methodological details.

Werner 2013 (score= 3.0)	Kyphoplasty	Two-armed RCT trials	No industry sponsorship or COI.	N = 100 with 1 or more osteoporotic vertebral compression fractures of thoracic, thoracolumbar, lumbar spine. Mean± SD age 70±13 years.	Mean age=70 years; 25 males, 40 females.	BKP or balloon kyphoplasty with use of Jamshidi needles and working cannulas, general or local anesthesia (n = 50) vs VBS or vertebral body stenting with use of Jamshidi needles and working cannulas, general or local anesthesia (n = 50).	No mention of follow up.	Statistical significance between 2 intervention arms, p = 0.014. Vertebral body stenting was associated with higher pressure during balloon inflation compared to balloon kyphoplasty, 12 to 34 bar, compared to 5.-28 bar.	"No beneficial effect of vertebral body stenting over balloon kyphoplasty was found among patients with painful osteoporotic vertebral fractures with regard to kyphotic correction, cement leakage, radiation exposure time, or neurologic sequelae."	Details sparse. Higher complications in stent group.

SACROILIAC FUSION SURGERY

Sacroiliac joint-related surgical procedures are increasingly performed (2431-2438).

Recommendation: Sacroiliac Surgery for Treatment of Low Back Pain Disorders

Sacroiliac joint fusion surgery and other sacroiliac joint surgical procedures are not recommended for treatment of low back pain disorder.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are two trials with several reports comparing SI joint fusion surgery with non-operative management (2431-2432, 2439, 2440). Both trials excluded patients with worker's compensation (2439). Patients included in the larger US-based study had either SI joint disruption or degenerative SI joints (2431), but only had degenerative disease in the European study (2440). Neither of the two trials included a functional restoration program with progressive aerobic and strengthening exercises combined with CBT or sham-control (1973, 1974, 2030). Yet, in treatment of LBP, the analogous procedure of lumbar fusion has been shown to be ineffective compared with a quality rehabilitation program (see Lumbar Fusion section). There also are SI joint fusion case series (2433). Thus, there are no quality trials comparing SI joint fusion with a quality rehabilitative program.

The two moderate-quality RCTs suggest improved pain and function, but the comparison groups' treatments are ill-defined exercise and neither routinely incorporated CBT (2431, 2440). Prior studies of SI joint fusion reported relatively poor results (one study found that 18% of patients operated on were "satisfied;" 65% required additional surgery) (2194) but used different techniques than the more recent studies. Other surgical series have reported better results with unpublished results as high as 90% good or excellent.(2195-2197) Sacroiliac joint surgery is invasive, has adverse effects (10% of those ambulatory pre-operatively in one recent series using the recent appliances were not fully ambulatory 6mo. post-operatively (2433), is costly, but without quality trials addressing either sham- or quality functional restoration-control, there is no recommendation. SI fusion is a reasonable option for treatment of severe pelvic fractures with or without instability.(68) There may be limited uses for post-traumatic, unstable SI joints that requires further definition in quality studies.

Evidence for the Use of Sacroiliac Surgery

We searched PubMed, EBSCO, Cochrane review, Google scholar without limits on publication dates. We used following search terms: sacroiliac joint fusion surgery, sacroiliac surgery, chronic low back pain, radicular pain, sciatica, and sacroiliitis to find 17026 articles. Of 17026 articles, we reviewed 12 articles and included 9 articles (9 randomized controlled trials and 0 systematic reviews).

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Polly 2015 (score= 4.5)	Sacroiliac Joint Pain	RCT	Sponsored by SI-BONE. Dr. Polly has no financial conflict. Dr. Whang, Dr. Harvey, and Dr. Lockstadt are paid SI-BONE consultants participating primarily in educational events. Dr Frank is an SI-BONE consultant participating primarily in educational events but receives only reasonable expense reimbursement as compensation. Dr Cher and K. Wine are SI-BONE employees.	N = 148 patients with sacroiliac joint dysfunction.	Mean age: 51.32 years; 45 males, 103 females.	NSM (n = 46) – patients received nonsurgical management vs. sacroiliac join (SIJ) Fusion (n = 102) – patients received minimally invasive SIJ fusion with triangular titanium implants.	Baseline, 1, 3, 6, and 12 months	Success rate at 6 months was 81.4% in SIJ group and 26.1% in the NSM group. The Oswestry disability index at 6 months was 73.3% in the SIJ group and 13.6% in the NSM group (p<0.001). Mean SIJ pain score improved from 82.3 at baseline to 30.4 and the 6 month follow up (p<0.001) and 28.3 at the 12 month follow up (p<0.001) in the SIJ group. The mean SIJ pain score improved from 82.2 at baseline to 70.3 at 6 months (p=0.001). The ODI decreased from 57.2 at baseline to 29.9 at 6 months and 28.1 and 12 months in the SIJ group (p<0.001) and the ODI decreased from 56.0 at baseline to 51.6 at 6 months in the NSM group (p=0.06).	"This Level 1 study showed that minimally invasive SIJ fusion using triangular titanium implants was more effective than nonsurgical management at 1 year in relieving pain, improving function, and improving quality of life in patients with SIJ dysfunction caused by degenerative sacroiliitis or SIJ disruptions. Pain, disability, and quality of life also improved after crossover from nonsurgical to surgical treatment."	Baseline differences in smoking status between groups. Most participants were females in both groups. Patients allowed to crossover from NSM to SM after 6 months. Data suggest benefit at 12 months in pain, quality of life, and function in surgical group. Opioids continued throughout study. Allowed unstructured RF and injections in NSM group.
Whang 2006 (score= NA)	Sacroiliac Joint Pain	Nonsurgical management analysis of Polly	No mention of sponsorship or COI.	N = 148 patients with SI joint dysfunction due to degen	Mean age: 51 years; 45 males, 103 females.	Non-surgical management (n=46) – patients received either steroid injections, radiofrequency ablation of the SI joint,	6 months	The six month overall success rates (95% posterior credible interval) by group are 83/102 (81.4%, 72.4-88.4%) in SI Joint Fusion group and 11/46 (23.9%, 12.6-38.8%). The rate difference is 56.6% (41.5-70.0%). The VAS SIJ change from baseline in the NSM and SIJ groups are -13.0 and -49.2	"Six-month follow-up from this level 1 study showed that minimally invasive SI joint fusion using triangular titanium implants was more effective than non-surgical management in relieving pain, improving function and improving	Data suggest SIJ fusion group experienced improved function, pain and quality of life at 6 months.

		et al 2015.		erative sacroiliitis or sacroiliac joint disruptions.		and/or received pain medication for 6 months vs. SI Joint Fusion (n=102) – patients underwent surgery using the SIJ fusion method.		at month 1 (p<0.0001), -18.7 and -56.5 at Mo 3 (p<0.0001), and -12.1 and -52.6 at Mo 6 (p<0.0001), respectively. The Oswestry Disability Index change in ODI score for the NSM and SIJ fusion group are -3.7 and -17.4 at Mo 1 (p<0.0001), -10.3 and -29.5 at Mo 3 (p<0.0001), and -4.9 and -30.3 at Mo 6 (p<0.001).	quality of life in patients with SI joint dysfunction due to degenerative sacroiliitis or SI joint disruptions."	
Dengler 2017 (score=NA)	Sacroiliac Joint Pain	Sub analysis of Polly 2015	Sponsored by SI-BONE. Daniel Cher is an SI-BONE employee. Eddie van Eeckhoven is a clinical trials and regulatory consultant to SI-BONE. Bengt Sturesson, Djaya Kools and Robert Pflugmacher are paid consultants to SI-BONE. No author received direct payment for the study or received any reimbursement or honorarium in any other manner.	N = 103 patients with chronic low back pain originating from the SIJ.	Mean age: 48.1 years; 28 males, 75 females.	CM (n=51) – patients received medical therapy, individualized physiotherapy, and adequate information and reassurance at least twice a week for 8 weeks vs. SIJF (n=52) – patients received SIJ fusion using triangular titanium implants.	1, 3, 6 and 12 months.	The low back pain score in the CM and SIJF group at baseline were 73.0 and 77.7, at month 1 were 66.0 and 35.4, at month 3 were 67.5 and 33.6, at month 6 were 67.8 and 34.4, and at month 12 were 58.9 and 35.2, respectively (p<0.0001 at all data points). At 12 months, mean LBP improved by 41.6 VAS points in the SIJF group vs. 14.0 points in the CM group (p<0.0001). Mean ODI improved by 25.0 points in the SIJF group vs. 8.7 points in the CM group (p<0.0001).	"For patients with chronic LBP originating from the SIJ, minimally invasive SIJF with triangular titanium implants was safe and more effective than CM in relieving pain, reducing disability, and improving patient function and quality of life. Our findings will help to inform decisions regarding its use as a treatment option in this patient population."	1 year follow up results suggesting surgical group had improved pain, function, and disability compared with conservative management group.
Polly 2016 (score=NA)	Sacroiliac Joint Pain	Follow up at 2 years	Sponsored by SI-BONE. David Polly has no	N = 148 patients with	Mean age: 51.3 years; 45 males,	SIJ fusion group (n=102) – patients	1, 3, 6, 12, 18, and 24 months.	By month 6, 84 of 102 SIJF subjects (82%, 95% posterior credible interval [CI] 74-89%) and 12 of	"In this Level 1 multicenter prospective randomized controlled trial, minimally invasive	Suggests sustained benefit form minimally invasive SIJ fusion.

		from Polly et al 2015	financial interest in SIBONE. Peter Whang is a paid SI-BONE consultant participating primarily in educational events. Clay Frank is an SI-BONE consultant participating primarily in educational events, but receives only reasonable expense reimbursement as compensation. Daniel Cher and Kathryn Wine are SI-BONE employees.	SIJ dysfunction.	103 females.	received SIJF with triangular titanium implants. Vs. Non-surgical management (n=46) – patients received intraarticular steroid injections and radiofrequency ablation.		46 NSM subjects (26%, 14-41%) met the study's primary success endpoint. In the SIJF group, the mean SIJ pain score improved from 82.3 at baseline to 30.1 at 6 month follow-up, 28.6 at 12 months and 26.7 at 24 months, corresponding to improvements from baseline of 52.3, 53.7and 55.4 points, respectively (all p<.0001). In the NSM group, mean SIJ pain improved from 82.2 to 70.3 at 6 months.	SIJF with triangular titanium implants provided larger improvements in pain, disability and quality of life compared to NSM. Improvements after SIJF persisted to 24 months."	
Polly 2016 (score= NA)	Sacroiliac Joint Pain	Subgroup analysis of 2 RCTs (INSITE and SIFI)	Sponsored by SI-BONE. David Polly has no financial conflict. Peter Whang is a paid SI-BONE consultant participating primarily in educational events. Clay Frank is an SI-BONE consultant participating primarily in	N = 320 patients with SIJ dysfunction.	Mean age: 61.1 years; 97 males, 223 females.	SIJF (N=274) – patients received SI Joint fusion surgery. Vs. NSM (n=46) – patients received non-surgical management.	6 and 12 months.	At 6 and 12 months, the mean (SD) reductions in VAS SIJ pain were 50.9 (28.6) and 50.8 (29.2) points (both p<.0001 compared to baseline). Relative to baseline, the percent reductions in VAS SIJ pain at 6 and 12 months were 62.8% and 62.9%, respectively. The 6- and 12-month reductions in ODI scores were 24.6 and 25.8 points (p<.0001 for both comparisons vs. baseline); the corresponding percentage reductions were 43.3 and 45.6%, respectively.	"The degree of pain improvement during SIJB did not predict improvements in pain or ODI scores after SIJF. A 50% SIJB threshold resulted in excellent post-SIJF responses. Using overly stringent selection criteria (i.e. 75%) to qualify patients for SIJF has no basis in evidence and would withhold a beneficial procedure from a substantial number of patients with SIJ dysfunction."	Data suggests the amount of pain improvement during SIJB was not predictive for decreased pain or reduced ODI score. Study suggest at 6 and 12 months post SIJB pain rating were about 51 points less with a n ODI reduction of about 25 points (50.9, 24.6).

			educational events, but receives only reasonable expense reimbursement as compensation. Daniel Cher is an SI-BONE employee.							
Dengler 2017 (score=NA)	Sacroiliac Joint Pain	Pooled analysis of 3 SIJF implants (SIFI, INSITE, and iMIA).	SI-BONE Inc. is funding the iMIA trial in support of this work. Relevant financial activities outside the submitted work.	N = 423 patients from the INSITE (n=148), iMIA (N=103), and SIFI (N=172) studies with SIJ dysfunction.	Mean age: 50.4 years; 125 males, 298 females.	Non-surgical management (n=97) – patients received anti-inflammatory and opioid pain medications, physical therapy, intra-articular SIJ steroid injections, and radiofrequency neurotomy. vs. SIJF (n=326) – patients received sacroiliac joint fusion surgery.	2 year follow up data from 2 US completed studies, and 1 year follow up from European RCT.	The adjusted reduction at month 6 in SIJ pain was 37.9 points larger (95% CI 32.5-43.4, p<0.0001) in the SIJF group vs. the NSM groups. Similarly, the improvement in ODI was 18.3 larger (95% CI 14.3-22.4, p<0.0001) and the improvement in E1-5D TTO index was 0.24 points larger (95% CI 0.17-0.30, p<0.0001).	"Our results support the view that SIJF lead to better treatment outcome than conservative management of SIJ pain and that higher margin of improvement can be predicted in non-smokers, non-opioid users, and patients of increased age and with longer pain duration."	Data from 3 trials (2 RCTS and 1 prospective cohort) suggests pain, function, and quality of life improvements were large compared to conservative management.
Duhon 2016 (score=NA)	Sacroiliac Joint Pain	iMIA study prospective cohort 2 year follow-up.	Sponsored by SI-BONE, Inc. Bradley Duhon, Fabien Bitan, Don Kovalsky and Harry Lockstadt conduct clinical	N = 172 patients with SI joint dysfunction.	Mean age: 50.9 years; 52 males, 120 females.	SIJF (n=172) –patients received minimally invasive SI joint fusion with triangular titanium implants.	1, 3, 6, 12, 18, and 24 months.	The mean VAS SI joint pain score (mean improvement form baseline score) at baseline, month 1, month 3, month 6, month 12, month 18, month 24 are: 79.8 (NA), 37.0 (42.7), 30.7 (49.2), 30.0 (49.9), 30.4 (49.3), 28.1 (51.5), 26.0 (53.3), respectively. (p<0.0001 for all time points). The mean Oswestry disability index score	"In this study of patients with SIJ dysfunction, minimally invasive SI joint fusion using triangular titanium implants showed marked improvements in pain, disability and quality of life at 2 years. Imaging	High percent non-compliant with protocol or ineligible but included in analysis. No control or comparison groups.

			research for SI-BONE. Bradley Duhon, Fabien Bitan and Harry Lockstadt are paid consultants to SI-BONE. Travis Hillen worked as a subcontractor to BioMedical Systems, Inc., as an independent core laboratory radiographic reader. Daniel Cher is an SI-BONE employee.					(mean improvement from baseline score) at baseline, month 1, month 3, month 6, month 12, month 18, month 24 are: 55.2 (NA), 42.6 (12.5), 33.8 (21.3), 32.5 (22.7), 31.5 (23.8), 30.9 (24.5), respectively ($p<0.0001$ for all time points).	showed that bone apposition to implants was common but radiographic evidence of intraarticular fusion within the joint may take more than 1 year in many patients."	
Sturesson 2017 (score= 4.5)	Sacroiliac Joint Pain	RCT	Sponsored by SI-BONE. Bengt Sturesson, Julius Dengler, Djaya Kools, Robert Pflugmacher, Domenico Prestamburgo and Alessandro Gasbarrini are investigators in SI-BONE clinical trials. Bengt Sturesson, Djaya Kools and Robert Pflugmacher are paid	N = 103 patients with chronic SIJ pain.	Mean age: 48.1 years; 28 males, 75 females.	SIJF (n=52) – patient underwent SIJF using triangular titanium implants. Vs. CM (n=51) – patients received conservative management consisting of optimization of medical therapy, individualized physical therapy, adequate information and reassurance.	6 months.	At 6 months, mean LBP improved by 43.3 points in the SIJF group and 5.7 points in the CM group (difference of 38.1 points, $p<0.0001$). Mean ODI improved by 26 points in the SIJF group and 6 points in the CM group ($p<0.0001$).	"In patients with chronic SIJ pain, minimally invasive SIJF using triangular titanium implants was safe and more effective than CM in relieving pain, reducing disability, improving patient function and quality of life."	Data would suggest at 6 months there is improved pain function and quality of life. Unclear structure of conservative management variable.

			consultants to SIBONE.							
Dengler 2016 (score= 4.0)	Sacroiliac Joint Pain	RCT	Sponsored by SI-BONE Inc. BS, DK, and RP have received personal fees from SIBONE. JD has received a research grant from the German Federal Ministry of Education and Research via a grant from the Center for Stroke Research Berlin not related to this project. PV has received personal fees from Brainlab and Ulrich medical not related to this project. DP and EE have no conflicts of interest to report.	N = 101 patients with low back pain originating from the sacroiliac joint.	Mean age: 46.8 years; 27 males, 74 females.	CM (n=49) – patients received optimization of medical treatment and at least two physical therapy sessions for at least 8 weeks emphasizing muscle control and trunk stabilization vs. MISM (n=52) – patients received minimally invasive surgical management (sacroiliac joint fusion) using transarticular triangular titanium implants	3 months and 6 months	The changes in the intensity of referred leg pain (RLP) over time VAS at baseline was 51.0 (IQR 17.0–75.0) in CM compared to 58.0 (IQR 24.5–80.0) in MISM ($p = 0.35$). The improved changes in RLP in patients with baseline VAS of at least 20 points after 3 months was 9 in the CM group and 35 in the MISM group ($p<0.01$), and after 6 months was 11 in the CM group and 32 in the MISM group ($p<0.01$)	"Our analysis shows that RLP is a frequent phenomenon in patients with SIJ-associated pain. At 6 months of follow-up, MISM helped relieve RLP more effectively than CM."	Conservative management is not specifically described. Data suggest RLP originating from SIJ improved at 6 months following minimally invasive surgery.

IMPLANTABLE SPINAL CORD STIMULATORS

Spinal cord stimulators (SCSs) deliver electrical impulses to the spinal cord area through electrodes that are implanted by laminotomy or percutaneously.(2198-2201, 2441-2445) Proponents believe that this device is successful via the gate-control theory in which stimulating nerve fibers closes other paths of pain conduction;(2202) however, this mechanism is poorly understood.(2203) (This review includes only evidence concerning indications for treatment of LBP with or without lower extremity pain. The use of SCSs for the treatment of complex regional pain syndrome is discussed in the Chronic Pain Guideline.)

Recommendation: Spinal Cord Stimulators for Treatment of Acute, Subacute, or Chronic Low Back Pain or Radicular Pain Syndromes or Failed Back Surgery Syndrome

Spinal cord stimulators are not recommended for treatment of acute, subacute, chronic low back pain, radicular pain syndromes or failed back surgery syndrome. Indications are provided for highly select circumstances when a worker has primarily radicular extremity pain, all other indicated treatments have failed, the patient has inadequate function, and the provider wishes to seek approval from a worker's compensation carrier for consideration of possible coverage despite the lack of quality evidence of efficacy in these patients.

Indications:	See Table 11.
Benefits:	Potential to improve pain and possibly function.
Harms:	Medicalization, paralysis, higher opioids use, fatalities. One-third of patients reportedly have adverse effects [396].
Frequency/Dose/Duration:	N/A
Indications for Discontinuation:	Resolution of pain, complications necessitating discontinuation of therapy or device removal, or loss of therapeutic effect.

Strength of Evidence – **Not Recommended, Insufficient Evidence (I)**
Level of Confidence – Low

Rationale for Recommendation

There are few quality studies evaluating SCS for the treatment of LBP, none of which compared SCS with a non-surgical treatment such as a quality multi-disciplinary rehabilitation program or a sham procedure.(2204, 2205) Problems with study design have been noted for many years (2207, 2446), but to date have not been addressed in quality studies.

Reports with worker's compensation patients include a controlled, 2-year cohort study of workers' compensation patients in Washington State which found a low success rate, lack of long-term benefits, and increased opioid use among those receiving stimulators. (2207) Cost effectiveness was also not shown in Washington State (2447), resulting in a decision to not cover the procedure for worker's compensation patients (2207).[15] Others have opined worker's compensation results in worse outcomes (2204, 2402).

One moderate-quality study showed reduced pain ratings by 6 and 12 months after implantation, but improvements diminished over time.(2204) One study of SCSs for complex regional pain syndrome also found diminished differences over time – SCS recommendations for the treatment of complex regional pain syndrome Type I are addressed in the Chronic Pain Guideline.(2206) A recent RCT found better efficacy with high-frequency stimulation than with traditional SCS, but had no sham- or functional restoration-controlled arm, similar to the weaknesses of prior studies (2448).

A non-RCT of 40 patients with chronic LBP with intractable leg pain attempted to determine whether operating when the patient was awake and able to provide feedback would improve outcomes.(2208) Leg scores pre-operatively at 6 months were 7.38, 4.18, 5.55, and 6.27. Total pain scores were 69.11, 54.79, 58.64, and 63.01. There appears to be a lack of lasting benefit.

Spinal cord stimulators are costly (2442),[16] invasive, have reported serious complications (including surgical procedures for loose leads, repairs, and surgical removal of the devices), and have a significant revision rate.(2209, 2210) Without quality evidence of enduring efficacy compared with either sham-control or a quality functional restoration program, SCS is not recommended. Potential indications are provided in Table 11 in the event that there is a patient with predominant radicular pain, unamenable to surgery, with inadequate function after complying with functional restoration program components for at least 6 months who wishes to seek potential approval from a worker's compensation insurer.

Evidence for the Use of Implantable Spinal Cord Stimulators

We searched PubMed, EBSCO, Google Scholar, and Cochrane Review with no limits on publication dates and then an updated search was conducted using PubMed for publications between 1/1/2013 and 11/15/2017. We used the following search terms: Spinal cord stimulator, spinal cord stimulation,) sub-acute low back pain, chronic low back pain, radicular pain syndromes, sciatica, back, and random to find 9106 articles. Of the 9106 articles, we reviewed 31 articles and included 31 articles (9 randomized controlled trials and 22 systematic reviews).

[16] A cost-effectiveness analysis from Canada has been used to support cost-effectiveness of SCS. The cost analyses for conservative care included annual, 3-day hospitalizations for breakthrough pain ($9,405 total), 24 annual visits with a family physician, and physician therapy charges over 5 years (estimated at $8,680). Five-year costs were estimated at $28,123 SCS versus $38,029 for conservative care. Hospitalization for breakthrough pain ($9,405) is highly unusual in the U.S., and without that expense (without consideration of the other unusual numbers of visits), the fiscal advantage of SCS completely disappeared. As the study contains unusual assumptions and elimination of hospitalization causes the purported fiscal advantage of the SCS to disappear, the conclusions of this study do not appear applicable to typical U.S. patients. A second cost-effectiveness estimate in the United Kingdom reported approximately 4.8-fold higher costs in those receiving SCS (2442). Neither study had surgical costs reasonably close to US costs.

Table 11. Selection Criteria for Implantable Spinal Cord Stimulator in a Chronic Radiculopathy Patient*

1. Clear diagnosis of chronic radiculopathy including supportive evidence on electrodiagnostic study. Leg pain should predominate over axial back pain (2449)
2. Poor or inadequate response to surgical treatment such as discectomy.
3. Poor or inadequate response to functional restoration program with treatment generally for at least 6 months.** Program shoud have been in an experienced interdisciplinary clinic with proven good outcomes that included core, emphasized elements of progressive aerobic exercise, strengthening, and cognitive behavioral therapy, and for which the patient demonstrated good compliance.
4. Remedial surgery inadvisable or not feasible.
5. Major psychiatric disorders have been treated with expected responses. Somatization disorder not amenable to treatment disqualifies the patient for use of invasive procedures, as the risk of the procedure is higher than the expected success rate. The candidate should have a successful independent, psychological evaluation and a structured interview performed by a psychologist specialized in chronic pain management including appropriate psychometric testing (see Chronic Pain guideline, Appendix 1). The psychological evaluation should be performed by a practitioner who is not employed by the requesting or treating physicians.***
6. Willingness to stop inappropriate drug use before implantation.
7. No indication that secondary gain is directly influencing pain or disability complaints.
8. Ability to give informed consent for the procedure.
9. Successful results of at least 50% pain reduction from a trial of a temporary external stimulator of approximately 2-3 days and reduction of use of opioid medication or other medication with significant adverse effects or functional improvement such as return to work that may be evaluated by an occupational or physical therapist prior to and before discontinuation of the trial.

*Adapted from Kumar K, Hunter G, Demeria D. Spinal cord stimulation in treatment of chronic benign pain: challenges in treatment planning and present status, a 22-year experience. *Neurosurgery*. 2006;58(3):481-96(; Lee AW, Pilitsis JG. Spinal cord stimulation: indications and outcomes. *Neurosurg Focus*. 2006;21(6):E3[38]; Segal R, Stacey BR, Rudy TE, et al. Spinal cord stimulation revisited. *Neurol Res*. 1998;20(5):391-6.(873)

**Some authors advocate earlier intervention,(37, 859); however, quality evidence is lacking.

***Presence of depression is common in patients with chronic pain, requires evaluation and may require treatment. Depression that is particularly severe may require treatment prior to assessing appropriateness of SCS, however, the presence of depression does not preclude SCS.

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
SCS - Management Arm										
Schu 2014 (score=7.0)	Spinal Cord Stimulators	RCT	Sponsored by St. Jude Medical. COI, Drs. Schu and Vesper, Slotty, and Bara.	N=20 Patient with Failed back surgery syndrome and preexisting spinal cord stimulation system.	Mean age: 58.6 years; 7 males, 13 females.	Group 1: received tonic stimulation at a frequency of 500 Hz (subsensory amplitude; period of one week vs. Group 2: received burst stimulation—packets of five pulses (pulse width 1 msec) at 500 Hz, delivered 40 times per second (subsensory amplitude); period of one week vs. Group 3: placebo stimulation, where no stimulation was programmed (the device was switched off) period of one week. All groups received all three treatments	Follow up at 1, 2, and 3 weeks.	Pain Quality (SFMPQ ± SD) at baseline (5.6 ± 1.7), 500-Hz Tonic (7.1±1.9), Burst (4.7± 2.5), Placebo (8.3±1.1). Burst stimulation preferred over all other methods (Fisher's exact test, p=0.0004).	"The study found that burst stimulation resulted in significantly better pain relief and improved pain quality in the short term compared with 500-Hz tonic stimulation and placebo stimulation."	Very small sample (n=20). Burst stimulation better for short term pain relief s. 500-Hz tonic stimulation or placebo.
Kumar 2007 (score=6.5)	Spinal Cord Stimulators	RCT	All logistical aspects of study managed and funded by Trial Steering Committee that consisted of four external advisors and two representatives from Medtronic Inc.	N = 100 with radicular pain syndrome symptoms required to primarily have lower extremity pain from any of L4-S1 nerve roots.	Mean age= 49 years; 21 males, 79 females.	SCS (n = 52) vs. Conventional medical management arm (CMM, n = 48). Both groups' medical management "actively managed" and included NSAIDs, anti-	Follow up at 6 month, and 12 months.	At 12 months, 16 of 48 (25%) randomized to CMM remained in that arm, while 28 crossed over to SCS; 5 in SCS group crossed over to CMM. At 6 months, 9% of CMM	"[C]ompared with the CMM group, the SCS group experienced improved leg and back pain relief, quality of life, and functional capacity, as well as greater treatment satisfaction."	No sham. Compared SCS added to medical management. Medical management unstructured and appears to have many co-interventions. High cross overs and compliance rate in

						depressants, anticonvulsants, other analgesics, nerve blocks, epidural corticosteroids, physical and psychological rehab therapy, and/or chiropractic care. Long-term follow-up at 12 months.		group and 48% of SCS group had at least 50% pain relief. By 12 months, per-protocol analyses showed 34% of SCS group and 7% of CMM group achieving at least 50% pain relief.		CMM arm so low at 1 year (33%), questions result. Unclear if CMM interventions different from prior care and thus potentially biased in favor of SCS. CMM appears to have not consisted primarily of multidisciplinary program emphasizing aerobic and strengthening exercises plus psychological interventions. Reduction in numbers with 50% pain reduction at 12 months (from 48% to 34%) suggests benefits may not be long term.
Manca 08	N/A	2nd report of Kumar 07	See above.	N=100, same as above.	See above.	See above.	See above.	See above.	"The addition of SCS to CMM…results in higher costs to health systems but also generates important improvements in patients' EQ-5D over the same period."	Data suggest ~4.8-fold higher costs with SCS. Study outcomes limited by original design. Subjective improvement in EQ5D compared with conventional medical management (see above).
North 2016 (score=4.0)	Spinal Cord Stimulators	2x2 Crossover RCT	Sponsored by Boston Scientific. COI, Dr. Rauck, Drs. North, Hong, and Captain Cho.	N= 22 Patients with Spinal Cord Stimulation.	Mean age: 57.3 years, 14 males, 8 females.	Group A (n=11): received 1 kHz subperception stimulation followed by paresthesia-based stimulation. Treatment lasted	7 week follow up.	NPRS scores: treatment effect of subperception stimulation was significantly greater than paresthesia	"In conclusion, the current findings suggest that 1 kHz subperception stimulation is an effective alternative for subjects with failed	Small sample, Subject blinding not addressed. Data suggest NPRS scores were lower with sub perception stimulation compared to

						3 weeks, with a 7-10 day washout period between treatments vs. Group B (n=11): received paresthesia-based stimulation followed by 1 kHz subperception Stimulation. Treatment lasted 3 weeks, with a 7-10 day washout period between treatments		based stimulation on ODI scores (p=53.9737 x 10^{-5}) and PGIC scores (p=53.0396 x 10^{-5})	paresthesia-based stimulation."	paresthesia-based stimulation.
SCS - Surgery										
North 2005 (score=5.5)	Spinal Cord Stimulators	RCT	No mention of COI or industrial sponsorship.	N = 50 with surgically remediable nerve root compression, concordant persistent or recurrent radicular pain, with or without LBP, after ≥1 lumbosacral spine surgeries	Mean age= 50.2 years; 30 males, 30 females.	SCS (N = 24) vs. repeated lumbosacral spine surgery (N = 26); 3 years follow-up. Surgery individualized and included discectomy (n = 9 refused, n = 15 accepted), laminectomy (28/47), foraminotomy (24/40), fusion (10/11), and instrumentation (9/12).	6 month follow up.	Long-term success rates at 2.9±1.1 years: SCS 9/19 (47%) vs. reoperation 3/26 (12%).	"[S]CS is more effective than reoperation as a treatment for persistent radicular pain after lumbosacral spine surgery, and in the great majority of patients, it obviates the need for reoperation."	Study evaluated SCS vs. re-operation. No quality rehabilitation control. As inclusion criteria required failed surgery, the study design is potentially comparing SCS to "more of the same" and thus may be biased in favor of SCS.
HF10 Therapy vs. Traditional SCS										
Kapural 2015 (score=4.5)	Spinal Cord Stimulators	RCT	Sponsored by Boston Scientific, Medtronic, and St. Jude Medical, Nevro Corp. COI, Drs., Kapural, Yu, Vellejo, Amirdelfan, Brown, and Benyamin.	N=198 patients with both back and leg pain.	Mean age: 54.9 years, 78 males, 120 females.	Group 1 (n=101) 10-khz High-Frequency Therapy (HF10 therepy): received 30 µs pulses delivered at 10,000 Hz with amplitude adjusted to	Follow up at baselin3, 6, and 12 months.	Baseline Mean back pain VAS decreased from 7.4 ± 1.2 to approx. 2.5 over 12 months with HF10 therapy compared with a decrease	"HF10 therapy promises to substantially impact the management of back and leg pain with broad applicability to patients, physicians, and payers."	No blinding. Data suggest HF 10 groups had better response for both back and leg pain than SCS group at 3 months and was largely sustained at 12 months. 50% of baseline outcomes

						optimal analgesic response, intraoperative testing and programming were not needed vs. Group 2 (n=97): Spinal Cord Stimulation (SCS) group: Paresthesia testing and associated device programming were performed intraoperatively for control subjects.		from 7.8 ± 1.2 to approx 4.3 for traditional SCS. Baseline Mean leg pain VAS decreased from 7.1 ± 1.5 at baseline to approx. 2.1 (a over 12 Months with HF10 therapy and from 7.6 ± 1.4 to approx. 3.8 with traditional SCS.		measures (e.g., ODI scores) not provided. No placebo group. Data suggest HF modestly superior, but opioid use only 19% lower with HF and ODI improved 16.5U.
Kapural 2016 (score=NA)	Spinal Cord Stimulators	Secondary analysis of Kapural 2015.	Sponsored by Nevro Copr. No mention of COI.	N = 179 patients with both back and leg pain.	Mean age: 54.89 years; 71 males, 108 females.	Group 1 (n=92) 10-khz High-Frequency Therapy (HF10 therepy): received 30 µs pulses delivered at 10,000 Hz with amplitude adjusted to optimal analgesic response, intraoperative testing and programming were not needed vs. Group 2 (n=87): Spinal Cord Stimulation (SCS) group: Paresthesia testing and associated device programming were performed intraoperatively for control subjects.	24 month follow up	At 24 months more subjects responded to HF10 therapy compared to traditional SCS - Back pain: 76.5% vs 49.3% (Difference = 27.2%, 95% CI (10.1%-41.8%), p < 0.001 for non-inferiority and superiority, Leg pain - 72.9% vs 49.3% (Difference = 23.6%, 95% CI (5.9%-38.6%), p < 0.001 for non-inferiority, p = 0.003 for superiority). Back pain decreased - HF10 therapy (66.9% ±	"This study demonstrates long-term superiority of HF10 therapy compared with traditional SCS in treating both back and leg pain. The advantages of HF10 therapy are anticipated to impact the management of chronic pain patients substantially.	Data suggest at 24 months, previous gains were mostly maintained in HF-10 group for both leg and back pain over traditional SCS.

								31.8%), traditional SCS (41.1% ± 36.8%, p < 0.001 for non-inferiority and superiority).		
Re-operation vs. SCS										
North 1994, 1995 (score=3.5)	Spinal Cord Stimulators	RCT	N = 27 with failed back surgery syndrome			SCS trial (percutaneous placement of temporary electrode for 2-2.5 days, n = 12) vs. re-operation (n = 15).		Ten of 15 (67%) surgical patients opted to crossover to SCS at 6 months vs. 2 of 12 (17%) SCS patients.	"[T]he role of spinal cord stimulation can be expanded, as an alternative to reoperation."	Small sample sizes. Patients not well described.

Rehabilitation for Delayed Recovery

If an individual fails to recover within the appropriate biological healing timeframe, the acute care paradigms of specific diagnosis and treatment change to biopsychosocial approaches that address pain, function, work, and psychological distress that impede progress. Such programs focus on restoration of work-related function. These programs include work conditioning, work hardening, functional rehabilitation, behavioral interventions, chronic pain programs, and other interdisciplinary approaches. They may also include education about risk/rewards of declined surgical procedures.(553)

Initiation of these programs should be considered in the subacute stage if disability is not adequately explained by physical findings (see Chronic Pain Guideline). Chronicity by itself is a major predictor of poor outcome.(2214) The longer it takes to resolve the disability (delayed recovery), the higher the cost, the less likely patients are to return to work at all, the greater the risk for costly medical care, and the greater the likelihood for costs to be shifted from the workers' compensation system to other payment systems (e.g., long-term disability, Social Security Disability Insurance). The increased costs of rehabilitation programs may be justified by cost benefit analysis of program outcomes. Consistent with the above, earlier intervention should be considered.

See the recommendations in the Chronic Pain Guideline for the following:

- Work Conditioning, Work Hardening, Early Intervention Programs, and Back Schools for Chronic Pain
- Interdisciplinary Pain Rehabilitation Programs, Multidisciplinary Rehabilitation Programs, Chronic Pain Management Programs, and Functional Restoration Programs
- Participatory Ergonomics Programs for Patients with Chronic Pain
- Psychological Evaluation for Chronic Pain Patients
- Cognitive Behavioral Therapy for Patients with Chronic Pain
- Fear Avoidance Belief Training
- Biofeedback

Appendix 1: Low-Quality Randomized Controlled Trials

The following low-quality randomized controlled studies (RCTs) were also reviewed by the Evidence-based Practice Spine Panel to be all inclusive, but were not relied upon for purposes of the development of this document's guidance on treatments because they were not of high quality due to one or more errors (e.g., lack of defined methodology, incomplete database searches, selective use of the studies and inadequate or incorrect interpretation of the studies' results, etc.), which may render the conclusions invalid. ACOEM's methodology requires that only moderate- to high-quality literature be used in making recommendations.(9)

FUNCTIONAL CAPACITY EVALUATIONS

Author/ Year	Score (0-11)	Study Design	Population/ Case Definition	Investigative Test	Gold Standard/ Comparative Test	Results	Conclusion	Comments
Brouwer 2003	3.5	Diagnostic	N = 30 (24 males, 6 females) with chronic LBP selected for rehab working or <1 year out of work due to chronic LBP, mean age 40±8.1 years, LBP duration 5-10 years, 15 (50%) out of work, all receiving compensation out of work mean 17±19.2 weeks.	Isernhagen Work System (IWS) functional capacity evaluation (FCE) modified; 2, 2 weeks apart	Compared to self	Test-retest reliability of material-handling tests and shuttle walk test (intraclass correlation – ICC, 95% CI of ICC): lifting in kg (0.81, 0.63 to 0.91), overhead lifting in kg (0.87, 0.73 to 0.94), short carry 2-handed in kg (0.81, 0.63 to 0.91), long carry 2-handed, kg (0.81, 0.62 to 0.91), long carry right-handed, kg (0.81, 0.63 to 0.91), long carry left-handed, kg (0.81, 0.63 to 0.91), pushing static, kg (0.75, 0.53 to 0.88), pulling static, kg (0.78, 0.58 to 0.89), walking, meters (0.84, 0.67 to 0.93). Of all 28 test items overall: ICC values, 11 of 18 tests (61%) acceptable reliability; kappa values and percentage of absolute agreement, 15 of 19 tests (79%) showed acceptable agreement.	"Test-retest reliability of 15 tests (79%) of the modified IWS FCE was acceptable based on kappa values and percentage of absolute agreement. For 11 tests (61%), test-retest reliability was acceptable based on the ICC values."	Data suggest that FCEs done by Isernhagen Work Systems can be reliable from one test day to another. However, they do not make any correlation between the results and clinical outcomes.
Cheng 2010	3.5	Diagnostic	N = 713, mean age 41.6 (10.5) years, 60.5% male, 39.5% female. Had LBP for >3 months without any definitively identified and precise pathoanatomical diagnosis.	Job-specific FCE determined after hierarchical task analysis guided by modified Dictionary of Occupational Titles Physical Demand Questionnaire.	All contacted 3-months post FCE and interviewed concerning current employment status.	Agreement between RTW recommendation and 3-month employment status: change job – 146 vs. 204 (71.6%); previous job – 275 vs. 243 (88.4%); prior job with modification – 164 vs. 38 (23.2%); do not seek work at moment – 60 vs. 160 (37.5%) (p <0.0001 all values). Only 3 variables sig. in predictive validity of job-specific FCE: days from injury – OR = 0.632, 95% CI = 0.563-0.871; compensability – OR = 0.51, 95% CI = 0.33-0.79; heavy physical job demand level – OR = 0.527, 95% CI = 0.233-0.817.	"Job-specific FCE shows a high level of predictive validity that could be used to evaluate the employment status of patients with nonspecific chronic LBP."	Data suggest duration of the injury, compensability and a heavy demand job all impact outcomes in return to work after FCE.

ROENTGENOGRAMS (X-RAY)

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of X-rays	CT used	MRI used	More than One Rater	Blinding of rater	Myelography	Surgery performed	Clinical Outcomes Assessed	Long term follow-up	Results	Conclusion	Comments
Deyo 1987 Diagnostic	3.5	101	Lumbar	LBP	Lumbar roentgenograms	-	-	-	-	-	-	+	3 weeks or 3 months follow-up	Severe pain rate on x-ray group vs. education: 53% vs. 31% (p = 0.03). Proportion who agreed "everybody with bak pain should have x-rays" at index visit and follow-up on roentgenograms vs. educational: 56% and 73% vs. 47% and 44% (p = 0.02)	"[O]ur experimental study supported our hypothesis, suggesting that the educational intervention would maintain patient satisfaction and provide adequate reassurance."	Suggest x-rays unnecessary for non-specific LBP and education by provider as efficient and causes less harm and cost less vs. lumbar radiographs in patients with chronic back pain.

MAGNETIC RESONANCE IMAGING (MRI)

Author/Year Study Type	Score	Number	Area of Spine	Diagnoses	Type of MRI used	Type of CT used	T1 weighted images	T2 weighted images	X-ray	Myelography	More than one rater	Surgery Performed	Clinical outcomes	Long term follow-up (mean when noted)	Results	Conclusion	Comments

Jarvik 2003 Diagnostic	3.5	380	L	Primary care LBP patients	1.5T, 0.3T, 0.35 T	-	-	+	+	-	-	+	+	12 months	After adjusting for baseline modified Roland score and study site, 12- month Roland Scale score in radiograph group 8.75 vs. 9.34 in rapid MRI, not clinically or statistically significant (mean difference -0.59; 95% CI -1.69 to 0.87; p = 0.53). Mean cost of health care services higher among patients randomized to rapid MRI than radiograph ($2,121 vs. $1,651, respectively).	"Rapid MRIs and radiographs resulted in nearly identical outcome for primary care patients with low back pain."	Baseline differences between x-ray and rapid MRI group could have affected outcomes. Data suggest using rapid MRI in place of x-ray in primary care patients results in no longer term difference in disability, pain or general health status. However, rapid MRI group trended towards more surgical interventions. Follow-up at 12 months. Suggests rapid MRI does not significantly change clinical outcome over radiographs, but increases costs.
Chang 2011 Diagnostic	N/A	13	L	Lumbar foraminal stenosis	1.5 Tesla version B15	-	+	-	-	-	-	+	+	1 year	Sensitivity and specificity of sagittal sign: 77% and 43% respectively. Sensitivity and specificity of root-lift-up sign: 92% and 60% respectively, better ability to diagnose foraminal stenosis, p <0.046.	"Thin-slice coronal MRI was helpful in the imaging diagnosis of this disease."	Small numbers limit findings.

Hsieh 1999 Diagnostic	N A	10 + 2 cont rols	L	Lumbar far lateral disc (FLD) herniation	0.5 tesla	-	-	-	-	-	-	+	+	1 year	Diagnostic accuracy: MRI only, 60% 3D images with single-axis cross sections, 90% for 3D images with multiaxis cross sections. No diagnostic imaging findings of FLD seen in 2 controls. Surgical diagnosis matched MRI diagnosis for all 10 patients.	"[M]ultiaxial 3D MR imaging markedly increases image resolution and, therefore, appears to be a useful diagnostic tool."	Too small numbers to evaluate.

MYELOGRAPHY

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of Myelography used	CT used	MRI used	X-rays used	More than one Rater	Blinding of rater	Surgery Performed	Clinical Outcomes Assessed	Long-term Follow-up	Results	Conclusion	Comments
Kebede 2010 Diagnostic	3.0	N = 1688	L	Low back pain	Lumbar Myelography	-	-	+	-	-	-	-	-	1073(63.6%) had abnormal myelography. Remainder normal. Most abnormals, disc prolapse (57.7), majority were found L4-L5 and L5-S1. 21.7% of abnormalities due to disc bulge and 15.2 % due to canal stenosis.	"The myelogram best shows whether the changes seen on MR images result in nerve root compression or obstruction. Since myelographic procedure is invasive and not without attendant complications, proper diagnostic clinical triage should first be well taken before subjecting patients to the procedure."	Data suggest some limited utility for myelography. No comparison in study. No specific diagnosis given in study. Unable to draw conclusions on imaging as no comparison and no direct contact with patients.

SURFACE ELECTROMYOGRAPHY

Author/Year Study Type	Score	N	Area of Body	Surface EMG (Type)	Needle EMG used for comparison	MRI	CT	X-ray	More than one rater	More than one muscle group tested	Surgery Performed	Long term follow-up (mean when noted)	Results	Conclusion	Comments
Ahern 1988 Comparative case-control	3.5	80	L	Surface EMG	-	-	-	-	-	-	+	No	Patients showed average of 27° lumbar flexion compared to 52° in controls. Analysis of FI found 57.5% showed no flexion/relaxation response, vs. 7.5% in controls. (p >0.05). Statistically significant differences between patients and controls for trunk rotation (p <0.01).	"Although the two groups did not differ on absolute levels of EMG during quiet standing, significant differences were found for EMG patterns during dynamic postures. In addition, most patients did not show the flexion-relaxation response or the expected pattern of EMG responses during trunk rotation, most likely because of restricted range of motion and/or compensatory posturing."	Baseline differences in weight (p <0.03). Lack of baseline characteristics including if controls ever had LBP. Data suggest different muscle activity and inactivity patterns in chronic LBP patients vs. controls. Electrodes placed L3-4, L4-5. Data suggest patients with CLBP move/activate muscles differently when moving vs. controls. This can help in developing rehab programs.
Lariviere 2008 Cross-Sectional Study	3.0	73	Multifidus at L5, Iliocostalis and Longissimus	Surface EMG	-	-	-	-	+	+	-	No	EMG fatigue indices based on EMG amplitude showed non-significant correlations at L5, L3 and L1. However, EMG at T10 showed significant correlations with first 5 minutes (r = -0.45, p = 0.000) and 10 minutes (r = -0.44 p = 0.000) of data. Correlation between activation levels and NIMNFslp across 4 electrode levels significant (r = -0.40, p = 0.000).	"The EMG indices assessed in the present study are conventionally used to assess fatigue and were consequently more correlated to absolute endurance than to strength."	Study suggests that surface EMG could possibly aid in rehabilitation after injury. Further studies are needed in patients with back pain and in rehabilitation that include outcome measures to show efficacy
Huppertz 1997 Diagnostic	N/A	133	Abductor pollicis brevis muscle	High spatial resolution electro-myograp	-	-	-	-	-	-	-	No	High spatial resolution EMG able to assign correct diagnosis to about 81% of patients. Sensitivity for detection of abnormal 82%	"A diagnostic evaluation procedure calculating automatically the most probable diagnosis from the parameter results could	Data suggest HSR-EMG can recognize myopathic disorders at similar sensitivity and specificity as needle EMG in abductor

				hy (HSR-EMG) (surface EMG) of abductor pollicis brevis									with specificity of 97% and positive prediction of 97%. Myopathic disorders had sensitivity of 85% with specificity of 97% and positive prediction of 92%. Neuropathic disorders recognized with sensitivity of 68%, specificity of 98% and positive prediction of 91%. Needle EMG recognized 97.8% of myopathic and 98.9% of neuropathic alterations.	assign the correct diagnosis to about 81% of the investigated patients and healthy subjects. Myopathic disorders were recognized with a sensitivity of 85% (specificity: 97%), neuropathic disorders with a sensitivity of 68% (specificity: 98%)."	pollicis brevis muscle. EMG on neuromuscular disease.
Chisari 2001 Diagnostic	N/A	39	Tibialis anterior	Surface EMG	-	-	-	-	-	-	-	No	Significant difference found between myotonic dystrophy (MyD) group and control group. For normalized ARV values in MyD group vs. control group ($p < 0.05$). After 5, 15 and 30 seconds EMG stimulation at 15Hz, (p 0.05) in MyD vs. control.	"..May evaluate the spontaneous evolution of myopathy in order to understand the relationship between myotonia and dystrophy."	Patients had diagnosis of myotonic dystrophy.
Lindeman 1999 Diagnostic	N/A	82	Proximal leg muscles	Surface EMG	-	-	-	-	-	-	-	No	Maximum voluntary contraction (MVC) lower in both patient groups than controls and Myotonic dystrophy (MyD) had lower knee torque than Charcot-Marie-Tooth (CMT) disease patients ($p = 0.005$).	"We found that measurements of knee extension torques in combination with SEMG revealed quite a number of significant differences between our patient groups and normal controls."	Patients had diagnoses of myotonic dystrophy and Charcot-Marie- Tooth disease. Neuromuscular patients.
Roy 1998 Diagnostic	N/A	24	Paraspinal	Surface EMG	-	-	-	-	-	?	-	No	Back muscle biopsies taken in earlier study and fiber type percentages compared with surface EMG percentages. Close correlation between data ($r = 0.88$-0.95). Intraclass correlation coefficients for data from iliocostalis lumborum muscle 0.93 for IMF and 0.80 for MF slope.	"Further research and development are needed to accomplish the long-term objective of providing assessment procedures to clinicians."	Small numbers. Data suggest with additional technology and research surface EMG may assist in providing assessment for LBP patients, yet impact on outcomes not shown.

Thompson 1989 Diagnostic	N/A	5	Neck and back	Hand-held surface EMG machine	-	-	-	-	-	-	-	No	Surface EMG signal found to have standard error <5% when averaging all sites. 95% of muscle sites scanned required <5 data points (<10 seconds) to reach <5% standard error level.	"The stability of the EMG signal detected by hand-held post-style electrodes is satisfactory."	Very small number of "healthy volunteers." No baseline characteristics given. Conclusions difficult to draw because of lack of details.
Meyer 1989 Diagnostic	N/A	43	Biceps Brachii	Surface EMG	-	-	-	-	-	-	-	No	Mean muscle contraction velocity of controls was 4.4m/s with SD of 0.44m/s. vs. group with duschenne	"The method of multichannel surface EMG can demonstrate how MUPs propagate along the muscle axis…The few clinical applications have shown that the method contributes to research and diagnosis of neuromuscular disease."	Sparse details on patients examined. Uncertain as to what area of body is being examined. EMG in neuromuscular diseases.
van der Hoeven 1994 Diagnostic	N/A	89	Biceps brachii	Surface EMG	+	-	-	-	-	-	-	No	An increase in MFCV reached supernormal levels and exceeded pre-exercise values of MFCV. Statistically significant at duty cycles of 25% (p <0.001) and 20% (p <0.006).	"[W]e found clear changes in the MFCV in a large family of HOPP patients with the surface as well as with the invasive determination method. Since, however, only the invasive determination methods showed MFCV disturbances in all proven carriers, we suggest that it is more sensitive than the surface method in detecting carriers of the membrane defect."	All members of same family. Data suggest sEMG not sensitive enough for screen for HOPP.
Nishizono 1979 Diagnostic	N/A	4	Biceps brachii	Surface EMG	-	-	-	-	-	-	-	No	Relationship between 2 interface patterns could help to identify same action potentials at different potentials. Conduction velocity from electrode 4 to electrode 6 4.4m/s. Time delay of 9ms recorded.	"In the present study new methods were developed for estimation of conduction velocity using surface electrodes."	Very small numbers.
Cram 1986 Diagnostic	N/A	32	Various	Surface EMG	-	-	-	-	-	+	-	No	All correlations between narrow and wide filters significant. (r = 0.9 or greater). Suggests at least 80% of variance is shared	"From a pragmatic point of view, it would appear that the narrow filter settings provides an adequate representation of the source	All inpatient chronic pain patients. Surface EMG electrodes placed paraspinally in various areas depending on area of

													by narrow and wide filter sites. Only 16% of samples shared common variance of 65% or less.	EMG activity in the face and low back. However, the wide filter setting may be providing different information in the neck, upper back, and abdominal regions."	pain. Data suggest filter settings can influence surface EMG readings and need to be adjusted according to location of test. Differentiating types of EMG in chronic pain patients, not just LBP.
Wenzel 1998 Diagnostic	N/A	112	Lower extremities	Surface EMG	+	-	-	-	-	+	-	No	Agreement of results for both EMG and Myosonography r = 0.72. Interobserver agreement regarding prevalence of fasciculations as assessed by means of both surface EMG and myosonography r = 0.94 for surface EMG (70 muscles) and r = 0.85 for myosonography (91 muscles) (p <0.01).	"Among both control subjects and patients, the number and amplitude of fasciculations recorded with surface EMG correlated negatively with the thickness of the subcutaneous fat beneath the electrodes… In conclusion, long-term surface EMG proved fasciculations to be a common finding even among subjects without neuromuscular disease."	Patients had diagnosis of ALS. Data suggest surface EMG can detect fasciculations, and is an inverse relationship between subcutaneous fat and ability to detect fasciculations and MUPs.
Wimalaratna 2002 Diagnostic	N/A	20	Tibialis anterior muscle	Surface EMG	+	-	-	-	-	-	-	No	3 EMG types used: MPF, Turns (TN), Zero-crossings (ZX). MPF at surface showed significant difference in control group from disease group (p = 0.002). ZX at 0.5% threshold at surface also showed significant difference in control vs. disease group. (p = 0.003). TN at 0.5% threshold with needle showed significant difference between control vs. disease group. (p = 0.001).	"[Q]uantitative sEMG that is described in this paper could be adopted as a simple, rapid and non-invasive technique to be used in the out patients clinic by EMG-naive clinicians as a screening method for neuromuscular disorders, before referring the patients for detailed clinical neurophysiological examinations."	Data suggest surface EMG not sufficient for confident diagnosis of neuromuscular disorders. Over tibialis anterior muscle sEMG can help differentiate between normal and abnormal muscle.
Ramaekers 1993 Diagnostic	N/A	63	Abductor pollicis brevis	Multi-electrode Array EMG	-	-	-	-	-	-	-	No	Noninvasive EMG can be considered a match for invasive EMG for diagnostic purposes.	"Compared to classical needle EMG the application of this new noninvasive EMG technique in children is painless and offers an easy-to-handle diagnostic tool to differentiate between neuromuscular	Children neonatal to age 24. Data suggest multi-Electrode array surface EMG may be viable option to evaluate neuromuscular disease in superficial hand muscles.

														diseases of denervating or myopathic origin."	
Schneider 1989 Diagnostic	N/A	?	Lower arm muscles	Surface EMG	-	-	-	-	-	-	-	No	Superior smoothing characteristic with w = 0.1 shown in low SD for contraction velocity. Compared to CCF method, SD increased by about 60%.	"As a whole, this study could show that spatial filtering EMG recording technique makes the noninvasive registration of conduction velocity in single MUAPs possible."	No mention of participants' characteristics or number of participants.
Drost J Clin Neuro-physiol 2004 Diagnostic	N/A	7	Biceps brachii	High density sEMG	‡	-	-	-	-	-	-	No	Mean maximal force for patients with generalized myotonia (GM) 214N vs. 307N in healthy controls. Standard deviation of mean force 0.42% maximum voluntary contraction (MVC) in healthy controls. 0.68 MVC in GM group. Results not significant.	"We found that patient with generalized myotonia, despite abnormal SEMG characteristics, can produce stable force curves."	Small numbers, not all evaluated the same. Needle EMG on 2 found myotonic discharges not seen on sEMG.
Drost Muscle Nerve 2004 Diagnostic	N/A	18	Vastus lateralis	High density sEMG	-	-	-	-	-	-	-	No	Mean maximal voluntary force (MVF) 409 N (± 160N) in PPS subject group and 465N (± 130N) in control group. Difference not significant. Mean motor unit action potential of all of PPS subjects 4.60±1.84 mV.ms significantly higher than control group. 1.37±0.53 mV.ms (p= 0.0001) Bipolar RMS amplitude significantly higher at 5% maximal voluntary contraction (MVC) in PPS patients vs. control (p = 0.02). However, at higher force levels, no significant difference.	"We conclude that with HD-sEMG it is possible to detect neurogenic motor unit changes noninvasively, both by analysis of the raw signal itself and by analysis of extracted single MUAPs."	Small numbers. Data suggest high-density sEMG can detect changes in post polio syndrome patients.
Drost 2001 Diagnostic	N/A	7	Biceps brachii	High density sEMG	+	-	-	-	-	-	-	No	At 5% maximum voluntary contraction (MVC) force levels did not differ between groups, same true at 20% MVC. However, at 40 and 60% MVC, all 7 in GM group	"[H]igh-density surface EMG provides basic and unique information about electro-physiological and topographical aspects of the sarcolemma."	Small numbers all had diagnosis of generalized myotonia from needle EMG. Data suggest high-density surface EMG can help recognize pathology of sarcolemma. Patients had

													showed an irregular force pattern, with decline in force production.		autosomal recessive generalized myotonia or Becker's disease.
Sunnerhagen 2000 Diagnostic	N/A	20	Anterior tibialis	Surface EMG	-	-	-	-	-	-	-	No	Force at maximal voluntary contraction (MVC) was 124 N for late-polio group and 185 N for control group ($p < 0.05$). Force increase 362% for polio group and 519% for control group, difference not significant. RMS increased significantly with increased force levels. From 10% force level, 165% in polio group ($p < 0.01$) and in control group ($p < 0.005$) with significant difference between polio and control groups. ($p < 0.05$).	"We could not show that late-polio subjects fatigued during the exercise more than healthy controls using the same relative force levels."	Small numbers, data suggest sEMG viable investigative tool to use on anterior tibialis muscle.
Ershad 2009 Diagnostic	N/A	20	Rectus abdominis, external oblique, internal oblique, erector spine, multifidus	Surface EMG	-	-	-	-	-	-	-	No	CLBP group showed significantly higher levels of activation of the External Oblique muscle during a 12 kg load in the flexed trunk position compared to the control group ($p < 0.05$)	"Electromyography activity of trunk muscles changed in patients with chronic low back pain during holding loads as compared with healthy subjects. Activation of the Internal Oblique muscle decreased and activation of the External Oblique muscle increased in those patients with chronic low back pain."	Data suggestive of deconditioning in a small chronic LBP population.
Hanada 2011 Diagnostic	N/A	18	Rectus Abdominis, Lumbar Erector Spinae, Lumbar Multifidus, and Internal Oblique	Surface EMG-Ag-AgCl electrode pairs	-	-	-	-	-	-	-	No	Control group activated rectus abdominus muscle (p 0.05) and right internal oblique muscle more than LBP group ($p < 0.05$). LBP group activated left lateral erector spinae and lumbar multifidis more than controls ($p < 0.05$)	"Given that no differences were found between the groups in gait parameters and other outcome measures, surface EMG may provide a useful means for detecting changes in trunk muscle activation during a functional task such as walking."	Data suggest patients over age 50 with CLBP have different muscle activation patterns compared to controls on surface EMG.

ULTRASOUND

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of Ultrasound	CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical Outcomes Assessed	Long-term Follow-up	Results	Conclusion	Comments
Oliveira 2009 Diagnostic	3.0	35	L	Chronic LBP	Real time ultrasound imaging	-	-	-	-	-	-	+	-	Reproducibility of static images ICC2, 1 = 0.97, 95% CI = 0.96–0.97.	"Improvements in the testing protocol must be performed in order to enhance reproducibility of US as an outcome measure for abdominal muscle activation."	Study not heavily focused on LBP, rather abdominal thickness using ultrasound. Suggest ultrasound measurements of abdominal muscles may be useful in monitoring physiotherapy programs.

THERMOGRAPHY

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of Thermography	Type of CT used	MRI Used	More than on rater	Blinding of rater	Myelography	Surgery Performed	Clinical Outcomes Assessed	Long-term Follow-up	Results	Conclusion	Comments
Rubal 1982 Diagnostic	3.5	112	L	Mechanical LBP	Liquid crystal thermography	-	-	-	-	-	-	-	-	No significant differences between the control group and patients with LBP (F = 1.05) and skin temperatures. Patients with lesions portrayed greater thermal gradients than control group at p <0.05 and F = 10.3.	"The results of this study suggest that liquid crystal thermography may be a useful supplement to present clinical methods for objectively documenting soft tissue trauma in patient with LBP. When liquid crystals are applied to the skin, they produce a color-coded display of skin temperatures visible to the unaided eye permitting direct clinical correlation between heat and	Limited baseline characteristics. Patient population is not applicable to clinic patient. Study suggests thermography may have had some indication in a selective group prior to the development of newer imaging modalities

															tenderness to palpation during routine assessment..."	
Gillstrom 1985 Diagnostic	3.5	87	L	LBP with or without sciatica	Thermography with infrared camera	-	-	-	-	-	-	-	-	Group 1: no difference in temperature change between each leg. Group 2: mean difference between sciatic leg and healthy leg 1.8°C. Group 3: mean difference between sciatic leg and healthy leg 1.8°C and range from 1-3°C. Group 4: mean difference between sciatic leg and healthy leg 1.1°C and range 0.5-2°C.	"In summary, the controls demonstrated no definite difference of temperature in the lower extremities."	Study also reports retrospective data. Based on small number in each group, conclusions difficult to use

VIDEOFLUOROSCOPY

Author/Year Study Type	Score	Number of Patients	Area of Spine	Diagnoses	Type of X-ray used	CT used	MRI used	Myelography	More than one rater	Blinding of rater	Surgery performed	Clinical outcomes assessed	Long-term Follow-up	Results	Conclusion	Comments
Ahmadi 2009 Diagnostic	3.0	30	L	15 healthy subjects; 15 patients diagnosed with chronic LBP and suspected lumbar segmental instability (LSI).	Digital video fluoroscopy	-	-	-	-	-	-	-	-	Average arc length of pathway of instantaneous center of rotation (PICR) 53.2+17.4mm healthy subjects, 57.8+10.9mm patients. Arc length differences of PICR for extension movement at L1-L2 and L5-S1 statistically significant ($p < 0.05$). Multiple comparison significant between all phases of movement for all	"This study determined some kinematic differences between two groups during the full range of lumbar spine."	Excluded patients with pain >3 on VAS. 15 healthy and 15 patients. Did not compare to another diagnostic test. No blinding performed. Relatively small number.

														motion segments in both directions (p <0.005).		
Wong 2006 Diagnostic	3.0	30	L	Healthy volunteers	RS Polystar Top	-	-	-	-	-	-	-	-	Average error in measuring angular speed: 0.32±0.24 degrees per second. Intervertebral flexion and extension (IVFE) increased from 10 degrees of extension to 40 degrees of flexion. IVFE decreased in descending order from L1-L2 to L5-S1.	"The newly developed technique in assessing the dynamic lumbar motion is reliable and able to analyze the lumbar intervertebral movement from videofluoroscopic images automatically and accurately."	Many methodological weaknesses. Study suggests videofluoroscopy may aid in determining lumbar spine instability.

MRI DISCOGRAPHY

Author/Year/Study Type	Score	N	Area of Spine	Diagnoses	Injected Medications	Intradiscal Local Anesthetic	Sedation Used	Fluoroscopy/imaging	Pressure Readings	MRI	CT	CT Myelography	X-ray	More than one rater	More than one level	Surgery Performed	Long term follow-up	Results	Conclusion	Comments
Kluner 2006 Diagnostic	NA	11	L	Chronic discopathy confirmed by MRI and scheduled for anteroposterior spondylodesis.	0.5ml iodine-based contrast medium, 0.01ml gadolinium-based contrast medium, 1.0ml sodium chloride solution	-	-	+	-	+	+	-	+	+	+	-	-	Both CT and MRI demonstrated sensitivity of 100% in identifying lesions of disc spaces. Both had specificity of 100%. Fluoroscopy had sensitivity of 75%.	"In summary, the diagnostic accuracy of CT-guided low-dose discography with only about 10% of the radiation exposure of a standard-dose CT protocol seems to be similar to that of MRI-based discography in identifying segmental degeneration and appears superior to conventional fluoroscopy."	Small numbers.

BED REST

Author/ Year	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Wiesel 1980	3.0	N = 200 basic combat trainees, males age 17-34 with back pain incurred by single episode of bending over	Bed rest (n = 80) randomized to 2 groups, experimental group of hospital admission with bed rest vs. controls ambulatory and assigned restricted-duty status to stop exercise, but required to observe peers in training which kept them on their feet. Evaluated QD and sent back to full duty when pain abated, full ROM returned with no muscle spasm. Follow-up QD for 15 days.	Bed rest group favored over ambulatory group for mean number of days to return to full activity ($p < 0.01$). No significant differences in anti-inflammatory or analgesic medication group sections of study.	"Antiinflammatory medication, when added to bedrest in the treatment of lumbago, does not provide an advantage over bedrest alone."	Randomization mentioned, but method and success data not reported. Methods mention randomly assigned to experimental or control group, yet 80 in bed rest, 45 in NSAID, 60 in analgesic groups. Control appears subjected to punitive treatment of watching peers work, thus potentially fatally flawed design.

SITTING POSTURE

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Delitto 1993 RCT No mention of COI's or industry sponsorship.	1.0	N = 24 with low back syndrome (LBS) referred to physical therapy.	Experimental group, mobilization technique supported to affect sacroiliac joint, matched, specifically directed (n = 14) vs. Comparison group, unmatched nonspecific (n = 10). All supervised with PT session 3x a week. Follow-up baseline, days 3 and 5.	No significant differences between groups. Oswestry scores different among groups, p-value not reported.	"This study illustrates that a prion' classification of selected patients with LBS into a treatment category of extension and mobilization and subsequently treating the patients accordingly with specified interventions can be an effective approach to conservative management of selected patients."	Short follow up (48 hours). Small sample size. Details sparse. Inadequate to draw strong conclusions.
Williams 1991 RCT No mention of industry sponsorship or COI.	1.0	N = 210 with LBP and/or pain referred to leg, age15 years and over.	Category I with LBP received either kyphotic posture (KP) or lordotic posture (LP), plus PRE-TEST questionnaire, then assigned posture 10 minutes, then POST-TEST1 questionnaire 48 hours POST-TEST2 questionnaire, then 10 minutes posture sitting, and POST-TEST3 questionnaire, final (n = 70)	Significant age difference, Category III patients being older, $p = 0.001$. Pain location (PL)/Back-pain intensity (BPI)/Leg pain-intensity (LPI): did not differ significantly at PRE-TEST. LP group mean pain scores at POST-TEST2 and POST-TEST3 at $p = 0.009$ and 0.045. Back pain intensity, compared to	"[LP] results in less back pain than a KP, and also demonstrates that a lumbar roll is a useful aid in the facilitation of a LP in general setting environments."	Good sample size. Short follow-up, 48 hours. Many methodological details sparse.

			vs. Category II, pain referred to buttocks and/or lower limb above knee same procedure as Category I (n = 70) vs. Category III, pain refereed to lower limb below knee, same procedure as Category I (n = 70). Data collection/follow-up to 10-month period.	PRE-TEST, and between groups compared to PRE-TEST, at $p < 0.05$.		

MATTRESSES, WATER BEDS, AND OTHER SLEEPING SURFACES

Author/ Year	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Monsein 2000	2.0	N = 30 with self-reported severe CLBP	Airbed (28 days) vs. subject's own bed (14 days, control). A-B-A design. A: subject sleeping in own bed; B: sleeping on airbed.	A-B-A showed an improvement in VAS pain scores, $p < 0.0003$. Baseline-airbed showed significant difference in VAS pain and sleep scores, $p < 0.001$.	"[T]hat most patients with chronic nonspecific back pain will have improved sleep on the adjustable airbed."	Lack of details, baseline characteristics, co-interventions. No blinding. Study of new adjustable mattress vs. old bed. Data showing improvement with air mattress, but likely biased against current bed.
Garfin 1981	2.0	N = 15 with chronic LBP ≥3 months	4 types of beds. Orthopedic hard bed 720 reinforced coils, built-in bed board vs. softer 500 coil bed vs. standard 10 inch thick waterbed vs. hybrid foam, water. Beds switched every 2 weeks.	No differences in primary outcome. Only 9 sampled all 4 beds, 6 left after 4 weeks, 2 quit study.	"The 500 coil bed and the hybrid bed proved of no benefit to any patient in this study group. This limited study indicates that hard beds should remain the first choice of patients with chronic low back pain."	Small sample size; 2 week study. Not all patients assigned to all beds, thus partial crossover.

EXERCISE

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Gillan 1998	3.5	N = 40 with acute LBP <12 weeks and lateral shift of lumbosacral spine	Non-specific back massage and standard back care advice (n = 21) vs. McKenzie management (n = 19). Both groups treated by same therapist 2-3 times 1st week then at therapist's discretion. Last follow-up 90 days.	After 28 days, resolution of trunk list significantly higher in McKenzie group at 91% than control group at 50%.	"The McKenzie method of assessment and treatment may assist in the resolution of trunk list, but it was ineffective in improving clinical condition."	Many details weak and overall dropout rates (6/21 and 4/19 at 28 days and 7/21 and 8/19 at 90 days) impair meaningful conclusions.

Rittweger 2002	3.5	N = 60 with chronic LBP	Lumbar extension exercises: repetitive contractions to 50% of baseline maximum with gradual increases (n = 30) vs. whole body vibration exercise: vibration maximum amplitude 6mm, 18Hz, and 4 minutes each exercise unit, gradually increased to 7 minutes (n = 30). Exercise sessions 2x a week for 6 weeks then 1x a week for 6 weeks.	No differences in pain, which decreased over time from 4.3 to 1.4. Isometric lumbar torque increased more in lumbar extension vs. vibration exercises, p <0.05. Tendency to depression reduced in lumbar extension group immediately after treatment and 6 months (p <0.05) vs. no change for vibration exercise group.	"[B]oth lumbar extension and whole-body vibration exercise can relieve pain and improve pain-related limitation in everyday life for patients with CLBP."	Lack of control group limits conclusion on effectiveness of either intervention compared with natural history. Study suggests isodynamic lumbar extension superior to whole-body vibration exercise.
Johannsen 1995	3.5	N = 40 with chronic LBP	Intensive muscle endurance training (n = 20): warm-up; dynamic exercises for muscle endurance for low back, abdominal, shoulder girdle, hip abductor muscles vs. muscle training including coordination (n = 20): exercises for coordination, balance, and stability for low back, shoulder, hips in groups up to 10 for 1 hour 2x a week for 3 months.	Baseline differences between two groups. Pain scores and other metrics, though not statistically significant, generally favored endurance group.	"[C]oordination training for patients with chronic LBP is as equally effective as endurance training."	Conclusion that coordination training is efficacious is not supported by these data, particularly with this many study weaknesses.
Geisser 2005	3.5	N = 100 with chronic LBP >3 months	Manual therapy (MT, "muscle energy technique" that depended on "positional diagnosis") vs. sham procedure with either specific adjuvant exercise program (SE, apparently unstructured BID stretching and strengthening exercises) or non-specific exercises (NE). MT-SE (n = 26) vs. sham MT-SE (n = 25) vs. MT-NE (n = 24) vs. sham MT-NE (n = 25). Follow-up for 6 weeks.	VAS pain ratings for manual therapy-specific exercise group decreased from 4.45 to 2.40.	"[M]annual therapy with specific adjuvant exercise appears to be efficacious in the treatment of CLBP, but not associated disability."	Baseline differences are concerning for randomization failure. Multiple co-interventions.
Davies 1979	3.5	N = 43 with subacute or chronic LBP >3 weeks and <6 months	Short-wave diathermy (SWD, n = 15) vs. diathermy plus extension exercises (n = 14) vs. diathermy plus flexion exercises (n = 14) for 4 weeks.	No significant differences between groups.	"[P]artial and complete relief of pain was achieved in more patients who underwent SWD combined with exercises than SWD alone but the differences were no significant."	Many weaknesses. Significant differences in baseline populations that would be predicted to be against extension exercises.

Stafne 2012 RCT Funded by Norwegian Fund for Postgraduate Training in Physiotherapy and Liaison Committee for Central Norway Regional Health Authority (RHA) and Norwegian University of Science and Technology. Authors stated no COI.	3.5	N = 855 pregnant women with singleton fetus.	Intervention group assigned to low impact aerobic activity for 30-35 minutes, strength training for 20-25 minutes and 5-10 minutes of stretching, breathing and relaxation (n = 429) vs. control group assigned to standard antenatal care (n = 426).	No difference for women reporting lumbopelvic pain (LPP) in groups; however, there was lower odd ratio, and reports of sick leave in intervention group was lower than in control group, p = 0.001. Intervention group showed tendency to weigh less (69.3±8.1 vs. 70±10.3 kg), had lower BMI (24.5±2.7 vs. 25.0±3.4 kg/m2), and reported lower evening pain (23.6±23.1 vs. 28.7±24.2) than control group.	"In summary, the present study has shown that women offered a 12 week exercise program during the second half of pregnancy report LPP as frequently as women in the control group. However, regular exercise reduced the need for sick leave due to LPP."	This study was on pregnant women, and might or might not be relevant for this Guideline.
Tsui 2004 RCT/ two centered No mention of industry sponsorship or conflict of interest (COI).	3.5	N = 42 with LBP that radiated down to thigh or calf for ≥3 months and positive straight leg rise (SLR) findings.	Electroacupuncture (EA) group: dual channel EA machine (frequency from 1Hz to 999Hz) 4 channels and acupuncture points over bilateral side of lower back, 2 extra distal points over buttock and leg, exercises (n = 14) vs. Electrical Heat acupuncture (EH) group: electrical heat machine 4 channels delivered heat from 38°C-48°C, same acupuncture points as EA group and exercises (n = 14) vs. controls: back exercises: 6 mobilization exercises, 1 abdominal stabilization exercise (n = 14).	EA group 56.37% reduction from baseline to follow-up in numerical pain rating scale (NPRS) significant (p = 0.000) while 60.24% cumulative reduction for EH group (p = 0.000), 15.14% in control group (p = 0.013). Difference on NPRS between groups at session 4, 8 and follow up shown (p = 0.006, 0.001 and 0.001). Significant difference between groups at session 8, follow-up on SLR (p = 0.001 and 0.002). Across groups, RMDQ decreased significantly for all (p = 0.000).	"The addition of either EA or EH to exercise is more effective than exercise alone in reduction of chronic LBP. But EH seems to be more efficient for producing analgesic effect in the initial 2 weeks of treatment. In contrast, EA plus exercise is a better choice if the patients have more problems in SLR or greater disability as reflected by RMDQ.	Many weaknesses. Details sparse.
Helewa 1999 RCT No mention of industry sponsorship or COI.	3.5	N = 402 without LBP at beginning of study, age 23-67	Experimental group (n = 203) received back education along with instructions for abdominal exercises and an exercise diary to ensure compliance vs. control group (n = 199) only received back education.	Relative risk (RR) and risk difference (RD) experimental group vs. control group at 6, 12, 24 months: RR = 0.70, RD = 4.8% (-2.4 to 12.0, p = 0.191); RR = 1.05, RD = -1.0% (-9.5 to 7.6, p = 0.821); RR = 1.16, RD = -	"The results of this study indicate that abdominal exercise and back education, compared to back education alone, does not appear to reduce the risk of low back pain episodes over a 24 month experimental period."	High dropout in exercise group (>50%). Method details sparse.

				3.3% (-12.6 to 5.9, p = 0.483).		
Dettori 1995	3.5	N = 149 military personnel with acute LBP	Flexion-flexion (n = 30) vs. flexion-extension (n = 30) vs. extension-extension (n = 30) vs. extension-flexion exercises (n = 30) vs. control (n = 30). Follow-up 6, 12 months.	No difference for any outcomes between flexion or extension exercises groups.	"However, either exercise was slightly more effective than no exercise when patients with acute LBP were treated."	Many weaknesses. Lack of details on compliance, co-interventions. Data suggest acute LBP patients improve at 1 week regardless of intervention, and exercises result in better recovery by recurrence over 12 months.
Häkkinen 2005 RCT Supported by the Jyvaskyla Central Hospital, Finland. No commercial party direct financial interest or benefit to the authors.	3.5	N = 126 after lumbar disc surgery	Strength-training group: at-home bilateral leg press or step-on bench, hip extension, knee flexion, toe rise, etc., 3x a week (n = 65) vs. control group (n = 61): trunk flexion in supine position, passive extension of lumbar spine, stretching of quadriceps, iliopsoas, gluteus medium, maximus muscles lying supine. Follow-up for 1 year.	2 months after surgery, median back and leg pain decreased by 61% to 78%, p < 0.001. Mean increase in isometric trunk extension and flexion forces: 118N 31% p <0.001, and 49N or 12%, p = 0.002, during first 2 months STG group. Median amount of leisure time used for physical activities during the 12-month follow-up was 241 minutes per week in STG and 271 in CG group.	"At the 12-month follow-up, no statistically significant changes were found in the physical function, pain, or disability measures between the groups."	High dropout, specialized population may not be generalizable. Methodological details sparse. Strengthening and stretching details poorly described.
Seferlis 1998	3.0	N = 180 with acute LBP for <1 month	Manual therapy program (MTP, n = 60) vs. intensive training program (n = 60) vs. GP program as control (n = 60). Follow-up at 1, 3, 12 months.	Mean days off work 57±78 days (MTP) vs. 49±76 vs. 52±63 (vs. 62±79 for dropouts). Disease-specific sick leave percentages: 17.6±25 vs. 13.6±20.8 vs. 16.7±21.3. No differences in pain or disability ratings.	"[M]anual treatment or intensive training do not give better treatment results than conventional GP care in patients sick listed for acute low-back pain, although the patients are less satisfied with GP care."	Data suggest no differences. Lack of randomization details, blinding, co-interventions, compliance. Suggests patients with acute LBP improve with all or no treatments. Patients preferred active intervention with more supervision and time with provider.
Dolan 2000	3.0	N = 21 micro-discectomy patients	Exercise: 2 1-hour sessions a week for 4 weeks 6 weeks after surgery supervised by physiotherapist (n = 9) vs. control (n = 11). Follow-up	Pain diary scores lower in exercise group than control group at 12 months (p <0.05). Also at 12 months, Low Back Outcome Score	"A 4-week postoperative exercise program can improve pain, disability, and spinal function in patients who undergo microdiscectomy."	Small sample size limits conclusions. Suggests post-microdiscectomy exercise program may provide additional benefit in hip/lumbar flexion, pain and disability

			1 week before treatment; 6, 10, 26, 52 weeks after.	higher in exercise group (p <0.05).		scores. Absolute improvements appear clinically small.
Rasmussen-Barr 2003	3.0	N = 47 with subacute and chronic LBP	Stabilizing training (ST, n = 24) vs. manual treatment (MT, control group, n = 23) for 6 weeks.	No differences between groups for pain (VAS), Oswestry score, or health VAS. Oswestry significant between groups at 12 months: ST group (13) vs. MT (23), p = 0.042.	"Stabilizing training seemed to be more effective than manual treatment in terms of improvement of individuals and the reduced need for recurrent treatment periods."	Data suggest statistical but clinically uncertain improvement in pain scores in ST group vs. manual therapy at end of treatment. Long-term results inconclusive due to high dropouts at 3 and 12 months.
Bendix 1995	3.0	N = 132 with LBP	Program 1 (n = 40) full-time: 135 hours 6 weeks, all-day schedules. Program 2 (n = 31) progressive resistive training and endurance for all major muscle groups and Swedish back school 2 hours 2x a week 6 weeks. Program 3 (n = 35) active combined psychophysical program 2 hours 2x a week 6 weeks, but 15 minutes of work-up exercises not aerobic followed by 30 minutes of progressive resistive training and endurance then 75 minutes psychological pain management class and relaxation.	Percentages ready to work: 65% Program 1, 19% Program 2, 17% Program 3, p = 0.01. Most returned to same pre-injury work. Over year of follow-up, fewer health care provider visits Program 1 (median 4.5 vs. 11.8 and 12), p = 0.05. Days of sick leave lower Program 1 (52 vs. 100 and 295), p = 0.005. Function improved more Program 1 vs. other programs, p = 0.002. 80% Program 1, 61% Program 2, and 42% Program 3 physically active at 4 months follow-up.	"[A]lthough the multidisciplinary program is initially expensive compared to the less intensive programs, the savings in sick pay, early retirement pensions, and health care contacts make it economically worthwhile."	Methods not well described. Baseline differences, especially history of back surgery and sick leave, are concerning. Data suggest most intensive program most effective.
Franca 2010 RCT No mention of sponsorship and COIs.	3.0	N = 30 Department of Orthopedics, University Hospital, non-specific chronic LBP at least 3 months between T12 and gluteal fold. excluded history back surgery, rheumatologic	Interventions conducted over 6 weeks, 2x a week, each 30 minute session 3 series of 15 rep for each exercise. Segmental stabilization (ST) group (n = 3) consisted of exercises focused on TrA and LM muscles vs. superficial strengthening (SS) group where exercises focused on rectus abdominus, abdominus	Mean gain (difference of before and after in each group). ST vs. SS: Pain VAS: 3.6 (1.56) vs. 5.8 (1.61) p<0.001. Pain-McGill: 17.87 (6.73) vs. 31.8 (6.06) p <0.001. Functional disability - Oswestry: 8.86 (2.82) vs. 15.26 (3.43) p <0.001.	"[B]oth techniques lessened pain and reduced disability. Segmental stabilization is superior to superficial strengthening for all variables. Superficial strengthening does not improve TRA activation capacity."	Small sample size.

		disorder, spine infections, spine exercise 3 months before study.	obliquus internus, abdominus obliquus exernus, erector spinae.			
Turner 1990	2.5	N = 96 with chronic LBP >6 months	Behavioral therapy (n = 25): information on pain behaviors and role of social reinforcers in maintaining pain behaviors, group discussion, role playing, feedback on performance, homework assignments with social reinforcement vs. aerobic exercise (n = 24): increase aerobic fitness by increasing fast walking/slow jogging vs. behavioral therapy/ exercise combined (BE) (n = 24) vs. wait-list controls (n = 23) for 8 weekly 2 hour sessions.	No differences between groups; all participants improved over time.	"[O]utpatient group treatment including both behavioral therapy and aerobic exercise (BE) results in greater pretreatment to posttreatment improvement than a WL condition for mildly disabled chronic low-back-pain patients."	Many details sparse. Population not well described. As data negative in a study with wait-listed controls (that bias in favor of intervention), this suggests lack of efficacy.
Kellett 1991	2.5	N = 111 workers	Exercise program (EP, n = 58) vs. no program (n = 53) on sick leave. Exercise 1 hour a week during paid working hours. Began with low-intensity workouts first 10 weeks. Programs changed every 6 months for variety. EP additionally walk for 30 minutes (or cycle, ski) at least 1x a week. Last follow-up 1.5 years.	Controls did not change in days missed due to back pain or episodes of back pain. Exercise group decreased significantly in sick days due to back pain ($p < 0.5$), but no change in number of back pain episodes.	"This study has shown that a weekly exercise program has resulted in a reduction of sick leave for people with relatively short (<50 days) episodes of back pain. Investment in exercise programs for people with back pain could lead to considerable benefits for the employer, society, and individuals with back pain."	Lack of study details for randomization methods, allocation, co-interventions and compliance. Dropout rate of 36% in exercise group limits study conclusions that exercise may reduce number of back pain episodes and absenteeism.

Timm 1994	2.5	N = 250 L5 laminectomy with chronic LBP	Physical agents (hot packs, ultrasound, TENS, n = 50) vs. joint manipulation (large-amplitude, low-velocity manual therapy, segmental and facet joint gliding, Maitland joint manipulation, n = 50) vs. low-tech exercise (spinal stabilization exercises with physiotherapist and HEP, n = 50) vs. high-tech exercise (bike ergonometer, spinal dynamometers, n = 50) vs. control (n = 50). All treated 3x a week for 8 weeks. Follow-up >1 plus year.	Treatment arms and costs for 24 treatments: 1) physical agents ($1,842); 2) joint manipulation ($1,260); 3) low-tech exercises ($1,392); and 4) high-tech exercises ($1,716). Only low tech and high tech exercises had significant improvements (p <0.05).	"The results support the findings of previous studies that, in general, active approaches to treatment are more effective than passive methods for the relief of CLBP…clinically, the low-tech exercise may be the treatment method of choice for the effective management of chronic LBP."	Lack of study details for randomization, allocation, baseline comparability, cointerventions and compliance limit study conclusions on effectiveness of exercise.
Alexandre 2001	2.5	N = 56 female nursing personnel with LBP of ≥6 months	Exercise program (n = 27): 45-minutes of strength and flexibility vs. intervention program (n = 29): ergonomic orientation 1 hour. Both 2x a week for 4 months.	Reduction in cervical pain intensity in last 7 days or 2 months for intervention group, and in lumbar pain intensity in last 7 days.	"[A] program of regular exercise with an emphasis on ergonomics can reduce musculoskeletal symptoms in nursing personnel."	Few data to assess randomization. Ergonomic training lacked details precluding assessment of that component.
Smith 2011 RCT No mention of sponsorship and COIs.	2.5	N = 42 with chronic LBP	Lumbar extension training with pelvic stabilization (n = 16) vs. lumbar extension training without pelvic stabilization (n = 17) vs. Control (same LBP treatment, n = 13). Follow-up at baseline, 12 weeks.	Significant differences in effect size isometric lumbar extension torque.	"[P]elvic stabilization during lumbar extension exercise is essential to produce meaningful results. This is true both in terms of increasing the strength of the lumbar muscles and, more importantly from a clinical point of view, reducing the intensity of LBP and associated disability."	Discrepancy in number of participants 42 vs. 46.
Danneels 2001	2.5	N = 59 with chronic LBP	Group 1 – stabilization based on daily living activities to activate muscles (n = 19); Group 2 – dynamic stabilization training plus progressive resistance training (n = 20); Group 3 – dynamic-static stabilization with progressive resistance training (n = 20); 3x week for 10 weeks.	Group 3 shown to benefit and it was felt that static holding component between concentric and eccentric phases was critical to induce muscle hypertrophy in first 10 weeks.	"The results of this study suggest that general stabilisation exercises and dynamic intensive lumbar resistance training have no significant effect on the CSA of the lumbar multifidus muscle in patients with CLBP."	Gender not reported. Main details sparse. Study primary aim of cross sectional area of multifidus. Data suggest stabilization plus dynamic resistance training superior. Importance of multifidus CSA unclear, especially as did not include clinical outcomes.

Khalil 1992	2.0	N = 28 with chronic myofascial LBP	Control group received complex program (n = 14) vs. group receiving same program with addition of 6 aggressive stretches performed in 4 sessions (n = 14) in a 2-week period.	Final pain rating 5.29±2.03 in controls vs. 1.64±1.39 with stretching; final strength: 311.19±125.98 in controls vs. 415.14±121.71 with stretching.	"For chronic low-back pain patients, muscle stretching results in an immediate gain, as well as in a cumulative gain (over the treatment period studied) in ME activity, muscle force produced, and ranges of motion, and contributes to reduction in pain level."	Baseline differences present and no mention of how randomization done. Many details sparse.
Mayer 2004 RCT/single blinded Supported in part by grants 2K02 MH01107, 2R01 MH46402 and 2R01 DE10713 from the National Institute of Health; however, authors state no COI.	2.0	N = 421 with chronic disabling work-related lumbar spinal disorders and segmented rigidity (SR)	Group A combined stretching exercises and facet injection treatments under fluoroscopy control, each joint was injected with mixture of 1ml 2% lidocaine, 1ml 0.5% bupivacaine, and 1ml of depot corticosteroid preparation (n = 36) vs. Group B exercise only (n = 34).	Mean (SD) pain intensity group A vs. group B pre- and post-trial: 6.3 (1.5) and 5.4 (1.6, p <0.003) vs. 6.7 (1.8) and 5.9 (2.1, p <0.004). Mean (SD) for million VAS pre- and post-treatment for group A vs. group B: 99.7 (16.7) and 85.6 (21.5, p <0.001) vs. 100.0 (29.2) and 92.2 (25.1, p <0.003).	"[I]n the randomized trial, facet injections significantly increased the percentage of patients with SR showing ROM improvement, as well as the degree of improvement in lumbar mobility after treatment. There is no evidence that facet injections increase the improvements in pain/disability report noted in both groups."	Details sparse.
Descarreaux 2002 RCT Supported by La Foundation Chiropractique du Quebec. No mention of COI.	2.0	N = 20 with chronic or subacute LBP	Experimental group assigned to increase muscular force and extensibility of trunk and hip muscles, and upgraded at 3 weeks (n = 10) vs. control group same amount of exercises, but based on back school program (n = 10).	Mean (SD) for Oswestry score for experimental group vs. control group: -10.2(5.3) vs. -3.5(6.5, p = 0.028). Mean (SD) for VAS pain level for experimental group vs. control group: -14.5(9.7) vs. -3.5(9.0, p = 0.014).	"[S]ubjects with subacute and chronic LBP did benefit from an individualized specific training program based on muscle force and extensibility evaluation […] Short-term specific exercise programs seem to be more effective than classical exercises in reducing pain and disability level in an LBP population."	Small sample size.
Stankovic 2012 RCT No mention of industrial sponsorship. No COI.	1.5	N = 160 with chronic LBP lasting >12 weeks. Mean age 49.5+/-12 years.	Combined exercise of spinal segmental stabilization exercises (n = 100) vs. Control group of exercises, excluding pelvic mobilization and core stabilization (n = 60).	Study group improved on Oswestry Disability scores vs. control (34.28+/-17.8 to 23.44+/-14.4 vs. 38.10+/-17.7 to 32.83 +/- 17.9; p <0.001). Both groups improved for all other measures (p <0.001).	"Specifically designed stabilization exercises program in combination with strengthening and stretching aerobic exercises had positive effect on pain reduction, functionality and quality of life parameters in patients with CLBP."	Very high dropout. Even/Odd Randomization.
Schenk 2003 RCT	1.5	N = 31 with subacute low back pain and had been classified with a	Following initial exam, formed an exercise group, subjects seen for 3 PT visits plus performed therapeutic exercises based on results of	Significant change in VAS rating at p <0.04 and a significant change in Oswestry scores at p <0.04. Poor relationship between	"Pain scale ratings (VAS) and perceived level of function (Oswestry) scores of people classified with lumbar derangement were found to	Small sample size. Powered for 60 subjects so possibly underpowered.

No mention of industry sponsorship or COI.		lumbar disc derangement.	repeated movement exam (n = 15) vs. Mobilization group 3 PT plus joint mobilization based on results of active, repeated, passive movement exam and palpatory findings (n = 10). Follow-up unknown.	the QTF and the outcome data.	improve significantly after three visits for those individuals who underwent a program that included therapeutic exercises as opposed to joint mobilization."	
Delito 1993 RCT No mention of COI's or industry sponsorship.	1.0	N = 24 with low back syndrome referred to physical therapy	Experimental group, mobilization technique supported to affected sacroiliac joint, matched, specifically directed (n = 14) vs. comparison group, unmatched non-specific (n = 10). All supervised with PT session 3x a week basis. Follow up baseline, days 3 and 5.	No significant differences to report between groups. Oswestry scores different among groups, p-value not reported.	"This study illustrates that a prion' classification of selected patients with LBS into a treatment category of extension and mobilization and subsequently treating the patients accordingly with specified interventions can be an effective approach to conservative management of selected patients."	Short follow up (48 hours). Small sample size. Details sparse. Inadequate to draw strong conclusions.
AlBahel 2013 RCT Single-blinded No mention of industry sponsorship or conflict of interest (COI).	1.0	N = 20 with chronic LBP age 25-45 with mean age 34.45±7.45 years.	PT sessions 3 times per week for 4 weeks included stretching exercises for back, hamstring (n = unknown) vs. Kinesio taping or KT group performed stretching exercises for back iliopsoas and hamstring muscles and strengthening exercises for abdominal muscles using kinesio taping, using Cure-Tape (n = unknown). Follow-up for 4 weeks.	Significant differences in measures of pain, ADL and trunk flexion and extension ROM before and after treatment, $p < 0.05$. Pain severity/activities of daily living/trunk flexion/and trunk extension; p = 0.0001/0.0001/0.037 and 0.001.	"A physical therapy exercise program that involves stretching of the back, hamstring and iliopsoas muscles and strengthening of abdominal muscles using KT together may be effective in the treatment of NSCLBP in terms of relieving LBP, increasing the range of pain-free active trunk flexion and extension and improving ADL."	Small sample size (N = 20).
Snook 2002 RCT No mention of industry sponsorship or COI.	0.5	N = 60 with chronic non-specific LBP.	Treatment group instructed to restrict bending activities in the early morning vs. Control group (received instruction in commonly prescribed exercises. Study duration lasted 18 months.	Decrease in pain for all patients was -13.8 days per month after 3 years, no significant difference between compliant and non compliant patients.	"The original trial concluded that the control of lumbar flexion in the early morning is a form of self-care that can help develop a sense of control results also suggest that therapists should not instruct patients with chronic or recurrent low back pain to perform morning exercises that involve lumbar flexion. The results of the follow-up study provide continued support for the original conclusion, especially for the compliance group. However, the	3 year follow up of original study. Methodological details sparse.

					improvement of some of the noncompliant subjects cannot be fully explained by this follow-up study."	
Hollinghurst 2008 RCT Industry Sponsored (Medical Research Council). No COI's.	0	N = 579, with chronic or recurrent LBP.	Single intervention (massage = 204, Alexander technique = 163, 100 = exercise) vs. 2-stage intervention (Alexander technique = 392, massage+exercise = 392, Alexander technique + exercise = 86, Alexander technique + exercise = 22) vs.3-stage intervention (Alexander technique+plus exercise = 421) 12 months.	Days free of pain/QALY gain (Massage and Alexander technique and Exercise) vs. (Alexander technique and Massage+exercise, and Alexander technique+ exercise, Alexander technique + exercise) vs. (Alexander technique+ plus exercise).	"An exercise prescription and six lessons in Alexander technique alone were both more than 85% likely to be cost effective at values above £20 000 per QALY, but the Alexander technique performed better than exercise on the full range of outcomes."	Economic Evaluation
Yardley 2010 RCT Industry sponsored (Medical Research Council). No COIs.	0	N = 359	Lessons in Alexander Technique with 6 or 24 lessons (n = 183) vs. exercise prescription (n = 176); 3 month follow up.	At 3 months, non-significant changes attitudes and perceived behavioural control in exercise arm; attitude in Alexander technique arm significant after Bonferroni correction for 8 comparisons, p = 0.000.	"Using the Alexander Technique was viewed as effective by most patients. Acceptability may have been superior to exercise because of a convincing rationale and social support and a better perceived fit with the patient's particular symptoms and lifestyle."	Secondary analyses of prior study evaluating qualitative issues of intervention acceptance.
Rackwitz 2007 RCT Industry Sponsored (BMGS). No mention of COI.	N/A	N = 100 with LBP episode in the last 2 years	Multimodal prevention program (n = 100) consisted of 18 units of 90 minute sessions conducted over 13 weeks.	More participants had positive prone test results at post-assessment (72%) compared to baseline (50%), p <0.001. Participants experienced less LBP at post assessment, p <0.001.	"[Segmental stabilizing exercises] reduces present LBP during exercise and so can help LBP sufferes to help themselves. Participants in a multimodal program perform [segmental stabilizing exercise] at home and transfer them to their daily life."	Pilot study analysis of 1 arm of randomized trial, does not meet inclusion criteria.
Multiple Modes of Exercise						
Spratt 1993 RCT No mention of industry sponsorship or COI.	3.5	N = 56 with back pain at least 4 weeks but less than 5 years, age 18-60.	Flexion Treatment designed to minimize lumbar extension or lordosis (n = 21) vs. Extension Treatment designed to maintain lumbar extension or lordosis (n = 18) vs. Control Treatment designed to produce no effect and no information was provided regarding	20% of sample had history LBP <6 months, 60% reporting low back problem for >1 year, 56% indicated previous experience with LBP, 32% not employed because of LBP. At 1-month follow-up extension VAS score of 6.85 significantly greater than flexion and control group,	"Significant reductions in pain interference at 1-month follow-up were demonstrated."	Small sample size in each treatment arm (n = 17, 18, and 21). Methodological details sparse.

			either procedure (n = 17). 1 month follow-up.	5.48 and 5.97. Only extension group showed significant improvement across time, p <0.004.		
Sherman 2013 RCT Supported by National Center for Complementary and Alternative medicine (NCCAM) of National Institutes of Health under Cooperative Agreement no U01 AT003208. No mention of conflict of interest or COIs.	2.5	N = 228 with non-specific LBP at least 3 months, age 20-64, rated pain at least 3 on 11-point scale.	Yoga classes including physical movement, breathing and relaxation (n = 78/57) vs. Intensive stretching classes, back exercise (n = 74/51) vs. Self-care book (n = 40/25). Main objective to explore whether physical, cognitive, and physiological factors mediated effects of yoga or stretching. Follow-up interview conducted at 6, 12, and 26 weeks after randomization.	Yoga and stretching had with statistically significant changes in several of 6-week mediator variables, at 0.10 level vs. usual care, in favor of yoga improved self-efficacy, p = 0.010, decreased sleep disturbance due to back pain, p = 0.050, and increased hours of back exercise, p = 0.0006, vs. usual care stretching showed improved self-efficacy, p = 0.002, and increased hours of back exercise, p <0.0001. In 12 weeks mediator variables measured to 6 weeks after randomization, in yoga group, fear voidance/self-efficacy/ conscious awareness/sleep disturbances due to back pain/hours of back exercise/p = 0.062/< 0.0001/0.027/0.0006/ 0.081 statistically significant at 0.10 level, compared to stretching group (compared to usual care), p <0.0001/ 0.003/ 0.0064/0.00038 and hours of back exercise 0.040.	"Both yoga and stretching were superior to self-care, and our mediator analyses suggest that increased participation in back exercise and self-efficacy was responsible for more of these benefits."	Posthoc analyses included analysis of sleep quality sub set analyses of saliva for cortisone and DHEA. Difference in relationship between main cohort and sub set analyses were minimal.
Donelson 1991 RCT	2.0	N = 145 with non-specific LBP with or without referred leg pain presenting at 12 physical	Protocol 1, includes flexion and extension movements, 4 sets of 10 repetitions with brief resting periods (30-60 seconds) between each of 10 (n = 75) vs. Protocol 2,	No significant differences between two protocol groups for gender, age, work status, back, leg symptoms or most other painful episodes. 14	"Forty percent of individual subjects had a clear preference for extension and 7% a clear preference for flexion."	Methodological details sparse.

No mention of industry sponsorship or COI.		therapy clinics in 5 different countries.	flexion and extension movement, 4 sets of 10 repetitions with brief resting periods (30-60 seconds) between each of 10 (n = 70). Order in which flexion and extension movements performed. Follow-up not specified.	experienced decrease in central pain intensity or CI flexion movements, vs. CI of 31 subjects with extension movements, p <0.05. Distal to most peripheral pain or DIST decreased for 11 subjects with flexion movement and decreased for 56 with extension movements.		
Schenk 2003 RCT No mention of industry sponsorship or COI.	1.5	N = 31 with subacute LBP and classified with lumbar disc derangement.	After initial exam, directional exercise group of subjects seen for 3 PT visits, plus performing therapeutic exercises based on results of repeated movement exam (n = 15) vs. Mobilization group subjects 3 PT visits, plus joint mobilization based on results of active, repeated, passive movement exam and palpatory findings (n = 10). Follow-up unknown.	Significant change in VAS rating at p <0.04 and a significant change in Oswestry scores at p <0.04. Poor relationship between QTF and outcome data.	"Pain scale ratings (VAS) and perceived level of function (Oswestry) scores of people classified with lumbar derangement were found to improve significantly after three visits for those individuals who underwent a program that included directional exercises matching patient as opposed to joint mobilization."	Small sample size (N = 25) powered for 60 subjects, so possibly underpowered.
Williams 1991 RCT No mention of industry sponsorship or COI.	1.0	N = 210 with LBP and/or pain referred to leg, age 15 years and over.	Category I: LBP only received kyphotic posture (KP) or lordotic posture (LP), plus PRE-TEST questionnaire, then assigned posture 10 minutes, then POST-TEST1 questionnaire, within 48 hours POST-TEST2 questionnaire, then 10 minutes assigned posture sitting, and POST-TEST3 questionnaire, final (n = 70) vs. Category II: pain referred to buttocks and/or lower limb above knee same procedure as Category I (n = 70) vs. Category III, pain refereed to lower limb below knee, same procedure as Category I (n = 70).	Significant age difference, with Category III patients being older, p = 0.001. Pain location (PL) / Back-pain intensity (BPI) / Leg pain-intensity (LPI): Did not differ significantly at the PRE-TEST. LP group the mean pain scores at POST-TEST2 and POST-TEST3 at p = 0.009 and 0.045. Back pain intensity, compared to PRE-TEST, and between groups compared to PRE-TEST, at p <0.05.	"[LP] results in less back pain than a KP, and also demonstrates that a lumbar roll is a useful aid in the facilitation of a LP in general sitting environments."	Short follow-up, 48 hours.
Yoga						

Pushpika Attanayake 2010 RCT No mention of industry sponsorship or COI.	0.5	N = 12 experiencing back pain for >3 weeks	Group A-Yoga intervention group (n = 6) vs Group B-Control group, educated on proper diet and lifestyle (n = 6).	11 subjective parameters and 3 objective parameters measured in both groups. Yoga intervention group-7/14 parameters significant at p <0.01 with 4/14 parameters significant at p <0.05. Comparison of groups showed 79% relief in both subjective and objective parameters for yoga group vs. control.	"Low back pain can be prevented in a majority of cases, provided maintaining of correct posture, regular and proper exercises, intake of proper selections of food and preserving proper mental health are all followed. Since *yoga* is a holistic method, it is equipped with multi-target approaches. Hence, testified successful results have been obtained."	Small sample size. Details sparse.
Aquatic Therapy						
Dogan 2011 RCT No industry sponsorship. No COI.	3.5	N = 60 with chronic LBP for at least 12 weeks	Group 1, Balneotherapy for 20 minutes daily 5 days a week plus physiotherapy of ultrasound 6 minutes, TENS 20 minutes, hot pack 20 minutes and standard exercise therapy (n = 35) vs. Group 2, physiotherapy only (n = 25) 3 weeks. Assessment at baseline, end of treatment.	VAS after treatment: Group 1 (2.9±1.5) v. Group 2 (3.7±1.4), p = 0.003. Schober test after treatment: Group 1 (15.2±1.3) v. Group 2 (14±1.3, p = 0.001. ROI (%): Group 1 (27.1±10.3) v. Group 2 (37±12.1), p = 0.01.	"[T]he results of the present study reiterate that besides conventional physiotherapy, balneotherapy may be effective in the treatment of patients with chronic low back pain."	Hospitalization in 2 different hospitals (balneo vs. PMR). Applicability to US dubious.
Lumbar Extension Machines						
Friedrich 1998 RCT No COI's. No mention of industry sponsorship.	3.0	N = 93 with LBP age 20-60, back pain duration ≥4 months	Standard exercise program; trunk and lower limb muscle length, force, endurance and coordination; 10 training sessions, 25 minutes a session (n = 49) vs. Combined exercise and motivation program; counseling and information strategies, importance of exercise in reducing pain and likelihood of recurrent episodes (n = 44). Follow-up day 1 of randomization, 3.5 weeks, 4, 12 months.	Mean±SD for Disability: motivation vs. control: baseline: 42.5±14.6 vs. 42.8±13.9. 12 months: 58.9±12.650.9±18.7, p = 0.000. Mean vs. Mean for Working Ability: baseline: 50.0 vs. 55.1. 12 months: 73.5 vs. 57.1, p = 0.0249. Pain Intensity: baseline: 50.2±22.8 vs. 54.5±21.7. 12 month: 26.4±22.2 vs. 41.9±29.6, p = 0.006.	"[A] program combining conventional exercise therapy with a motivation-enhancing intervention strategy significantly reduced the level of disability and pain in low back patients."	Some methods weaknesses that limit conclusions.
Christensen 2003 RCT No COIs or industry sponsorship.	2.5	N = 81 with chronic LBP, age 24-60, lumbar spinal fusion surgery.	Video group; learn rehabilitation exercises via video, one-time instruction provided (n = 29) vs. Café group; same as above, physical therapist, other spinal fusion patients, exchange experiences and	Median score (pain scale range) for Back Pain vs. leg pain last 14 days: pre-op: 6.0 (0-8) vs. 6.0 (0-10). 3 month: 3.3 (0-8) vs. 1.3 (0-8). Café vs. video: 3 month: 4.0 (0-10) vs. 2.0 (0-10), p <0.008. 2 year: 3.0 (0-10)	"The patients in the back-cafe´ group were significantly better at accomplishing a succession of daily tasks compared with the video and training groups 2 years after lumbar spinal fusion. At the 2-year follow-up the training group had a	Many methodological weaknesses.

			support; 3 times for 8 weeks, duration of 1.5 hours (n = 26) vs. Training group; special training regimen, 2 times over 8 weeks, condition training, muscular endurance training, and stretching, 2 times for 8 weeks, duration of 1.5 hours (n = 26). Follow-up 3, 6 months; 1, 2 years.	vs. 3.5 (0-10), p <0.03. Percent positive response Daily Function: café vs. video vs. training: 2 year: 58% vs. 21% vs. 21%, p <0.01. Carry bag of 5kg: 67% vs. 35% vs. 26%, p <0.01. Up from chair: 82% vs. 52% vs. 57%, p <0.01. Climb stairs: 89% vs. 66% vs. 52%, p <0.01. Percent ime exercising at home: Individual Back Training: >2 times per week: 6 month: café vs. training vs. video: 63% vs. 21% vs. 57%, p <0.006.	significant pain problem compared with the video and back-cafe´ groups. The video group had significantly more treatment demands outside the hospital system. This study demonstrates the relevance of the inclusion of coping schemes and questions the role of intensive exercises in a rehabilitation program for spinal fusion patients."	
Smith 2011 RCT No mention of COIs or industry sponsorship.	2.5	N = 42 with chronic LBP, mean age 42.93, SD 10.80	Lumbar extension training with pelvic stabilization (STAB); MedX machine, 1x a week, 12 reps (n = 16) vs. Lumbar extension training without stabilization (NO-STAB), 1x a week, 12 reps (n = 17) vs. Control: normal LBP treatment with physiotherapist; mobilization, muscle imbalance, home exercises, postural advice (n = 13). Follow up 1, 12 weeks.	Percentage increase (joint angle): Lumbar strength, joint angle: STAB: 78.60% (0^{o}), 41.55% (12^{o}), 52.45% (24^{o}), 32.16% (36^{o}), 26.75% (48^{o}), 17.12% (60^{o}), 12.02% (72^{o}); p < 0.001. Mean±SD for post-test VAS and ODI score: STAB vs. NO-STAB vs. control: post VAS: 13.40± 10.80 vs. 28.07±21.82 vs. 26.50±10.20, p <0.05 for STAB vs. NO-STAB; post ODI: 27.30±11.60 vs. 34.00 ±12.60 vs. 33.80±6.30, p <0.05.	"Isolated lumbar extension exercise is very effective in reducing LBP in chronic patients. However, when the pelvis is not stabilized, otherwise identical exercises appear ineffective in reducing LBP."	Discrepancy in number of participants 42 vs. 46.
Manniche 1991 RCT Industry support (Danish Research Council and the Danish Health Foundation, Sygekassernes Helsefond). No mention of COIs.	2.5	N = 105 with chronic LBP, age 20-70 years.	Alternative medicine; hot compresses, massage of back and gluteal muscles, mild exercise program, 10 times, 1 hour, 8 sessions for 1 month (n = 32) vs. Modified back strengthening program; 3 exercises (same group below), 20 times, 45 minutes, (n = 31) vs. Intensive back strengthening program; trunk lifting, leg lifting, includes straps around knees and chest, pull	Median (10/90 percentile) for Low Back Pain Rating Scale: group C vs. group A vs. group B: 3 month: 15.0 (-8.4/31.4) vs. 5.5 (-12.8/19.5) vs. 7.0 (-11.0/21.5), p = 0.005.	"[T]he form of treatment has been tested as a whole. Thus, we are not able to demonstrate whether it is specifically the intensive back muscle training or, on the contrary, the use of hyperextension back exercises that yield the favorable result. Furthermore, we wish to better identify that group of patients who will benefit from the training and to exclude in advance those patients who can neither tolerate this form of	Details sparse.

			to neck; hot pack 15 minutes before, each exercise 50 times, 1.5 hour (n = 27). Follow-up: 3, 6 months, 1 year.		treatment nor benefit from it. Further training studies are in preparation in order to elucidate these questions more closely."	
Choi 2005 RCT No mention of COIs or industry sponsorship.	2.5	N = 75 with unilateral leg pain with or without back pain, mean age 46.09, lumbar spine surgery	Exercise; MedX, measurement of isometric strength of extensor muscles, computed tomography (CT) of lumbar spine (n = 35) vs. Control; home based basic lumbar conditioning exercises (n = 40). Follow-up: 6, 12 and 18 weeks, 1 year.	Mean pain score for VAS: exercise vs. control: pre-VAS: 8.28 vs. 8.1; post 12 weeks: 4.3 vs. 2.51; post 1 year: 1.5 vs. 1.3, $p < 0.05$.	"The introduction of lumbar extension exercises after surgery in patients undergoing discectomy helps achieve an early return to work and also improves spinal function and pain. The exercise regimen increases the cross-sectional area of longissimus and multifidus muscle with parallel increase in strength and endurance as quantified objectively."	Many methodological weaknesses.

MEDICATIONS

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Non-Steroidal Anti-inflammatory Drugs (NSAIDs) and Acetaminophen						
Aghababian 1986	3.5	N = 56 with acute LBP (<72 hours duration)	Diflunisal (1,000mg then 500mg Q 8 to 12 hours PRN, n = 16) vs. naproxen (500mg then 250mg Q 6 to 8 hours PRN, n = 17). Patients evaluated on Days 1, 3, 5, 8, 11, and 15 or until experienced complete pain relief.	Patients free of pain: 81.2% of diflunisal vs. 41.2% naproxen.	"[D]iflunisal rated slightly better in efficacy and tolerability and in improving limitation of function and motion. In addition, diflunisal has a longer duration of action and thus requires less frequent dosing than naproxen."	PRN nature of NSAID prescriptions combined with comparison between maximal dosage diflunisal vs. half maximal doses of naproxen eliminates robust conclusions.
Waterworth 1985	3.5	N = 112 with acute LBP of <1 month	Diflunisal, 1000mg then 500mg BID 10 days (n = 36) vs. physiotherapy directed at lower back, local heat-shortwave for 15-20 minutes then ultrasound for 5-10 minutes (n = 34) vs. manipulative therapy. Some received mechanical therapy; others only manipulation (n = 38). Follow-up at 2 weeks.	Diflunisal group had less time off work (33% less than 1 week vs. 15% vs. 32%).	"Diflunisal (Dolobid) has shown itself to be as effective as physiotherapy in treating low back pain with an acceptable adverse reaction profile."	Baseline differences. Heterogeneous and not well controlled comparison group's treatments that limits strength of conclusions that otherwise suggest NSAID superior to physiotherapy.

Reuben 2005 RCT Support provided solely from institutional and/or departmental source.	0	N = 434 undergoing elective decompressive posterior lumbar laminectomy; 8-year period to assess incidence of non-union following peri-op administration of ketorolac, celecoxib, or rofecoxib.	Perioperative ketorolac 20-240mg·day^{-1}, plus enforced bed rest for 24 hours post-op (n = 120) vs. Celecoxib 200–600 mg·day^{-1}, bed rest for 24 hours (n = 60) vs. Rofecoxib (50mg·day–1), bed rest for 24 hours (n = 124) vs. no NSAIDs in 5 days following spinal fusion surgery, plus bed rest for 24 hours (n = 130). Follow-up for 1 year.	Non-union was identified in 11 of 130 patients or 8.5% who received no NSAIDs group, 7.3%/8.3% in rofecoxib/ celecoxib group. 23 rofecoxib, or low-dose out of 120 patients (19.2%) that received ketorolac had a significantly ($p < 0.001$) higher incidence of non-union compared to non-NSAID users.	"This study revealed that the short-term perioperative administration of celecoxib, rofecoxib, or low-dose ketorolac (# 110 mg·day–1) had no significant deleterious effect on nonunion. In contrast, higher doses of ketorolac (120–240 mg·day–1), history of smoking, and two level vertebral fusions resulted in a significant increase in the incidence of non-union following spinal fusion surgery."	Author with >20 retracted articles. Retrospective case series.
Reuben 2006	N/A	N = 80 posterior spinal fusion	Retracted article.	Retracted article.	Retracted article.	Retracted article.
Reuben 2000	N/A	Retracted article.	Retracted article.	Retracted article.	Retracted article.	Retracted article.
Anti-convulsant Agents						
Khoromi 2005 RCT/crossover Supported by NIDCR Intramural Research Grant Z01 DE00366 in addition to partial support of data technician by Ortho McNeil educational grant. Dr. Max had previously served as paid consultant for Ortho McNeil but resigned before planning study. Ortho McNeil had not input into study design, data interpretation, or manuscript preparation.	3.5	N = 42 with lumbar radiculopathy: presence of pain in one or both buttocks or legs for ≥3 months. Average pain of 4-10 for past month.	Topiramate 50mg at bedtime and doses escalation of 50mg in 2 divided doses during week 1, by 50mg increments in each AM and PM doses during week 3 and 4 for maximum of 400mg vs. Placebo: diphenhydra-mine started at 6.25mg at bedtime, increased to 6.25mg 2x a day during week 1, then increased in 6.25mg interval in each dose at week 2, and by 1.25mg increments in each dose during week 3 for maximum of 50mg a day divided in 2 doses. Follow-up week 2, 6, 8, 10, 14, 16 and 18.	Topiramate reduced average leg pain by 19% (95% Confidence Interval 41% to -3%) compared with placebo $p = 0.06$). Patients reported global pain relief ratings in topiramate group compared with placebo ($p = 0.005$, Wilcoxon signed rank test).	"[I]n summary, we cannot completely rule out the possibility that the apparent pain reduction we observed was due to chance or dropout bias, but we consider it more likely that topiramate has a small but real analgesic effect. A modest effect size might also explain the conflicting results in the diabetic neuropathy studies."	Dropout rate was very high. Small sample size (N=29).
Anti-depressants						
Ward 1984, 1986	3.0	N = 36 with chronic LBP and depression	Doxepin vs. desipramine. Initial doses 50mg QD; final doses 188mg vs. 173mg	No differences found. 2nd report of apparently same study concluded desipramine as effective as	[P]ain relief was associated with depression relief. Patients who had a substantial physical	Randomization and blinding not described; 6 continued in study on fixed doses of opiate-related medications; 5 of 6 responded

			respectively. Follow-up weekly for 4 weeks.	doxepin with 60% having significant pain relief.	basis for their pain responded as well as those who did not."	positively to treatment. Appears to be same population as other study by Ward.
Skeletal Muscle Relaxants						
Valtonen 1975	3.5	N = 400 with painful muscle spasm from 5 spine-related disorders	Chlormezanone 200mg TID (n = 100) vs. orphenadrine 100mg BID (n = 100) vs. orphenadrine amd paracetamol 450mg TID (n = 100) vs. placebo TID (n = 100).	Percent moderate/good effect at 1 week: 53% placebo, 57% chlormezanone, 66% orphenadrine, 71% orphenadrine/paracetamol. Combined drowsiness, insomnia, vertigo and/or muscle weakness, tremor: 22% vs. 18% vs. 24% vs. 41%. Combined effect orphenadrine/paracetamol superior at half recommended dose.	"There is no doubt that a combination of a muscle relaxant and an analgesic is of value in the symptomatic relief of painful muscular conditions."	Lack of details on randomization, baseline characteristics and co-interventions. Placebo effect 53%. Data suggest no significant differences between placebo and some interventions.
Middleton 1984	3.5	N = 113 with acute back pain	Forte (methocarbamol 400mg and aspirin 325mg, n = 55) vs. Lobak (chlormezanone 100mg and paracetamol 450mg, n = 52). Final follow-up at 7 days.	No significant differences found.	"There was no specific difference between the two treatments so far as symptoms relief was concerned, but there were more side-effects and drop outs on Lobak than on Robaxisal Forte and this difference was significant ($p<0.05$)."	Many details sparse and unclear whether this is an RCT.
Borenstein 1990	3.5	N = 40 with mild to moderate acute LBP with associated muscle spasm ≥10 days duration	Cyclobenzaprine and naproxen (cyclobenzaprine 10mg Q 8 hours and naproxen 500mg, then 250mg Q 6 hours, n = 20) vs. naproxen alone (500mg, then 250mg Q 6 hours, n = 20). Trial 14 days.	Naproxen and cyclobenzaprine had less objective muscle spasm and tenderness ($p <0.05$) and maximum motion of lumbosacral spine ($p <0.05$). More adverse effects in combination group ($p <0.05$).	"Patients experienced a more rapid decrease in pain and tenderness as well as greater range of motion with combination therapy."	Small numbers. Patients told to limit activities for 3 days. Data suggest short-term combination therapy may decrease muscle spasm but does not increase function over naproxen alone. Combination had 3 times more adverse effects.
Pipino 1991	2.0	N = 120 with chronic LBP	Pridinol mesilate (n = 60) vs. thiocolchicoside (n = 60). Each received 1 IM injection of 4mg of preparation BID first 3 days then pridinol 2mg or thiocolchicoside 8mg BID. Final follow-up at 7 days.	No differences found, although more patients reported overall efficacy ratings as very good in pridinol group than thiocolchicoside (11 vs. 8).	"[P]ridinol mesilate showed good clinical efficacy and statistically significant and clinically important advantages in local and general tolerability, compared with an established reference treatment, thiocolchicoside."	Tables and graphs representing distance walked and ROM suggest substantial baseline differences. Lack of discussion of randomization suggests not an RCT or randomization failure.
Weber 1980	2.0	N = 98 with acute lumbago-sciatica although some cervical pain	Levomepromazine (doses 7.5+7.5+15mg, n = 43) vs. diazepam (7+7+10mg, n = 29). All given Paralgin forte	10 dropped out of diazepam group due to "intolerable side effects." Authors observed no particular	"Levomepromazine should be preferred as supplementary drug if analgesics (paracetamol	Lack of baseline characteristics provided. High drop-out rate >20 %. No control group to

			2 tablets (paracetamol 0.4g, codeine 20mg, promethazine 5mg) TID with test drugs start of trial for 3 days.	difference between effects of drugs. However, diazepam dose considered too high for many patients.	or acetylsalicylic acid) do not give sufficient relief of pain."	evaluate, no treatment. Data suggest equal (in)efficacy.
Vitamins						
Chiu 2011 RCT Research funded by International Medical University, Seremban, Malaysia. No mention of COIs Three of 5 authors are employees.	3.5	N = 60 ages 30-65 years, mean 47.6±9.6 years, with chronic nonspecific LBP	Placebo (n = 27) NS 1mL injections (route not specified) 3x a week for 2 weeks vs. Methylcobalamin (n = 33) received 1ml intramuscular injections of 500 µg IM 3x/week for 2 weeks.	Methylcobalamin group had reduction in ODI from 64.0±18.3 to 47.0±22.3 ($p < 0.05$) and VAS from 56.0 ±18.6 to 38.6±22.3 ($p < 0.05$). Placebo group no significant reduction ODI (60.5±15.4 to 55.3±20.5, $p = 0.102$) or VAS (54.8± 16.1 to 51.5±19.4, $p = 0.420$) scores.	"Intramuscular methylcobalamin is both an effective and safe method of treatment for patients with nonspecific low back pain, both singly or in combination with other forms of treatment."	Details sparse. Patients not described. Method to blind not stated. Efficacy of blinding not assessed.
Kühlwein 1990 (in German)	8.0	N = 123 with acute lumbar vertebral syndrome	Of 122 completing study, 61 randomized to diclofenac with/without vitamin B complex compared with recommended daily allowances of 1.1mg, 1.2mg, 1.3mg, and 2.4mg.	Showed earlier resolution of pain among vitamin group.	"The results document the positive influence of B-vitamins on painful vertebral syndromes and indicate that B-vitamins contribute to saving of NSAIDs by shortening the treatment time and reducing daily NSAID-dosage."	Article in German. Provocative theory, particularly with earlier pain resolution among vitamin group. High doses of vitamin B complex of 50-100 times recommended daily allowance raises concerns regarding risks. Needs replication.
Vetter 1988 (in German)	8.0	N = 256 with painful spinal diseases with degenerative changes	Of 238 completing study, 116 randomized to diclofenac and Vitamin B_1, B_6, B_{12} (N group), and 122 to diclofenac (D group).	Difference between N and D groups statistically significant ($p < 0.05$).	"The study results document the positive influence of B-vitamins on painful symptoms and indicate that less NSAID is needed for pain relief when combined with B-vitamins."	Article in German. Same concerns regarding high dose and need for replication as for Kühlwein 1990, as one study was of acute LBP and one of chronic LBP.
Complementary or Alternative Methods or Dietary Supplements, Etc.						
Chiu 2011 RCT Research funded by International Medical University, Seremban, Malaysia. No mention of COIs Three of 5 authors are employees.	3.5	N = 60 ages 30-65 years, mean 47.6 ± 9.6 years, with chronic nonspecific LBP	Placebo (n=27) NS 1mL injections (route not specified) 3x/week for 2 weeks vs. Methylcobalamin (n = 33) received 1ml intramuscular injections of 500 µg IM 3x/week for 2 weeks.	Methylcobalamin group had reduction in ODI from 64.0±18.3 to 47.0±22.3 ($p < 0.05$) and VAS 56.0±18.6 to 38.6±22.3 ($p < 0.05$). Placebo group did not have significant reduction in ODI (60.5±15.4 to 55.3± 20.5, $p = 0.102$) or VAS (54.8±16.1 to 51.5 ±19.4, $p = 0.420$) scores.	"Intramuscular methylcobalamin is both an effective and safe method of treatment for patients with nonspecific low back pain, both singly or in combination with other forms of treatment."	Details sparse. Patients not described. Method to blind not stated. Efficacy of blinding not assessed.

PHYSICAL AND OCCUPATIONAL THERAPY

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Bruce-Low 2012 Modified RCT No mention of COI or industry sponsorship.	3.5	N = 72 with chronic LBP.	Group 1: exercised once a week with the lumbar extension machine (n = 31) vs. Group 2: exercised twice a week with lumbar extension week (n = 20) vs. Control group: did not exercise (n = 21). Last follow-up at 12 weeks.	Significant increase in maximal strength scores when training 1 x week and 2x week ($t30 = -6.42$, $p < 0.001$ and $t19 = -3.95$, $P < 0.001$, respectively). Significant increases in ROM seen with Group 1 ($t30 = -2.65$, $p = 0.01$) and 2 x week training ($t19 = -3.68$, $p = 0.002$).	"[O]ne lumbar extension training session per week is sufficient for strength gains and reductions in pain in low back pain in CLBP patients."	Modified RCT. Pragmatic with multiple cointerventions. Patients not well descried. Data suggests strengthening exercises effective.
Kofotolis 2006	3.0	N = 108 females with chronic LBP (longer than 24 weeks for majority)	Rhythmic stabilization training with alternating isometric contractions (n = 28) vs. combination isotonic with alternating concentric and eccentric contraction of agonists without relaxation exercises (n = 28) vs. control (n = 30), 5 times a week for 4 weeks. Follow-up at 4, 8 weeks.	Both training groups improved significantly in lumbar mobility and on Oswestry Disability Index.	"Static and dynamic PNF programs may be appropriate for improving short-term trunk muscle endurance and trunk mobility in people with CLBP."	Female participants only. Lack of details such as baseline characteristics and co-interventions. Drop-out rate >20 %. Data suggest exercise may improve chronic LBP.
Garcia 2011 RCT To the Fundação de Amparo a Pesquisa do Estado de São Paulo (FAPESP) for supporting and funding study. No mention of COI.	NA	Incomplete inclusions. N = 18 in this preliminary report with chronic non-specific LBP	Back school group: 1 individual session and 3 group sessions vs. McKenzie group: exercises guided per preferred direction of movement. Both groups received 4 treatment sessions, 1x a week for 45-60 minutes. Study on-going, preliminary data taken at 4 weeks.	At beginning, pain intensity 6.4 points decreasing to 4 points at the end (95% CI = 0.84 to 3.93; $p = 0.005$). No improvements seen in trunk flexion ROM ($p = 0.11$).	"The Mckenzie and Back School's approaches may be beneficial for the treatment of patients with chronic non specific low back pain for the outcomes pain intensity and disability."	Incomplete RCT. Data on only 18 completed – exclude.

Domenech 2011 RCT No mention of COI or industry sponsorship.	N/A	N = 170 2nd-year physical therapy students	Experimental group received specific education module based on the biopsychosocial model of back pain management (n = 87) vs. control group received lectures on biomechanics of spine (n = 79).	All dependent variables significantly different after educational sessions. Experimental group had significantly reduced scores on FABQ-Work, HC-PAIRS, FABQ-Physical Activity and perception of severity of symptoms and pathology reduced.	"Our results confirm the possibility of modifying the behavior of students through the modification of their beliefs and attitudes. We also conclude that a strictly biomedical education exacerbates maladaptive beliefs, and consequently results in inadequate activity recommendations."	Trial on students and not patients.
Rackwitz 2007 RCT Research project sponsored by BMGS (Grant No. 124-43164-1/527). No mention of COI.	N/A	N = 100 with LBP episode in last 2 years. Follow up.	Multimodal prevention program (n=100) consisted of 18 units of 90 min sessions conducted over a period of 13 weeks.	More participants had positive prone test results at post-assessment (72%) compared to baseline (50%), p <0.001. Participants experienced less low back pain at post assessment, p <0.001.	"[Segmental stabilizing exercises] reduces present LBP during exercise and so can help LBP sufferers to help themselves. Participants in a multimodal program perform [segmental stabilizing exercise] at home and transfer them to their daily life."	Pilot study analysis of 1 arm of randomized trial, does not meet inclusion criteria.
Verra 2012 Case series The Zurzach Rehabilitation Foundation SPA, Bad Zurzach, Switzerland, supported study. No COI.	0.0	N = 88 with non-specific back pain or fibromyalgia at least 6 months	Intervention group: horticultural therapy plus pain management program (n = 41) vs. Control group: pain management program only (n = 47). Last follow-up at 4 weeks.	Control group improved in 7 scales SF-36 physical functioning (ES = 0.30; p = 0.O43); SF-36 bodily pain (ES = 0.67; p = 0.015); SF-36 vitality (ES = 0.63; p = 0.005);	"[T]he implementation of horticultural therapy as a component of an inpatient pain-management program might have biopsychosocial benefits."	Not randomized. Case series.

DEVICES

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Shoe Insoles and Shoe Lifts						
Tooms 1987	3.0	N = 100 nursing students prolonged standing/walking 3 times a week, 8 hours a day	Viscoelastic insoles (n = 50) vs. usual footwear (n = 49) for 5 weeks.	Location of post-work pain, duration of post-work pain, and frequency of pain during work day significantly different at post-test: p = 0.02, p = 0.04, p = 0.02.	"Post-test comparisons between groups indicated significant differences which were not present at pre-test."	LBP dropped with viscoelastic insoles from 27% to 18%. However, controls rose from 30% to 42%, suggesting potential bias.

Milgrom 2005 RCT Supported by grant from Israeli Defense Forces.	3.0	N = 404 military recruits	Semirigid biomechanical orthoses (n = 136) vs. soft custom orthoses (n = 133) vs. simple shoe inserts (n = 135) for 14 weeks.	81% reported positive difference. No significant difference between treatment groups. Using study to treat others with back pain, 78% good or excellent results at 1 year follow-up.	"The results of this study do not support the use of orthoses, either custom soft or semirigid biomechanical, as prophylactic treatment for weight bearing-induced back pain."	High dropouts in all groups weakens the conclusions. Data suggests that orthoses cannot prevent low back pain in military recruits. Utilization rate of the orthoses was also low.
Defrin 2005	2.0	N = 33 with CLBP ≥6 months	Fitted shoe inserts (n = 22) vs. control (n = 11). Final follow-up at 12 weeks.	Both groups increase in active straight leg raising, decrease spinal mobility, and increase functional capacity.	"[T]he correction of an LLD of 10mm or less can significantly reduce CLBP."	Two to 1 intervention to controls. Baseline differences present, some favor one or other groups, so effects difficult to predict. Conclusions questionable.
Kinesiotaping (including KT Tape and RockTape) and Taping						
Enciso 2009 RCT No mention of COI or industry sponsorship.	2.0	N = 14 with chronic non-specific LBP	4 each in Kinesiotaping and exercise groups completed.	No significant differences before vs. after kinesiotaping. Exercise associated with improved pain and disability.	"There seems to be a considerable improvement in low back pain and disability when treating the patient with exercise therapy…No beneficial effects were found in Kinesio taping Group."	Small sample size with high dropouts. No evidence of kinesiotaping efficacy, and trial suggests inferior to exercise.
Karatas 2012 No mention of COI or industry sponsorship.	0.0	N = 32 surgeons working within university hospital	Surgeons without kinesiotape (n = 32) vs. same surgeons on 1st and 4th day of kinesiotape application (n = 32). Follow-up at Day 1 and Day 4 of kinesiotaping.	Reduction in ODI and Neck Disability index significant on Day 4. Cervical flexion, cervical extension, cervical right lateral flexion, cervical left lateral flexion, cervical right rotation and cervical left rotation increases significant. Lumbar flexion, lumbar extension, lumbar right lateral flexion, lumbar left lateral flexion increases significant.	"[K]inesiotaping would be an effective method for reducing neck and low back pain and improving cervical and lumbar range of motions and functional performance."	Not randomized. Small sample size.
Lumbar Supports						
Alexander 1995	3.5	N = 60 nursing and service workers	Back belts (n = 30) vs. control (n = 30) for 3 months.	No differences between groups self-report work-related back injuries, perceived pain in total back and individual regions of back.	"[A]lthough back belts did not significantly decrease the number of work-related back injuries and did not improve perceived pain levels, belts made employees feel more secure and supported when lifting…."	Data suggest lack of efficacy.
Chronic Low Back Pain						
Lumbar Corset with and without Spinal Support						

Million 1981 RCT No mention of COI or industry sponsorship.	2.0	N = 19 with chronic LBP for at least 6 months, who had not previously tried some form of spinal support.	Lumbar corset with a spinal support (n = 9) vs. Lumbar corset without spinal support. Patients asked to wear corset during day and also given instruction on appropriate methods of bending, lifting, care of back.	At 4-week follow-up, group with spinal support showed significant improvements in pain vs. without spinal support group. (p <0.05). At 8-week follow-up, results more significant support vs. without support (p = 0.01).	"There was significant improvement in those with a support compared with those without. On the other hand objective changes measured with the corset removed did not differ between the 2 groups. This study indicates that the spinal support in a lumbosacral corset makes a significant contribution towards the relief of symptoms."	Details sparse.
Subacute Low Back Pain						
Lumbar Support vs. Control Group						
Kraus 2002 RCT No mention of COI or industry sponsorship.	2.0	N = 12,772 workers of 9 different home attendants who perform general domestic tasks in homes of clients.	Back BeltGroup (Lumbar support belts) who also received use instructions (n = 3,837) vslifting advice only group (n = 4,300) vs. Control Group (No advice given nor lumbar support belts) (n = 4,635).	Back injury rates and rate of injury ratios higher in control and advice-only groups; lower back belt group. Advice-only (rate ratio-1.28), Back Belt (rate ratio- 1.09), Control (rate ratio 1.48). With 95% CI Advice-only vs. Back Belt 1.18 (0.87-1.59). Control vs. Black Belt (1.36 (1.02-1.82)	"The back-belt group had a lower rate of low back injury than did those in both the advice-only and control groups, though the differences were marginally significant. The findings suggest that use of back belts is associated with some reduction in risk of low back injury."	Few details.
Lumbar Support vs. Standard Therapy						
Valle-Jones 1992 RCT No mention of COI or industry sponsorship. Bauerfeind UK supported and provided Lumbotrain.	3.0	N = 216 with 1st episode of LBP, chronic LBP or an acute exacerbation of longer-standing problem	Lumbotrain back support of appropriate size worn throughout day and optional HS (n = 111) vs. standard therapy consisting of advice on rest and lifestyle (n=105) for 3 weeks.	VAS pain at rest: lumbotrain 456.6 vs. control 627.7, p <0.004. Pain on activity: 581.1 vs. 769.2, p <0.001. Pain at night 382.8 vs. 507.0, p <0.03. Activity limitation: 587.1 vs. 763.8, p <0.003. Mean dose number analgesics taken: lumbotrain 24.5 vs. control 51.0, p <0.0001.	"[T]he use of a 'Lumbotrain' back support increases the speed and extent of alleviation of symptoms compared with conventional management, increases the speed at which patients can return to normal work and is very acceptable to patients."	"Standard therapy" control likely biases in favor of intervention. Randomization process unclear and may be quasi-randomized (?every other?).

PHYSICAL METHODS

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Massage						
Mackawan 2007 RCT Study supported by a 2002-2003 Khon Kaen University research grant, Khon Kaen University, Khon Kaen, Thailand. No mention of COI.	3.0	N = 67 self-reported LBP >12 weeks then selected by trained physical therapists or rehab doctors	Part 1: Traditional Thai Massage (TTM) to back muscles 10 min. using 10 Sens theory (n = 5) vs. Mobilization grade 2 5min/set, 2 sets/level at lumbar spinous process of L2-L5 (n = 5). Part 2: TTM (n= 35) vs. joint mobilization (n = 32). Each treatment 10 minutes and level of P in salvia collected 5 in. after each of treatments. 10 received TTM or mobilization and about 2ml of salvia collected in order to test substance P. Saliva collected over pre- and immediate post-treat.	Mean and SD of substance P levels in salvia: Pretreatment vs. post-treatment: TTM 73.86±62.31-50.43±64.39 p = 0.019. vs. Mobilization: 80.61±85.26-56.27±72.77 p = 0.006. Mean and SD VAS. Pre-treatment vs. Post-treatment: TTM: 4.22±1.98-2.45±1.75 p = 0.000 vs. Mobilization: 4.35±1.71-3.39±1.66 p = 0.002.	"[B]both TTM and joint mobilization can relieve pain in patients with non-specific low back pain. However, TTM yields slightly more beneficial effects than joint mobilization."	Active control group. Limited patient description and few results. Small groups tested. No differences between groups in substance P.
Walach 2003 RCT Study sponsored by German Association for Physical Therapy. No mention of COI.	3.0	N = 29 with chronic non-inflammatory rheumatic pain duration >6 months	Massage (n = 19) vs. standard medical care (n = 10) at 3 measurements: pre-treatment, post-treatment, and 3 months follow-up.	ANOVA showed difference in pain between groups (p = 0.001) and a change over time (p <0.05).	"[M]assage can be at least as effective as standard medical care in chronic pain syndromes."	Abstract notes "Because of political and organizational problems, only 29 patients were randomized…" Impacts of these issues unclear and statement seems to allude to high dropout rate among those in standard care. Does not demonstrate efficacy of massage; may have been underpowered. Marked differences in baseline data prohibits strong conclusions, demonstrates methodological flaw.

Zheng 2012 RCT Study supported by Olympic Games scientific research project of General Administration of Sport of China and National Natural Science Foundation of China. No mention of COI.	2.5	N = 64 with non-specific LBP with or without sciatica, lasting >3 months. Age 21-70.	Tender point deep massage plus lumbar traction (n = 32) vs. lumbar traction (n = 32).	VAS pain scores were significantly improved in both groups, for massage (6.7 +/- 1.6 to 4.9 +/- 1.3; p<0.05) and for lumbar traction VAS pain scores (6.9+/- 1.6 to 5.9+/-1.3; p<0.05).	"…This study shows that tender point deep tissue massage in combination with lumbar traction can increase local paraspinal pressure pain threshold and decrease muscle hardness level, while also lowering pain intensity and demonstrates that pain intensity may be related to pressure pain threshold and muscle hardness."	Lack of study details for baseline characteristics. No blinding described. No control of cointerventions and compliance.
Romanowski 2012 RCT No mention of COI or industry sponsorship.	2.5	N = 26 with chronic LBP, aged 60-75 years	Therapeutic massage (TM) using effleurage, petrissage, tapping, and friction (n = 13) vs. deep tissue massage (DTM) (n = 13) using oblique pressure, lengthening and cross-fiber stroke, anchor and stretch.	DTM group with significant VAS score changes from pre-treatment 59.15 +/- 13.17 to post-treatment 34.23 +/- 10.7 (p<0.001) and ODI scores from pre-treatment 48.3 +/- 13.63 to 31.92 +/- 11.72 (p<0.001).	"…The study showed positive, statistically significant effects of massage on the CLBP in these research. The lack of a control group with no massage treatment in the present study does not allow us to make the conclusions on the usefulness of any kind of massage for patient with CLBP. Further research is needed to verify the results."	No randomization details and other methods sparse. Small sample size. Baseline differences (e.g., VAS 43 vs. 59). Weaknesses too many for strong conclusions.
Hernandez-Reif 2001	2.5	N = 24 with CLBP ≥6 months	Massage therapy 2 30-minute sessions a week for 5 weeks vs. relaxation therapy consisting of progressive muscle relaxation exercises tensing and relaxing large muscle groups, 30-minutes at home 2x a week for 5 weeks.	After 1st and last massage sessions, subjects less depressed and anxious. Relaxation group less anxious after 1st session. Massage group improved trunk flexion (p = 0.001), and pain flexion measures (p = 0.002).	"Massage therapy is effective in reducing pain, stress hormones and symptoms associated with chronic low back pain."	Massage and relaxation control treated differently as relaxation controls asked to perform home exercises. Study suggests relaxation may not have been compliant, but did not report compliance. Dropouts not reported.
Reflexology						
Eghbali 2012 RCT Study supported by Isfahan University of Medical Sciences. No COI.	2.0	N = 50 no age range mentioned. Nurses included if LBP, chronic non-specific back pain diagnosed by neurosurgery specialist for >3 months, healthy feet without injury or damage,	N = 5 (reflexology) vs. n = 25 (non-specific massage, controls); 3-part questionnaire: demographic data, characteristics of pain, (length, frequency, treatment, drug use), assessment of pain intensity at time of completing questionnaire	No significant difference in personal detail between 2 groups. Comparison of pain characteristics between groups not significant. Average pain scores before/after intervention revealed significant reduction in pain scores in both test and control groups (p <0.01). Comparing average pain scores after intervention in control and	"Recognizing the impact of reflexology on chronic back pain makes it possible to use this technique as a complementary intervention with other treatments for complicated conditions such as back pain in which patients do not usually benefit from other methods. In addition, reflexology can be easily taught to people in order to take effective steps to reduce chronic pain.	Patients not described well. Sparse information for methods and results. Unclear how double blinding was performed. Quasi-randomization for every other patient.

		and willingness to participate in study.	based on Numerical Analogue Scale for pain. Researchers performed 6 40-minute sessions of interventions (2x a day, 3 days a week 2 weeks). Then massage starting at lower legs, ankles, soles, then toes.	test groups showed significantly higher score reduction in test group than control group.	The treatment team can also take advantage of this method for treating low back pain patients."	
Traction						
Tesio 1993	3.5	N = 44 with lumbar disc herniation, and LBP ≥1 month	Conventional passive traction (sessions every day, n = 22) vs. autotraction (every 2-3 days for 3-10 session, n = 22). Non-responders crossed over: autotraction (AT, n = 5), conventional passive traction (PT, n = 18). Final follow-up at 3 months.	Differences in response: AT 17/22, PT 4/22, p <0.001. Improvement in subjects treated with AT (75%) vs. PT (22%), p <0.001. Those who responded to AT had decrease in VAS median pain, and MPQSF scale: 75%-33%, 17.78%-11.11%, p <0.001.	"After 3 months, 19 of the 30 responders to AT (63%) reported continued improvement."	Open trial and involved patient vs. passive treatments, thus a finding in favor of autotraction is not surprising.
Lidström 1970	2.5	N = 62 with subacute, chronic sciatica	Conventional treatment (n = 21, hot packs, massage, mobilizing, strengthening exercises) vs. alternative treatment (n = 20, intermittent pelvic traction, isometrical training of abdominal. hip extensor muscles) vs. control (n = 21, hot packs and rest).	Conventional vs. alternative vs. control; subjects needing analgetics before treat/after treat: 12/9/9, 7/-/4. Difference between groups for clinical evaluation, and patients' opinion significant: p <0.01, p <0.01.	"The results show a significant priority for the group that was treated with intermittent pelvic traction combined with isometrical training of the abdominal muscles."	Statistical testing results indicated no difference between alternative treatment that included traction and control group despite lack of active treatment of controls, suggesting lack of, or weak, efficacy.
Mirovsky 2006 RCT No mention of COI or industry sponsorship.	2.5	N = 84 patients with LBP for at least 6 months, but less than 2 years	Vertical ambulatory traction device (VATD), 12 sessions daily VATD then 8 more sessions QOD alternating days, after 1st 3 sessions traction increased both groups but group 1 stand or sit during sessions (n = 42) vs. group 2 walk on treadmill 3 km/h 15 minutes after 3rd session. Follow-up 1, 6, 12 months after program completed.	Only significant difference found between groups was for pain and group 2 was favored (p <0.001).	"[T]traction combined with treadmill walking is effective in the treatment of patients with chronic LBP."	Sparse methods. No control for traction device. Data suggest walking beneficial.

Ljunggren 1992 RCT No mention of COI or industry sponsorship.	2.5	N = 51 with herniated intervertebral disc. L5 or S1 clinical diagnosis	Manual traction 1x a day 10 minutes or 2x a day 5 minutes for 5-7 days (n = 24) vs. isometric exercise for abdominal, back, hip, thigh muscles repeated 5-10 times for each muscle group (n = 26).	Ten of 24 patients (41.6%) vs. 10 of 26 (38.5%) were pain free or improved within the 5 to 7 day trial. No significant differences between groups.	"It is unlikely that the treatments applied in the present study will alter the course of lumbago-sciatica due to disc herniation. A longer treatment period might have shown different results."	Sparse methods. Effect of both manual traction and isometric exercise is doubtful in patients with lumbago-sciatica and herniated lumbar disc.
Decompression through Traction and Other Decompressive Devices						
Ramos 2004	3.0	N = 142 with herniated lumbar discs, LBP, and failed standard medical therapy	VAX-D therapy: 20 sessions (n = 51) vs. 10 sessions (n = 91).	Significant difference with 20 sessions for remission vs. negative response: p <0.01; 20 sessions higher remission rate/lower failure rate vs. 10 sessions: p <0.0002.	"Seventy-six percent of the higher dosage group achieved remission of low back pain compared to 43% of the lower dosage group."	Methods not well described.
Manipulation and Mobilization						
Nwuga 1982	3.5	N = 51 with disc protrusion age 20-40	Conventional treatment (diathermy, gentle isometric exercises, lifting and postural education, n = 26) vs. manipulative treatment (lumbar oscillatory rotation, n = 26) 3 times a week.	Numbers returning for treatment after 3 months: 28% in conventional group vs. 11.5% in manipulation group.	"[M]anipulation therapy as shown by this study was found superior to the conventional method in the treatment."	Details sparse. Dropout rate high.
Godfrey 1984	3.5	N = 90 with acute LBP <14 days	Rotational manipulation and massage (n = 25) vs. massage (n = 23) vs. rotational manipulation and electrostimulation (n = 23) vs. electrostimulation (n = 19) for 2-3 weeks.	Significant improvement for all groups measured at baseline-final assessment for each index, p <0.001.	"[M]anipulation in a population with acute low back pain without any specific organic cause is not clearly superior to two physiotherapeutic maneuvers that we considered unlikely to have any effect."	No pure controls to evaluate natural history. No baseline characteristics. Data suggest all acute patients improved regardless of treatment group.
Arkuszewski 1986	3.5	N = 100 with sciatica or LBP	Manually traction (n = 50), mobilization, and manipulation of spine) vs. control group (n = 50). Both groups given bed rest, ASA 1.5gm, Bernard's current, and 10 sessions of massage to lumbosacral region. Control treatments average 3.8 weeks; 3.1 weeks for manual traction. Final follow-up at 6 months.	Differences between groups in posture vs. measured at admission, after treatment, after 6 months: p >0.05, p <0.001, p <0.001. Differences in active movement of spine: >0.05, p <0.001, p <0.001. Gait: p >0.05, p <0.001, p <0.001. Pain: p >0.05, p <0.001, p <0.05.	"[I]mprovement was significantly greater in MTG even six months later."	High ratings given for symptoms and signs of "LBP syndrome" suggest population did not primarily represent sciatica. Use of bed rest for groups when this is now not recommended, poorly complied with, compliance not evaluated also limits conclusions.

Evans 1978	3.5	N = 32 with mostly chronic LBP ≥3 weeks	Group A: spinal manipulation immediately after assessment (n = 15) vs. Group B: 3 weeks after assessment (n = 17).	Spinal flexion decreased in Group A from 1 to 4 weeks post manipulation; p <0.05.	"[P]ain scores were reduced to a significant degree within four weeks of starting treatment only in the group manipulated in the first treatment period."	Study too small for conclusions; compares only timing at which manipulation performed.
Herzog 1991	3.5	N = 37 with chronic LBP and thought to have SI joint problems	Spinal manipulative therapy (SMT, n = 16) vs. back school therapy (BST, n = 13) chiropractic 10 sessions over 4-week period (discharge if earlier complete resolution).	Differences in pain scores widened over treatment. Gillet motion palpation scores by blinded chiropractic assessors showed no differences. No p-values or CI given.	"[B]ack school therapy was a better treatment modality than the spinal manipulative therapy, according to the clinical measures of rehabilitation. Precisely the opposite result was found for the biomechanical measures."	Many details sparse. Statistical testing not performed. Results conflict.
Zylbergold 1981	3.0	N = 28 thought to have lumbar disc disease, age 25-65	Moist heat 15-minutes then 15-minute lumbar flexion exercise session with pelvic rhythm training (n = 10) vs. moist heat 15 minutes then 15-minute manual therapy (n = 8) vs. home instruction (control) in back care and body mechanics (n = 10).	All groups improved, but manual therapy group showed more improvement in pain scores.	"[N]o statistically significant differences in measurements of pain, forward, right-side, and left-side flexion, or functional activity between the 3 groups."	Small sample size. Data suggest no differences or underpowered.
Kinalski 1989	3.0	N = 11 with LBP syndromes and not candidates for surgery	Manual therapy (n = 61) vs. physiotherapy (n = 50) plus group exercises. Mean treatment for manual therapy 2-16 days, and 14-29 days for physiotherapy plus group exercises.	No difference in erector spinae muscle strength between two groups found. No p-values given in article.	"With the use of manual therapy in patients with LBP syndrome, there is decreased reflexive muscular hypertonia in the lumbar region with decreased pain and increased lumbar spine mobility…there was no significant increase in erector spinae muscular strength utilizing manual therapy."	No baseline characteristics. No mention of co-interventions or randomization methods. Comparison group/experimental group interventions not standardized. Data suggest manual therapy may help LBP.
Postacchini 1988	2.5	N = 398 with various types of LBP, but excluding radicular pain syndromes by only allowing radiation to thigh	Group 1: LBP only (Subgroup A acute; Subgroup B chronic; Subgroup C acute with history of chronic pain) vs. Group 2: LBP radiating to buttocks and/or thighs and no neurological changes. Subgroups assigned to manipulation, diclofenac, physiotherapy, placebo,	At 3-weeks follow-up, greatest mean improvement observed in manipulation group (p <0.001). Lowest improvement was observed in placebo group (p <0.05). Placebo group abandoned "because it was difficult to convince patients not to undergo treatment…"or were lost to follow-up."	"Considering the mechanisms of action of this method of treatment, it is logical that the therapeutic benefits are obtained slowly and tend to persist over a long period. This is consistent with the results of our study showing that Low Back School is most effective in the long-term treatment of patients with chronic back trouble."	Described as "comparative study" and "prospective study" raise concerns whether an RCT despite random assignments (not supported by table). Group I only LBP, and Group II LBP and buttock and/or thigh pain. Placebo abandoned raising questions about adequacy of blinding.

			bed rest (only acute, 20-24 hours a day), and low back school (only chronic).			
Hoehler 1981	2.5	N = 95 with acute, subacute, and chronic LBP and naïve to manipulation and treatments	Rotational spinal manipulation (n = 56) vs. soft tissue massage (n = 39). Assessment at 3 weeks after discharge (discharge time not well described).	Number of patients reporting treatment was effective 3 weeks after discharge: 88 (manipulation) vs. 68 (control); p <0.05.	"[P]atients who received manipulative treatment were much more likely to report immediate relief after the first treatment," and "at discharge, there was no significant difference between the two groups because both showed substantial improvement."	Dropout rate 40%, limiting conclusions; 3 weeks post discharge, 48% of controls vs. 21% manipulated had moderate to very severe pain. Follow-up of same study, but with more patients concluded that those failing to respond tended to have high measures of neuroticism and anxiety.
Rupert 1985	2.0	N = 145 Egyptian workers age 18-68 with LBP or leg pain and/or restriction in lumbar ROM	Chiropractic adjustments with short-level manipulation vs. sham manipulation with touching and palpating plus non-therapeutic massage vs. drugs and bed rest. All received treatment and assessed 3 times a week.	Graphs of results (no data) suggest that those with chiropractic adjustments did better.	"[I]nitial data analysis relating to these four variables reflected greater improvement in the group given chiropractic treatment."	Number of subjects assigned to each treatment not given. Without data, no statistical analysis possible.
Cibulka 1988	2.0	N = 26 LBP non-specific origin and undefined duration with sacroiliac joint dysfunction	Manipulation (n = 10) vs. control group (n = 10) who received no treatment.	Manipulation had altered innominate tilt of same side and opposite tilt of opposite side; p <0.05.	"SIJD can be identified reliably in patients with LBP and that a manipulative procedure purported to be specific to the sacroiliac joint change innominate tilt bilaterally and in opposite directions."	Non-interventional controls biases in favor of intervention. Study too small to support strong conclusions.
Cramer 1993 RCT Supported by Shiraz University of Medical Sciences. No mention of COI.	2.0	N = 60 with acute LBP (mechanical pain on L3/S1) for <2 weeks, ≥8 in Oswestry questionnaire, and ≥33mm on VAS	Treatment with side lying manipulation (n = 17) vs. Control group (n= 19) treated with detuned ultrasound, application of cold pack, and 15-30 minutes of gentle soft massage.	Hmax/Mmax Mean±SD difference between Treatment group -0.101±0.211 in left, and -0.117±0.315 on right vs. control group: 0.038±0.300 on left, and 0.036±0.231 on right.	"[A]lthough the H reflex physiology appears to be responsive to perturbation by spinal manipulation, the effect is probably too small to be clinically useful."	P values not shown.
Bicalho 2010 RCT No mention of COI or industry sponsorship.	2.0	N = ? with non-specific chronic LBP, no pain radiating below the knee.	Spinal manipulation (n = 20) vs. sham manipulation (n = 20).	Manipulation group improved in pain intensity (p = 0.001) and finger-floor distance (p <0.001). Controls improved significantly in finger-floor distance (p = 0.031), but not pain intensity (p = 0.433).	"[H]igh-velocity sinal manipulation technique acutely modifies the EMG activity during flexion-extension movements performed by chronic low-back patients."	No follow-up. Some baseline differences in the outcome measures. Experimental study limits conclusions.

Petersen 2011	1.5	N = 350 with or without leg pain and symptoms and signs of disc herniation	Spinal manipulation to lumbopelvic spine plus information about exam findings and advice about back care vs. McKenzie exercises.	Better reduction in disability with McKenzie vs. manipulation. Higher proportion in McKenzie group had success vs. manipulation; p = 0.02.	"In patients with persistent low back pain and clinical signs of intervertebral disc problem study found the McKenzie method to be the most effective choice of treatment comparing spinal manipulation when used adjunctive to information and advice. Clinical method, however was questionable."	Short report of conference proceedings. Most details sparse.
Hot and Cold Therapies						
Cryotherapy						
Melzack 1980	3.5	N = 44 with chronic LBP, age 18-73, mean pain duration 7.4 years; all failed to respond to conventional treatment	Two treatments of ice massage (n = 22) then transcutaneous electrical stimulation vs. same treatments given in reverse order (n = 22) at intervals of 1-2 weeks.	Mean decrease in pain 50.4% with ice massage and 48.7% with TENS. After crossover, slightly more pain relief in ice group.	"Evidence that cold signals are transmitted to the spinal cord exclusively by A-delta fibers and not by C fibers suggests that ice massage provides a potential method for differentiating among the multiple feedback systems that mediate analgesia produced by different forms of intense sensory input."	Long-term follow-ups ranged from 1 to 12 months after last testing session, resulting in an uncontrolled potential confounder.
Hot Packs						
Kumar 2009 RCT No mention of COI or industry sponsorship.	3.5	N = 30 male hockey players age 18-28 with non-specific subacute or chronic LBP	Conventional treatment, n = 15 (ultrasound, short wave diathermy, lumbar strengthening exercises) vs. dynamic muscular stabilization treatment (DMST): week 1 target muscle isolation, facilitation; week 2 training of trunk stabilization, static conditions of increased load; week 3 develop trunk stabilization during slow controlled movement of lumbar spine; weeks 4-5 lumbar stabilization during high speed, skilled movement (n = 15). Treatments alternate days for 35 days 40 minutes each session.	Walking (mean±SD) day 0/day 21/day 35: conventional 350.53±5.67/353.40±4.07/355.80 ±5.56 vs. DMST 353.20±5.45/361.33±3.75/379.87 ±3.93, p >0.05/<0.01/<0.01. Stand ups: 17.67±2.19/19.47±2.17/21.47±1.4 6 vs. 18.60±1.59/22.73±1.94/28.53±0.9 9, p >0.05/<0.01/<0.01. Pain: 7.00±1.07/5.80±0.94/4.33±0.82 vs. 7.07±0.96/4.93±0.88/1.47±0.99, p >0.05/<0.01/<0.01.	"[B]oth therapies (conventional and DMST) are found to be effective in the early recovery of patients with subacute of chronic low back pain, especially in pain control. The hypothesis that the treatment DMST is more effective than the conventional was found to be true."	Many details sparse.
Kumar 2009 RCT	3.5	N = 102 males age 20-40 with subacute or	Conventional treatment, n = 51 (USultrasound, short wave diathermy, and lumbar strengthening	Back pressure changes (sedentary/ desk workers/movement job/ shopkeepers/other): conventional 8.50±1.69/10.36±1.70/7.73±1.70/	"[F]or the management of occupational LBP, DMST is more effective than conventional treatment. The Pain of Sedentary and	Many details sparse. Exercises heterogeneous and unclear. Non-exercise

No mention of COI or industry sponsorship.		chronic non-specific LBP.	exercises) for 20 days vs. dynamic muscular stabilization treatment (DMST, n = 51).	6.78±1.59/9.80±1.36 vs. DMST 17.25±1.76/19.50±1.11/16.77± 1.46/19.67±2.04/16.25±2.08, p <0.05/<0.05/<0.05/<0.05/<0.01.	Shopkeepers and physical strength of Movement job and Other may need more clinical attention."	treatments likely ineffective.
Durmus 2010 RCT No mention of COI or industry sponsorship.	3.0	N = 59 females with LBP at least 3 months	Electrical stimulation (ES) with frequency 50Hz and exercises (45 minutes of back and abdominal exercises), group 1 (n = 20) vs. Ultrasound (US) continuous with frequency 1 MHz and exercises, group 2 (n = 19) vs. control group that was only given exercises, group 3 (n = 20). All programs 3 days a week for 6 weeks. Evaluations at baseline, 3 and weeks, and 6 weeks of therapy.	NS between groups.	"[A] combination of ES or US therapy and exercises provide comfortable life functions by improving pain, muscle strength, and QOL."	Many details sparse. No blinding. Data mostly suggest equal results, suggesting ES and US of little benefit.
Siems 2010 RCT No mention of COI or industry sponsorship.	3.0	N = 270 with degenerative osteoarthritis (coarthrosis or gonarthrosis), LBP, and rheumatoid arthritis	Verum (IR-A): infrared radon (n = 32 low back), treated for 2 weeks with Infra Care HP 3631 and HP 3641 appliances. Duration approximately 15 minutes per session at indicated distance (30-50cm) vs. placebo (visible radiation only, no infrared) (n = 11) vs. no irradiation (n = 32). All treatments lasted 2 weeks.	MDA measurement as determined according to Wong (2005) with modifications of Somerburg (1993) as thiobarbituric acid derivative. MDA mean and SD Low Back pain: MDA pre Verum: 0.58±0.06 (p ≤0.05) Placebo: 0.53±0.06 (p ≤0.0005). MDA Post: Verum: 0.53±0.009(p ≤0.0005) Placebo: 0.55±0.08 (p ≤0.0005).	"[I]n patients suffering from low back pain or rheumatoid arthritis, the pain and mobility improvements were accompanied by significant changes in MDA serum levels. However, MDA appears not a sensitive biofactor for changes of pain intensity in degenerative osteoarthritis. Nevertheless, unaffected or lowered MDA levels during intensive IR-A therapy argue against previous reports on free radical formation upon infrared. In, conclusion, rapid beneficial effects of IR-A towards musculoskeletal pain and joint mobility loss were demonstrated."	Details sparse, short follow up, not equal randomization within LBP group.
Mohseni-Bandpei 2006 RCT Supported by Islamic Republic of Iran Ministry of Health and Medical	2.5	N = 120 age 18-55 with LBP >3 months	Spinal manipulation (2-7 sessions 1-2x a week with an exercise program (manipulation/exercise group, n = 60) vs. USultrasound (frequency of 1 MHz for 5-10 minutes minutes, 3-11 sessions 1-2x a week) with same exercise	Mean between group differences (95% CI) following treatment favor manipulation/ exercise group: pain intensity 16.4 (6.1-26.8), p = 0.001; ODI Oswestry Disability Index 7.8 (2.4 to 13.2), p = 0.001; lumbar flexion 9.4 (5.5-13.4), p = 0.017; lumbar extension 3.4 (1.0-5.8), p = 0.014. Median frequency for multifidus	"[S]pinal manipulation therapy, in conjunction with an exercise programme, can be an effective therapeutic approach for patients with chronic LBP. Participants in the manipulation/exercise group showed a greater benefit than those in the ultrasound/exercise group in both the short and the long term."	Baseline duration 36 vs. 51 months favored manipulation. Exercise poorly described and compliance unknown. High dropouts at 6mo. many details sparse. Wide ranging numbers of treatments.

Education. No mention of COI.			program (USultrasound/exercise group, n = 60). Exercise program provided by PhysioTools. Follow-up end of treatment and 6 months.	and iliocostalis: NS. Median frequency slope in favor of manipulation/ exercise group: multifidus 0.3 (0.1-0.5), p = 0.013; iliocostalis NS. 6 month follow up in favor of manipulation/ exercise group: pain intensity 1.4 90.1 to 2.7), p = 0.001; Oswestry Disability Index 7.4 (0.1-13.8), p = 0.001.		
Constant 1998 RCT No mention of COI or industry sponsorship.	2.5	N = 224 any age experiencing LBP defined as pain between 12th rib and gluteal fold, lasting at least 1 year (physician assessed) recruited from health care centers and only referred after GP using clinical exam, radiography, and lab investigations determined LBP.	Routine drug therapy from personal physician (n = 96) vs. treatment 1: Routine drug therapy (same as control) plus spa therapy for 6 days a week for 3 consecutive weeks: 10 min bath at 36ºC with underwater flow (everyday), local application mud at 45ºC for 15 min.(everyday), 20 min. massage under flowing water at 36ºC (every other day).	No significant differences at baseline. Health status improved in each group at 3 weeks and 3 months, but no significant differences. Mental health and depression scores differed at baseline between treatment and control groups (p = 0.02), controls better. Treatment effects at 3 weeks and 3 months suggest patients' health status improved in treatment group. Improvements in mean and SD noted in anxiety (p = 0.00.1) Physical (p = 0.011) mental (p <0.00014), depression (p <0.001).	"[T]his study suggests that spa therapy is an effective treatment for chronic low back pain patients."	Block randomization performed every 7 subjects in random 2-2-3 design. No sample size differentiation between treatment 1 and 2 they were combined for the final analysis and no mention of sample size was given for initial treatment. Thus, study excluded.
Diathermy						
Gibson 1985	3.5	N = 109 with subacute or chronic LBP pain >2 months but <12 months	Short-wave diathermy (n = 34) vs. detuned short-wave diathermy (placebo, n = 34) vs. osteopathy (n = 41) 3 times week for 4 weeks.	At 12 weeks, no treatment arm superior.	"[O]ur results almost certainly attest to the magnitude of the placebo response which may be achieved when harmless treatments are applied with conviction."	Baseline characteristics dissimilar and may bias against diathermy (percent worsening LBP at enrollment was 41% vs. 27% vs. 23%), favoring osteopathy.
Beyerman 2006 RCT Funded by Farington Foundation. No mention of COI.	3.5	N = 252 with documented history of osteoarthritis and experiencing LBP at time of study; 35 drop-outs	Moist hot pack plus chiropractic care, flexation/distraction technique applied (n = 143) vs. Moist heat group subjects (n = 109); examination of subject's back at initial visit and moist got pack applied for 15 minutes at each visit for both groups.	OPI current, average, during past week pain levels with treatment x time and pain levels attributable to heat alone/ROM right/left lateral flexion/average extension and great alone/ADL lifting and traveling: (p <0.05 & p <0.01)/(p <0.05 and p <0.01)/(p = 0.098 and p = 0.06).	"This study suggests an argument for using manipulation, flexion-distraction, and moist heat for patients who have documented OA of the lumbar spine."	Many details sparse.

Ahmed 2009 RCT No mention of COI or industry sponsorship.	3.0	N = 111 with chronic LBP, from 2002-2003	Shortwave diathermy low back region, 15 minutes, 3 times a week for 6 weeks (n=47) vs. Detuned placebo shortwave, with machine on, but not producing heat (n = 50).	End of 2, 3, 4, 5, 6 weeks scores: (15.34± 4.82, treatment score 20.44±3.02 vs. 17.58±3.39, treatment 20.10±3.51, p = 0.01, and 13.06±5.01 vs. 15.70±3.77 p = 0.005, and 11.06±4.15 vs. 15.04±3.77, p = 0, and 8.34±3.62 vs. 14.02±3.31, p = 0, and 6th week Group A score 6.44± 3.06).	"In conclusion, present study showed that shortwave diathermy is an effective modality in the treatment of the patients with chronic low back pain."	Many details sparse.
Shakoor 2008 RCT Supported by University Grants Commission. No mention of COI.	3.0	N = 127 with chronic LBP, >3 months; 25 drop-outs	Group A or short wave diathermy (SWD) and NSAID or Non-Steroidal Anti-Inflammatory Drugs (n = 58) vs. Group B or placebo SWD & NSAID (n = 56). 6 weeks follow up.	Group A vs. B (pre-treat/week 1) and (pre-treat/post-treat): (15.16±3.01, & 13.9±2.63, p = 0, 95% CI = 0.62 to 1.82) and (15.16±3.01, and 9.04±2.49, p = 0, 95% CI = 5.38-6.85) vs. (15.16±3.01, and 13.94±2.62, p = 0) and (15.46±3.25, and 11.48±4.02, p = 0).	"From the present study, it may be concluded that both the treatment (NSAID and SWD) is effective for the treatment of Chronic LBP."	Many details sparse.
Kettenmann 2007 RCT parallel-designed Funded by unrestricted grant from Procter & Gamble, Egham, UK. No mention of COI.	2.5	N = 38 with acute LBP >5 and no higher than 0 VAS	Oral analgesics, if needed (n = 15) vs. Oral therapy and heatwrap therapy once a day for 4 hours, at least for 4 consecutive days (n = 15).	EEG measurements, for treatment group significantly larger drop.	"In addition to classic psychophysical assessment of pain-related parameters and sleep quality, performance in daily life, we were able to obtain objective measures (EEG) that suggest an acute therapeutic relaxation on the basis of the central nervous system effects accompanying the reported significant pain relief:"	Extremely short follow-up.
Infrared Therapy						
Buselli 2011 Double-blind RCT Study associated with Engineering Department of Themesys Srl, company that designed and manufactured SMATH® system. Authors declare no competing interests.	4.5	N = 72, with non-specific, sub-acute, & chronic LBP, age 18-70	SMATH system (medical device that combines basic principles of mechanical massage, thermotherapy, acupressure, infrared therapy, and moxibustion) (n = 36) vs. sham therapy (medical device without active principles), (n = 36). 7 months of trial, total 11 months including observational follow-up. 4 sessions first 2 weeks, 3 sessions weeks 3 and 4.	RMDQ average score of 10.96 (sd = 3.04; p < 0.05) at baseline and 3.21 (sd = 2.99; p < 0.05); at 3 months, and the average quality adjusted life year (QALY) was 0.46 (sd = 0.13; p < 0.05) at baseline and 0.81 (sd = 0.12; p < 0.05) after 3 months.	"These data have not been published because they were not suitable for publication and represented the results obtained by one clinical study in which the primary outcome was the demonstration of clinical safety."	Only a study protocol, no results.
Siems 2010 RCT	3.0	N = 270 with degenerative osteoarthritis	Verum (IR-A): infrared radon (n = 32 low back), treated for 2 weeks with	MDA measurement as determined according to Wong et al (2005) with modifications of Somerburg	"[I]n patients suffering from low back pain or rheumatoid arthritis, the pain and mobility improvements were	Details sparse, short follow up, not equal

No mention of COI or industry sponsorship.		(coarthrosis or gonarthrosis), LBP, and rheumatoid arthritis.	Infra Care HP 3631 and HP 3641 appliances. Duration approximately 15 minutes per session at indicate distance (30-50cm) vs. placebo (visible radiation only, no infrared) (n = 11) vs. no irradiation (n = 32). All treatments lasted 2 weeks.	et al. (1993) as thiobarbituric acid derivative. MDA mean and S.D. LBP: MDA Pre: Verum: 0.58±0.06 (p ≤0.05); Placebo: 0.53±0.06 (p ≤0.0005). MDA Post: Verum: 0.53±0.009(p ≤0.0005) Placebo: 0.55±0.08 (p ≤0.0005).	accompanied by significant changes in MDA serum levels. However, MDA appears not a sensitive biofactor for changes of pain intensity in degenerative osteoarthritis. Nevertheless, unaffected or lowered MDA levels during intensive IR-A therapy argue against previous reports on free radical formation upon infrared. In, conclusion, rapid beneficial effects of IR-A towards musculoskeletal pain and joint mobility loss were demonstrated."	randomization within LBP group.
Ultrasound						
Cramer 1993 RCT Supported by Shiraz University of Medical sciences. No COIs mentioned.	2.0	N = 60 with acute LBP (mechanical pain on L3/S1) for <2 weeks, ≥8 in Oswestry questionnaire, and ≥33mm on VAS.	Treatment with side lying manipulation (n = 17) vs. control group (n = 19) treated with detuned ultrasound, application of cold pack, and 15-30 minutes of gentle soft massage.	Hmax/Mmax Mean±SD difference between Treatment group -0.101±0.211 in left, -0.117±0.315 on right vs. control group: 0.038±0.300 on left, 0.036±0.231 on right.	"[A]lthough the H reflex physiology appears to be responsive to perturbation by spinal manipulation, the effect is probably too small to be clinically useful."	P values were not shown.
Low-level Laser Therapy						
Gur 2003	3.5	N = 75 with chronic LBP ≥1 year, age 20-50, no previous spinal surgery	Low-power laser therapy (n = 25) vs. exercise (n = 25) vs. laser therapy plus exercise (n = 25).	Pain ratings (pre-/post-therapy) combined 6.2±2.1 to 1.8±1.2; exercise 6.5±1.6 to 2.9±1.3; laser 6.1±1.9 to 1.9±1.4. Roland disability scores (pre-/post-therapy) combined 17.8±4.6 to 6.3±3.5; exercise 15.1±4.2 to 5.5±3.2; and laser 16.3±3.9 to 6.6±2.9.	"Low power laser therapy seemed to be an effective method in reducing pain and functional disability in the therapy of chronic LBP."	Compliance and co-interventions unclear. No true control group. Data suggest equal (in)efficacy.
Jovičić 2012 RCT No mention of COI or industry sponsorship.	3.0	N = 66 with subacute LBP with radiculopathy, ≤4 weeks LBP, after 1-2 weeks of Nimesulide.	Low level laser therapy given in three different doses: Group A 0.1 Joules per point vs. Group B 1 Joules vs. Group C 4 Joules.	All groups significantly reduced lumbar pain (p >0.05). Lumbar spine flexion improved in all groups (p <0.0001). Group C significant improvements in walking (p = 0.007), sitting (p = 0.005), and standing (p = 0.013) vs. other groups.	"The results in this study show that the three investigated energy doses are equally effective in reducing lumbar and leg pain without side effects in patients with acute LBP and radiculopathy, but the dose of 4 J per point seems to be more effective in improving the activities of daily living and lumbar mobility."	Method for blinding unclear. Baseline differences in outcome measures limit conclusions.
Transcutaneous Electrical Nerve Stimulation (TENS) and Neuromuscular Electrical Stimulation (NMES)						
Warke 2006 RCT	3.5	N = 90 with chronic LBP	Low-frequency TENS group (4 Hz, 200ms) (n= 30) vs. High-frequency TENS group (110 Hz, 200ms) (n = 30) vs.	Primary outcomes: statistically significant interactive effect between groups over time (p = 0.008) in VAS for average LBP. VAS scores decreased in all	"In conclusion, the findings of this study suggest that high-frequency TENS is more effective for pain relief during application, with low-frequency TENS demonstrating a	20% drop out in high intensity group.

No mention of COI or industry sponsorship.			Placebo TENS (n = 30). Patients observed at 1, 6, 10, and 32 weeks.	groups but high-frequency group had greatest reduction at week 6 (63% high-frequency; 42% low-frequency; and 57% placebo). At week 32, low-frequency group had greatest reduction in VAS score (29% high-frequency; 52% low-frequency; and 44% placebo).	more sustained hypoalgesic effect in the long term. During the treatment period, improvements in function were also noted in the low-frequency group with both active TENS groups showing the greatest improvements in quality of life scores. However, it must also be acknowledged that a placebo effect was noted throughout the trial, which in itself, is an interesting observation. The findings of this study could have important implications for clinical prescription of TENS for pain relief and improved quality of life in the MS population."	
Topuz 2004	3.0	N = 55 with chronic LBP 15-21 months	Percutaneous neuromodulation therapy: 4 Hz (PNT, n = 13) vs. conventional TENS: high frequency electrical stimulation of 80 Hz (n = 15) vs. low-frequency TENS: 4 Hz (n = 15) vs. placebo-TENS (n = 12) for 20 minutes 5 x a week for 2 weeks.	PNT and TENS more effective than placebo TENS for current pain, activity pain, LBP Outcome Scale, ODI and SF-36, p <0.05. PNT better than conventional TENS and low-frequency TENS for activity pain score, general health score on SF-36, p <0.05.	"PNT was more effective than C-TENS and low-TENS in both relieving activity pain and relieving limitations of emotional role, increasing vitality and general health perception."	Randomization process in doubt with unequal size groups and baseline comparability issues. Dropouts also high.
Yokoyama 2004	3.0	N = 53 with chronic LBP	PENS 8 weeks (Group A, n = 18) vs. PENS first 4 weeks and TENS for second 4 weeks (Group B, n = 17) vs. TENS for 8 weeks (Group C, n = 18) 2x week for 8 weeks.	Peak pain VAS lower Group A vs. Group C. At 2 weeks: p <0.05; 4 weeks: p <0.01; 8 weeks: p <0.01; 1 month follow-up, p <0.01. VAS scores in Group A lower than Group B at 8 and 12 weeks.	"[R]epeated PENS is more effective than TENS for chronic LBP but must be continued to sustain the analgesic effect."	Conclusion that treatment must be continued to sustain improvement not directly tented with this study.
Puranik 2002 RCT Manufacturer's agent in UK provided Action Potential Simulator. No COI stated.	3.0	N = 24 with chronic LBP.	Action potential simulation therapy (n = 12) vs. placebo device (n =2) for 5 consecutive sessions, each lasting 8 minutes.	VAS scores significantly different at visit 4 (p = 0.03) and visit 5 (p = 0.021) for sham vs. active treatment.	"[T]he APS device produced analgesia but the size of the effect is small and clinically not significant. The treatment seems to require four to five sessions before improvement is seen."	Details sparse, small sample size (n=24).
Kerr 2003 RCT Supported by Department of Health and Social Services	3.0	N = 60 with chronic LBP >6 months with or without leg pain, and no neurologic deficits.	Acupuncture for 30 minutes per each 1 of 6 sessions over a 6 weeks period (n = 30) vs. Placebo TENS for 30 minutes, patient carried 6	Results for SF36 quality of life questionnaire significant (p = 0.004), and also range of movement and VAS (p = 0.01, and p = 0.03, respectively). 91% (n = 21) of acupuncture group	"[T]he treatment regimen used in this clinical trial has demonstrated no significant difference between Acupuncture and Placebo-TENS for chronic low back pain."	Many weaknesses.

for Northern Ireland. No stated COI.			sessions over 6-week period (n = 30).	experienced pain relief vs. 75% (n = 13) in Placebo-TENS group.		
Glaser 2001 RCT Supported in part by grant from RS Medical Corporation, Vancouver, WA, but no COI stated.	2.0	N = 80 with LBP at least 6 weeks duration	Electrical stimulation (n = 32) vs. placebo (n = 23) 30 minutes 2x a day for 2 months. Follow-up at 2 and 6 months.	Mean LBP outcome instrument summative scores baseline/2 months/6 months for electrical stimulation vs. placebo for job exertion: 2.87± 1.30/2.69±1.21/2.74± 1.24 vs. 3.09± 1.42/2.83±1.12/2.89 ± 1.37.	"[T]his combines therapeutic approach does seem to be helpful in this patient population and may offer patients with subacute and chronic back pain a more effective combined therapeutic rehabilitation protocol. We believe it is one more tool that can be used for this difficult group of patients."	One sided tests performed, high dropout rate.
Presser 2000 RCT No mention of COI or industry sponsorship.	1.5	N = 30 with sciatica, painful lumbar radiculopathy >3 months, herniated disc, no history of back surgery or epidural steroid injection.	Real TENS of frequency: 100 Hz, pulse width: 0.1 ms, a symmetric biphasic waveform (n = 30) vs. sham TENS with electrodes with sub-threshold electrical current (n = 30) vs. no treatment.	Mean±SD pain levels at end of treatment for TENS 47 ± 7 vs. sham TENS 46 ± 5 vs. no TENS 49 ± 5.	"TENS does not reduce pain in the epidural steroid injection model. Thus, the efficacy of TENS in reducing pain associated with invasive procedures remains questionable."	Details sparse.
Percutaneous Electrical Nerve Stimulation (PENS)						
Topuz 2004	See TENS above.					
Yokoyama 2004	See TENS above.					
North 2002, 2005	2.5	N = 24 with lumbosacral root injury pain, and pain prior to back surgery	Percutaneous 4-contact electrode (n = 12) vs. insulated 4-contact array electrode via laminectomy (n = 12).	Laminectomy vs. percutaneous had significant reduction in reliance on prescription analgesics, p <0.05.	"Laminectomy electrode placement, although more invasive than percutaneous placement, yields significantly better clinical results in patients with failed back surgery syndrome at mean 1.9 years follow-up."	Methods sparse.
Acupuncture						
Coan 1980	3.5	N = 55 with chronic LBP >6 months, no previous acupuncture, no history of diabetes, infection or cancer, not more than 2 back surgeries	Immediate acupuncture treatment (n = 23) vs. delayed acupuncture (controls, n = 16) with last follow-up 40 weeks after enrollment. Could receive regular acupuncture or electrical. Third group of those who did not receive adequate treatment included (n = 11).	At 40 weeks, immediate treatment group scores dropped in hours of pain per day, pain pills per week, pain score, limitation of activity by 44%, 49%, 30%, 40% respectively. In delayed treatment, scores dropped in pain pills per week, pain score, limitation of activity, by 3%, 29%, 33%. Inadequate treatment dropped in pain pills per week by 24%.	"[A]cupuncture was a superior form of treatment for these people with low back pain, even though they had the condition for an average of 9 years."	Different sized groups. Traditional Chinese acupuncture appears to have been utilized. Many weaknesses. Given data suggest immediate treatment superior to delayed treatment.
Kerr 2003	3.0	N = 60 with chronic LBP >6 months	Acupuncture at set locations with 11 needles each session (n = 30) vs. placebo TENS (n = 30).	No significant differences found at any time.	"Results from the 6-month follow-up would suggest that the response was better in the acupuncture group."	Baseline characteristics lacking. Dropout rate >20%. Lack of co-interventions at 6 month

			Both groups treated weekly for 6 weeks. Final follow-up at 6 months.			follow-up. Data suggest advice of exercise may have more effect than either intervention.
MacPherson 1999 RCT No mention of COI or industry sponsorship.	3.0	N = 20 with LBP lasting 1 month or more	10 session of individualized acupuncture from a traditional acupuncturist. Six months follow-up.	6 months vs. post-treat, Oswestry scores showed reduced levels of pain, decreasing 40% from baseline. Post-treat; statistical significance improvements in Oswestry, present pain intensity, effect on daily living, physical functioning, social functioning, bodily pain, vitality and mental health sub-scales of the SF36.	"Though the improvements in pain and quality of life may be due to the natural course of back pain, the promising response justify further research."	Small sample size. Pilot study.
Lin 2010 RCT No mentioned of COI or industry sponsorship.	1.5	N = 100 with chronic LPB more than 6 months without radiation pain.	PRF therapy modulated by 500KHz (n = 29) vs. Electro-acupuncture therapy (n = 36) vs. conservation treatment with medication and no stimulation by PRF or EA (n = 35).	ODI (assess pain intensity, personal care, lifting, walking, sitting, standing) mean (SD) before treatment and month after: male vs. female 38.2 (33.6) vs. 35.8 (28.2) p = 0.0029 1 month after: 35.6 (32.8) vs. 28.0 (28.2) p = 0.0023. VAS scores all nonsignificant.	"[T]his study provides sufficient evidence of the superiority of pulsed radiofrequency (PFR) therapy for low back pain relief compared with both elector-acupuncture (EA) therapy and the control group. But the functional improvement of the lumbar spine was proved under EA therapy only. Both therapies are related to electricity effects."	No age range is recorded.
Laser Acupuncture vs. Sham Laser						
Glazov 2010 RCT Secondary analysis of Glazov 2009 Supported by Australian Medical Acupuncture College, no COI.	N/A	N = 100 with chronic non-specific LBP	10mV laser group (n = 45) vs. Sham group (n = 45); baseline and after treatment comparability of characteristics between groups examined, required minimum of 5-10 treatment sessions.	Significant difference between groups only at 6 weeks follow up in PPC (% pain change), with 23% pain reduction in favor of laser. Effect of laser vs. sham, p = 0.055, only at short term follow-up.	"The findings of this study suggest which characteristics of patients with chronic low back pain are more likely to respond to laser acupuncture treatment, but require replication in other studies."	Secondary analysis of RCT limits conclusions to hypothesis generating.
Shankar 2011 RCT No mention of COI or industry sponsorship.	3.0	N = 60 with chronic LBP	Electro acupuncture (10 sittings total) (n = 30) vs. conventional therapy of Valdecoxib and physiotherapy (n = 30) vs controls.	VAS pain scores decreased in both groups, acupuncture (6.8+/-1.33 to 3.3 +/- 1.5) and drug therapy (6.9 +/- 1.45 to 4.2 +/-1.8). GPE scores increased both groups, acupuncture (2.03+/-0.65 to 5.5+/-6.8) and drug therapy (2.0 /-0.45 to 5.3+/-0.74).	"…Following electro acupuncture and drug therapy, there was a significant reduction in vagal tone and a decrease in the sympathetic tone…It was also observed that subjects in the acupuncture group showed a better response as compared to the drug group…"	Lack of study details. No blinding. Author suggest statistical differences in % VAS reduction favoring acupuncture. But actual VAS score reductions likely not clinically significant. Data do not support effectiveness.
Inversion Therapy						
Güvenol 2000 RCT	3.5	N = 29 with CT diagnosed lumbar disc herniation,	Inversion table traction 5 minutes 1st day, 8 2nd day, 10 3rd day,	Significant decreases in number of disc protrusions favored conventional traction over	"Clinical efficacies of the two traction methods were not significantly different from each other. CT efficacy	Many methodological weaknesses. Baseline differences in mean disc

No mention of sponsorship or COI.		LBP and lower extremity pain 1+ mo. duration; Mean (±SD) age 33.8 (±6.0) for inversion traction and 39.6 (±5.8) for conventional traction.	following suit for 10 days total (n = 15) vs. Conventional traction for 20 minutes/day, starting at 30kg increased to 45kg by 3kg/day for 10 days (n = 14). Both groups mandated bedrest and received 15 minutes IR and isometric exercises. Assessments at baseline, 10 days, 3 months.	inversion table traction; 69.2% versus 35.7%, (p = 0.0185). No significant differences between groups for total pain cluster, straight leg raising or finger to floor scores. Both groups improved from baseline.	of the conventional traction group was apparently better. Patients seemed to tolerate conventional traction better than inversion."	protrusion likely confound results on changes in disc protrusion. Data suggest equal (in)efficacy.
Kim 2013 RCT Sponsored by Hanseo University, Republic of Korea. No mention of COI.	2.5	N = 47 women with 12+ weeks LBP; Mean (±SD) age 20.5 (±0.52) for laying supine group, 20.7 (±0.69) for -30° Inversion group and 20.9 (±0.66) for -60° Inversion group	Laying supine group (n = 15) vs. -30° Inversion group (n = 18) vs. -60° Inversion group (n =14). All groups received 3 minute treatment for 3 reps a session. Sessions 4x a week for 8 weeks. Assessments at baseline and 8 weeks.	At 8 weeks both inversion groups more % change in VAS back pain vs. controls after exercising; -30° Inversion group: -59.42%±16.41% vs. -60° Inversion group: -59.85%±16.46% vs. Supine group: -32.03%±32.43%, (p = 0.009). Significant % improvement change also in trunk flexion, trunk extension and extensor peak torque vs. baseline.	"[A]n 8 week of inversion traction at the angles of -30° and -60° significantly improved VAS scores, trunk flexibility, trunk muscles strength and muscle mass. In particular, inversion traction at -60° for 8 weeks seems to be an effective treatment for back pain or discomfort."	Many outcome measures of unclear clinical significance. Some data suggest potential effectiveness, however, weaknesses are numerous and impair ability to draw firm conclusions.

INJECTION THERAPIES

Author Year (Score):	Category:	Study type:	Conflict of Interest:	Sample size:	Age/Sex:	Comparison:	Follow-up:	Results:	Conclusion:	Comments:
Lumbar Epidural Steroid Injections										
Friedly 2017 (score= 9.0)	Injection	RCT	No mention of sponsorship or COI.	N=400 patients with central lumbar spinal stenosis	Mea age= 68.0 years; 179 males, 221 females.	Participants received up to 2 epidural injections during the initial 6 weeks of the study prior to being offered crossover, and up to 2 injections between 6 and 12 weeks. Group 1: participants is given corticosteroid(1 to 3mL of 0.25% to 1% lidocaine with triamcinolone (60-120mg), betamethasone (6-12mg), dexamethasone	Follow up at baseline, 3 weeks, 6 weeks, and 3, 6, and 12 months.	At 12 months, RDQ (adjusted mean differences, -0.4, 95% CI, -1.6-0.9; *P*=.55) or leg pain intensity (adjusted mean difference, 0.1; 95% CI, _0.5 to 0.7; PZ.75) showed no significant difference between Group 1 and Group 2.	"For patients with lumbar central canal spinal stenosis, treatment with epidural injections of corticosteroid plus lidocaine offers no additional benefits from 6 weeks to 12 months beyond that of	Allowed self-selected crossover at 6 weeks point No minimum differences between groups.

						(8-10mg), or methylprednisolone (80-120mg) Group 2 (n=200): participants is given only lidocaine			injections of lidocaine alone in terms of self-reported pain and function or reduction in use of other treatments, such as opioids and spine surgery."	
Cohen 2015 (score= 8.0)	Injection	RCT	Sponsored by congressional grant from the Center for Rehabilitation Sciences Research, Bethesda, MD.COI, one or more of the authors have received or will receive benefits for personal or professional use	N=145 Participants with lumbosacral radicular pain	Mean age= 42.7 years; 107 males, 38 females	Group 1 (n=73): participant receive l epidural steroid Injection and placebo gabapentin. Injection is administered by certified physician who conducted either an interlaminar injection or transforaminal epidural injection. Solution consisted of 60 mg of depomethylprednisolone +1 mL of 0.25% bupivacaine was administered Vs. Group 2 (n=72): receive gabapentin and sham injection. Same technique was use from group 1 except the sham injections the needle was position 1-2 cm proximal to the epidural space into the posterior ligaments.	Follow up at baseline, 1, and 3 months.	Improvement of average leg pain scores (mean 3.3 points (SD 2.6) at 1 month and mean change from baseline -2.2 points (SD 2.4) in Group 1 vs. 3.7 points (SD 2.6) and -1.7 points (SD 2.6) in gabapentin group, but no significant difference between groups was observed (adjusted difference 0.4 points, 95% confidence interval −0.3 to 1.2; P=0.25)	"Although epidural steroid injection might provide greater benefit than gabapentin for some outcome measures, the differences are modest and are transient for most people."	Data suggest a slight benefit of epidural injection at 3 months over gabapentin.
Maniquis-Smigel 2016 (score=8.0)	Injection	RCT	No mention of sponsorship. COI, Liza Maniquis-Smigel	N=35 Moderate to severe non-surgical low back pain.	Mean Age=54 years; 43 males, 11 females.	Group 1 (n=19) :participant were allocated to 10 ml caudal 5% Dextrose epidural Injections	Follow up at 2 weeks.	Greater than 50% of pain reduction in 4 hours is reported by 84% (16/19) of dextrose recipients and 19%	"Compared with blinded saline, dextrose caudal epidural injection resulted in	Single injection intervention, Short follow-up time of 2 weeks. Data suggest dextrose caudal

			including David Smigel, practice manager, Roquita Kaisen office manager, and Sasha Mooina, medical receptionist.			Group 2 (n=16): participants were allocated to 10 ml caudal 0.9% saline for non-surgical (NS) (using a published vertical caudal injection technique.)		(3/16) of saline recipients. Dextrose participants reported greater NRS pain score change at 15 minutes (4.4±1.7 vs 2.4±2.8 points; P = 0.015), 2 hours (4.6±1.9 vs 1.8±2.8 points; P = 0.001), 4 hours (4.6±2.0 vs 1.4±2.3 points; P < 0.001), and 48 hours (3.0 ± 2.3 vs 1.0 ± 2.1 points; P = 0.012), but not at 2 weeks (2.1 ± 2.9 vs 1.2 ± 2.4 points; P = 0.217)	substantial analgesia within 15 minutes that persisted for 48 hours among chronic nonsurgical LBP patients with buttock and/or leg pain, suggesting a neurogenic effect of dextrose in the caudal space."	epidural injection provided short term analgesic.
Huiges 2012 (score=7.5)	Injections	RCT	No sponsorship. No mention of COI.	N=63 Participants with acute radiculopathy.	Mean age= 43.6 years; 30 males, 30 females.	All patients received care as usual from their GP. Care included Intervention pain treatment with analgesics, maintaining normal daily activities as much as possible, and referral if necessary. Control group (n=36) vs. Intervention group (n=37): received the same care, plus segmental epidural steroid injection in addition. Epidural steroids consisted of 80 mg of triamcinolone in normal saline.	Follow up at 2, 4, 6, 13, 26, and 52 weeks.	Mean total cost for the study period were €4414 or $5985 per patient in the intervention group and €5121 or $6943 in the control group, with loss of productivity as major contributor. CEAC showed that the probability that epidural steroids in acute radiculopathy are cost-effective rises to 100% with an additional investment of about €1200 or $1627 per patient.	"The effect on pain and disability of epidural steroids in lumbosacral radicular syndrome is small but signifi cant, and at lower costs with no reported complications or adverse effects. Segmental epidural steroid injections could be considered by policy makers as an additional	Usual care Bias, Single injection intervention. Data suggest epidural steroids for the treatment of lumbosacral radicular pain via a single injection has a small favorable effect.

									treatment option."	
Chun 2015 (score=6.5)	Injections	RCT	No sponsorship or COI.	N = 62 patients experiencing lumbar radicular pain with a pain intensity of 40/100 or greater who had been diagnosed with a herniated nucleus pulposus or spinal stenosis after a series of physical, neurologic, and radiologic examinations.	Mean age: 65.9 years; 26 males, 36 females.	DL8 group receiving 8 mL of injectate (0.33% lidocaine (n = 32) vs DL3 group receiving 3mL of injectate (0.33% lidocaine) (n = 30)	Follow up at 4 weeks.	Meaningful pain relief at 4 weeks was 59.4% for DL8 vs 30% for DL3 (p=0.024). VAS at 4 weeks was 33.3 for DL8 vs 46.3 for DL3 (p=0.036).	"Injectate at a volume of 8 mL was more effective than injectate at a volume of 3 mL for radicular pain in a lumbar transforaminal steroid injection, although both of the injectates contained the same dose of dexamethasone ."	Four week follow-up. Small sample. Data suggest high volume injectate (8 ml) better than low volume injectate (3 ml) even though the same dose of dexamethasone was contained in each group.
Denis 2015 (score=6.5)	Injections	RCT	No mention of sponsorship. No COI.	N = 56 patients with lumbosacral radicular pain and considered as good candidates for TFESIs by their treating physician.	Mean age: 47.7 years; 27 males, 29 females.	Lumbar transforaminal injection of 7.5 mg dexamethason e group (n = 29) vs injection of 6.0 mg betamethasone group (n = 27)	Follow up at 1, 3, and 6 months.	Mean difference in VAS at 3 months for the Dexamethasone group was -2.7 vs -1.7 for the betamethasone group (p=0.209). Mean difference in ODI at 6 months was -30.7 for the Dexamethasone group vs -18.7 for the Betamethasone group (p=0.05).	"According to this study, pain relief and functional improvement are similar for both dexamethasone and betamethasone at 3 months. Considering its safety profile, dexamethasone could be considered as first choice for TFESI. However, given that the study was underpowered,	Data suggest comparable efficacy at 3 months. At 6 months dexamethasone was better than betamethasone for pain relief and functional improvement.

									more research is needed to support a recommendation of systematically using dexamethasone in TFESI."	
Singla 2016 (score=6.0)	Injections	RCT	No sponsorship or COI.	N = 40 ASA grade I and II patients with chronic low back pain of moderate intensity for greater than 3 months.	Mean age: 36.1 years; 32 males, 8 females.	Group S received 1.5 mL of methylprednisolone and 1.5 mL of 2% lidocaine and 0.5 mL saline group (n = 20) vs group P who received 3 mL of leukocyte-free PRP with 0.5 mL calcium chloride (n = 20)	Follow up at 2, 4, and 6 weeks and 3 months.	Median VAS score at 3 months was 1 for group P vs 5 for group S (p=0.0002).	"The intra-articular PRP injection is an effective treatment modality in low back pain involving SIJ."	Open label study. Data suggest both PRP and steroid groups experienced pain relief but at 3 months, the PRP efficacy was better while the steroid gains deteriorated.
Spijker-Huiges 2014 (score=6.0)	Injections	RCT	No mention of sponsorship. No COI.	N = 63 patients with a diagnosis of LRS established by the GP, complaints of LRS for at least two weeks and no more than four weeks.	Mean age: 43.7 years; 30 males, 33 females.	SESI group (n = 33): Patients were admisnistered80 milligrams of triamcinolone in 10 milliliters of normal saline and were administered using a lumbar translaminar approach without additional imaging, vs care as usual group (n = 30): patient were provided usual care from the start, and patients received translaminar injection with a transformational approach with fluoroscopic guidance and administering of local anesthetics.	Follow up at 2, 4, 6, 13, 26, and 52 weeks.	Mean RMDQ score at 52 weeks was 2.3 for the intervention group vs 4.1 for the control group (p=0.0173). Mean NRS back pain at 52 weeks was 1.3 for the intervention group and 2.0 for the control (p=0.0115). Mean NRS score for impairment at 52 weeks was 1.0 for the intervention group vs 1.9 for the control (p=0.0361)	"We found a small, statistically significant, but not clinically relevant positive effect of SESIs on back pain, impairment and disability in acute LRS. We do not recommend implementing SESIs as an additional regular treatment option in general practice."	Usual care bias. Baseline differences between groups. Data suggest a small positive benefit from interventional group.

Milburn 2014 (score=5.0)	Injections	RCT	No mention of sponsorship. No COI.	N = 57 patients with symptomatic degenerative lumbar spinal canal stenosis.	Mean age: 65.3 years; 20 males, 37 females.	Patient received an injection for ILESI at the level of maximal stenosis group (group 1) (n = 30) vs Patient received an injection for ILESI at a less stenotic level group (group 2) (n = 27) The injectate consisted of 2 mL of 40 mg/mL methylprednisolone (Pfizer), 2 mL of bupivacaine 0.25% (Hospira), and 2 mL of normal saline for a total injectate volume of 6 mL.	Follow up at 1, 4, and 12 weeks.	Maximal pain with ambulation score for group 1 was 8.8 at baseline vs 6.7 at week 12 (p<0.001).	"Results suggest that patient symptom improvement is optimized when the ILESI is performed at the intervertebral level of maximal stenosis."	12 week follow up time. Data suggest ILESI most effective if performed at maximal intervertebral level of stenosis but 29 patients did not reach 12 week endpoint as they left the current study to pursue other treatments such as surgery or more steroids.
Kamble 2016 (score=5.0)	Injections	RCT	No sponsorship or COI.	N = 90 patients who had complaints of low back pain with radiculopathy and MRI evidence of disc prolapse.	Mean age: 49.6 years; 39 males, 51 females.	Transforaminal steroid injection group (n = 30) vs caudal steroid injection group: combination of triamcinolone acetate 40 mg with 1 ml of bupivacaine and 2 ml of lignocaine in dilution of 10 ml of normal saline was injected (n = 30) vs interlaminar epidural steroid group (n = 30): A combination of triamcinolone acetate 40 mg with 1 ml of bupivacaine and 1 ml of lignocaine in dilution of 10 ml of normal saline was injected.	Follow up at 1 hour, 1 and 6 months.	OSD score for the Transoraminal group at baseline was 37.7 vs 16.8 at 6 months (p<0.018). OSD score for the caudal group at baseline was 38.3 vs 21.9 at 6 months (p<0.018). OSD score for the Epidural group at baseline was 36.9 vs 21.4 at 6 months (p<0.018)	"In current study, transforaminal steroid injection group has better symptomatic improvement for both short and long term as compared to interlaminar and caudal steroid injection group."	At 6 months data suggest transforaminal steroid better than both caudal and epidural steroids for symptoms of low back pain with radiculopathy.
Okmen 2017 (score=3.5)										Single injection. Data suggest at 1 year, ILES injections may

										decrease VAS and ODI scores.
Meadeb 2001 (score=3.5)										Method to double blind not noted. Methods sparse. Data suggest epidural glucocorticoids have short (1 month) effect on post-op sciatica with epidural fibrosis, but no evidence of residual nerve root compression. 2 to 3 epidural injections of NS induced steady but modest (nearly significant) improvement in pain over 4-month period.
Lutze 1997 (score=3.5)										Data suggest no differences.
Serrao 1992 (score=3.5)										Patients had chronic LBP and did not have either sciatica or spinal stenosis. True blinding seems unlikely due to sedating effects of midazolam. Small sample size.
Aronsohn 2010 (score=3.5)										Sparse details.
Butterman 2004 (score=3.5)										Many methodological details sparse.

										Protocol violations suboptimally handled (taking 2 opting out of surgery into non-surgical group after randomization). Data suggest short-term benefits of surgery over ESI, but not different by 1 year
Fukusaki 1998 (score=3.5)										Sparse details.
Reverberi 2005 (score=3.0)										Short report (2 pages). No placebo arm. Sparse methods and results.
McGregor 2001 (score=3.0)										Baseline scores different (e.g., physical function scores 42.6±19.2 vs. 35.0±22.9), suggest randomization failure in addition to inadequate description of methods.
Lee 2009 (score=3.0)										Details sparse.
Aminmansour 2006 (score=3.0)										Few details
Dikmen 2005 (score=3.0)										Short follow-up time. Small sample size (N=33).
Kraemer										Percentage of "good" results

1997 (score=2.5)										appears to be 68% with perineural steroid vs. 54% epidural vs. 26% paravertebral anesthetic.
Aldrete 2003 (score=2.5)										Sparse details.
McNeill 1995 (score=2.5)										Sparse details.
Langmayr 1995 (score=2.5)										Low sample size. Details sparse.
Debi 2002 (score=2.5)										Details sparse.
Glasser 1993 (score=2.5)										Small sample size (N=32).
Watters 1989 (Score=2.5)										Small sample size. Details sparse.
Rocco 1989 (score=2.5)										Details sparse. Small sample size (N=24).
Lavyne 1992 (score=1.5)										No significant P-values were found in this study. Details sparse.
Diagnostic Facet Joint Injections										
North 1996 (score=3.0)										Short follow-up (3 hours). Small sample size (N=33).
Therapeutic Facet Joint Injections										
Park 2013 (score=6.0)	Injections	RCT	Sponsored by Inje University. No COI.	N = 110 patients with unilateral radicular pain.	Mean age: 57.9 years; 40 males, 70 females.	Patients received two consecutive thera-peutic injections, with a 2-wk interval between the injections. The second injection proceeded condi-tionally. US-guided caudal block group (n = 55): ml	Follow up at 2 and 12 weeks.	VNS for the US group at baseline was 6.41 vs 2.53 at week 12 (p<0.05). VNS for the FL group at baseline was 6.45 vs 2.64 at 12 weeks (p<0.05) No significant difference between groups.	"The ultrasound approach with color Doppler mode may avoid Intravascular injectionYinduc ed complications. The results	Data suggest comparable efficacy for short term pain benefits and function but the Doppler device may eliminate some of the complications

						(Omnipaque 300; GEHealthcare, Carrigtohill, County Cork, Ireland) + 15 ml (13.0 ml of 0.5% lidocaine + 2 ml of dexamethasone 10 mg vs. FL-guided caudal block group (n = 55): 5 ml (Omnipaque 300; GE Healthcare) + 15 ml (13.0 ml of 0.5% lidocaine + 2 ml of dexamethasone 10 mg)			showed similar improvements in short-term pain relief, function, and patient satisfaction with both ultrasound and fluoroscopic guidance."	associated with IV injections.
Visser 2013 (score=4.5)	Injections	RCT	No mention of sponsorship. No COI.	N = 51 patients with sciatica.	Mean age: 46.2 years; 14 males, 37 females.	Physiotherapy group (n = 15) : patient were given 5 exercise (6 mins each, 5-6x a day) which consisted of exercising therapy following a fixed schedule aiming at improving the flexibility of the SIJ and strengthening the muscles of the back and pelvic floor. vs manual therapy group: consisted of manipulation techniques in order to mobilize the SIJ. During two sessions with an interval of 2 weeks, patients received high-velocity thrust SIJ manipulation techniques. (n = 18) vs. intraarticular injection group (n = 18): Patient were receive booklet from group like group 1 and 2, but are also	Follow up at 6 and 12 weeks.	Succes of physiotherapy was 30% vs 72% for manual therapy (p=0.011)	"In this small single-blinded prospective study, manual therapy appeared to be the choice of treatment for patients with SIJ-related leg pain. A second choice of treatment to be considered is an intra-articular injection."	Small sample. Short term follow up. Data suggest manual therapy better than PT or injection.

						injected with a mixture of 30 mg of lidocaine and 20 mg Kenacort.				
Kawu 2011 (score=2.0)										Small sample size.
Manchikanti 2001 (score=2.0)										Methodological details sparse.
Manchikanti 2008		Follow-up of Manchikanti 2001	No industry sponsorship or COI.	N = 120 with lumbar facet joint pain, chronic function-limiting LBP for ≥6 months, with no disc related pain		Group I: lumbar facet joint nerve blocks with injections of local anesthetic: bupivacaine 0.25% (n = 60) vs. Group II: lumbar facet joint nerve blocks with mixture bupivacaine and Sarapin (mixed equal volumes), and 0.15mg betamethasone (n = 60). Each nerve injected with 0.5-1.0mL of assigned mixture.		Mean±SD for average relief per procedure for Group I vs. Group II: 15±9.9 vs.15±9.2. Mean±SD of Oswestry Disability Index at baseline and at 12 months of Group I compared to Group II: 26.6±4.6 and 12.3±4.8 vs. 25.9±5.0 and 12.0±5.4.	"The results of this randomized, double-blind controlled evaluation of lumbar facet joint nerve blocks in chronic function-limiting low back pain demonstrate the effectiveness in over 82% of the patients with improvement in functional status."	At 1 year, data suggest no differences in interventions. Lack of control or placebo group limits conclusions.
Manchikanti 2010		2 year follow-up report of Manchikanti 2001	No industry sponsorship or COI.	N = 120 with chronic function-limiting LBP for ≥6 months		Group IA:Lumbar facet joint injections with bupivacaine(n = 30) vs Group IB: lumbar facet joint injections with bupivacaine and sarapin (n = 30) vs. Group IIA: lumbar facet joint injections with bupivacaine and steroid (n = 30) vs. Group IIB: lumbar facet joint injections with bupivacaine, Sarapin and steroids (n = 30). All underwent controlled		Mean±SD average of pain scores at Baseline and 24 months for Group I vs. Group II: 8.2±0.8 and 3.5±1.5 vs. 7.9± 1.0 and 3.2±0.9. Mean±SD average relief per procedure for Group I vs. Group II: 19±19.9 vs. 19±18.2. Mean±SD average total relief with	"The evidence in this report demonstrates lumbar facet joint pain diagnosed by controlled, comparative local anesthetic blocks may be treated with lumbar facet joint nerve blocks either with or without steroid."	At 1 year, data suggest no differences in interventions. Lack of control or placebo group limits conclusions.

						comparative local anesthetic blocks 0.5mL 1% preservative-free lidocaine, followed by 0.5mL 0.25% bupivacaine 3-4 weeks after first injection if lidocaine block results positive.		sequential procedure for Group I vs. Group II: 82±31.8 vs. 84±27.5. Mean±SD average for ODI at baseline and 24 months for Group I vs. Group II: 26.6±4.6 and 12.0±4.9 vs. 25.9±5.0 and 11.0±4.8. Mean±SD average total opioid intake at baseline and 24 months for Group I vs. Group II: 31±25.2 vs.37±40.4 (p = 0.294) and 27 ± 23.8 vs. 30±27.1 (p = 0.549).		
Botulinum toxin vs. Triamcinolone										
Lee 2010 **(Score**=0)										Non-randomized study
Botulinum Injections										
Fishman 2002 (score=3.5)										Details of original group not presented. Follow-up interval for final results also unclear.
Herskowitz 2004 (score=3.5)										Abstract only. Many details sparse.

SURGICAL CONSIDERATIONS

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Discectomy, Microdiscectomy, Sequestrectomy, Endoscopic Decompression						
Hermantin 1999	3.5	N = 60 with single-level lumbar disc herniation	Open laminotomy and discectomy (n = 30) vs. video-assisted arthroscopic microdiscectomy (n = 30).	Duration of disability favored micro-discectomy with 27 vs. 49 days. More use of post-op medications in laminotomy group (e.g., mean days of narcotic use 25 days vs. 7 days). Three patients (2 open laminotomy) required re-operation.	"Although the rate of satisfactory outcomes was approximately the same in both groups, the patients who had had an arthroscopic microdiscectomy had a shorter duration of postoperative disability and used narcotics for a shorter period."	No statistical analyses, thus low-quality study though meets other quality metrics. No blinding or post-op rehab. Arthroscopically microdiscectomy appears to have shorter recovery time.
Krugluger 2000	3.5	N = 29 with painful disc herniation confirmed with discography	Chemonucleolysis (n = 11) vs. automated percutaneous discectomy (n = 11). Final follow-up at 2 years.	Significant improvement for neurological deficits and Oswestry scores at 6 weeks: p <0.05, p <0.001.	"At 2 years after surgery the CN treated patients were significantly better with respect to Oswestry score, back pain and leg pain recurrence."	Small numbers, lack of details make conclusions difficult. Suggests similar outcomes 1st 2 years with some deterioration in percutaneous discectomy group.
Van Alphen 1989 RCT No mention of industry sponsorship or COI.	3.5	N = 151 with radicular pain due to disc herniation at L4-5 or LS-S1	Open discectomy (n = 78) vs. Chemonucleolysis (n = 73). Follow-up at 2, 6, 12 months after treatment.	After 1 year of the treatments, 2 (3%; 95% CI: 0.3 to 9%) patients in discectomy group underwent second treatment because of failure of first treatment vs. 18 (25%; 95% CI: 15 to 36%), (p <0.0001) in chemonucleolysis group. Patients' assessment of treatment at 12 months was no significantly different in both groups (1.71 vs. 1.95; p = 0.20).	"[A] patient who has a radicular syndrome caused by a lumbar disc herniation can benefit from chemonucleolysis, and it may be that radicular signs and symptoms disappear rapidly; however, pain may also persist or recur, requiring open surgery in 25% of cases. The clinical course is, therefore, more complicated when chemonucleolysis rather than open surgery is chosen as the primary treatment."	Patients not well described. Methods sparse. Data suggest comparable results at 1 year.
Barth 2008 RCT No funds were received in this work. No COI.	3.5	N = 84 with lumbar disc herniations.	Group D (n = 42): microdiscectomy with removal of herniated material plus discal tissue from the intervertebral space vs. Group S (n = 42): microscopic sequestrectomy with removal of herniated material. Follow-up at 2 years after surgery (early follow-up: 4-6 months, and late follow-up: 24 months).	After 2 years, group D reduction in LBP 2.9±2.6; group S reduction 1.8±2.4. Groups D and S almost reduction of sciatica 1.6±2.4 and 1.2±1.8. No significant differences in reduction of LBP and sciatica. Fewer reported improvements of sensory deficits in group D at late follow-up (p = 0.004); sensory deficits stable group S (p = 0.034). After 2 years, more in group S improved motor deficits vs. group D (p = 0.041). At 2 years, Performance (p =	"Reherniation rates within 2 years after sequestrectomy and microdiscectomy are comparable. However, outcome after microdiscectomy seems to worsen over time, whereas it remains stable after sequestrectomy. Thus, 2-year follow-up revealed clinical results favoring sequestrectomy. Performing sequestrectomy alone may therefore represent an	Details sparse. Follow up of previous study.

				0.054) and overall outcome (p = 0.004) better in group S vs. group D.	advantageous alternative to standard microdiscectomy."	
Tullberg 1993	3.0	N = 60 with lumbar disc herniation	Microscopic removal of disc herniation (n = 30) vs. standard procedure (n = 30). Final follow-up at 1 year.	Significant difference between groups for mean time for procedure, p <0.05. Microscopic group took longer to operate on, p <0.01.	"[T]he decision to use the operating microscope may be left to the surgeon, because it had no effect on the short-term results of those at 1 year."	Lack of baseline characteristics. Lack of study details. Data suggest no significant clinical outcomes.
Erginousakis 2011 Prospective RCT No mention industry sponsorship. No COIs.	3.0	N = 31 with sciatica due to intervertebral disk herniation.	Control group (17 men and 14 women): conservative therapy (administration of analgesics, antiinflammatory drugs, muscle relaxants, and physiotherapy) for 6 weeks vs. Percutaneous disk decompression (PDD) (19 men and 12 women). Follow-up at 3, 12, and 24 months.	Decompression group had significantly a greater reduction of pain in NVS units vs. control group at 12 (1.7±2.4 vs. 4.0±3.4; p = 0.005) and 24 (1.6±2.5 vs. 4.0±3.4; p = 0.004) months. Per statistically analysis, patients in either group that had large improvement (>4 NVS units) at 1-month follow-up maintained decreased symptoms (p <0.01).	"When compared with conservative therapy, PDD shows improved amelioration of symptoms at 12- and 24-month follow-up."	Quasirandomized. No neurological deficits. Patients not well described. Conservative outperformed surgery at 3 months, but surgery outperformed at 1 & 2 years.
Ryang 2008 RCT No mention of industry sponsorship or COI.	3.0	N = 60 with single level virgin lumbar disc herniation; typical monoradicular symptoms attributable to sciatica; non-response 8-12 weeks conservative treatment.	Standard open microdiscectomy (SOMD, n = 30) vs Minimal access trocar microdisectomy (MAMD, n=30) with follow-up at discharge, 6 to 8 weeks after surgery, and 6 to 26 months after surgery.	Only difference between groups was SF-36 follow-up mental component summary: SOMD 51.9±7.8 v. MAMD 44±13.2, p=0.03.	"MAMD yields results comparable to SOMD concerning improvement of neurological symptoms, pain relief, length of hospital stay, and quality of life."	Excluded workers compensation.
Chitragran 2012 RCT No mention of industry sponsorship. No COI.	1.5	N = 64 with radicular or axial LBP	Nucleoplasty (n = 32) vs. Conservative treatment (n = 32). Follow-up at 1, 3, 6, and 12 months.	Nucleoplasty group had statistically significant reduction of pain (VAS). After 3 months, bulging disc significantly shrank from 5.09mm (pre-treatment mean bulging) to 1.81mm.	"Nucleoplasty appears to be safe and effective in Thailand. Is an effective procedure for patients presenting with discogenic back and/or radicular pain that have failed conservative therapies and are not considered candidates for open surgical interventions. A result of this analysis indicated that PDD using Coblation technology, also referred to as nucleoplasty, is an effective procedure for patients presenting with discogenic back and/or leg pain who have failed conservative therapies and are not considered candidates for open surgical interventions."	Conservative care not defined and apparently subjects to more of the same bias. Definition of discogenic LBP appears to be based on MRI only. Methods sparse. Patients not well described. Results sparse.
Adhesiolysis						

Heavner 1999	2.5	N = 83 with radiculopathy plus LBP and scheduled for lysis of epidural adhesions	Hypertonic saline plus hyaluronidase (n = 17) vs. hypertonic saline (n = 15) vs. isotonic saline (0.9% NaCl, n = 17) vs. isotonic saline plus hyaluronidase (n = 10). All received an epidural corticosteroid and local anesthetic (10% NaCl). Final follow-up at 12 months.	No differences between treatment type and average time to additional treatment. VAS max scores improved in ≥25% in all groups for either back or right/left leg.	"The use of hypertonic saline may reduce the number of patients that require additional treatments."	Many co-interventions performed on completing RCT suggest intervention not particularly successful. Most methodological details not given.
Decompressive Surgery for Spinal Stenosis (Laminotomy/Facetectomy, Laminectomy)						
Grob 1995	2.5	N = 45 with degenerative lumbar spinal stenosis	Decompression with laminotomy and medial facetectomy (group I, n = 15) vs. decompression and arthrodesis most stenotic segment (group II, n = 15) vs. decompression and arthrodesis of all decompressed vertebral segments (group III, n = 15). Mean follow up at 28 months.	No significant differences between groups for relief in pain. Group I vs. II vs. III had significant improvement in walking distance at baseline-follow up: p<0.001, p<0.002, p<0.005.	"[I]n the absence of segmental instability, arthrodesis is not necessary after decompression of the lumbar spine in patients who have degenerative lumbar spinal stenosis, provided that the stabilizing posterior elements of the spine are preserved during the operation."	Lack of study details such as baseline comparisons and co-interventions lowered score. Data suggest arthrodesis did not improve outcomes in surgical patients with stable spinal stenosis.
Mahadewa 2010 No mention of industry sponsorship or COI.	1.5	N = 105 with lumbar stenosis	Bilateral laminotomy group (n = 46) vs laminectomy with fusion group (n = 59).	VAS scores post-op for bilateral and laminectomy groups not statistically significant between groups.	"[T]he use of bilateral laminotomy in lumbar stenosis can provide good surgical outcome comparable to that in laminectomy with fusion technique in short term follow up."	Not randomized.
Spinal Fusion						
France 1999	3.5	N = 83 with LBP recruited from 3 military medical centers	Screw-plate instrumentation with variable screw placement (n = 41) vs. fusion without instrumentation (n = 42). Final follow-up at 2 years.	Among patients with degenerative spondylolisthesis, 40% without instrumentation and 63% with instrumentation reported good or excellent results.	"No significant difference was shown in radiographic or patient-assessed clinical outcomes in this group of patients, perhaps with the exception of those patients with degenerative spondylolisthesis."	Military personnel. Lack of baseline characteristics. Co-interventions unclear. Data suggest no benefit from additional instrumentation.
Amundsen 2000	3.5	N = 100 with symptomatic lumbar spinal stenosis in Norway; 31 randomized, 19 to surgical treatment, 50 to conservative treatment	Surgical treatment (n = 13) vs. conservative treatment (n = 18). Final follow-up at 10 years.	Surgical vs. randomized surgical vs. randomized conservative treatment vs. conservative treatment. Light pain, moderate pain, severe pain at start of treatment (n = 100): 0/0/0/2, 5/6/2/20, 14/7/6//18. After 10 years: 8/5/2/12, 3/6/6/14, 5/0/0/1.	"The outcome was most favorable for surgical treatment. However, an initial conservative approach seems advisable for many patients because those with an unsatisfactory result can be treated surgically later with a good outcome."	Randomization not completely random for all participants. Lack of baseline characteristics. Conservative management hospitalized 1 month. Data suggest surgical treatment superior, but some responses to non-operative treatment.

Zdeblick 1993	3.5	N = 124 undergoing lumbar/ lumbosacral fusion for degenerative conditions	Posterolateral fusion with autogenous bone graft (Group I, n = 52) vs. autogenous posterolateral fusion semirigid pedicle screw/plate fixation system (Group II, n = 35) vs. posterolateral autogenous fusion rigid pedicle screw/rod fixation system (Group III, n = 37). Final follow-up at 2 years.	Overall fusion rate percent for Group I vs. II vs. III: 65%, 77%, 95%. Significant differences in overall fusion rates seen in III vs. I, and III vs. II: p = 0.002, p = 0.034.	"Rigid pedicle screw/rod fixation led to a significantly higher rate of fusion in degenerative lumbar disease than did fusion without instrumentation. The fusion rate was also higher with rigid instrumentation than with semirigid pedicle screw/plate fixation."	Many details sparse. Study primarily reports anatomic fusion rate rather than clinical outcomes.
McGuire 1993	3.5	N = 28 with Grade I/II symptomatic spondylolisthesis; 27 L5 laminectomy plus L5 nerve root decompression	In-situ posterolateral fusion (n = 14) vs. internal stabilization with Steffee plate/screw system (n = 13). Final follow-up at 2 years.	No statistical differences for rate of fusion.	"No statistically significant increase in the primary fusion rate occurred with addition of internal fixation compared to non-instrumented posterolateral grafting alone."	Small numbers. No statistical comparisons on baseline characteristics. Lack of reporting on co-interventions. Data suggest no clinical differences.
Cheng 2009 RCT No mention of sponsorship or COI	3.5	N = 138 spondylolisthesis patients within the age range of 36-63 and mean age of 48 years.	PEEK cages. Pedicle screw fixation and posterior lumbar interbody fusion by auto grafting (n = 70) vs. pedicle screw fixation and posterolateral fusion by auto grafting (n = 68). In all, nerve root release procedure used. Progressive rehab therapy. Follow-up 3 months, 1 year, 4 years.	Pain index improved from pre-op to 4-year follow-up. 68 to 26 (p <0.001) for PLIF group and 67 to 29 (p <0.001) for PLF group. No difference between groups for pain index (p = 0.81) and ODI (p = 0.41). PLF group had high complication rate than PLIF group (p = 0.0258)	"[C]linical and functional outcomes in both groups were similar, and no significant statistical difference was found. But PLIF presented better fusion rate when compared with PLF."	Methodological methods sparse.
Jiya 2011 RCT Industry sponsored (Medtronic Sofamor Danek). No mention of COIs.	3.5	N = 26 with degenerative spondylolisthesis, canal stenosis, foramen stenosis or both chronic back pain, irradiating lower extremity symptoms.	N = 14 implanted with PEEK cages vs. n = 12 implanted with resorbable PLDDLLA.	50% of PLDLLA group showed >10% improvement in VAS scores (for leg and back) and ODI vs. 71% of PEEK group. Based on CT scan, solid fusion higher in PEEK vs. PLDLLA: 92% vs. 50% (p = 0.026). Higher rate of subsidence on PLDLLA group vs. PEEK (p = 0.0414).	"[T]his study demonstrates that PLIF significantly improves pain (VAS scores) and disability (ODI) symptoms in patients with symptomatic single segment degenerative spondylolisthesis."	Small sample size. Some baseline differences. Data suggest PEEK superior.

Ohtori 2011 RCT No COIs or industry sponsorship.	3.5	N = 41 with chronic LBP for ≥2 years with no radicular pain, and 1 level disc degeneration on MRI.	Minimal treatment control group (walking and stretching) (n = 20) vs. ABF treatment (n = 15) vs. PLF treatment (n = 6).	VAS, ODI and JOAS scores improved in ABF and PLF groups after treatment compared with Minimal treatment group (p<0.01). JOAS score was different between ABF and PLF groups (p <0.01)	"In conclusion, if DLBP is strictly diagnosed, surgical therapy is suitable for its treatment. ABF gives good results, but PLF is also an option for patients who do not want anterior surgery or who present a difficult approach because of anterior vessels."	>2 year LBP. Excluded WC and MVA's.
Müslüman 2011 RCT No COIs or industry sponsorship.	3.5	N = 50 with lumbar spondylolisthesis (Grade 1 or 2) with or without sciatica. Mean age 50.6 years for PLIF; 47.3 years for PLF.	Posterior lumbar interbody fusion (PLIF; N = 25) vs. posterolateral fusion (PLF; n = 25).	Post-op no significant difference between groups for leg pain at all follow-up periods (p >0.05). Back pain significantly improved in PLIF group at 3-months and 1.5-6 years follow-up (p = 0.001) vs. PLF.	"…Both surgical interventions were effective, but Group 2 exhibited better clinical outcomes at an earlier stage, including improvements in quality of life, pain relief, and functional ability. The difference between the PLF and PLIF groups in the early follow-up period was thought to be due to the earlier maintenance of an adequate sagittal axis and lower loading to the posterior segment of the vertebra with PLIF."	Lack of randomization, allocation, control of cointervention details. Loss to follow-up. No blinding.
Geisler 2004 RCT Industry COI (not specified). No industry sponsorship.	3.5	N = 304 with single-level DDD at L-4-5 or L5-S1, age 18-60.	Charite disc-treated group (n = 205) vs. BAK fusion-treated (control) group wearing hard-brace for 3 months following surgery (n = 99).	Neurological deterioration baseline-6, 12, or 24 months; p=0.4233, p=0.5765, or p = 0.3242. Clinical results baseline & 24 months ODI/VAS; (50.6 & 25.8 vs. 52.1 and 30.1)/(72 & 30.6 vs. 71.8 & 36.3). At 24 months VAS / ROM; (65 % decrease vs. 56%, p = 0.1028) / (7.4±5.28 vs. 1.1±0.87).	"The Charité intervertebral disc is safe and effective for the treatment of mechanical back pain caused by one-level DDD at L4-5 or L5–S1."	Lack of randomization allocation, co-interventions details. No blinding. Device trial for FDA exemption. Suggests no difference between interventions. Populations limited to single level DDD. No control-group limits conclusion of efficacy for CLBP.
Korovessis 2004 RCT No COIs or industry sponsorship.	3.5	N = 45 with symptomatic degenerative lumber spine stenosis	A group or Rigid (n = 15) vs. B group or Semirigid (n = 15) vs. C group or Dynamic (n = 15) spinal instrumentation.	SF-36/VAS after 1 year improvement; (21%, 23%, 19%, A,B,C respectively) / (58%. 59%, 58%, respectively).	"[A]ll three instrumentations applied over a short area for symptomatic degenerative spinal stenosis almost equally after surgery maintained the preoperative global and segmental sagittal profile of the lumbosacral spine and was followed by similarly significant improvement of both self-assessment and pain scores."	Lack of study details for randomization, allocation, baseline comparability, assessor blinding. Data suggest no advantages of one device over the others.
Boden 2002 RCT	3.5	N = 25 with single-level degenerative disc disease.	Group1 autogenous iliac crest bone graft with Texas Scottish Rite Hospital (TSRH) pedicle screw instrumentation (n = 5) vs.	Oswestry scores: radiographic fusion rate (2/5) = 40% in autograft/TSRH group, (11/11) = 100% on BMP-2/TSRH, and (9/9) = 100% BMP-2 only. Radiographic	"Consistently, rhBMP-2 with the biphasic calcium phosphate granules induced radiographic posterolateral lumbar spine fusion	Small sample size, failed randomization.

No COIs or industry sponsorship.		Patients also had not succeed in nonoperative treatment at least 6 months.	Group 2 rhBMP- 2/TSRH (n = 11) vs. Group 3 rhBMP-2 only with no instrumentation (n = 11). Patients were observed 1.5, 3, 6, 12, and 24 months after surgery.	fusion success rates significant in BMP-2/TSRH and BMP-2 only groups vs. TSRH group: p = 0.018 vs. p = 0.028. Only group with improvement at 6 weeks was BMP-2 only group (-17.6±5.1; p = 0.009). Main improvements: BMP-2/TSRH at 3 months showed (-17.0 ± 4.4; p = 0.003) vs. Autograft/TSRH group at 6 months (-17.3±5.8; p = 0.041). Greatest improvement BMP-2 only group (-2.28.7±3.1; p = 0.001).	with or without internal fixation in patients whose spondylolisthesis did not exceed Grade 1. Statistically greater and quicker improvement in patient-derived clinical outcome was measured in the rhBMP-2 groups."	
Gibson 2002 RCT No COIs or industry sponsorship.	3.0	N = 69 with predominant BP, mean age 40.42.	Allograft bone (n = 37) vs. Own bone (n = 32); 9 in group 1 and 12 in group 2 with previous surgery.	33% vs. 40% had results that was the same or poor. Average Ronald & Morris scores at 1 year in patients in two groups with p = 0.036.	"Allograft bone (in the form of fresh-frozen human femoral head) is at least as effective as autologous bone in instrumented posterolateral spinal fusion surgery when the results are assessed in terms of clinical outcome."	Lack of details for randomization, allocation, blinding, follow-up. Data suggest similar clinical outcomes 1 and 6 years. At 6 years, high percentage had same or poor outcome.
Ekman 2005 RCT Industry sponsored (The Swedish Society of Spine Surgery). No mention of COIs.	3.0	N = 111 with adult lumbar isthmic spondylolisthesis at L-3 or L-4 with at least 1-year duration of severe lumbar pain, age 18-55	Exercise group (n = 34) based on strength and postural training 3 times a week for 6 months and 2 times 6-12 months vs. Fusion with instrumentation (n = 37) vs. Fusion without instrumentation (n = 40).	DRI & Pain &Worked; 48 to 33, p <0.001 and 63 to 40, p <0.0001 % & 25% to 51% at long term, p <0.0001 in surgical group combined vs. 44 to 38, p = 0.13 & 65 to 49, p = 0.013 % & 38% worked compared to 46% conservative group. Between 2-year to long-term DRI 29 to 33, p=0.049 in surgical group vs. 28 to 31.	"In conclusion, the significantly better global outcome of fused patients compared with conservatively treated patients supports a limited but positive long-term effect on fusion in adult isthmic spondylolisthesis."	Follow-up report of Moller 2000. 9-year follow-up study. Data suggest no significant differences in surgical fusion groups compared with non surgical group except in global assessment.
Bridwell 1993	3.0	N = 44 with degenerative spondylolisthesis and undergoing fusion	No fusion (Group I, n = 9) vs. transverse process fusion with autogenous iliac bone graft without instrumentation (Group II, n = 11) vs. transverse process fusion with autogenous iliac crest bone graft and instrumentation (Group III, n = 24). Average final follow-up 3 years and 2 months; minimum 24 months.	Group I plus II vs. III significant increase in spondylolisthesis progression, p = 0.001. Group III vs. II had higher proportion of solid fusion, p = 0.002. Post-op spondylolisthesis progression vs. no progression had significant functional difference between groups, p <0.001.	"A higher proportion of spondylolisthesis unchanged subjects reported they were helped by the surgery than those whose spondylolisthesis progressed postoperatively (p <0.01)."	Randomization not completely random. Methods sparse. Patients not well described. Co-interventions unclear. Data suggest fusion with autologous bone and instrumentation has better fusion rate but lack of details makes conclusions difficult.

Burkus 2003 RCT Industry COI (not specified). No industry sponsorship.	3.0	N = 42 with symptomatic degenerative lumbar spondylosis at L4-L5 or L5-S1. Disabling LBP, leg pain, or both for >6 months, no response to non-operative treatment.	Investigational group: LT–CAGE device with rhBMP-2 on absorbable collagen sponge carrier or rhBMP-2/ACS (n = 22; 11 men and 11 women) vs. control group: LT–CAGE device with autogenous iliac crest bone graft or ICBG (n=20; 11 men and 9 women). Patients observed 6, 12 and 24 months after surgery.	Bone Density Increases within the Interbody Fusion Device From the Immediate Postoperative Scan Mean ± SD: rhBMP-2 average increase from 142.0 ± 143.3 at 6 months, and to 213.9 ±186.5 at 24 months, p = 0.001 vs. Autograft average were 42.0±79.2, p = 0.109 at 6 months, and to 64.3 ± 199.9, p = 0.289 at 24 months. (p = 0.046, at 6 month).	"The use of rhBMP-2 is a promising method for facilitating anterior intervertebral spinal fusion in patients who have undergone anterior lumbar fusion surgery."	Details sparse.
Boden 2000 RCT Industry sponsored (Medtronic Sofamor Danek, Inc., Memphis TN.). Industry COI (category 17).	3.0	N = 14 with lumbar generative disc disease and back pain of discogenetic origin. No success in nonoperative treatment for at least 6 months.	Control group: Autogenous iliac crest bone (n = 3) vs. investigational: rhBMP-2 (n = 11). Patients observed 3, 6, 12 and 24 months after surgery.	Operative time: rhBMP-2 (1.9±0.2 hours) vs. iliac crest bone (3.3±0.6 hours), (p = 0.006, 95%). Blood loss rhBMP-2 (95±31mL) vs. iliac crest bone (167±117), p = 0.4. Oswestry scores: pre-op for rhBMP-2 38.9 ±3.5 vs. iliac crest bone graft 34.7 ± 7.7. Post-op for rhBMP-2 13.5± 5.1 vs. iliac crest bone graft 20.0 ±12.9 at 24 months. Mean improvement in Oswestry score for rhBMP-2 patients 25 points (71.8%) at 24 months vs. 15 points (54.1%) improvement in controls (p = 0.12).	"The arthrodesis was found to occur more reliably in patients treated with rhBMP-2–filled fusion cages than in controls treated with autogenous bone graft, although the sample size was limited. There were no adverse events related to the rhBMP-2 treatment. This study is one of the first to show consistent and unequivocal osteoinduction by a recombinant growth factor in humans."	Small sample size, failed randomization.
Glassman 2005 RCT Industry sponsored (Norton Healthcare, Medtronic Sofamor Danek). No COIs.	3.0	N = 74 single-level degenerative disc disease. Grade 1 or less spondylolisthesis, no previous fusion at same level. No succeess non-operative treatment for >6 months.	Investigational group: rhBMP-2/CRM (n = 38) vs. control group: iliac crest bone graft or ICBG (n = 36). Patients observed 6 months and 1 year after surgery.	Operative time (p <0.0001) and blood loss (p <0.0043) lower in rhBMP-2/CRM group vs. ICBG group: 2.8 hrs and 358 mL vs. 3.5 hrs and 538 mL. Mann-Whitney U test: mean fusion grade at 6 months and 1 year in rhBMP-2/CRM group vs. ICBG group: 4.5 vs. 3.09 (p <0.0001) and 4.62 vs.3.77 (p <0.0023).	"These early results are encouraging and suggest a more rapid incorporation and development of the fusion mass with rhBMP-2/CRM than iliac crest autograft in a single level posterior instrumented fusion."	Details sparse, preliminary report of partial study participants
Inamdar 2006 RCT No mention of COIs or industry sponsorship.	3.0	N = 22 lumbar spondylolisthesis (grade 1-4) and symptoms severe enough to warrant surgery.	Decompression, posterior instrumentation, posterior lumbar interbody fusion (n = 11) vs. decompression, posterior instrumentation, intertransverse fusion (n = 11). Follow up: 1, 3, 6, and 12 months after surgery.	No statistically significant differences between groups.	"Morbidity and complications are much higher following PLIF than ITF. ITF is recommended because of the simplicity of the procedure, lower complication rate, and good clinical and radiological results."	Small groups. Sparse details.

Niu 2009 Prospective Randomized Study	3.0	N = 43 age 27-75 with degenerative spondylolisthesis, spondylolytic spondylolisthesis, segmental instability	Group I (n = 21) Segmental instability 15, 5, and 1 vs. Group II Segmental instability 17, 4, and 1 (n = 22). Both group receive 10mL of autogenous iliac cancellous bone graft placed on 1 side of the posterolateral gutter on the control side.	Fusion rates between control and test sides showed statistically significant difference (p = 0.0016. Group I's test side with laminectomy bone chips BMA achieved a fusion rate similar to control side of p >0.05 at 90.5%. Group II exhibited bone fusion at 90.9% on control side while test side showed 45.5% where calcium sulfate and BMA applied p <0.05.	"ICBG performs as expected with fusion rates and laminectomy bone with BMA performs equally as well. Osteoset is significantly inferior to ICBG despite the addition of BMA, which is osteoinductive and has improved fusion rates and osteogenesis in other models."	Title indicates randomization but actually not randomized.
Ohtori 2009 RCT No COIs or industry sponsorship.	3.0	N = 42 with LBP for at least 3 years	Discography using 22-gague needle (n = 15) vs. Discoblock (n = 15) 0.75mL of 0.5% bupivacaine injected into disc.	VAS / JOAS / ODI; (69% vs. 83%, p <0.05)/(75% vs. 93%, p <0.05)/(62% vs. 83%, p <0.05 3 years after surgery).	"In conclusion, the current study showed that, compared with discography, pain relief after injection of a small amount of bupivacaine into the painful disc was a useful tool for the diagnosis of discogenic LBP."	Many method details lacking. No control group. Study assumes non-specific LBP discogenic. Data suggest modestly better outcomes in Discoblock group. Small sample size.
Tezeren 2009 RCT No mention of COIs or industry sponsorship.	2.5	N = 42 with thocolumbar burst fractures.	Long-segment instrumentation with fusion performed (n = 21) vs. Long-segment instrumentation without fusion performed (n = 21).	LBOS/pre-op/post-op/follow-up sagittal index(◦), pre-op/post-op/follow-up anterior body compression (%); 57.8 vs. 55.7/(20±2◦/5±2◦/7±2◦ and 45±12%/9± 5%/15±10% vs. 21±3◦ /5±2◦/8 ±1◦ and 44±12%/8±4%/19±14% in without fusion group.	"Radiological and clinical parameters demonstrated that spinal fusion is not necessary in long segment posterior instrumentation for the management of thoracolumbar burst fractures."	Pseudo randomization, lack of details for baseline characteristics, timing of assessments, completion rates. Suggests no clinical differences in outcomes at 36 months.
Wilson-MacDonald 2008 RCT Industry sponsored (Medical Research Council of Great Britain). No COIs.	2.5	N = 106, with chronic LBP.	Postero-lateral fusion (n = 55) vs. Interbody 360° fusion (n = 57) vs. Flexible Instrumentation or Graf (n = 24).	Baseline characteristics for Shuttle walking test in meters/SF-36/ODI; (251.2 vs. 234.4 vs. 232.9)/46.5 (SD 14.6) to 34.2 (SD 21) at 2 years/18.9 vs. 19.2 vs. 17.2/48.8 vs. 45.6 vs. 50.8; health costs higher for more complex procedures.	"More complex surgery is more expensive with more complications than postero-lateral fusion."	Follow-up report of Fairbank 2005. Reported data from surgical arm. Data suggest similar clinical outcomes of 3 suggesting compliance is favorable.

Dimar 2006 RCT No COIs or industry sponsorship	2.5	N = 98 with single-level lumbosacral degenerative disease L2-3-L5-S1, no response to at least 6 months conservative care. Clinical symptoms included LBP, radicular leg pain, or both.	ICBG group (n = 45) vs. rhBMP-2/CRM (n = 53) group. Patients observed 6 weeks, 3, 6, 12 and 24 months after surgery.	Average of surgical time/blood loss: rhBMP-2/CRM 2.4 hours/273.1cc (p <0.001) vs. ICBG 2.9 hours/465cc. SF-36 PCS and ODI scores similar for both groups, but not significant. The 5.7 point decrease in back pain in rhBMP-2/CRM group and 5.2 in ICBG group indicate a clinically significant diminution in back pain following surgery. ICBG 33/45 = 73.3% vs. rhBMP-2/CRM 48/53 = 90.6% had solid fusion. Mann-Whitney test showed p = 0.0512 significant difference in fusion grades between 2 groups.	"In conclusion, rhBMP-2/CRM demonstrated similar clinical outcomes and increased fusion rates when compared to ICBG for a single-level instrumented posterolateral fusion."	Details sparse.
Burkus 2009 RCT Industry sponsored (Medtronic Sofamor Danek). Industry COI (Medtronic Sofamor Danek).	2.5	N = 146 symptomatic degenerative disc disease from L4-L5 or L5- S1, LBP and had not succeed in non-operative treatment for at least 6 months.	All patients treated with rhBMP-2/ACS. Cohort: laparoscopic surgery arm (n = 68) vs. RCT: open surgery arm (patients received either rhBMP-2/ACS or ICBG) (n = 78). Patients observed 1, 2, 4, and 6 years.	Clinical outcomes measures improved significantly from pre-op values by 6 weeks and maintained at each time interval of time (p <0.001).	"The use of dual tapered threaded fusion cages and recombinant human bone morphogenetic protein-2 on an absorbable collagen sponge obtained and maintained intervertebral spinal fusion, improved clinical outcomes, and reduced pain after anterior lumbar interbody arthrodesis in patients with degenerative lumbar disc disease."	6 year follow up of pooled data from two prior RCTs evaluating surgical approach.
Jenis 2000	1.5	N = 61 requiring lumbar spine fusion	Adjunctive PEMF (n = 22) vs. DC electrical stimulation (n = 17) vs. nonstimulated treatment (n = 22). Adjunctive PEMF (SpinalStim model 8212 fitted within 30 days of surgery). DC (SpF2T stimulator implanted day of surgery). Final follow-up at 1 year.	One year radiographic fusion rates not different among groups (35% excellent vs. 32% vs. 43%).	"[E]lectrical stimulation does not significantly enhance fusion rate in instrumented lumbar arthrodesis, although we observed a statistically insignificant trend toward increased fusion mass BMD in the electrically stimulated groups."	Lack of details lowered score. No baseline characteristics; co-interventions not reported. Data suggest no benefit from DC or PEMF on bone healing after posterior spinal surgery.
Froholdt 2011 RCT Industry sponsored (Norwegian Research Council). No COIs.	1.5	N = 124 with LBP at least 1 year, score of at least 30/100 on Oswestry Disability Index	Lumbar fusion (n = 66) received posterolateral autologous bone transplantation and transpedicular screw fixation of L4-L5 and/or L5-S1 segments vs. Cognitive intervention and exercise therapy (n = 58). Follow-up at 8 years.	55/124 completed long-term follow-up at 8 years (lumbar fusion n = 32; cognitive exercise n = 23). General function scores changes significant from baseline to 8-year follow-up in both lumbar fusion (-20.8; p <0.001) and cognitive/exercise (-22.9; p <0.001).	"Although this study did not directly assess muscle morphology of muscles likely damaged by surgery, gross muscle strength, cross-sectional area, and density above the lesion or cognitive intervention and exercises at 7- to 11-years after lumbar fusion."	8-year follow-up to Brox 2003/2006. Data suggest no long-term differences in extension/flexion strength. Most dropped out (55.6%), thus validity of comparative data in significant doubt. Data suggest no meaningful differences.
Burkus 2005 RCT	0	N = 131 with symptomatic degenerative disc disease at	Investigational group: rhBMP-2 on an absorbable collagen sponge (n = 79) vs. control group: iliac crest bone graft or autograft (n =	Operation time, blood loss, hospital stay for rhBMP-2 vs. autograft: 1.4, 87.4, 2.9 vs. 1.8, 184.7, 3.3, p = <0.001, <0.001, 0.020. Oswestry mean scores rhBMP-2 group vs.	"In patients undergoing anterior lumbar interbody arthrodesis with threaded allograft cortical bone dowels, rhBMP-2/ACS was an	Near duplicate report of 2006 article.

Industry sponsored (Medtronic Sofamor Danek). Industry COI (Medtronic Sofamor Danek).		L4-L5 or L5-S1, disabling low back with or without leg pain at least 6 months, no response to non-operative treatment.	52). Patients observed 6 weeks, and 3, 6, 12 and 24 months after surgery.	Autograft group pre, 6 weeks, and 6, 12, 24 months: 53.7/39.4/28.4/21.5/20.9/20.9/20.4 vs. 56.6/47.6/38.5/30.8/29.3/28.9, p = 0.144/0.008/0.001/0.003/0.018/0.037.	effective replacement for autogenous bone graft and eliminated the morbidity associated with graft harvesting."	
Burkus 2004 RCT	0	N = 85 with 1 level lumbar degenerative disc disease.	Investigational group: rhBMP-2/ACS (n = 55) vs. control group: autogenous iliac crest bone graft (n = 30) Patients observed at 1.5, 3, 6, 12, and 24 months.	Operative time shorter in rhBMP-2 group compared with iliac crest bone graft group (1.2 hours vs. 1.7 hours; p< 0.001). Blood loss less in rhBMP-2 group in contrast to iliac crest bone graft group (71.4 mL vs. 140.5mL; p = 0.001). Mean Oswestry scores rhBMP-2 group improved 33.1 vs. 31.5 in iliac crest bone graft group. Fusion rates for rhBMP-2 group 98% vs. iliac crest bone graft group89% and 82%, at 12 and 24 months.	"At 24 months, results from this large prospective IDE lumbar spine study with cortical allograft show several improvements by using rhBMP-2/ACS as a replacement for autologous iliac crest bone graft. Trends in average operative time, blood loss, and hospital stay reveal improved surgical and hospitalization efficiencies and greater improvements in clinical outcomes among patients receiving rhBMP-2/ACS over those treated with autograft, while donor site pain is eliminated."	Abstract only.
Bae 2007 RCT No mention of COIs or industry sponsorship.	0	N = 46 with 1-level symptomatic degenerative disc disease.	Investigational group: rhBMP-2/ACS with granular osteoconductive bulking agent (n = 25) vs. control group: autogenous iliac crest bone graft or ICBG group (n = 21). Patients observed at 1.5, 3, 6, 12, and 24 months.	Clinical outcomes p = 0.004. ODI scores for rhBMP-2 group was 26.8 vs. 21.8 in ICBG group at 12 months. SF-36 PCS scores for rhBMP-2 group was 12.5 vs. 9.9 in ICBG group. Mean back pain scores for rhBMP-2 group 8.8 vs. 7.9 in ICBG group. Fusion rate (IDE): rhBMP-2 group 81.8% vs. 60% in ICBG group at 6 months. At 12 months, rhBMP-2 group 81% vs. 65% in ICBG group.	"In this ongoing study, radiographic fusion success was higher in the investigational patients than in control patients at 6 and 12 months, and the morbidity associated with ICBG harvesting was avoided. Functional outcomes for all patients were significantly improved from preoperative values by 6 weeks. RhBMP-2/ACS with ceramic granules may be an effective autograft replacement for single-level instrumented posterolateral fusion."	Abstract only.

Burkus 2004 RCT No mention of COIs or industry sponsorship.	0	N = 131 symptomatic, single level lumbar spondylosis.	RhBMP-2/ACS group (n = 79) vs. autogenous iliac crest bone graft or ICBG group (n = 52). Patients observed 6, 12 and 24 months after surgery.	At 6 months, 72% of rhBMP-2 group showed complete incorporation of Grade I vs. 45% in ICBG group. At 12 months, rhBMP-2 group 96% of incorporation vs. 66% in ICBG group. At 24 months, 100% of rhBMP-2 group had incorporation vs. 79% in ICBG group. RhBMP-2 group had higher new bone formation in all time intervals than ICBG group.	"There was a higher percentage of complete allograft incorporation, as determined by CT assessment, and a higher incidence of new bone formation in the rhBMP-2 treated group than in the autograft group at all time points studied. We believe the use of rhBMP-2 is a promising method of facilitating allograft incorporation and new bone formation in patients undergoing ALIF surgery with allograft bone interbody constructs."	Abstract only.
Disc Replacement						
Guyer 2004 RCT Industry sponsored (Johnson & Johnson). Industry COIs (PCM consultant for J&J; RDG, SLB, SHH consultants for DePuy Spine).	3.5	N = 144, with DDD or discogenic back pain, age 18-60.	Charite, artificial disc (n = 100) vs. BAK, threaded fusion cages packed with iliac crest autograft or surgical control group (n = 44).	VAS: 53.6% vs. 53.7%, at 24-month follow up.	"This controlled, prospective, randomized study comparing Charite´ with BAK patients has shown that in single-level disease the artificial disc has the ability to produce significant improvement in VAS and Oswestry scores."	Few methodological details.
Sasso 2008 RCT No COIs or industry sponsorship.	3.5	N = 67 with Degenerative Disc Disease or DDD at single level between L1 and S1.	FlexiCore or metal-on-metal intervertebral disc (n = 67) vs. Control or fusion group, using femoral allograft posterior pedicle screw instrumentation and autogenous iliac crest bone graft (n = 22).	ODI/VAS : (36 vs. 50, 30 vs. 32, 25 vs. 25, 18 vs. 26, 6 vs. 12, scores at 6 weeks, 3, 6, 12, 24 months respectively)/(36 vs. 43, 39 vs. 33, 33 vs. 26, 24 vs. 32, 16 vs. 20, scores at 6 weeks, 3, 6, 12, 24 months respectively).	"The results for this study show that artificial disc replacement with the FlexiCore metal-on-metal intervertebral disc prosthesis compares favorably and may be a viable alternative to the gold standard of fusion for the treatment of DDD."	Initial report of RCT. Incomplete trial.
Berg 2011 RCT No COIs. No mention of industry sponsorship.	2.0	N = 152 with chronic LBP assumed to be discogenic for at least 12 months in 1-2 motion segments	Fusion group: treated with fusion (n = 72) vs. Total disc replacement group (TDR): treated with total disc replacement (n = 80). Last follow-up 2 years after surgery.	Absence of mobility in fusion group achieved in 43/61 (70%); in TDR group 58/68 (85%). When L4-L5 adjacent segment, translational motion favored in fusion group (p = 0.009). Anteroposterior displacement at adjacent segments larger in fusion group than TDR (p = 0.01). Post-op disc heights differed between groups (p <0.001). Both groups at 2-year	"Clinical and surgical outcome was better in the TDR group compared with the fusion group, but it was not possible to draw any conclusion to explain this difference based on mobility in treated or adjacent untreated segments."	Details sparse.

		between L3 and S1.		follow-up disc heights of adjacent segments unchanged vs. pre-op exams.		
Vertebroplasty						
Venmans 2012 RCT Open-label Study sponsored by ZonMW and grant from Cook Medical. No mention of COIs.	3.5	N = 95 with vertebral compression fractures. Mean±SD age VAS score ≤3 group vs. VAS score >3 group: 77.7±8.0 vs. 80.6±8.6 (p = 0.30).	Following Vertebroplasty treated patients, until sufficient pain relief defined as VAS score > 3 (n = 38) vs. Conservative therapy treated patients until sufficient pain relief, defined as VAS score ≤3 (n = 57). 1 year follow-up.	95 or 60% has sufficient pain relief with VAS score ≤3. 38 or 40% had pain with VAS score ≥4 at last follow-up interval of 12 months.	"In the VERTOS II trial, most conservatively treated patients with acute osteoporotic compression fractures had sufficient pain relief during the first 3 months."	Details sparse. Follow-up of Klazen 2010.
Liu 2010 RCT Study supported by grant from Chung-Shan Medical University Hospital (CW08110). No COI.	3.0	N = 100 with VCF at (T-L) junction (T12-L1). Age 57-88 years old.	Vertebroplasty (n = 50) vs. Kyphoplasty (n = 50) Procedure: IV general anesthesia (Propofol) + 2% xylocaine injured locally, needle, PMMA, x-ray. Follow-up duration of 6 months.	VAS V vs. K score prior/3days/6 months; (8.0±0.8) /(2.6±0.6,p<0.001)/(2.6±0.6, p = 0.001) vs. (7.9±0.7)/(2.3±0.5, p <0.001)/(2.6 ±0.6, p <0.001).	"[In] terms of clinical outcomes we found little difference between vertebroplasty and kyphoplasty treatment groups."	Lack of study details, randomization, allocation, blinding of assessor, cointerventions, follow-up rate, ITT. Data suggest no clinical differences in outcomes of pain. Lack of control group limits conclusion regarding invasive treatment of VCF vs. conservative care.
Kyphoplasty						
Rebolledo 2013 RCT No industry sponsorship or COI.	3.5	N = 44 with acute vertebral compression fracture causing pain and functional limitations in daily activities, age >50.	Unipedicular group a single dose of first-generation cephalosporin intravenously immediately before surgery (n = 23) vs. Bipedicular group a single dose of first-generation cephalosporin intravenously immediately (n = 21); 12 month follow-up.	No differences between Uni- and Bi-pedicular kyphoplasty groups for pre-operative ODI, VAS, RDQ, p = 0.88, 0.95, 0.79. At 3 months post-op both groups improved significantly: ODI, VAS, RDQ; p = 0.85, 0.67, 0.17. Bi-pedicular group showed improvement from 3 months 10.6 points RDQ points, to 12 months 5.9 points, p = 0.008.	"In conclusion we would encourage the use of a unipedicular approach as the preferred surgical technique for treatment of osteoporotic vertebral compression fractures."	Many sparse methodological details.

Werner 2013 Two-armed RCT trials No industry sponsorship or COI.	3.0	N = 100 with 1 or more osteoporotic vertebral compression fractures of thoracic, thoracolumbar, lumbar spine. Mean± SD age 70±13 years.	BKP or balloon kyphoplasty with use of Jamshidi needles and working cannulas, general or local anesthesia (n = 50) vs VBS or vertebral body stenting with use of Jamshidi needles and working cannulas, general or local anesthesia (n = 50).	Statistical significance between 2 intervention arms, p = 0.014. Vertebral body stenting was associated with higher pressure during balloon inflation compared to balloon kyphoplasty, 12 to 34 bar, compared to 5.-28 bar.	"No beneficial effect of vertebral body stenting over balloon kyphoplasty was found among patients with painful osteoporotic vertebral fractures with regard to kyphotic correction, cement leakage, radiation exposure time, or neurologic sequelae."	Details sparse. Higher complications in stent group.
Implantable Spinal Cord Stimulators (SCSs)						
North 1994, 1995	3.5	N = 27 with failed back surgery syndrome	SCS trial (percutaneous placement of temporary electrode for 2-2.5 days, n = 12) vs. re-operation (n = 15).	Ten of 15 (67%) surgical patients opted to crossover to SCS at 6 months vs. 2 of 12 (17%) SCS patients.	"[T]he role of spinal cord stimulation can be expanded, as an alternative to reoperation."	Small sample sizes. Patients not well described.
North 2002, 2005	See PENS under Physical Methods above.					

REHABILITATION FOR DELAYED RECOVERY

Author/Year Study Type Potential Conflict of Interest (COI)	Score (0-11)	Sample Size	Comparison Group	Results	Conclusion	Comments
Back School/Education						
Lønn 1999	3.5	N = 81 workers with LBP in past year	Secondary prophylaxis plus active back school (ABS, n = 43) vs. no treatment (n = 38). Treatments consisted of 20 sessions (20 minute theoretical part plus 40 minute exercise part) in 13 weeks. Follow-up at 12 months.	ABS vs. control for number of LBP sick days over 1 year: 10.4±9.3 (1.8-19)/37.8±28 (19-56.6). First 12 months, ABS less new LBP episodes/duration of sick leave. At 12 months, significant increase in LB function score. Baseline to 5 and 12 months, BEF tests improved in ABS group. At 12 months, ABS improved quality of life, p = 0.03.	"Active Back School reduced the recurrence and severity of new low back pain episodes according to results of follow-up examinations performed 5 and 12 months after enrollment."	No blinding. Total compliance defined as attendance at 20 sessions, 75% compliance. Allowed use of other treatments and participation in physical activities. Data suggest back school successful.
Berwick 1989	3.5	N = 222 with LBP ≥6 months, and no prior back surgery	Usual care (UC) (n = 74) vs. 4 hour low-back school (n = 72) vs. compliance package (low back school plus 1 year compliance program to promote LBP self-management, n = 76). Final follow-up at 18 months.	At 3 months, UC had greater psychosocial scale score, p = 0.02. At 12 months, UC subjects with baseline VAS of ≥2 pain free, p = 0.048.	"[A] short version of Back School, with or without follow-up reinforcement contacts, is unlikely to affect the course of pain and disability for a relatively unselected group of victims of LBP in an ambulatory environment."	Several methods not specified. Usual care likely did not include typical modern care.

Donchin 1990	3.5	N = 142 with ≥3 episodes of LBP a year	Calisthenics (3 months with biweekly 45 minute sessions of flexion exercises, n = 46) vs. back school program (n = 46) vs. control (n = 50). Final follow-up at 6 months.	At 3 and 6 months, calisthenics group had improved trunk forward flexion plus abdominal muscle, p <0.0001. Differences between groups, p <0.003 adjusted for sex. At 6 months, calisthenics vs. other groups had significant improvement in trunk forward flexion, p = 0.019.	"The current study clearly demonstrates the effectiveness of the calisthenics group in reducing the number of recurrent LBP episodes."	Wait-listed controls biases against that group. Baseline measurements of trunk forward flexion, Schober's test, SLR Rt, and abdominal muscle strength score collected for only men.
Julkunen 1988	3.5	N = 204 females with chronic LBP ≥1 year in Finland	Back school treatment (n = 95) vs. control (n = 93). Treatment group: 1 hour meetings 6 times for 3 weeks by physiotherapist. Control received back school treatment in written form. Final follow-up at 12 months.	Difference on HYS scale for good responders (+) for control vs. poor responders (-) to controls, p = 0.05. Difference in Rorschach R variable back school + vs. control -, back school - vs. control +, and control + vs. control: p = 0.02, p = 0.01, p = 0.02.	"[T]hose patients who reacted favorably to the back school intervention could be described as emotionally well adjusted and controlled showing relatively good cognitive capacity with undisturbed reality testing."	Rorschach scorer blinded. Data suggest efficacy.
Lankhorst 1983	3.5	N = 48 with idiopathic LBP ≥6 months	Back school sessions (4 over 2 weeks, n = 21) vs. detuned pulsating shortwave applications (n = 22). Final follow-up at 12 months.	Both groups had increased active SLR, decrease in spinal mobility, and increase in functional capacity. Back school subjects had decrease in functional capacity and increase in pain immediately after treatment.	"Given the proven efficacy of the Back to School in (sub)acute Low Back Pain, it should be administered when it is most beneficial, i.e. in the early phase of Low back Pain."	Quasi-randomized; subjects allocated in groups of 6 consecutive patients.
Bergquist-Ullman 1977	3.5	N = 217 workers with acute or subacute LBP <3 months in Sweden	Back school (45 minute sessions 4 times a week for 2 weeks, n = 70) vs. combined physiotherapy (n = 72) vs. placebo (n = 75).	Back school vs. combined physiotherapy vs. placebo sick days during initial pain in treatment groups at ≤21, >21 days, and total: 37/30/25, 18/31/41, 55/61/66. Difference between groups significant, p <0.01.	"[B]ack School and combined physiotherapy are superior to "placebo" treatment in acute low back pain. The Back School also reduces the absence from work."	100% attendance at all back school sessions; only 59 control group followed treatment; 4 drop outs in combined physiotherapy group.
Versloot 1992	3.5	N = 500 with LBP working as drivers for Dutch bus company	Individualized back school program (3 sessions/6 month intervals between sessions, n = 200) vs. control (n = 300). Both treatments administered for 2 years. Study lasted 6 years.	Between 2 years during treatment-2 years after treatment, decrease in length of short absenteeism for control group, p <0.046. At 6 years, decrease in length of absenteeism for back school, p <0.024.	"Although the internal validity of this study may be criticized, results indicate that a tailor-made back school program given by expert instructor was capable of reducing absenteeism."	Sample population randomized into groups (North and South). First back school session mandatory, but sessions 2 and 3 voluntary. Subjects not described.
Roberts 2002	3.5	N = 64 with recent acute LBP	Back Home leaflet in addition to regular advice and management (n = 35) vs. regular advice and management (n = 28). Final follow-up at 12 months.	At Week 2, easiest position for putting on socks/tights attitude question significantly increased, p = 0.036. Differences at 2nd day/2 weeks/3 months/6 months significant for behavioral observation.	"The Back Home trial has shown that a simple leaflet may be a useful adjunct to management strategies that is particularly well suited to primary care."	Researcher blinded. Data suggest leaflet helpful, but many study weaknesses.

Moffett 1986	3.0	N = 92 with chronic LBP ≥6 months	Back school program (n = 40) vs. exercise-only program (n = 38). Back school with 3 sessions of anatomy/biomechanics education, ergonomic lifting exercises, and ergonomic counselling. Exercise only with ergonomic lifting exercises. Both programs 3 times a week. Follow-up at 6 and 16 weeks.	Baseline vs. 6 week differences between groups for activity: p <0.001, p <0.001. Baseline vs. 16 weeks for quiz: p <0.05, p <0.05; 6 weeks vs. 16 weeks for pain, and functional disability: p <0.05/NS, p <0.05/p <0.01.	"[A]ll chronic back pain patients would benefit from a program of back care education, such as is offered by the back school. It can be considered an important adjunct to other forms of treatment, both conservative and surgical."	Dropout rate high at 16 weeks (39/92), precluding strong conclusions.
Penttinen 2002	3.0	N = 93 with non-specific LBP ≥1 month	Back school with social support (2 sessions/week for 10 weeks, n = 47) vs. control (2 sessions a week for 5 weeks, n = 46). Follow-up at 6 and 12 months.	Six vs. 12 month differences between groups for Oswestry index disability and life quality scores: p = 0.25/p = 0.02, p = 0.04/p = 0.19. For males, difference in trunk extension force (Nm) at 6 months significant between groups: p = 0.04. Females, difference in trunk extension force (Nm), and VO_{2max} (ml kg^{-1} min^{-1}) at 6 months significant between groups: p = 0.05, p = 0.05.	"[S]ocial interaction between patients suffering from non-specific back pain reduces subjective disability."	Dropout rate and baseline differences concerning. Compliance unclear. Intervention period may have been too short to see changes in objective measurements. Post-hoc data suggest better results among males.
Maul 2005	2.5	N = 148 with LBP ≥2 months preceding year before recruitment	Back school (3 1-hour sessions, n = 86) vs. back school plus supervised physical training (training therapy twice a week plus back school once a week for 3 months, n = 97). Follow-up at post-treatment, 6 months, 1 year, and 10 years.	Differences between groups measured pre- vs. post-treatment vs. 6 months for muscular endurance index, strength isokinetic index, lifting index, ROM: p = 0.0001, p = 0.006, p = 0.001, p = 0.01. Differences between groups measured pre- vs. post-treatment vs. 6 months vs. 1 year for pain drawing, current pain (NRS), pain (Mc Gill), disability (Waddell), disability (Roland Morris): p = 0.001, p = 0.0001, p = 0.0001, p = 0.002, p = 0.005.	"[S]upervised physical training applying strengthening exercises effectively improved objective functional outcome parameters and subjective self rates disability and pain scores during short-term follow-up."	Large dropout rates (from 358 to 148) limit conclusions. For all follow-ups, participation ranged from 66-96%. Data suggest long-term benefits if weaknesses not fatal.
Sirles 1991	2.5	N = 74 city employees with back injuries	Back school education with exercise (exercise 6 times a week, n = 29) vs. counseling intervention (n = 45). Treatment once a week for 6 weeks.	Baseline 6 week differences in anxiety (Spielberg) score, and depression inventory (Beck) significantly less in back school group: p = 0.03, p <0.01. At Week 6, significant increase in flexibility between groups, p <0.01.	"No significant differences were found, on any of the measures, between employees who did and who did not receive the counseling intervention."	Intervention occurred during work hours. Only subjects who completed both pre-and post-tests included in analyses.

Lindequist 1984	2.5	N = 56 with acute LBP	Back school program (n = 24) vs. control (n = 32). Final follow-up at 1 year.	In year of follow-up, 16% in treatment group had LBP recurrence vs. 31% controls; not statistically significant.	"[T]he initial treatment could be limited to advice about back care, preferably a few days bed-rest, with concrete advice about the back and prescriptions for analgesics when needed."	Subjects took advantage of extra physiotherapist visits an average of 2.4 times over 6-week period; 3 patients in each group required more than 100 days of sick-leave.
Postacchini 1988	See Manipulation and Mobilization under Physical Methods above.					
Schenk 1996	2.0	N = 205 healthy subjects with previous LBP	Back school education (n = 74) vs. video group (n = 64) vs. control (n = 67).	No significant differences between video and control groups on measures with additional univariate testing.	"[T]he back school is an effective tool for influencing lifting posture and conveying information regarding spinal mechanics and lifting technique. In addition, the back school videos may not be an effective means of preventing low back injury."	Methods discuss potential randomization failure. Appropriateness of lordotic lifting posture for manual patient transfers dubious as unlikely to reduce intradiscal pressures with long horizontal distances required.
Stapelfeldt 2011 RCT No mention of industry sponsorship or conflict of interest (COI).	0	N = 351 employees age 16-60 requiring sick leave for 3-16 weeks due to back problems	Brief intervention (clinical exam and advice) (n = 175) vs. Multidisciplinary (clinical exam, advice, multidisciplinary team, and case worker) (n = 176).	Work and health-related models were the biggest indicator of whether an intervention worked or not depending upon individual.	"[P]articipants with low job satisfaction, no influence on work, no interest in returning to the same job and at risk of losing their job seemed to return earlier to work when they received the multidisciplinary intervention, whereas participants without these characteristics returned to work earlier when they received the brief intervention."	Secondary analyses of Jensen C, Jensen OK, Christiansen DH, Nielsen CV: 1-year follow-up.
Overmeer 2011 RCT Department Occupational and Environmental Medicine at Orebro University Hospital funded research. No mention of COI.	N/A	N = 42 physical therapists	Course group 8 day university course identifying and addressing psychosocial prognostic factors (n = 22) vs. control group on waiting list (n = 20). Physical therapists then saw 266 patients to compare treatment efficacy. Last follow-up at 6 months.	No difference seen in pain in patients (F = 0.85; df = 1,225; p = 0.9) or disability (F = 1.1; df = 1,222; p = 0.03). No differences found when patients in the risk group saw physical therapist who took course than one who did not take course (F = 2.38; df = 1,221; p = 0.1).	"An 8-day university course for physical therapists did not improve outcomes in a group of patients as a whole or in patients with a risk of developing long-term disability. However, patients who had a risk of developing long-term disability and had higher levels of catastrophizing or depression may have shown greater reductions in disability if the attitudes and beliefs of their physical therapists changed during the course."	RCT of educational course for PTs. Exclude.
Behavioral Interventions						

Strong 1998	3.5	N = 30 with chronic LBP	Psychoeducational treatment (n = 15) vs. control group (n = 15). Treatment group received existing hospital program plus 8-hour psycho-educational program. Controls received existing hospital program plus 8-hour non-specific program with health education video. Final follow-up at 12 months.	Pre- to post-treatment: depressed and negative cognitions (treatment group: pre = -0.33±0.792, post = -.355±, control group: pre = 0.304±.738, post = 0.633±.762, F (23,1) = 4.77, p <0.04). No other variables significantly different between groups.	"[P]articipation in an 8-hour psychoeducational program resulted in a significant reduction in the patient's level of degressed and negative cognition."	Small sample sizes. No differences between groups or over time on other pain components.
Turner 1988	3.5	N = 81 with chronic LBP	Operant behavioral (OB, n = 30) vs. cognitive-behavioral (CB, n = 26) therapy vs. waiting-list (WL) control (n = 25). OB aerobic exercises and operant conditioning, participation of spouses; 2 hours a week for 8 weeks. CB systematic progressive muscle relaxation and imagery; 2 hours a week for 8 weeks). Reference treatment (R) included WL control. Final follow-up at 12 months.	Pre-/post-treatment: McGill Pain Questionnaire (OB: pre = 23.07±12.27, post = 18.50±12.43; WL: pre = 22.57±13.67, post = 22.14±12.35, p < 0.05), sickness impact profile (OB: pre = 8.70±7.09, post = 3.96±4.70; WL: pre = 9.25± 9.12, post = 5.74±6.90; p < 0.05), 6 month follow-up: OB vs. CB pain behavior checklist (OB: 35.77± 10.18, CB: 34.95±9.12; p <0.05).	"The operant behavioral condition appeared to be more effective than the waiting list and the cognitive-behavioral conditions at posttreatment; however, the two treatments were equivalent at the 12-month follow-up."	Lack of study details. Data suggest both cognitive behavioral therapy and operant behavioral therapy help improve outcomes.
Corey 1996	3.5	N = 200 with work-related soft tissue injury and no neurological involvement or disability expected based on injury	Limited functional restoration program (FRP, n = 74) vs. usual care (UC, n = 64) from family doctors for LBP referred 3-6 months after injury in Canada. Intervention: exercise, work conditioning, group education, behavioral counseling. UC doctors received recommendations for limiting narcotic use and encouraging activity despite pain.	At follow-up, 100% of FRP back to work vs. 62.5% UC (p = 0.02). FRP reported less pain than UC (5.3±2.90 vs. 6.5±2.24, t = -2.70 p = 0.008). FRP reported better sleep than UC (.72 vs .38, t = 3.18, p = 0.002).	"The results of the present study provide support for the efficacy of a limited functional restoration program in reducing subjective pain levels and enhancing return-to-work rates for WCB claimants with chronic pain, particularly with low back pain."	Usual care not clarified and may not have included effective treatments, thus probable bias against usual care. Narcotic use did not differ and did not decrease in either group (11.7 pills a week to 13.7 vs. 11.0 to 10.7 for usual care).
Rose 1997	3.5	N = 84 with chronic LBP in England	Applying closely similar cognitive-behavioral pain management approaches to individuals and groups of patients.	No differences between groups.	"This study suggests that neither 'one-to-one' therapy nor therapy lasting more than 15 hours significantly enhanced immediate or medium-term therapeutic response."	Demographic baseline data not reported. Many details sparse.
Nicholas 1992	3.0	N = 20 outpatients with chronic LBP	Cognitive-behavioral group, including relaxation, plus physiotherapy (TG) vs. control group (CG).	Difference between groups from pre-treatment to post-treatment in SIP-O (TG: Pre = 22.86±13.52, Post = 16.92±12.03; CG: pre = 24.22±18.47, post = 26.80±16.40, F (1,16) = 10.78, p <0.05), CSQ (p <0.01), and PSEQ (p <0.05). From Pre-treat to 6 month follow-up only difference was SIP-S. No	"[T]he initial treatment and follow-up results suggest that cognitive-behavioral treatment for chronic low back pain has a positive effect on daily activity level, medication use, and coping strategies that is beyond those effects which can be attributed	Small sample size. Patients not well described. Data suggest CBT had minimal efficacy, but not prolonged.

				differences between post-treatment and 6 month follow-up.	to attention, back-care education and exercises."	
van den Hout 2003	3.0	N = 84 with LBP at least 6 weeks, on sick leave with LBP no more than 20 weeks and ≤120 days sick leave past year	Graded activity plus problem solving therapy (n = 45, GAPS) vs. graded activity plus group therapy (n = 39, GAGE).	Baseline: treatment creditability (GAPS: 6.9±2.0, GAGE: 8.0±1.1, p <0.01), RDQ (GAPS: [0-8] = 20, [9-16] = 40, [17-24] = 40; GAGE: [0-8] = 12.8, [9-16] = 66.7, [17-24] = 20.5; p = 0.05). Nothing significant at 6 and 12 months.	"[P]ST turned out to be an effective treatment in LBP. It showed favorable effects in the course of sick leave in the year after the intervention."	Baseline randomization data mostly favor problem-solving group. Non-significant fewer lost workdays in problem-solving group and fewer failures to RTW (7% vs. 19%).
Nicholas 1991 RCT No mention of sponsorship or COI.	3.0	N = 62 with history of chronic non-malignant LBP. Mean age 41.2 years.	Cognitive treatment with relaxation training (n = 10) vs. cognitive treatment without relaxation training (n = 10) vs. behavioral treatment (medication reduction plan, goal setting) with relaxation training (n = 10) vs. behavioral treatment without relaxation training (n = 10) vs. control (physiotherapy plus 5 sessions with psychologist, n = 10) vs. control (physiotherapy only, n = 10). Treatments one 2 hour and one 1.5 hour session a week for 5 weeks. All patients received standard physiotherapy. Assessments pretreatment, post-treatment, 6 months, and 12 months after end of treatment.	Immediate effects: treatment: conditions improved significantly more vs. control conditions on pain index, PI (p <0.05), Sickness Impact Profile – Self, SIP-S (p <0.05), and Pain Beliefs Questionnaire, PBQ (p <0.01). 6 month follow-up: univariate only – treatment conditions improved significantly vs. controls on SIP-S (p <0.05), Coping Strategy Questionnaire, CSQ (p <0.05), and PBQ (p <0.05). 12 month follow-up: univariate only – treatment conditions improved significantly vs. controls on PI (p <0.05), Beck Depression Inventory BDI (p <0.05), SIP-S (p <0.05), PBQ (p <0.05).	"[T]he resulted indicated that, for the sample as a whole, improvements were obtained on measures of affective distress, functional impairment, medication use, pain-related dysfunctional cognitions and use of active coping strategies and that these improvements were generally maintained at 6- and 12-month follow-ups."	Sparse methods. High dropout rate.
McCauley 1983	2.5	N = 17 who exhibited CLBP at least 6 months	Relaxation (n = 8) 8 50-minute individual sessions vs. self-hypnosis (n = 9) 8 50-minute sessions.	No statistical significance between groups.	"While both treatments were effective, neither proved superior to the other."	Small sample precludes significant conclusions. Dropout and compliance issues.
Basler 1997	2.5	N = 76 diagnosed with chronic LBP in Germany	Cognitive behavioral therapy and prescribed medical treatment (2.5 hours a week, n = 36) vs. control (n = 40) for 12 weeks. Subjects in cognitive group told to keep pain diary for 4 weeks. Both groups treated with medication, nerve blocks, TENS, and PT.	Experimental subjects reported less pain, better control over pain, more pleasurable activities and feelings, less avoidance and less catastrophizing. Results maintained at follow-up. Patients who only received medical treatment showed little improvement."	"Data indicate that the program meets the needs of the patients and should be continued."	Dropout rates concerning and baseline differences may be present.
Turner 1982	2.0	N = 36 with LBP for at least 6 months	Waiting list/attention condition (WL, n = 9) completed daily pain ratings while waiting for next round of treatments vs. progressive relaxation training (PRT, n = 14) who were given audiotapes of relaxation procedures vs. cognitive behavioral	Pre-/post-treatment: PRT vs. CBT: ability to tolerate pain (PRT: 2.9±0.6; CBT: 3.5±0.6, p <0.05); participation in activities (PRT: 2.5±0.7; CBT: 3.1±0.8, p <0.05); 1 month followup: PRT vs. CBT: severity of pain (PRT: 2.6±0.9,	"[C]ognitive-behavioral patients did not differ significantly from the relaxation-training group in pain-related behavioral and psychosocial impairment, average pain intensity, or depression. However,	Baseline variables show substantial differences and appear to be against wait-listed group who had worse severity measures. Two active treatment groups also do not appear particularly

			therapy (CBT, n = 13) taught progressive relaxation training and at end of each session received cognitive behavioral therapy training.	CBT: 3.3±0.6, p <0.01); ability to tolerate pain (PRT: 2.9±0.8, CBT: 3.5±0.6, p <0.05); VAS rating of pain relief [%] (PRT: 38.0±28.0, CBT: 62.0±25.0, p <0.05).	cognitive-behavioral-therapy patients felt they were better able to tolerate their pain and participate in normal activities. They also reported significantly greater progress toward behavioral goals specified at the beginning of treatment."	comparable, precluding strong conclusions.
Bru 1994	1.0	N = 111 female hospital staff with relatively severe pain in neck, shoulder, and/or low back	Cognitive behavior therapy (cognitive, n = 19) vs. relaxation therapy (relaxation, n = 15) vs. combined therapy (combined, n = 24) vs. control (n = 53).	Pre to post 1: only cognitive and combined showed reduction (t = 2.63, p = 0.017, t = 3.81, p = 0.001) in intensity of neck pain. Relaxation group had reduced intensity of LBP (p = 0.10). Cognitive (p = 0.017) and combined (p = 0.029) showed change in duration of neck pain, only combined (p = 0.002) showed change in duration of shoulder pain. Only relaxation group (p = 0.009) showed change in duration of back pain.	"The Cognitive and Combined intervention procedures were the more effective in reducing neck pain, whereas Relaxation was relatively successful in reducing low back. For shoulder pain, however, all three interventions were effective in reducing intensity of pain, whereas only the Cognitive approach to intervention was significantly effective in reducing duration of shoulder pain."	For shoulder pain, all 3 interventions found effective in reducing pain intensity, whereas only cognitive approach to intervention was significantly effective in reducing duration of shoulder pain.
Maiers 2010 RCT Supported by grant from HHS, HRSA, BHPr, and DMD. No mention of COI.	0	N = 201 with chronic LBP ≥6 weeks duration.	Chiropractic care, (n = 101) vs. Integrative care including acupuncture and Oriental medicine (AOM), chiropractic (DC), cognitive behavioral therapy (CBT), exercise therapy (ET), massage therapy (MT), medication (Med), and self-care education (SCE), (n = 100), 12 week follow up.	Most changes made included the addition of CBT (17/36), AOM (7/36), and ET (6/36).	"This clinical care pathway was a useful tool for the consistent application of evidence-based care for low back pain in the context of an integrative setting."	Assess use of clinical pathways with variety of treatment options
Goossens 2005 2 pooled RCTs No support from grant or mention of COI.	0	N = 171 with fibromyalgia and LBP	Fibromyalgia or FM study (n = 74): educational program plus cognitive coping skills training (COG) vs. educational program plus attention control (CON), vs. wait-list control group (WLC). Chronic LBP study (n = 97): operant-behavioral treatment plus COG plus CON or WLC.	Post-treatment expectancy significantly correlated with pain coping and control/negative effect/motorist behavior/quality of life. Pretreatment expectancy for better pain coping, control (r = 0.24; p <0.01), better quality of life (r = 0.25; p <0.01).	"[I]ndicating that treatment expectancy influences the outcomes of cognitive-behavioral interventions in patients with chronic pain."	Report of pooled data that are reported individually elsewhere.
Fear Avoidance Belief Training (FABT)						
Fritz 2001 RCT	2.0	N = 78 with acute, work-related LBP	Guideline-based therapy using recommendations of AHCPR (n = 37) vs. individualized therapy based on classification system (n = 41). All 2-3 therapy sessions a week for 4 weeks.	The 4 week Oswestry score shows that disability significantly less in AHCPR group vs. classification, p = 0.024.	"Screening for fear-avoidance beliefs may be useful for identifying patients at risk of prolonged disability and work absence."	Study discusses RCT, but report appears to be about an observational study and details sparse.

Biofeedback						
Nouwen 1983 RCT	3.5	N = 20 with chronic LBP, and EMG levels >5μV	EMG biofeedback training (n = 10) vs. wait-listed control (n = 10). Both groups received 15 treatment sessions over 3 weeks.	EMG pain scores showed significant main effect between pre-post treatment (p <0.0003), and for interaction between groups (p <0.0003). Control vs. EMG had higher pretreatment EMG levels, p <0.01.	"[T]hat reduction of standing paraspinal EMG does not lead to reductions in pain."	Small numbers excluded obese. Lack of baseline characteristics, co-interventions for controls. Suggests biofeedback may help chronic LBP, but lack of details make conclusions difficult.
Stuckey 1986 RCT	3.0	N = 24 with chronic LBP symptoms ≥6 months	EMG-biofeedback training (n = 8) vs. relaxation training (n = 8) vs. placebo-control (n = 8). All groups received 8 sessions.	Decrease at Session 8 in upper trapezius EMG for EMG biofeedback and relaxation training: p <0.03, p <0.006. Mean pain intensity decreased significantly for relaxation training, p <0.03.	"Relaxation training gave better results in reducing EMG and pain, and in increasing relaxation and activity than either EMG biofeedback alone or a placebo condition."	Comparisons among conditions found relaxation significantly superior to placebo and to biofeedback.
Vlaeyen 1995 RCT	2.5	N = 71 with chronic LBP	Operant treatment (OP, n = 21) vs. operant-cognitive treatment (OC, n = 18) vs. wait-list control (n = 13). Final follow-up at 12 months.	Pre treatment, 6-month follow-up differences for variable outcome efficacy better in OC vs. OR group, p = 0.002. Pre-treat,12-month follow-up differences better in OC vs. OR group, p = 0.008.	"During the treatment the three treatment groups improved significantly more than the waiting-list control group on most of the measures."	Quasi-randomized by time of presentation (first 18 months vs. another time). Many weaknesses. Small groups of different sizes.
Flor 1993 RCT	2.5	N = 100 with chronic back pain or chronic temporomandibular pain in Tubingen	EMG biofeedback (BFB, n = 26) vs. cognitive-behavioral therapy (CBT, n = 26) vs. conservative medical treatment (MED, n = 26). Final follow-up at 24 months.	Pain reduction BFB vs. MED, p <0.05. Reduction in catastrophizing BFB vs. other groups, p <0.05. At 6 months, significant difference in BFB vs. other groups, at 24 months BFB vs. MED: p ≤0.01, p <0.05.	"[E]MG-BFB may be a superior treatment method for patients with chronic musculoskeletal pain who are not severely impaired by their pain problem."	Location of spine pain not noted, and considering it is mixed with TMJ pain suggests it may have been thoracic-trapezius pain. Dropout rates 40%.
Hasenbring 1999 RCT	2.5	N = 50 with acute sciatic pain and high psychosocial risk factors for chronicity	Medical care plus risk factor-based cognitive behavior treatment (RCBT, n = 12) vs. standardized electromyographic biofeedback (BFB, n = 11) vs. high-risk-patients undergoing usual medical care (HRIS, n = 12) vs. high-risk not in behavior treatment (RBT, n = 12).	BFB group better improvement than HRIS and RBT; RCBT better improvement than BFB on discharge and 6-months. RCBT group, 75% change of pain intensity vs. BFB group. At discharge, 83% of RCBT fell into range of functional group HRIS vs. 18% of BFB patients.	"[B]ehavioral interventions in the medical treatment of patients with acute sciatica and psychosocial high risk factors are effective in preventing the transition of acute pain to chronic pain."	High-risk patients and refusers of therapy showed poor outcome in pain. Dropouts 42.5%, precluding strong conclusions.
Newton-John 1995 RCT	2.5	N = 44 with history of non-malignant LBP for ≥6 months	EMG biofeedback (EMGBF, n = 16) vs. cognitive behavioral therapies (CBT, n = 16) vs. wait list control (n = 12). Both treatments 1 hour session twice a week for 8 weeks. Final follow-up at 6 months.	At 6 month follow-up, CBT (n = 13), and EMGBF (n = 10). ANOVA differences between groups for coping skills questionnaire, pain beliefs questionnaire, and pain diary significant at 6 month follow up: p <0.05, p <0.01, p <0.001.	"[C]BT and EMGBF are both effective in producing short term improvements in pain intensity, perceived level of disability, adaptive beliefs about pain and the level of depression."	Dropout and compliance rates appear so low that it is not clear that the non-responders might not have dropped out artificially, thus amplifying the results.

Magnusson 2008 RCT No industry sponsorship or COI	2.5	N = 47, with chronic LBP with or without referral to leg, age 20-70 years.	Standard rehabilitation program group (n = unknown) vs. Biofeedback group, received standard program and additional guided motion (n = unknown); 6 month follow-up. (21 drop-outs.)	VAS before/after rehab at 6 weeks/ months, p <0.001. SF-36 for physical functioning, role limitations, daily pain between groups, time, p <0.001. Biofeedback ROM results at 6 weeks; extension angle (p <0.043), clockwise circumduction area, angular velocity in extension/right rotation, p <0.028.	"The study strongly suggests that postural feedback is a useful adjunct to conventional physiotherapy of chronic low back pain participants."	Lack of study details, randomization method, allocations, not blinded, control of cointerventions, compliance. 45% dropouts (lack of time). Data suggest possible improved outcome measures in subjective SF-36 plus ROM of spine.
Sousa 2009 RCT Single-Blind	2.0	N = 60 facing chronic LBP who experienced pain enduring longer than 3 months. Mean age 46.39 years	Treatment group, sessions 2x a week 8 weeks of muscular relaxation, abdominal exercises, cognitive restructuring techniques. Biofeedback reduced as improvement, visual biofeedback via F 1000 system with visual EMG (n = 30) vs. controls (no treatment, n = 30). All 500mg paracetamol every 6 hours if needed.	In control group, VAS score change from 5.88 to 4.76 documented from initial to final assessment while the treatment group reported a change from 4.79 to 3.35, p = 0.131. Roland-Morris Disability questionnaire Pre-Treat vs. Post-Treat: Control Group 12.57 vs. 8.16. Treatment group 9.97 vs. 5.31; p = 0.183.	"We conclude that our treatment program did not lessen pain, improve quality of life or anxiety in patients with CLBP, or change paraspinal muscle toning during abdominal contraction."	Details sparse.
Multi-disciplinary Rehabilitation						
Mitchell 1994	3.5	N = 542 with chronic soft tissue/low back injuries, not recovered after 90 days of injury	Functional restoration program (n = 271) vs. control (n = 271). Both 7 hours a day, 5 days a week, 8-12 weeks. Intervention: exercise, functional stimulation, behavioral/ cognitive therapy, individual group counseling, biofeedback.	FRP (n = 71) vs. control (n = 91) had significantly less subjects granted permanent disability, p <0.05.	"Using the difference in total costs as a measure of relative success, back injuries had better results than other injuries in this study."	Only small differences between treated and control groups. Aerobic exercise components appear weak, possibly contributing to suboptimal results.
Strand 2001	3.5	N = 177 with LBP on long-term sick leave >8 weeks	Multidisciplinary rehab program (6 hours a day, 5 days a week, n = 81) vs. control (n = 36) for 4 weeks. MRP consisted of physical treatment, education, cognitive/behavioral modification, workplace intervention. Final follow-up at 12 months.	At 1-year follow-up, 50% returned to work. Statistically significant improvements demonstrated from baseline to follow-up evaluation in returners to work.	"Return to work was related to physical function and pain. More importance seemed to be attributed to physical performance in the intervention group than in the controls as a basis for returning patients to work."	Stratified results between those working and not working 1 year later suggest significant differences between each group.
Tavafian 2008 RCT Sponsored by Tehran University of Medical Sciences and Iranian Institute for Health Sciences Research. No COI.	3.5	N = 102 females, chronic LBP no back surgery lasst 2 years. back school mean age 42.9±10.7, clinic 44.7±10.8	Back School: 4 day, 5 session multidimensional and interdisciplinary educational program to get patients to highest levels of functioning (n = 50) vs. clinic group: just medication (n = 52). Both groups received acetaminophen, NSAIDs, and chlordiazepoxide. Follow-up at 3, 6, and 12 months.	Mean±SD SF-36 Physical component summary (PCS) baseline/3 mo/6 mo/12 mo: Back School group 44.3±16.8/ 76.7±17.3/66.6±27.5/ 64.7±36.3 vs. clinic group 42.6±24.0/ 51.2±28.1/ 51.2±28.8/ 51.1±28.3 (p = 0.01).	"[T]he findings from this randomized trial suggest that the back school program is an effective intervention and could play an important role in improving QOL in participants who suffer from CLBP even up to 12 months."	No placebo. Both groups received meds. Interventional group reported better quality of life measures at 3,6,12mo. Generalizability of study data beyond Iran unclear.
Abbasi 2012 RCT	3.5	N = 36 married with chronic LBP. Mean age 45±10 years.	Patient-oriented multi-disciplinary pain management, P-MPMP, 7 weekly 2 hour sessions, self-management strategies (n = 12) vs. spouse-assisted	No significant differences between groups for primary outcomes: Roland Disability Questionnaire (p = 0.44) or	In patients suffering from CLBP, an intervention that combines spouse-assisted coping skills training with a	Small sample size. Sparse methods.

Sponsored by grant from Family Excellence Centre and Tehran Medical University. No COI.			multi-disciplinary pain management, SA-MPMP, 7 weekly 2 hour sessions, similar to P-MPMP (n = 12) vs. standard care, data collected at baseline, 7 weeks (n = 12). Follow-up study end, 12 months post-treatment.	VAS (p = 0.44) at 12 month follow-up.	multidisciplinary pain management programme can improve fear of movement and rumination about low back pain."	
Bültmann 2009 RCT Sponsored by grants from Danish National Labor Market Authority, Vejle County, and Danish Chiropractic Research Fund. COI, Kilsgaard now director of KIApro (work rehab program).	3.0	N = 119 absent from work 4-12 weeks with reimbursement request indicating LBP or MSD as main cause of sick leave. Mean age 43.7±11.3 years.	Coordinated and Tailored Work Rehab (CTWR): 2 components – work disability screening and formulation and implementation of coordinated, tailored and action-oriented work rehab plan developed by interdisciplinary team using feedback-guided approach beginning after 4-12 weeks of sick leave for ≤3 months (n = 68) vs. Control: conventional case management (CCM) – provided by the municipality (n = 51). Follow-up at 3, 6, and 12 months.	Mean±SD cumulative sickness absence hours: 6-12 months CTWR 190.4±312.1 vs. CCM 411.7±423.1 (p = 0.009); 0-6 months CTWR 465.9±319.3 vs. CCM 585.6±322.6 (p = 0.034); 0-12 months CTWR 656.6±565.2 vs. CCM 997.3±668.8 (p = 0.006). Mean improvement±SD pain intensity last month: 3 months CTWR -2.91±2.6 vs. CCM -1.27±2.6, mean difference 1.64 (95% CI 0.47, 2.81).	"[T]he findigns of this pragmatic randomized trial provide suggestive evidence that CTWR employed by an interdisciplinary team is effective compared to conventional case management in workers absent from work due to MSDs."	A pragmatic economic RCT. Some baseline differences between groups which could impact outcome. CTWR vs. CCM showed potential for less lost productivity due to sick time.
Harkapaa 1990	3.0	N = 476 blue collar workers with history of physically strenuous or moderately strenuous work ≥10 years, and chronic LBP ≥2 years	Inpatient (3 week period, n = 157) vs. outpatient treatment (2 sessions/week for 2 months, n = 159) vs. control (n = 160). Final follow-up at 2.5 years.	At 1.5 years, decrease in LB pain index for inpatients vs. outpatients and at 22 months inpatients vs. control: p <0.02, p <0.04. Long-term gains different between groups, and inpatients vs. controls: p <0.01, p <0.01. At 2.5 years, number of sick days increased in controls vs. inpatients: p <0.03. Significant increase in sick days due to all MSDs for controls vs. inpatients, p <0.05.	"[t]he overall results showed that occasional back treatment periods were not essentially more efficient in preventing or slowing down the subjective disability process than repeated physical check-ups and self-care instructions. The treatment seemed, however, to produce short-term improvements in the subjects' back trouble, offer short-term relief from pain and, for the inpatients, rest and relief from daily work stress."	Stated results statistically positive, yet graphic results and trends over time nearly non-significant and may reflect heavy program educational and passive modality components. Combination of entry criteria (strenuous work) with policies may have biased results away from finding significant benefits as results meager.
Cherkin 1996 RCT Study supported by grant from Agency for Health Care Policy and Research (The Back Pain Outcome Assessment Team)	3.0	N = 391 age 20-69 with back pain, LBP, hip pain, or sciatica	Usual care (n = 129) vs. usual care plus and educational booklet and increasing exercise (n = 103) vs. usual care plus an educational session with registered nurse for 20 minutes and educational booklet (n = 98). Educational interventions focused on improving patient understanding of back problems and what they could do about them. Assessments by phone interview at 1, 3 7 weeks after index	Changes after 1 week: perceived knowledge – nurse (+18) vs. booklet (+12) vs. usual care (+5), p = 0.0001; evaluation of care – nurse (+3) vs. booklet (-3) vs. usual care (-6), p = 0.01; evaluation of care information subscale – nurse (+9) vs. booklet (+3) vs. usual care (-3), p = 0.001; regular exercise in past week – nurse (+0.31) vs. booklet (-	"These findings challenge the value of purely educational approaches in reducing functional impact or health care use related to back pain and also challenge the value of fitness exercise in the most acute phase of back pain."	Used a preconsent randomization process where only the participants who received treatment in addition to usual care were randomized.

and Northwest Health Services Research and Development Field Program. No mention of COI.			visit; and at 1 year by mailed questionnaire.	0.09) vs. usual care (-0.06), p <0.001.		
Basler 1997	2.5	N = 76 diagnosed with chronic LBP in Germany	Cognitive behavioral therapy plus prescribed medical treatment (2.5 hours/week, n = 36) vs. control (n = 40) for 12 weeks. Subjects in cognitive group told to keep pain diary for 4 weeks. Both groups treated with medication, nerve blocks, TENS, and PT.	Interaction group x time for pain intensity, control over pain, avoidance behavior, pleasant activities, catastrophizing, social roles, physical functions, and mental performance: p <0.01, p <0.05, p <0.05, p <0.01, p <0.01, p <0.05, p <0.01, p <0.05.	"Patients who only received medical treatment showed little improvement."	Dropout rates concerning. Baseline differences present.
Esmer 2010 RCT Study supported by University of New England College of Osteopathic Medicine and Osteopathic Heritage Fund. No COI.	2.5	N = 42 with persistent leg pain, back pain or both or failed back surgery syndrome without history of lumbosacral spinal surgery within last 2 years.	Mindfulness-based stress reduction instruction: 8 weeks classroom learning 1.5-2.5 hours once a week, encourage meditation 45 minutes a day, 6 days aid of guided meditation audiotapes; 6th week of treatment: 6 hour session in addition to weekly session; provide coping strategies (intervention, n = 19) vs. wait-list control (n = 21) for 12 weeks. Both groups received regular medical care during study. Follow-up 40 weeks.	Outcomes at 12 weeks (mean±SD). Chronic Pain Acceptance Questionnaire: MBSR 7.0±13.5 vs. control -6.7±11.0, p <0.014. Roland-Morris: MBSR -3.6±3.4 vs. control 0.1±1.9, p <0.005. VAS for pain: MBSR -6.9±6.9 vs. control -0.2±6.0, p <0.021. Abridged Pittsburgh Sleep Quality Index: MBSR 2.0±3.5 vs. control -0.2±1.7, p <0.047. Analgesic Medication Log: MBSR -1.5±1.8 vs. control 0.4±1.1, p <0.001.	"The results suggest that MBSR can be a useful clinical intervention for patients FBSS."	Pilot. High dropouts. Blind not described. "Traditional therapy" not described and may be usual care bias.
Schiltenwolf 2006 RCT No mention of industry sponsorship or COI.	2.5	N = 64 age 18-50 with subacute LBP with 1rst episode of sick leave due to LBP longer than 3 weeks up to 12 weeks.	Biomedical therapy (MT, n = 31) functional restoration program of individual physiotherapy, group therapy in water, workout, back school, stretching, strengthening, improving mobility, body control, passive interventions (massage, PT) vs. biopsychosocial therapy (BT, n = 33): biomedical therapy plus specifically adapted psychotherapy 3x a week, relaxation therapy 4x a week. All treatment 6 hours a day 15 days in 3 weeks. Co-interventions avoided. Follow-up 6 months, 2 years.	Mean changes at the end of 3 weeks of treatment (mean±SD). Pain: MT (-0.52±3.2) vs. BT (2.96±2.5), p = 0.0001. Functional capacity: MT (1.19±31.4) vs. BT (25.75±22.4), p = 0.0050. Depression: MT (-0.86±7.8) vs. BT (6.62±7.5), p = 0.0034. Sick leave during first 2 years after therapy: sick leave periods per patient – MT 11.4 vs. BT 3.86, p = 0.004; sick leave days per patient – MT 111.40 vs. BT 41.45, p = 0.001.	"[A] biopsychosocial treatment option in patients with subacute low back pain and a first episode of sick leave appears to positively influence pain, functional status and work performance after completion of therapy compared to a treatment with conventional biomedical therapy."	Data suggest BT modestly superior.
Coole 2012 RCT Sponsored by Arthritis Research UK. No COI.	2.0	N = 59 currently employed with LBP >6 weeks and referred to group rehab. Mean age	Individual work support – OT, back pain management at work, home or outpatient clinic up to 8 face-to-face contacts to 90 minutes, assessment of work environment for 16 weeks (n = 30) vs. multi-disciplinary back pain rehab only, control – self-	No significant differences between groups at 6 months.	"The outcome of the intervention was equivocal and further research is required to evaluate work-focused interventions with this client group."	Many details sparse. Pilot study with 6 month followup. High dropout rate.

		41.46±11.93 years, control group 48.30+10.14 years.	management back pain, education, physical conditioning, cognitive behavioral treatment (n = 29). All 10 weeks group multi-disciplinary back pain rehab. Follow-up at 6 months.			
Fordyce 1986 RCT No COI.	1.0	N = 107 with LBP within past 7-10 days no treatment for back pain during past 9 months	Group A – analgesics as needed, exercise if prescribed, return visit as needed 2 weeks (n = 50) vs. Group B – analgesics fixed intervals, activity, exercise fixed time, preset number of reps incremented on physician-prescribed schedule; return visit 2 weeks (n = 57). Follow-up 6 weeks and 9 months.	No significant differences between groups at 6 weeks.	"The central point of these findings seems to be that the prevention of chronicity in recent-onset back pain is furthered by distinguishing between pain and healing and designing regimens based on healing, not report of pain."	Patient driven treatment.

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