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Evidence-Based Medicine

Comprehensive Review of Neurophysiologic Basis and Diagnostic Interventions in Managing Chronic Spinal Pain

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Dr. Hirsch is a consultant for Cardinal Healthcare and Medtronic, he has previously served as a consultant for Arthrocare, he serves on the Steering Committee for KAVIAR trial (volunteer position), and on the Data and Safety Monitoring Board (DSMB): CEEP trial (volunteer position).Dr. Datta receives research support from Sucampo Pharmaceuticals and an honorarium from Smith and Nephew.
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Background: Understanding the neurophysiological basis of chronic spinal pain and diagnostic interventional techniques is crucial in the proper diagnosis and management of chronic spinal pain.Central to the understanding of the structural basis of chronic spinal pain is the provision of physical diagnosis and validation of patient symptomatology. It has been shown that history, physical examination, imaging, and nerve conduction studies in non-radicular or discogenic pain are unable to diagnose the precise cause in 85% of the patients. In contrast, controlled diagnostic blocks have been shown to determine the cause of pain in as many as 85% of the patients.

Objective: To provide evidence-based clinical practice guidelines for diagnostic interventional techniques.

Design: Best evidence synthesis.

Methods: Strength of evidence was assessed by the U.S. Preventive Services Task Force (USPSTF) criteria utilizing 5 levels of evidence ranging from Level I to III with 3 subcategories in Level II.

Diagnostic Criteria: Diagnostic criteria established by systematic reviews were utilized with controlled diagnostic blocks. Diagnostic criteria included at least 80% pain relief with controlled local anesthetic blocks with the ability to perform multiple maneuvers which were painful prior to the diagnostic blocks for facet joint and sacroiliac joint blocks, whereas for provocation discography, the criteria included concordant pain upon stimulation of the target disc with 2 adjacent discs producing no pain at all.

Results: The indicated level of evidence for diagnostic lumbar, cervical, and thoracic facet joint nerve blocks is Level I or II-1. The indicated evidence is Level II-2 for lumbar and cervical discography, whereas it is Level II-3 for thoracic provocation discography. The evidence for diagnostic sacroiliac joint nerve blocks is Level II-2. Level of evidence for selective nerve root blocks for diagnostic purposes is Level II-3.

Limitations: Limitations of this guideline preparation include a continued paucity of literature and conflicts in preparation of systematic reviews and guidelines.

Conclusion: These guidelines include the evaluation of evidence for diagnostic interventional procedures in managing chronic spinal pain and recommendations. However, these guidelines do not constitute inflexible treatment recommendations. **These guidelines also do not represent a "standard of care."**

Key words: Diagnostic interventional techniques, chronic spinal pain, facet joint interventions, epidural procedures, provocation discography, sacroiliac joint blocks, post lumbar surgery syndrome, spinal stenosis, provocation discography

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Interventional pain management is a rapidly growing and evolving specialty (1-6). Consequently, multiple forces at work, both traditional medical and extra medical, continue to emerge and alter the manner in which we practice interventional pain management and maintain access for interventional techniques for our patients. All the forces in interventional pain management specifically, and spine care in general, both positive and negative, can be considered in a practical and philosophical manner (7,8). Chronic spinal pain is a multifactorial disorder with many possible etiologies. Thus, apart from political, bureaucratic, scientific, ethical, intersociety, interspecialty, and intra-specialty motives, the influence of evidence-based interventional pain management and the biopsychosocial model of illness have had and also will continue to have, significant implications in the way interventional pain management is practiced. While many of the implications are positive, little attention has been paid to the concerns that arise with the implementation of the biopsychosocial model or evidence-based practice. In essence, the structural or neurophysiological basis of pain is crucial in both the biomedical and biopsychosocial models. With the sole focus on the biological aspects of pain the behavioral aspects will be missed, whereas the sole focus on the behavioral aspects will miss biological aspects. Thus, central to the understanding of the structural basis of chronic spinal pain is the provision of a physical diagnosis and validation of patient symptomatology, whenever it is feasible.

1.0 Neurophysiological Basis of Spinal Pain

In the mid-1840s, with the emergence of pathological anatomy as the fundamental science of medicine, disease was envisioned outside of its embodiment in particular patients and imagined as an entity unto itself (7). The subsequent and continued growth of this "biomedical model" of disease succeeded in facilitating the treatment of patients for multiple disease and illness states.

The birth and rise of the biopsychosocial model is credited to some difficult and important medical problems which have proven resistant to the biomedical model (7-21). Along with many of the difficult problems such as pelvic pain, facial pain, myofascial pain syndromes, and some psychiatric illness, persistent spinal pain, with a societal and health care impact in the billions of dollars, has been included in this category of problems resistant to the biomedical model (7-20). The proponents of the biopsychosocial model believe that the complex, multidimensional nature of persistent spinal pain does not lend itself to the clean reductionist program of the biomedical model. Consequently, the clinician is presented with a set of biologic and psychosocial factors, with which to explain why people have persistent spinal pain and a set of alternative tools, addressing these factors, with which to treat patients (22,23). However, multiple concerns related to the biopsychosocial model have been described (7). These concerns include the reliance on self-reporting of outcomes, the disconnection between physical pathology and self-reporting, and the scientific status of the biopsychosocial model.

The scientific status of the biomedical and the biopsychosocial models have been questioned. It has been argued that the biopsychosocial model lacks the key ingredient of scientific theories — that they are attestable or falsifiable (24,25). Consequently, the biopsychosocial model is based on the premise that illness is a complex synthesis of biologic, cognitive, psychological, and social factors. Another concern is the ubiquity of biopsychosocial "pathology" (7,26,27).

Thus, in the 1990s the biopsychosocial approach dominated chronic spinal pain management, at least among academicians, with the introduction of "psychosocial" approaches, most often without the "bio." Even then, purists and proponents of the biopsychosocial model continue to describe this as the best and only model, whereas others argue that the biological model is also equally important, specifically when psychosocial variables do not play a role and a pathoanatomical diagnosis is made.

The multidimensional mechanism of pain and multidisciplinary management has taken different meanings for different specialties, sometimes ignoring the fundamental facts that pain is not explained by pure theories of either physical or psychological origins. Thus, pain management, in some circles, has reached a stage of psychosocial reductionism, which has essentially eliminated the bio part from the biopsychosocial approach, leaving "psychosocial," "psychological," or "functional" approaches. While the biopsychosocial model is under questioned could possibly be accepted by all without significant modifications, the concept of psychogenic pain has stimulated controversy in the field of pain medicine, not only regarding its prevalence, but indeed, its very existence (28,29). Unfortunately, the diagnosis of psychogenic pain not only fails to provide a valid organic diagnosis, but also fails to provide validation of patient symptomatology and complaints (30,31).

2.0 Diagnosis of Spinal Pain

The initial diagnosis of spinal pain poses numerous challenges due to the clinician's inability to diagnose accurately. The primary function of the evaluation, after ruling out non-spinal or serious spinal pathology and nerve root pain, is to identify the cause of spinal pain that is without nerve root pain. Even though this type of pain has been classified as "non-specific" pain, that may not be justifiable as this label results in disappointment, disillusion, lack of coverage, and finally being labeled as psychological pain. However, this creates a huge dilemma in that modern technology, including magnetic resonance imaging (MRI), computed axial tomographic scanning (CT or CAT scan), neurophysiological testing, and comprehensive physical examination with psychological examination, can identify the cause of low back pain in only 15% of patients in the absence of disc herniation and neurological deficit (6,27,32-67).

Rubinstein and van Tulder (46) provided a best-evidence review of diagnostic procedures for neck and low back pain. They commented that it was quite remarkable that the many named orthopedic tests of the neck and low back often illustrated in orthopaedic textbooks had very little evidence to support their diagnostic accuracy, and therefore, their use in clinical practice. Consistent with clinical experience, many studies have demonstrated that the physical examination serves primarily to confirm suspicions raised during the history.

Vroomen et al (47) found no systematic reviews which examined the diagnostic accuracy of history taking in patients with neck pain. Further, individual red flags did not necessarily mean the presence of serious pathology with low back pain. Vroomen et al (48) in a systematic review showed that the straight leg raise (SLR) test was the only sign that was consistently sensitive for sciatica due to disc herniation with a pooled sensitivity of 0.85 (95% CI, 0.38 – 0.98), but with low specificity of 0.52 (95% CI 0.25 – 0.76). However, diagnostic accuracy of other neurological signs including paresis, sensory loss, and reflex loss was unclear. Further, in another systematic review (49), the diagnostic accuracy of the SLR test was concluded to be limited by its low specificity.

In a systematic review by van Tulder et al (50), the most commonly used examination procedures by clinicians in patients with low back pain, including identifying the spinal level, passive accessory movements, establishing a comparable level, passive physiological movements, evaluation of muscle tension or spasm, and determining the existence of a fixation or manipulative lesion, and instability tests, were all shown to have conflicting results or low reliability. Further, Hancock et al (51), in evaluating the accuracy of various tests utilizing and diagnosing pain originating from the disc, facet joint, and sacroiliac joint, showed that the tests of the facet joint as the source of pain have limited or no diagnostic validity. Among all the tests evaluating the disc as a source of pain, centralization was the only clinical feature found to increase the likelihood of the disc as a source of pain. No single manual test seemed to be useful, including the thigh thrust or sacral thrust test, in the diagnosis of sacroiliac joint pain, but a combination of the tests seemed to be useful in increasing the likelihood of the sacroiliac joint as a source of pain.

Numerous imaging studies have been shown to lack accuracy and reliability in the absence of disc herniation and radiculopathy in the diagnosis of chronic low back pain (50,67-86).

3.0 Controlled Diagnostic Interventional Techniques

In contrast to the mixed picture provided by history, physical examination, imaging, and nerve conduction studies in non-radicular or discogenic pain, controlled diagnostic blocks have been shown to determine the cause of pain in as many as 85% of the patients in contrast to 15% of the patients with other available techniques (87-89).

3.1 Purpose

Diagnostic injections are performed to confirm or exclude a pain generator. A diagnostic injection is only indicated when the diagnosis is in question despite less invasive testing and further invasive treatment is indicated, and in the absence of clear-cut radiculopathy or disc herniation. Bogduk postulated that for a structure to be deemed as a cause of back pain (37):

- The structure should have a nerve supply.
- The structure should be capable of causing pain similar to that seen clinically, ideally demonstrated in normal volunteers.
- The structure should be susceptible to diseases or injuries that are known to be painful.
- The structure should have been shown to be a source of pain in patients, using diagnostic techniques of known reliability and validity.

Facet joint pain, discogenic pain, and sacroiliac joint pain have been proven to be common causes of pain with proven diagnostic techniques (90-105).

3.2 Rationale

The popularity of neural blockage as a diagnostic tool in painful conditions is due to several features. Idiopathic low back pain has confounded health care practitioners for decades and the cellular and neural mechanisms leading to facet joint pain, discogenic pain, and sciatica are not well understood (106). Multiple diagnostic challenges in chronic spinal pain include its characteristics, which are purely subjective, and the conditions which are, in most cases, inexactly defined with uncertain pathophysiology (91-108). Precision diagnostic blocks are used to clarify these challenging situations, in order to determine the pathophysiology of clinical pain, the site of nociception, and the pathway of afferent neural signals.

3.3 Validity

A critical property of any diagnostic test is that it must be valid. If an invalid diagnostic test is applied, the information obtained is not only wrong providing a wrong diagnosis, but also will lead to inappropriate treatment which may fail. Consequently, with any other diagnostic test, diagnostic neural blocks are subject to the requirement of validity. Various subtypes of validity have been described in the scientific literature with variable terminology. The terminology utilized in conjunction with diagnostic blocks is concept validity, content validity, face validity, construct validity, and predictive validity (109).

The theoretical basis of controlled diagnostic blocks is based on the fact that if a patient genuinely has pain from a particular target structure, complete relief of that pain should be obtained consistently whenever that structure is anesthetized, and repeating the diagnostic block tests either or both, the consistency of response and the effect of different agents. Further, there should not be relief if some other structure is anesthetized or if any inactive agent is used to block the target structure. If a patient responds to a first block, but fails to respond appropriately to subsequent controlled blocks, their initial response is deemed to have been false-positive (109).

3.3.1 Concept Validity

Concept validity is that the procedure appears in theory to have a reasonable anatomical or physiological basis. Diagnostic blocks have concept validity on the grounds that it sounds reasonable that if a structure is a source of pain, anesthetizing it will relieve that pain (109). Thus, the thrust of concept validity is the theoretical basis of the test.

3.3.2 Content Validity

Content validity essentially defines the test accurately and ensures that the procedure is performed consistently in the same manner (109). Thus, content validity does not render the procedure itself valid, but it ensures that the name of the procedure is used consistently to mean the same thing.

3.3.3 Face Validity

For a diagnostic block to have face validity it must be shown that the block actually does what it is supposed to do in an anatomical or physiological sense (109). If a particular structure is said to be the target, it must be shown that the structure is anesthetized. Face validity can be tested and established either by a study which replicates the results, or testing for face validity in each and every case. The face validity may be established by fluoroscopy and injection of contrast or by a physiological approach utilizing a detectable and testable function other than pain (i.e., sympathetic block). In addition to reaching the intended target to demonstrate the face validity, it also must be demonstrated that potentially confounding targets are not affected. Consequently the objective of face validity is to show that the intended target is selectively or discretely anesthetized. Thus, flooding everything in the vicinity of the target with local anesthetic does not secure face validity.

However, just because an injection is aimed at a particular structure, it is not certain that either the structure will be anesthetized or that only that structure will be anesthetized. This is an issue with almost all interventional techniques including epidurals, facet joint injections, and sympathetic blocks. In many cases the flow of injectate depends on the technique used. Fluoroscopic guidance is the only means available at present by which the face validity of diagnostic blocks can be confidently demonstrated except for superficial, palpable, or easily accessible nerves. Utilizing an inappropriate technique and injecting low volumes can also corrupt face validity assumptions.

3.3.4 Construct Validity

Construct validity is considered as the most critical of all the subtypes of validity. It establishes if the test actually achieves what it is supposed to achieve by measuring the extent to which a test correctly distinguishes the presence, but also the absence, of the condition that the test is supposed to detect. Construct validity measures if the test actually works or not, and how well it works (109).

Evaluation of the diagnostic accuracy tests is an important, dynamic, and emerging part of medicine. Testing a test involves comparing, in the same sample of patients, the results of a test with unknown validity with the results of some other test whose validity is beyond question or a criterion standard formerly also known as the gold standard. In reality, however, no test is perfect and no criterion standard is absolute. Thus, a criterion standard is a test whose results vary substantially less than the test undergoing scrutiny. Criterion standard may be defined by imaging findings, operative findings, pathological findings, or long-term follow-up. Simply put, the criterion standard is usually a test that allows a more direct detection of the condition in question than the test under scrutiny, and which is less subject to errors of observation.

Sensitivity and specificity of the test are used to determine the validity. Sensitivity is the extent to which the test correctly detects the condition that the test is supposed to detect. In contrast, specificity is the extent to which the test correctly detects the absence of the condition. Thus, sensitivity is also known as the true-positive rate whereas specificity is known as true-negative rate. A comparison statistic is the false-positive rate. This is the proportion of cases who did not have the condition, but in whom the test was, incorrectly, positive.

Failure to recognize both the occurrence and the prevalence of false-positive responses continues to be one of the major issues in medicine in general and interventional pain management in particular.

For diagnostic interventional techniques, there is no conventional criterion standard, such as imaging findings, operative findings, or pathological findings. However, long-term relief may be used to provide a criterion standard for certain types of blocks. Thus, Bogduk (109) has developed testing for construct validity of diagnostic blocks by other means. Features such as the false-positive rate can be estimated by determining how often a diagnostic block is positive in patients who should not, or demonstrably do not, have the condition in question. Once the false-positive rate is known, the specificity of the test can be derived as the complement of the false-positive rate.

Overall, 3 types of controls can be used (109). Anatomical controls involve deliberately anesthetizing some adjacent structure that is not the suspected source of pain. Construct validity is achieved if the patient obtains relief whenever the suspected source is anesthetized, but not when the adjacent structure is anesthetized. Any other pattern of response constitutes a false-positive response.

The second form of control involves using a placebo agent in which the protocol requires a sequence of 3 blocks. The first block must involve an active agent, in order to establish, prima facie, that the target structure does appear to be the source of pain. The other 2 agents are administered on a randomized double-blind basis. Under these conditions, a true-positive response would be the one in which the patient obtained relief on each occasion that an active agent was used, but no relief when the inactive agent was used.

A third more pragmatic approach, most commonly utilized in the United States, is to use comparative local anesthetic blocks. The blocks are performed on separate occasions using local anesthetic agents with different durations of action (110-117). In this approach, the consistency and duration of response are tested. Failure to respond to the second block constitutes inconsistency, and indicates that the first response was a false-positive. A response concordant with the expected duration of action of the agent used strongly suggests a genuine, physiologic response, even though lack of concordance does not invalidate the response. Comparative blocks are confounded by a peculiar property of local anesthetics, particularly lidocaine and bupivacaine. Patients can obtain prolonged effects from lidocaine and bupivacaine (115,118-136). It was believed that a concordant response results in a false-positive rate of 14%; whereas complete, but prolonged responses may result in false-positive responses of 35% (109,115,116). However, current data on the long duration of local anesthetic effect (118-136) may refute the potential false-positive rate of 14% to 35% with prolonged positive response. While comparative blocks reduce the false-positives, they may not prove that the response is true-positive with certainty. If the number of repetitions is increased but the responses remain consistent, the probability that the responses are false becomes dwindlingly small (109).

4.0 Assessment of Diagnostic Accuracy Studies

The world of diagnostic tests is highly dynamic. New tests are developed at a fast rate and technology of existing tests is continuously being improved (137). Exaggerated and biased results from poorly designed and reported diagnostic studies can trigger their premature dissemination and lead physicians into making incorrect treatment decisions. Since the diagnosis is a critical component of health care, clinicians, policy makers, and patients routinely face a range of questions regarding diagnostic tests (138). Well-designed diagnostic test accuracy studies can help in making appropriate diagnosis, improving outcomes, and in designing practice guidelines (139).

4.1 Definition of Diagnostic Accuracy

In studies of diagnostic accuracy, the outcomes from one or more tests under evaluation are compared with outcomes from the reference standard, both measured in subjects who are suspected of having the condition of interest. The term "test" refers to any method of obtaining additional information on a patient's health status. It includes information from history and physical examination, laboratory tests, imaging tests, function tests, and histopathology. In this framework, the reference standard is considered to be the best available method for establishing the presence or absence of the condition of interest. The reference standard can be a single method or a combination of methods to establish the presence of the target condition. It can include laboratory tests, imaging tests, pathology, and also dedicated clinical follow-up of subjects.

4.2 STARD Initiative

The Standards for Reporting of Diagnostic Accuracy (STARD) established reporting guidelines for diagnostic accuracy studies to improve the quality of reporting (137). They developed a checklist for the reporting of studies of diagnostic accuracy which included 25 items in 5 sections: title/abstract/key words, introduction, methods, results, and discussion. They also have provided a prototypical flow diagram of a diagnostic accuracy study.

4.3 Bias and Variation in Studies of Diagnostic Accuracy

In a classic diagnostic accuracy study, a consecutive series of patients who are suspected of having the target condition, undergo the index test, then all patients are verified by the same reference standard. The index test and reference standard are then read by persons blinded to the results of each and various measures of agreement are calculated including sensitivity, specificity, likelihood ratios, and diagnostic odds ratios. The classic design has many variations, including differences in the way patients are selected for the study, in test protocol, in the verification of patients, and in the way the index test and reference standard are read. Some of the differences may bias the results of a study and others may limit the applicability of results (140).

Variations arise from the differences among studies in terms of population, setting, test protocol, or definition of the target disorder (141). The variability does not lead to biased estimates of the test performance; rather, it limits the applicability of results. Consequently, it is an important consideration when evaluating studies of diagnostic accuracy.

While bias and variation are different, the distinctions are not (142). The design features associated with significant overestimations of diagnostic accuracy are inclusion of severe cases and healthy controls, non-consecutive inclusion of patients, and retrospective data collection. In interventional pain management settings, prevalence estimations of facet joint pain in the cervical and lumbar regions have been higher in prospective studies with inclusion of consecutive patients rather than in retrospective designs with consecutive patient population evaluations (89,143) compared to prospective consecutive assignments (118,119,144-150).

4.4 Quality Assessment

Several instruments have been designed for methodologic quality assessment of diagnostic studies. West et al (151), in the Agency for Healthcare Research and Quality (AHRQ) evidence report of technology assessment, provided pertinent evidence to rating the quality of individual articles including the studies of diagnostic tests. AHRQ developed 5 key domains for making judgments about the quality of diagnostic test reports: study population, adequate description of the test, appropriate reference standard, blinded comparison of test and reference, and avoidance of verification bias. This methodology has been applied in multiple systematic reviews (94-96,98-100,104). In addition, a tool for the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) included in systematic reviews (152) was de-

veloped by combining empirical evidence and expert opinion in a formal consensus method.

4.5 Systematic Reviews of Diagnostic Test Accuracy

Diagnostic test accuracy systematic reviews face 2 major challenges. First, they are limited by the quality and availability of primary test accuracy studies that address important relevant questions. More studies are needed that recruit suitable spectrums of participants, make direct comparisons between tests, use rigorous methodology, and clearly report their methods and findings. Second, more development is needed in the area of interpretation and presentation of results of diagnostic test accuracy reviews. Multiple systematic reviews of diagnostic accuracy studies in interventional pain management have been published (46,51,91-100,102-105,107).

4.6 Level of Evidence

The translation of systematic reviews into practice recommendations requires the determination of level of evidence (153-155). Often, the same information can be interpreted in different ways by different panelists, resulting in the provision of different guidance. Level of evidence is derived from quality assessment and results of individual studies. While there is no universally accepted approach to presenting levels of evidence, a rigorous approach in widespread use was developed by the U.S. Preventive Services Task Force (USPSTF) (153) (Table 1).

4.7 Review of Systematic Reviews

Methodologic quality assessment of systematic reviews is crucial for guideline preparation and recommendations. West et al (151) described a set of high-performing scales or checklists pertaining to systematic reviews with 7 key domains: study question, search strategy, inclusion and exclusion criteria, data abstraction, study quality and validity, data synthesis and analysis, and funding or sponsorship.

5.0 Low Back Pain

Facet joint pain, discogenic pain, and sacroiliac joint pain have been proven to be common causes of pain with proven diagnostic techniques (6,37,50,51, 55,57,63,65,68,87,88,91-93,97,98,102-105,143-148). In a prospective evaluation (88), the relative contributions of various structures in patients with chronic low back pain who failed to respond to conservative modalities of treatments (physical therapy, chiropractic, and drug therapy), with a lack of radiological evidence to indicate disc protrusion or radiculopathy, were evaluated utilizing controlled, comparative, double diagnostic blocks. In this study, 40% of the patients were shown to have facet joint pain, 26% discogenic pain, 2% sacroiliac joint pain, and possibly 13% segmental dural/nerve root pain. No cause was identified in 13% (87) and 19% (88) of the patients.

5.1 Lumbar Facet or Zygapophysial Joints

The facet or zygapophysial joints are paired diarthrodial articulations between posterior elements of the adjacent vertebrae (156,157). The term "facet joint" was coined in the 1970s, when surgeons became interested in the small joints of the lumbar spine as a source of back pain (157). Goldthwaite (158) has been generally credited for initiating interest in the lumbar facet joints as a source of pain, but his paper actually focused on their role in protecting the L5 vertebra from spondylolisthesis. Ghormley (159), in 1933, raised the clinical profile of lumbar facet joints, and introduced the oblique view of the lumbar spine to show the spaces of these joints and the degree to which they might be affected by osteoarthritis.

As true synovial joints, each facet joint contains a distinct joint space capable of accommodating between 1 mL and 1.5 mL of fluid, a synovial membrane, hyaline cartilage surfaces, and a fibrous capsule (156,160,161).

Lumbar facet joints are well innervated by the medial branches of the dorsal rami (162-165). Each facet

Table 1. *Modified quality of evidence developed by USPSTF.*

I	Evidence obtained from multiple properly conducted diagnostic accuracy studies.
II-1	Evidence obtained from at least one properly conducted diagnostic accuracy study of adequate size.
II-2	Evidence obtained from at least one properly designed small diagnostic accuracy study.
II-3	Evidence obtained from diagnostic studies of uncertainty.
III	Opinions of respected authorities, based on clinical experience descriptive studies and case reports or reports of expert committees.

Adapted and modified from the U.S. Preventive Services Task Force (USPSTF) (153).

joint receives dual innervation from medial branches arising from posterior primary rami at the same level and one level above the joint. Typically, the inferior pole of the L4/5 facet joint receives innervation from the L4 medial branch and its superior pole is innervated by the L3 medial branch, which are typically blocked on the transverse processes of L5 and L4, respectively. The medial branches of L1 to L4 dorsal rami course across the top of their respective transverse processes, one level below the named spinal nerve (e.g., L3 crosses the transverse process of L4), traversing the dorsal leaf of the intertransverse ligament at the base of the transverse process. Each nerve then runs downward along the junction of the transverse and superior articular processes, passing beneath the mamilloaccessory ligament and dividing into multiple branches as it crosses the vertebral lamina. In addition to the 2 facet joints, the medial branches also innervate the multifidus muscle, the interspinous muscle and ligament, and periosteum of the neural arch (156,162,163,166). The L5 nerve differs from L1 to L4 dorsal rami in that it is the dorsal ramus itself that runs along the junction of the sacral ala and superior articular process of the sacrum (162).

Neuroanatomical studies have demonstrated free and encapsulated nerve endings in facet joints, as well as nerves containing substance *P* (SP) and calcitonin gene-related peptide (165,167-169). Neurophysiological studies have also shown that lumbar facet joint capsules contain low-threshold mechanoreceptors, mechanically sensitive nociceptors, and silent nociceptors (165-177). The presence of low-threshold, rapidly adapting mechanosensitive neurons suggest that in addition to transmitting nociceptive information, the facet joint capsule also serves a proprioceptive function. A substantial percentage of nerve endings in facet capsules have also been found containing neuropeptide Y, indicating the presence of sympathetic efferent fibers (178,179). In addition, nerve fibers have been found in subchondral bone and the intraarticular inclusion of facet joints, signifying that facet joint pain may be contributed to by structures other than the joint capsule (174,180,181).

Inflammation leads to decreased thresholds of nerve endings in facet capsules as well as elevated baseline discharge rates (165,173-175,182-185). In degenerative lumbar spinal disorders, inflammatory mediators such as prostaglandins and the inflammatory cytokine interleukin (IL) 1 beta, IL 6 and tumor necrosis factor (TNF) alpha have been found in facet joint cartilage and synovial tissue (182). Biomechanical studies have shown that lumbar facet joint capsules can undergo high strains during spine-loading (165). These studies have confirmed the contribution of the facets to load transmission in the spine and have indicated the possibility of facet overload resulting in stiffness or rigidity through prolonged immobilization, even without degenerative or other pathologic findings on diagnostic imaging (186-189).

Inflammation, injury, and degeneration of facet joints can lead to pain upon joint motion, pain leads to restriction of motion, which eventually leads to overall physical deconditioning (161,186-201). It has been assumed that degeneration of the disc would lead to associated facet joint degeneration and subsequent spinal pain. These assumptions were based on the pathogenesis of the degenerative cascade in the context of the 3 joint complex that involves the articulation between 2 vertebrae consisting of the intervertebral disc and adjacent facet joints, as changes within each member of this joint complex will result in changes in the others (190-201).

In a review of lumbar facet joint osteoarthritis (202), it was shown that risk factors for lumbar facet joint osteoarthritis include advanced age and a background of intervertebral disc degeneration. An anatomic study of cadaveric specimens (203) showed that the evidence of facet arthrosis appears early in the lumbar spine, with up to 57% of the specimens in their third decade. In a cross-sectional study of facet joint osteoarthritis and low back pain in a community-based population (204), the results showed a high prevalence of facet joint osteoarthritis in the community-based population in 59.6% of males and 66.7% of females. The study also showed the increase of prevalence of facet joint osteoarthritis with age, reaching 89.2% in individuals 60 to 69 years old. However, this study showed that individuals with facet joint osteoarthritis identified by CT at any spinal level showed no association with low back pain, similar to other studies (68,202,203,205-207). Degeneration and loss of structural integrity of the intervertebral discs have been shown to result in concomitant degenerative changes in the facet joints (199,208-210). Degeneration and motion abnormalities at the facet joints can also induce and accelerate degeneration of the intervertebral discs (211-213).

Mooney and Robertson (214) demonstrated that facet joints could be a source of back pain in normal volunteers; and certain patients could be relieved of their pain by anesthetizing these joints. Other impor-

tant findings were that pain from facet joints could be referred distally into the lower limb and could be accompanied by hamstring tightness that limited SLR, mimicking some of the features of sciatica. These findings with respect to pain in normal volunteers (215) and pain being relieved in patients by anesthetizing the joints have been reproduced (216). Others also have described the distribution of referral patterns of pain from lumbar zygapophysial joints (217-219).

5.1.1 Diagnosis of Lumbar Facet Joint Pain

While historical, physical, radiological, or other studies do not provide specific markers of facet joint pain, facet joint blocks seem to do so (202-207). In a systematic review of the tests to identify the disc, sacroiliac joint, or facet joint as the source of low back pain, Hancock et al (51) concluded that the results of studies investigating the facet joint as the source of patients symptoms suggest that the currently available tests have limited or no diagnostic validity (56,91-96,101). The majority of the published clinical investigations report no correlation between the clinical symptoms of low back pain and degenerative spinal changes observed on radiologic imaging studies, including radiographs, MRI, CT, single photon emission computed tomography (SPECT), and radionuclide bone scanning (68,101,118,145,204,220-227). Specifically, the association between degenerative changes of the spine and symptomatic low back pain remains unclear and is a subject of ongoing debate (51,68,202-204,206,220-232).

5.1.2 Lumbar Facet or Zygapophysial Joint Blocks

Diagnostic blocks of a facet or zygapophysial joint can be performed by anesthetizing the joint with injections of local anesthetic intraarticularly or on the medial branches of the dorsal rami that innervate the target joint, to test whether the joint is the source of pain. Valid information is only obtained by performing controlled blocks, either in the form of placebo injections of normal saline or comparative local anesthetic blocks, in which on 2 separate occasions, the same joint is anesthetized using local anesthetics with different durations of action.

5.1.2.1 Rationale

The rationale for using facet joint blocks for diagnosis is based on the fact that facet joints are capable of causing pain and they have a nerve supply (106,160-163,214-219). They have been shown to be a source of pain in patients using diagnostic techniques of known reliability and validity (91-93,101,141-146,208,220,233). The value, validity, and clinical effectiveness of diagnostic facet joint nerve blocks was also illustrated by application of therapeutic modalities based on the diagnosis with controlled comparative local anesthetic blocks (6,91-93,95,119-126,234,235). The response has been claimed to be superior after the diagnosis was established with dual controlled local anesthetic blocks rather than single blocks (91-93,95,119-126,234-241).

5.1.2.2 Validity

The face validity and specificity (101,109,163,164) and construct validity (101,109,115,117) of lumbar medial branch or facet joint nerve blocks has been established. Provocation response was shown to be unreliable in one study (55). The false-negative rate of diagnostic facet joint blocks was shown to be 8% due to unrecognized intravascular injection of local anesthetic (163). False-positive rates were evaluated in multiple investigations (88,91-93,101,143-148,241) with an overall false-positive rate of 30% (95% CI, 27% – 33%) with a single block. The minimal effect of sedation (242,243), and lack of influence of psychological factors (244,245), and opioid exposure (246) on the validity of controlled lumbar diagnostic local anesthetic blocks of facet joints were demonstrated. Lack of influence of age (247) and variables of gender, smoking, and occupational injury (248) were also evaluated.

5.1.2.3 Cost Effectiveness

Diagnostic facet joint nerve blocks were not evaluated for cost effectiveness systematically. However, the feasibility and cost effectiveness of appropriately performed controlled comparative local anesthetic blocks have been described (88,249-252).

5.1.2.4 Safety and Complications

Safety of facet joint interventions with intraarticular injections and medial branch blocks has been demonstrated. Though rare and minor, the commonly reported complications of facet joint injections or nerve blocks are related to needle placement and drug administration. These complications include hemorrhage, dural puncture, spinal cord trauma, infection, intraarterial or intravenous injection, chemical meningitis, neural trauma, paralysis, radiation exposure, facet capsule rupture, hematoma formation, steroid side effects, and epidural, subdural, or subarachnoid spread (6,91-93,95,253-273).

5.1.2.5 Evidence Assessment

Our search yielded 5 systematic reviews (51,91-93,95) and multiple other manuscripts (55,68,88,91-93,95,101,123,143-148,163,164,220,233,245-248).

The recent systematic review by Datta et al (95) utilized 7 studies (88,143,144,147,148,221,233) meeting inclusion criteria with 80% pain relief and the ability to perform previously painful movements with controlled diagnostic blocks. These studies were subjected to methodologic quality assessment.

5.1.2.6 Prevalence

Based on the systematic review by Datta et al (95), prevalence was 21% to 40% in a heterogenous population and 16% in post lumbar laminectomy syndrome with confidence intervals (CIs) ranging from 9% to 23% in post surgery syndrome and 14% to 53% in the heterogenous population (Table 2). The overall prevalence was 31% (95% CI; 28%–33%) derived from average calculations.

5.1.2.7 False-Positive Rate

Based on Datta et al's (95) systematic review of the diagnostic accuracy of lumbar facet joint interventions, false-positive rates of 17% to 49% were demonstrated with CIs ranging from 10% to 59% with an overall false-positive rate of 30% (95% CI; 27% – 33%) (Table 2). In post surgery syndrome, a false-positive rate of 49% was demonstrated with a CI of 39% to 59%.

5.1.2.8 Level of Evidence

Based on the systematic review by Datta et al (95), utilizing criteria of 80% pain relief with controlled, comparative local anesthetic blocks, the evidence is Level I or II-1 based on the (USPSTF) criteria (153).

Rubinstein and van Tulder (46) in a best-evidence review of diagnostic procedures for neck and low-back pain concluded that there is strong evidence for the diagnostic accuracy of facet joint blocks in evaluating spinal pain.

5.1.2.9 Recommendations

Based on the present comprehensive evaluation and other guidelines (88,91-93,95,101,143,144,147,148,221,223,274-276), diagnostic lumbar facet joint nerve blocks are recommended in patients with suspected facet joint pain.

- Indications include:
  - Patients suffering with somatic or non-radicular low back and lower extremity pain, with duration of pain of at least 3 months.
  - Average pain levels are of greater than 6 on a scale of 0 to 10.

Table 2. *Data of prevalence with controlled diagnostic blocks and false-positive rates in the lumbar region.*

Study	Methodological Criteria *	Participants	Prevalence	False-Positive Rate
Manchikanti et al 2002 (148)	75	120	40% (95% CI 31%–49%)	30% (95% CI 20%–40%)
Manchikanti et al 2004 (144)	75	397	31% (95% CI 27%–36%)	27% (95% CI 22%–32%)
Manchukonda et al 2007 (143)	75	303	27% (95% CI 22%–33%)	45% (95% CI 36%–53%)
Schwarzer et al 1995 (221)	75	63	40% (95% CI 29%–53%)	NA
Manchikanti et al 2001 (88)	75	120	40% (95% CI 31%-49%)	47% (95% CI 35%-59%)
Manchikanti et al 2003 (147)	75	300	I. 21% (95% CI 14%–27%) II. 41% (95% CI 33%–49%)	I. 17% (95% CI 10%–24%) II. 27% (95% CI 18%–36%)
Manchikanti et al 2007 (233)	75	117	16% (95% CI 9%–23%)	49% (95% CI 39%–59%)
Overall		1,420	31% (95% CI; 28%–33%)	30%# (95% CI; 27%–33%)

CI = confidence interval; NA =not available; # Schwarzer et al (221) was without evaluation of false-positive rates.

*Methodologic quality assessment adapted and modified from West S, et al. Systems to Rate the Strength of Scientific Evidence, Evidence Report, Technology Assessment No. 47. AHRQ Publication No. 02-E016 (151).

Adapted with permission from Datta S et al. Systematic assessment of diagnostic accuracy and therapeutic utility of lumbar facet joint interventions. *Pain Physician* 2009; 12:437-460 (95).

- Pain is at least intermittent or continuous causing functional disability.
- Condition has failed to respond to more conservative management, including physical therapy modalities with exercises, chiropractic management, and non-steroidal anti-inflammatory agents.
- Lack of preponderance of evidence of either lumbar discogenic or sacroiliac joint pain and lack of lumbar disc herniation or evidence of radiculitis.
- No evidence of contraindications is present for the needle placement and injection of local anesthetics.
- Presence of contraindications or inability to undergo physical therapy, chiropractic management, or inability to tolerate non-steroidal anti-inflammatory drugs.

♦ A positive response is based on the following evidence:
- Patient has met the above indications.
- Patient responds positively to controlled local anesthetic blocks either with placebo control or comparative local anesthetic blocks with appropriate response to each local anesthetic of < 1 mL for each nerve or joint.
- At least 80% relief as criterion standard with the ability to perform previously painful movement without deterioration of the relief (i.e., extension, lateral rotation, flexion, etc.).
- The patient's response should be recorded independently by an assessor – generally a registered nurse familiar with the patient or another physician.

5.2 Lumbar Intervertebral Disc

The human intervertebral disc is a unique structure with 3 major components, the nucleus pulposus (NP), annulus fibrosis (AF), and vertebral endplates (VE), and 2 major regions, the outer ring, the AF, and the inner part, the NP (277). The disc is attached to the adjacent vertebral bodies by the vertebral endplates centrally and the ligamentous attachments of the AF peripherally. These components form a joint-like structure that allows for movements in the sagittal, horizontal, and coronal planes (278). The disc is supported posteriorly by 2 zygapophysial joints, the components of the "3-joint" structure.

The healthy human intervertebral disc is essentially avascular, with its nutrition being supplied through the vertebral endplates and AF via diffusion. The nucleus itself has no blood supply. The annulus contains blood vessels only in its most superficial lamellae. Nutrients that pass through the endplates come from the arteries supplying the vertebral bodies. Any number of factors can contribute to a breakdown in the functional capacity of the disc, including inflammatory mediators, changes in pH, and nutritional deficiencies (279-282). In fact, it was noted that vascular changes occurred before degeneration of the disc at every lumbar level, suggesting that disc disturbances in the nutritional supply may precede degeneration (283). In a study of 280 discs from L1/2 to L5/S1, 40 out of 280 discs (14.3%) demonstrated intravascular uptake utilizing real-time fluoroscopy (279). There was no statistical correlation between the degree of disc degeneration and the incidence of intravascular uptake.

Early studies failed to demonstrate nerve fibers or nerve endings within the discs (284,285). In subsequent studies, it was reported that even though in a normal intervertebral disc, the NP is devoid of nerve fibers, the outer AF contains an extensive network of sensory nerve fibers (166,284,286-290). It has also been demonstrated that a variety of free and complex nerve endings were present in the outer third of the annulus (284,291-303). Nerve endings in degenerated discs have been found in the deeper layers of the AF; in some studies, nerve endings have been found extending even into the NP (295-298,304). These nerve fibers transmit both nociceptive and non-nociceptive information (166,286,290,292,305-313).

5.2.1 Pathophysiology of Lumbar Disc-Related Pain

Kuslich et al (90) used progressive regional anesthesia in 193 patients who were about to undergo lumbar decompressive surgery for disc herniation or spinal stenosis. Pain was reported by 30% of the patients who had stimulation of the paracentral annulus and by 15% who had stimulation of the central annulus with blunt surgical instruments or through an electric current of low voltage. Soon after the description of disc herniation in the American literature by Mixter and Barr (314) in 1934, Mixter and Ayers (315) in 1935 demonstrated that radicular pain can occur without disc herniation. This was followed by reports from numerous investigators describing pain syndromes emanating from the lumbar intervertebral disc without mechanically compressed neural structures (87,88,316-

330). There is no established and causal relationship between disc degeneration and spinal pain. However, the biochemical behaviors of the disc may explain the pathophysiology of discogenic pain (326). Painful discs have a lower pH than non-painful discs in humans (331). Discography on canine discs that are deformed normally and experimentally reveals an increase in concentrations of neuropeptides, i.e., substance P (SP) and vasoactive intestinal peptide (VIP) in the dorsal root ganglion (327). Inflammatory factors may be responsible in some cases for which epidural steroid injections provide relief (253,254,332-339). Chemical nociception is supported by numerous studies (277,306,340-383). Elevated levels of nitric oxide, prostaglandin E2, interleukin (IL)-2, IL-6, IL-8, phospholipase A2, leukotriene B4, thromboxane B2, and tumor necrosis factor -α (TNF-α) in diseased intervertebral discs have been demonstrated. Thus, in combination, chemical and mechanical factors provide the explanation for disc-related pain (340-396). Mechanism also illustrates the role of dorsal root ganglion (397-411).

Internal disc disruption (IDD) is a condition in which the internal architecture of the disc is disrupted, but its external appearance remains essentially normal (328). IDD can be experimentally induced by endplate damage (396). Likewise, experimentally induced annular tears can lead to adverse and progressive mechanical changes in the disc. Annular degeneration has been shown to appear at an early age in lumbar discs and is clearly related to back pain (329). Disrupted discs may not exhibit either bulging or herniation. These features with a normal or near normal contour of discs producing back pain, but with no evidence of herniation or prolapse, were described by Crock (328) in 1976 as IDD.

5.2.2 Diagnosis of Lumbar Discogenic Pain

Diagnostic tests, such as clinical history, physical exam, and non-provocative imaging studies, have low sensitivity and specificity in diagnosing whether the disc is a source low back pain (51). Hancock et al (51), in a systematic review of tests to identify the disc as a pain generator, concluded that centralization was the only clinical feature found to increase the likelihood of the disc as the source of pain, based on review of multiple studies (60,412-414). Certain findings on physical exam have been purported to aid in the diagnosis of the cause of lower back pain but these have been difficult to confirm by scientific inquiry (36,48,49,415).

MRI scans and radiologic images of discography are both sensitive for diagnosing the presence of degenerative disc disease (DDD) (36,88,317,416-422). However, it has been demonstrated that these changes are present in patients asymptomatic of low back pain in as many as 64% to 89% (322,325-329,416,423-428). Hancock et al (51) described that among the various features observed on the MRI, absence of degeneration was the only test found to reduce the likelihood of the disc as the source of the pain.

Conversely, there is evidence that subtle but painful lesions may be present in discs that appear to be morphologically normal on MRI scans. Discography has been shown to reveal abnormalities in symptomatic patients with normal MRI scans (417-432).

Therefore, the detection of morphologic abnormalities consistent with degeneration or the lack thereof is becoming increasingly less relevant to therapeutic decision-making. This phenomenon has also validated the importance of lumbar discography as a diagnostic tool to aid in therapeutic decision making. The provocation of pain with real time imaging as an indicator of the presence of discogenic pain is the current raison d'être for performing discography. Appropriately performed, with care taken to optimize the accuracy of the patient's response, discography is considered to enhance the sensitivity and specificity compared to non-provocative imaging. This in turn can improve clinical outcomes and prognostication through appropriate decision-making and proper selection of therapies. Just as importantly, it reduces the risk of inappropriate treatment of discs that are not the source of pain.

5.2.2.1 Lumbar Provocation Discography

Discography is a procedure that is used to characterize the pathoanatomy/architecture of the intervertebral disc and to determine if the intervertebral disc is a source of chronic spinal pain. Implicitly, discography is an invasive diagnostic test that should only be applied to those chronic spinal pain patients in whom one suspects a discogenic etiology. Discography literally means the opacification of the NP of an intervertebral disc to render it visible under radiographs (422,433,434).

5.2.2.1.1 Rationale

Formal studies have shown that the discs are innervated and can be a source of pain that has pathomorphologic correlates (166,284-313,314,315,318,325-329,357,359,392,393,435-440). Even though the specific neurobiological events involved in how discography causes pain have not been elucidated, sound

anatomic, histopathological, radiological, and biomechanical evidence suggests that lumbar discography may help to identify symptomatic and pathological intervertebral discs (97,98,416-418).

5.2.2.1.2 Validity

Examinations of cadaver discs typically confirm the presence of annular tears and disc degeneration, as revealed by discograms (441-444). Multiple authors also have investigated the accuracy of lumbar discographic and CT/discographic findings based on the ability to demonstrate accurate pathology confirmed at the time of surgery. There is a high inter- and intra-observer agreement in assessing discographic morphology, i.e., the Adams classification (419,441,445). It was reported that the exact reproduction of pain was more likely in ruptured or fissured discs and less likely in degenerative discs, based on the Adams classification (441).

Lumbar discography was compared with myelography, CT, MRI, and results of surgical and conservative management. CT discography was reported to be more accurate than myelography (420,441,446-451). On similar grounds, discography was shown to be superior to plain CT (421,451-454). While comparing the results of lumbar discography with MRI, some found discography to be as good as MRI, even though MRI was preferable as it was non-invasive and allowed assessment of more levels with one test, with minimal risk of complications and minimal discomfort (455,456). However, others have identified advantages of discography with pain provocation, when MRIs were normal or equivocal (416,424,450). Strong correlation was demonstrated between MR/discography and CT/discography in assessing annular tears and degeneration of lumbar discs (454,457,458).

A good correlation between MRI, discography, and the high intensity zone (HIZ) has been established by some (457-463), while others have reported a poor correlation and limited value of discography (464-471).

Lei et al (467) correlated a new MRI classification of disc degeneration found to have good intra- and inter-observer agreement, with discography. The sensitivity and specificity of MRI in predicting a painful disc was 94% and 77%, which favorably compared to endplate signal changes and HIZs, which were found to have sensitivities of 32% and 27%, respectively. The authors concluded that an MRI is an excellent tool for assessing disc morphology, but should be used in conjunction with discography for planning surgical treatment.

O'Neill et al (468) evaluated the accuracy of MRI in diagnosing discogenic pain in 143 patients, taking into consideration the interdependence of MRI parameters. Moderate loss of nuclear signal and disc bulging had the best sensitivity (79.8%) and specificity (79.3%). Accounting for either moderate loss of disc height or the presence of a HIZ reduced sensitivity but improved specificity. Notably, the incorporation of a HIZ reduced sensitivity (73.6%) and improved specificity (92.6%).

Scuderi et al (469) prospectively conducted a biochemical analysis of disc leakage fluid obtained during discography. They found only weak correlations between demographic variables, Pfirrman grading (MRI), and discography. The authors concluded that pain provocation during discography cannot be predicted by non-invasive means, including biomarker assays.

Derincek et al (470) performed discography on a series of patients with back pain and MRI evidence of DDD. Those patients experiencing pain during injection into a morphologically normal disc were studied. These individuals underwent repeat discograms on the morphologically normal disc, but the morphologically abnormal (adjacent disc) was anesthetized. None of their patients experienced pain during the repeat discogram. The authors recommended anesthetizing the morphologically abnormal disc before testing potentially normal (control) discs.

The technique of lumbar discography is standardized by the International Association for the Study of Pain (IASP) criteria (433) and has been well studied (97,98,472-477). The definition of a positive discogram, per International Spine Intervention Society (ISIS) guidelines (434) is pain > 7/10, concordance, pressure ≤ 50 psi a.o, Grade III anular tear, and a painless control disc.

The greatest challenge concerning discography continues to be the gold standard problem. Three systematic reviews exhaustively discussed these issues (97,98,107). Treatment, particularly controversial treatments should not serve as the "gold standard" for a diagnostic test.

The sensitivity and specificity of intervertebral disc morphology are 81% and 64%, respectively. A recent meta-analysis of provocation discography in asymptomatic subjects obtained a specificity of 94% (95% CI; 89%–98%) and a false-positive rate of 6% (417).

5.2.2.1.3 Cost Effectiveness

There are no cost effectiveness studies of lumbar provocation discography available in the literature.

5.2.2.1.4 Safety and Complications

Complications related to discography include discitis, subdural abscess, spinal cord injury, vascular injury, epidural and prevertebral abscess, annular strain, and toxicity of antibiotics (6,97,98,422,433,434,478-498).

5.2.2.1.5 Evidence Assessment

The literature search provided 6 systematic reviews (51,97,98,107,276,417). All of the systematic reviews met the inclusion criteria. Hancock et al (51) focused on the diagnostic criteria comparing discography with other tests. Wolfer et al (417) evaluated false-positive rates. Shah et al (98), Buenaventura et al (97), and Manchikanti et al (107,276) performed systematic assessments of the value of provocation discography utilizing West et al's AHRQ criteria for systematic reviews. Manchikanti et al (107) utilized modified IASP criteria (433). For a disc to be judged positive, stimulation of the target disc produces concordant pain with an intensity of at least 6 on a 10-point pain measurement scale and 2 adjacent discs with provocation discography do not produce any pain at all except for the L5-S1 disc wherein only one negative disc is required. Manchikanti et al (107) utilized 9 studies meeting strict inclusion criteria and considered all other studies performed under controlled conditions. Wolfer et al (417) utilized multiple studies with methodologic quality evaluation and scoring of lumbar discographic studies in their evaluations.

Thus, the 2 latest systematic reviews by Manchikanti et al (107) and Wolfer et al (417) were utilized in the evidence synthesis for these guidelines.

5.2.2.1.6 Prevalence of Lumbar Discogenic Pain

Prevalence of pain due to IDD was reported to be 39% of patients suffering with chronic low back pain in the United States (317). In contrast, primary discogenic pain was reported in 26% of patients suffering with chronic low back pain in the United States (88). Table 3 illustrates the data of prevalence of lumbar discogenic pain utilizing IASP criteria.

5.2.2.1.7 False-Positive Rate

A series of published studies specifically investigated the potential false-positive rate of lumbar discography (446,485,496-510). The Holt study (502) was performed on prisoners, with outdated techniques and noxious, irritating contrast dye (503). Wolfer et al (417) pooled all the available data (from 1968 to 2008) on asymptomatic volunteers without confounding factors (somatization disorder, chronic pain, or discectomy), illustrating that there were a total of 33 patients and 48 discs. The data showed a false-positive rate of 3.0% (1/33) per patient (95% CI; 0%–9%) and 2.1% (1/48) per disc (95% CI; 0%–6%), utilizing both the Carragee criteria and ISIS/IASP criteria, even when the provocation stimulus measured by intradiscal pressure is uncontrolled (417).

5.2.2.1.8 Level of Evidence

Based on the AHRQ (151) and USPSTF (153) criteria, the indicated evidence is Level II-2 for lumbar discography.

5.2.2.1.9 Recommendations

The recommendation for lumbar provocation discography must include appropriate indications with patients with low back pain to prove the diagnostic hypothesis of the discogenic pain specifically after exclusion of other sources of lumbar pain and identification of the disc that should be targeted for treatment, or to establish either that no disc or too many discs are symptomatic, in which case surgery may not be indicated.

Table 3. *Data of prevalence of lumbar discogenic pain utilizing IASP criteria.*

Study	Methodological Quality Scoring	Participants	Prevalence
Schwarzer et al 1995 (317)	70	92 consecutive patients with chronic low back pain and no history of previous lumbar surgery referred for discography	The diagnostic criteria for internal disc disruption were fully satisfied in 39% of the patients, most commonly at L5/S1 and L4/5.
Manchikanti et al 2001 (88)	70	From a group of 120 patients with low back pain, 72 patients negative for facet joint pain underwent discography.	The prevalence of discogenic pain was established in 26% of total patient sample and 43% of patients negative for facet joint pain.

The discography should be performed utilizing appropriate criteria and results are considered positive only if the stimulation of the target disc produces concordant pain with an intensity of at least 7 on a 10-point pain measurement scale or reproduces at least 70% of the most severe pain the patient has experienced (i.e., 5 of 7) and 2 adjacent discs with low volume contrast injection with low pressure discography do not produce any pain at all.

5.2.3 Diagnosis of Lumbar Radiculitis

In a systematic review of epidemiologic studies and prevalence estimates, definitions of sciatica varied widely with a prevalence from different studies ranging from 1.2% to 43% (511). Sciatica can be precisely diagnosed in the majority of cases with available technology using MRI, CT, and nerve conduction studies. Diagnostic selective nerve blocks are utilized occasionally in patients with persistent pain when history, examination, imaging, electrophysiologic testing, and other precision diagnostic injections do not identify the pain generator.

5.2.3.1 Lumbar Transforaminal Epidural Injections or Selective Nerve Root Blocks

Transforaminal epidural injection (modern nomenclature) or a selective nerve root block (old nomenclature) consist of injection of contrast, local anesthetic, or other substances around spinal nerves under fluoroscopy (6,105,512). They have been described as 2 separate and distinct techniques. However, over the years authors have used them interchangeably.

5.2.3.1.1 Rationale

Lumbar transforaminal epidural or selective nerve root blocks provide clinically useful information (275,513,514). The validity of provocative and analgesic spinal injections was recognized as early as 1938 (513). The value of diagnostic, selective nerve root blocks in the preoperative evaluation of patients with negative or inconclusive imaging studies and clinical findings and in the diagnosis of the source of radicular pain when imaging studies suggested possible compression of several nerve roots has been reported (206,514-542).

5.2.3.1.2 Validity

In a review of the use of transforaminal epidurals for managing spinal disease, Young et al (542) concluded that as a tool for predicting surgical outcome, epidural spinal injection was found to have a sensitivity between 65% and 100%, a specificity between 71% and 95%, and a positive predictive value as high as 95% for one year surgical outcome. Rubinstein and van Tulder (46) concluded that there was moderate evidence for transforaminal epidural injections. However, North et al (535) showed that false-positive results were common and specificity was low.

The face validity of lumbosacral selective nerve root blocks may be accomplished by providing the blockade under fluoroscopic visualization utilizing contrast and a small volume of local anesthetic and with provocative and/or analgesic response. However, Furman et al (543), in a quantitative evaluation of contrast flow level and its selectivity during fluoroscopically guided lumbosacral transforaminal epidural steroid injections, showed that 30% of the transforaminal injections performed were not selective for the specified root level with injection of 0.5 mL of contrast. In addition, with injection of 1 mL of contrast, 67% of transforaminal injections performed were no longer selective for the specified root level, with injection of 1.5 mL of contrast, 87% were not selective, whereas, with injection of 2.5 mL of contrast, 90% were not selective for the specified root level. They concluded that diagnostic selective nerve root blocks limiting injectate to a single, ipsilateral segment level cannot be reliably considered diagnostically selective with volumes exceeding 0.5 mL. Others also have described contrast flow patterns and intravascular injections (544-549) with inadvertent vascular injection ranging from 9% to 26%; intradiscal filling of contrast during a transforaminal epidural injection (550,551), dural puncture and subdural injection (552), and other techniques to increase safety have been reported (540,545). Due to a multitude of these factors, which may result in an incomplete block or a block without selectivity involving more than one nerve root, face validity continues to be questioned.

The construct validity of selective nerve root blocks has not been established. As with facet joint block or sacroiliac joint blocks and provocative discography, no standards have been established to eliminate false-positive responses with transforaminal epidural injections. However, true-positive responses may be secured by performing controlled blocks with placebo injections of normal saline. Comparative local anesthetic blocks that have been shown to be valid in the diagnosis of facet joint pain have not been studied for transforaminal usage. The only study that com-

pared a short-acting local anesthetic (lidocaine) with a long-acting local anesthetic (bupivacaine) in selective nerve root blocks used 2 test blocks in a random order to test the validity of the block response (534). However, no differences in effect were found between lidocaine and bupivacaine. Further, multiple confounding factors of psychological issues and sedation have not been studied for selective nerve root blocks.

5.2.3.1.3 Cost Effectiveness

Cost effectiveness of diagnostic transforaminal epidural injections or selective nerve root blocks has not been evaluated. However, the feasibility and cost-effectiveness of appropriately performed controlled comparative local anesthetic blocks have been described (87,249-251).

5.2.3.1.4 Safety and Complications

Reported complications of transforaminal epidural injections are related to dural puncture, subdural injection, dorsal root ganglion (DRG) trauma, infection, intravascular injection, air embolism, vascular trauma, particulate embolism, cerebral thrombosis, epidural hematoma, neural or spinal cord damage, and complications related to administration of steroids (253,254,267,543-567). Recent reports of paraplegia, vertebral artery dissection, neurological disorders, and death are concerning. A blunt needle has been recommended to avoid multiple complications ascribed to transforaminal epidurals (555-557,568).

5.2.3.1.5 Evidence Assessment

The search showed 2 systematic reviews (105,512) and multiple other publications (366,515-519,523,524,527,529-531,534,535). Datta et al (105) showed moderate evidence in the diagnosis of confounding factors with selective nerve root blocks. The conclusion was also adapted by Rubinstein and van Tulder (46). Further, Young et al (542) also concluded that transforaminal epidural injections have been found to have a sensitivity between 65% and 100%, a specificity between 71% and 95%, and a positive predictive value as high as 95% for one year surgical outcome.

5.2.3.1.6 Level of Evidence

Based on multiple evaluations, the indicated level of evidence for lumbar transforaminal epidural injections or selective nerve root blocks is II-3 based on USPSTF criteria (153).

5.2.3.1.7 Recommendations

The diagnostic lumbosacral selective nerve root block must be performed utilizing fluoroscopy and contrast with a small dose (1.0 mL or less, preferably 0.5 mL) of local anesthetic injection with assessment of appropriate pain relief (≥ 80%) and the ability to perform previously painful movements. Lumbosacral nerve root blocks may be performed for diagnostic purposes prior to therapeutic injection and/or if it is indicated for diagnostic purposes in patients with clinical features which do not implicate a particular, single spinal nerve as responsible for the symptoms and when imaging suggests that symptoms could be arising from more than one particular segment if surgery is contemplated.

5.3 Sacroiliac Joint

The sacroiliac joint is accepted as a potential source of low back and/or buttock pain with or without lower extremity pain (88,102-104,569-576). The sacroiliac joint receives innervation from the lumbosacral nerve roots (577-587). Neurophysiological studies have demonstrated both nociceptive and proprioceptive afferent units in the sacroiliac joint (584,585,588,589). Referral patterns based on sacroiliac joint provocation and analgesic response to local anesthetics in asymptomatic volunteers (590) and patients with pain (591,592) have been published.

5.3.1 Diagnosis of Sacroiliac Joint Pain

In a systematic review evaluating a battery of tests to identify the disc, sacroiliac joint, or facet joint as the source of low back pain, Hancock et al (51) suggested that a combination of sacroiliac joint pain provocative maneuvers appears to be useful in pinpointing the sacroiliac joint as the principal source of symptoms in patients with pain below the fifth lumbar vertebra. They also concluded that although a positive bone scan has high specificity, it is associated with a very low sensitivity, which means that the majority of patients with the sacroiliac joint pain will not be accurately identified.

In a systematic review by Szadek et al (593), the authors evaluated the diagnostic validity of the IASP criteria for sacroiliac joint pain. The meta-analysis showed that the thigh thrust test, the compression test, and 3 or more positive stressing tests contain sufficient discriminative power for diagnosing sacroiliac joint pain. They concluded that in view of the lack of a gold standard for sacroiliac joint pain, the diagnostic

validity of tests for sacroiliac joint pain should be regarded with caution.

Song et al's (594) systematic review evaluating the diagnostic value of scintigraphy in assessing sacroiliitis and ankylosing spondylitis concluded that scintigraphy is at best of limited value in establishing a diagnosis of ankylosing spondylitis. Three systematic reviews evaluated the role of diagnostic intraarticular injections (102-104) in establishing the sacroiliac joint(s) as the primary pain generator. In a best-evidence review of diagnostic procedures for neck and low back pain that focused on previously published systematic reviews (51,102,103), Rubinstein and van Tulder (46) also concluded that there was moderate evidence for diagnostic sacroiliac joint blocks. Rupert et al (104) in the recent systematic review concluded the indicated evidence for validity of diagnostic sacroiliac joint injections is Level II-2 based on the USPSTF criteria (153).

5.3.2 Sacroiliac Joint Blocks

5.3.2.1 Rationale

Due to the inability to make the diagnosis of sacroiliac joint pain with non-invasive tests, sacroiliac joint blocks appear to be the evaluation of choice to provide appropriate diagnosis. Further, controlled studies have established the sacroiliac joints as a potential source of low back and lower extremity pain (6,88,102-104,570-577). Based on controlled diagnostic blocks, the sacroiliac joint has been implicated as the primary source of pain in 10% to 38% of patients with suspected sacroiliac joint pain (6,88,102-104,571,572,594,595).

5.3.2.2 Validity

The face validity of the sacroiliac joint blocks has been established by injecting small volumes of local anesthetic with contrast into the joint. Construct validity of sacroiliac joint blocks has been established by determining the false-positive rate of 20% to 54% with single, uncontrolled, sacroiliac joint injections (88,571,572,596). False-positive responses may occur with the extravasation of an anesthetic agent out of the joint due to defects in the joint capsule (596). False-negative results may occur from faulty needle placement, intravascular injection, or the inability of the local anesthetic to reach the painful portion of the joint due to loculations (102-104,574,576,597-602).

5.3.2.3 Cost Effectiveness

There are no studies evaluating the cost effectiveness of diagnostic sacroiliac joint blocks.

5.3.2.4 Safety and Complications

Complications of sacroiliac joint injection include infection, trauma to the sciatic nerve, embolic phenomena, and complications related to drug administration (6,102-104).

5.3.2.5 Evidence Assessment

Rupert et al (104) provided the latest evidence with inclusion of 5 studies which met methodologic quality assessment (88,571,572,595,596).

5.3.2.6 Prevalence

The prevalence of sacroiliac joint pain is estimated to range between 10% and 38% with 95% CIs of 0% – 5% (88,571,572,595,596) (Table 4).

5.3.2.7 False-Positive Rate

The false-positive rate of a single block is estimated to range between 20% and 54% with 95% CIs of 3% – 64% (88,571,572,596). However, in one study (595) the false-positive rate was 0%.

5.3.2.8 Level of Evidence

The indicated evidence for the accuracy of sacroiliac joint diagnostic injections is Level II-2 for the diagnosis of sacroiliac joint pain utilizing controlled diagnostic blocks.

5.3.2.9 Recommendations

Controlled sacroiliac joint blocks with placebo or controlled comparative local anesthetic blocks are recommended when indications are satisfied. A positive response is considered ≥ 80% relief with the ability to perform previously painful movements.

The primary indication for sacroiliac joint blocks is the need to know if a patient's pain is arising from the sacroiliac joint or not. Key indicators would be patients with chronic low back pain that is maximal below the level of L5 vertebra, with or without somatic referred pain in the lower limb, in whom no other diagnosis is readily apparent, in whom no other possible diagnosis is more likely, in whom a diagnosis has been made or cannot be made using less invasive options, whose pain is not evolving with the passage of time or conservative therapy, and fails to respond to conservative therapy.

Table 4. *Data of prevalence of sacroiliac joint pain based on controlled diagnostic blocks.*

Study	Methodologic Quality Assessment Score	# of Subjects	Prevalence Estimates	False-Positive Rate
Manchikanti et al (88)	65	20	10% (95% CI, 0% – 23%)	22% (95% CI, 3% – 42%)
Maigne et al (571)	65	54	18.5% (95% CI, 8% – 29%)	20% (95% CI, 8% – 33%)
Irwin e et al (572)	65	158	26.6% (95% CI, 20% – 34%)	53.8% (95% CI, 43% – 64%)
Laslett et al (595)	65	43/48	25.6% (95% CI, 12% – 39%)	0%
van der Wurff et al (596)	65	60	38% (95% CI, 26% – 51%)	21% (95% CI, 7% – 35%)

CI = confidence interval

Methodological criteria and scoring adapted from West S et al. Systems to Rate the Strength of Scientific Evidence, Evidence Report, Technology Assessment No. 47. AHRQ Publication No. E016 (151).

Adapted from Rupert MP et al. Evaluation of sacroiliac joint interventions: A systematic appraisal of the literature. *Pain Physician* 2009; 12:399-418 (104).

5.4 Other Causes of Low Back Pain

5.4.1 Post Lumbar Surgery Syndrome

Post surgery lumbar syndrome and other synonyms, such as failed back surgery syndrome (FBSS) or post lumbar laminectomy syndrome, represent a cluster of syndromes following spine surgery wherein the expectations of the patient and spine surgeon are not met (603-612). In fact, FBSS is considered to be the major disadvantage of surgical intervention on the lumbar spine with the addition of 80,000 or so patients a year with continued chronic disabling back pain (613). In this review (613), it has been pointed out that there were at least 392,000 surgeries to treat low back pain in 2000 and the rate of spine surgery has continued to rise since then. The study concluded that best estimates suggest that although 60% or more of initial back surgeries have a successful outcome, many are not successful. They noted that the long-term reoperation rate after spine surgery is high —19% over 11 years and that a substantial proportion of patients end up with chronic disabling symptoms (614). Based on these numbers, they have estimated that there may be over 80,000 failed back surgeries per year. They also described that surgical success rates dropped to roughly 30% after a second surgery, 15% after a third, and 5% after a fourth (615). Carragee et al (616) noted that many interventions are performed for axial back pain associated with common degenerative conditions, sometimes with weak or absent evidence of efficacy.

Animal models of post laminectomy syndrome demonstrate paraspinous muscle spasms, tail contractures, pain behaviors, tactile allodynia, epidural and perineural scarring, and nerve root adherence to the underlying disc and pedicle (617-623). Speculated causes of postlaminectomy syndrome include acquired stenosis, adjacent segment degeneration, IDD, recurrent disc herniation, retained disc fragment, spondylolisthesis, epidural or intraneural fibrosis, degenerative disc disease, radiculopathy, radicular pain, deconditioning, facet joint pain, sacroiliac joint pain, discitis, arachnoiditis, pseudoarthrosis, segmental instability, and others (233,607-611,624-635). Ultimately, many of these etiologies are interrelated. Facet joint

involvement in chronic pain following lumbar surgery has been shown to be present in approximately 8% to 16% of the patients (233). The prevalence of sacroiliac joint pain following lumbar fusion has been demonstrated in a study using a single block to be 35% (578).

Epidural fibrosis may occur following an annular tear, disc herniation, hematoma, infection, surgical trauma, vascular abnormalities, or intrathecal contrast media (277,617-623,633-644). Epidural fibrosis may account for as much as 20% to 36% of all cases of FBSS (624,625,645,646). There may be a final common pathway with all these etiologies, which results in peripheral and central facilitation potentiated by inflammatory and nerve injury mechanisms (617-623). Paraspinal muscles may also become denervated and involved in the pathogenesis of FBSS (647).

5.4.2 Spinal Stenosis

Spinal stenosis can be defined as a narrowing of the spinal canal, resulting in symptoms and signs caused by entrapment and compression of the intraspinal vascular and nervous structures (648,649). Disc bulging, protrusion, and herniation in the cervical, as well as lumbar area, combined with osteophytes and arthritic changes of the facet joints can cause a narrowing of the spinal canal, encroachment on the contents of the dural sac, or localized nerve root canal stenosis (648-654). The pain and disability associated with lumbar spinal stenosis can interfere with a patient's lifestyle (655).

A systematic review of the accuracy of diagnostic tests in lumbar spinal stenosis (656) was performed by de Graaf et al. After a comprehensive search, 24 articles were included in the review with 15 concerning imaging tests, 7 evaluating clinical tests, and 2 studies reporting on other diagnostic tests. The results showed that the overall quality was poor; only 5 studies scored positive on more than 50% of the quality items. Estimates of the diagnostic value of the tests differed considerably. The imaging studies showed no superior accuracy between myelography, CT, or MRI. Overall, there was considerable variation in the clinical tests; some studies showing high sensitivity and others showing high specificity. They concluded that because of the heterogeneity and overall poor quality, no firm conclusions about the diagnostic performance of the different tests can be drawn.

6.0 Neck Pain

Cervical intervertebral discs and facet joints, atlanto-axial and atlanto-occipital joints, ligaments, fascia, muscles, and nerve root dura have been shown to be capable of transmitting pain in the cervical spine with resulting symptoms of neck pain, upper extremity pain, and headache. However, very little is known about the causes of neck pain since the epidemiologic studies do not describe either the source or cause of the pain. Yin and Bogduk (89) demonstrated the prevalence of discogenic pain in 16%, zygapophysial joint pain in 42%, and lateral atlanto-axial joint pain in 9%, in 143 patients with chronic neck pain in a private practice pain clinic in the United States. Consequently, a diagnosis remained elusive in over 40% of those patients who completed investigations.

6.1 Cervical Facet or Zygapophysial Joints

Cervical facet or zygapophysial joints have been shown to be a source of pain in the neck and referred pain in the head and upper extremities (89,143,144, 148,149,150,657-665). Cervical facet joints are innervated by the medial branches of the dorsal rami (165,666-669). Neuroanatomic studies have demonstrated free and encapsulated nerve endings in facet joints, as well as nerves containing SP and calcitonin gene-related peptide (165,670). Neurophysiologic studies have shown that cervical facet joint capsules contain low-threshold mechanoreceptors, mechanically sensitive nociceptors, and silent nociceptors (176,671-676).

Inflammation leads to decreased thresholds of nerve endings in facet capsules as well as elevated baseline discharge rates (165). Biomechanical studies have shown that cervical facet joint capsules can undergo high strains during spine-loading (165,677-685).

6.1.1 Cervical Facet or Zygapophysial Joint Blocks

Diagnostic blocks of a cervical facet or zygapophysial joint can be performed by anesthetizing the joint by intraarticular injections of local anesthetic or by medial branch blocks. Valid information is only obtained by performing controlled blocks.

6.1.1.1 Rationale

The rationale for using cervical facet joint blocks for diagnosis is based on the fact that facet joints are capable of causing pain, have a nerve supply (165,666-669), and have been shown to be a source of pain in

patients using diagnostic techniques of known reliability and validity (89,143,144,148,149,245,247). Conventional clinical and radiologic techniques are unreliable in diagnosing cervical facet or zygapophysial joint pain. In addition, the value, validity, and clinical effectiveness of cervical diagnostic facet joint nerve blocks was illustrated by application of therapeutic modalities based on the diagnosis with controlled comparative local anesthetic blocks (6,91-93,96,101,119,121,686-694).

6.1.1.2 Validity

Controlled diagnostic blocks of cervical facet joints with 2 local anesthetics (or placebo-controlled) are the means of confirming the diagnosis of facet joint pain. The face validity of cervical medial branch blocks has been established by injecting small volumes of local anesthetic and contrast material onto the target points for these structures and by determining the spread of contrast medium in posteroanterior and lateral radiographs (668). Construct validity of cervical facet joint blocks to eliminate placebo effect as the source of confounding results and to secure true-positive results has been illustrated (54,115,117,145,146,149,150,657,658,660).

The validity of comparative local anesthetic blocks was determined not only by short-term relief with controlled diagnostic blocks and the ability to perform movements which were painful prior to the blocks, but also with the application of another appropriate reference standard (long-term follow-up) as described in the literature (119,121,235,239,276,686-696). Potential and real confounding factors were assessed in several studies (243,245-247,657,697,698). Influence of age, surgery, and psychopathology were evaluated in 3 reports and found not to have significant impact on the prevalence of cervical facet joint related chronic neck pain (245,247,657).

6.1.1.3 Cost Effectiveness

Diagnostic cervical facet joint nerve blocks were not evaluated for cost effectiveness systematically. However, multiple authors (88,250,251) described the feasibility and cost-effectiveness of appropriately performed controlled comparative local anesthetic blocks.

6.1.1.4 Safety and Complications

The safety of cervical facet joint interventions with intraarticular injections and medial branch blocks has been demonstrated. Though rare and minor, the common reported complications of cervical facet joint injections or nerve blocks are related to needle placement and drug administration. These complications include hemorrhage, dural puncture, spinal cord trauma, infection, intraarterial or intravenous injection, chemical meningitis, neural trauma, paralysis, pneumothorax, radiation exposure, facet capsule rupture, hematoma formation, steroid side effects, and epidural, subdural, or subarachnoid spread (6,91-93,96,101,239,255,256,267,270-272).

6.1.1.5 Evidence Assessment

Our search yielded 4 systematic reviews (91-93,96). The recent systematic review by Falco et al (96) utilized 9 studies (89,143,144,148-150,657,659,660) meeting methodologic quality assessment inclusion criteria with 80% pain relief and the ability to perform previously painful movements with controlled diagnostic blocks.

6.1.1.6 Prevalence

Based on the systematic review by Falco et al (96) which included controlled diagnostic blocks with a criterion standard of 80% or greater relief and included 9 studies (89,143,144,148-150,657,659,660) meeting methodologic quality criteria. The prevalence was estimated as 36% to 54% with CIs ranging from 27% to 75% in patients in a heterogenous population with an average of 49% with 95% CI of 45% to 52%. In addition, the prevalence was shown to be 36% with 95% CI of 22% to 51% in patients after surgical intervention (Table 5).

6.1.1.7 False-Positive Rate

Based on the systematic review by Falco et al (96), utilizing strict criteria with controlled diagnostic blocks and methodologic quality assessment, false-positive rates with a single block are 27% to 63% with CIs ranging from 15% to 78% with an average of 49% with 95% CI of 44% to 54% (Table 5).

6.1.1.8 Level of Evidence

Based on the systematic review by Falco et al (96), the evidence for diagnosis of cervical facet joint pain is Level I or II-1 based on the USPSTF criteria (151).

6.1.1.9 Recommendations

Based on the present comprehensive evaluation and other described evaluations (91-93,96,101,699, 700), diagnostic cervical facet joint nerve blocks are

recommended in patients with the following criteria:

- Patients suffering with somatic or non-radicular neck pain or headache and upper extremity pain, with duration of pain of at least 3 months.
- Average pain levels of greater than 6 on a scale of 0 to 10.
- Pain is at least intermittent or continuous causing functional disability.
- Problem has failed to respond and has not resolved with more conservative management, including physical therapy modalities with exercises, chiropractic management, and non-steroidal anti-inflammatory agents.
- Lack of preponderance of evidence of cervical discogenic pain, disc herniation, or radiculitis.
- There is no evidence of contraindications for the needle placement and injection of local anesthetics.
- Contraindications or inability to undergo physical therapy, chiropractic management, or inability to tolerate non-steroidal anti-inflammatory drugs.
- A positive response is based on the following evidence:
  - Patient has met the above indications.
  - Patient responds positively to controlled local anesthetic blocks either with placebo control or comparative local anesthetic blocks with appropriate response to each local anesthetic of < 1 mL.
  - At least 80% relief as criterion standard with the ability to perform previously painful movement without deterioration of the relief (i.e., extension, lateral rotation, flexion, overhead activity, etc.).
  - The patient's response should be recorded independently by an assessor – generally a registered nurse familiar with patient or another physician.

6.2 Cervical Intervertebral Disc

Cervical intervertebral discs are composed of a gelatinous NP surrounded by a laminated, fibrous AF. The discs are contained more closely in the cervical spine than at other levels owing to the deeply concave structure of the superior surface of the caudal vertebra and the more convex interior surface of the

Table 5. *Data of prevalence and false-positive rates of cervical diagnostic facet joint blocks.*

Study	Methodologic Criteria	# of Subjects	Prevalence Estimates	False-Positive Rate
Barnsley et al 1995 (150)	75	50	54% (95% CI, 40%, 68%).	NA
Barnsley et al 1993 (660)	75	55	NA	27% (95% CI, 15%, 38%)
Lord et al 1996 (149)	75	52 of 68	60% (95% CI, 46%, 73%)	NA
Manchikanti et al 2002 (148)	75	120	67% (95% CI, 58%,75%)	63% (95% CI 48%, 78%)
Manchikanti et al 2004 (144)	75	255 of 500	55% (95% CI, 49%, 61%)	63% (95% CI 54%, 72%)
Manchukonda et al 2007 (143)	65	251 of 500	39% (95% CI, 32%, 45%)	45% (95% CI 37%, 52%)
Manchikanti et al 2008 (657) *	65	Non-Surgery: 206 Post-Surgery: 45	Non-Surgery 39% (95% CI, 33%, 46%) Post-Surgery 36% (95% CI, 22%, 51%)	Non-Surgery 43% (95% CI 35%, 52%) Post-Surgery 50% (95% CI 32%, 68%)
Speldewinde et al 2001 (659)	50	97	36% (95% CI, 27%, 45%)	NA
Yin and Bogduk 2008 (89)	60	84 of 143	42%# (95% CI, 31%, 52%)	NA
Average			49% (95% CI, 45%, 52%)	49% (95% CI, 44%, 54%)

Authors reported adjusted prevalence as 55% (95% CI, 38%, 62%) and crude prevalence as 24%.
* Not included for averages

NA = not available or not applicable; CI = confidence interval
Adapted from Falco FJE et al. Systematic review of diagnostic utility and therapeutic effectiveness of cervical facet joint interventions. *Pain Physician* 2009; 12:323-344 (96).

rostral vertebra. The AF forms the outer boundary of each disc. In the cervical spine, the discs are thicker anteriorly than posteriorly and are entirely responsible for the normal cervical lordosis. They do not conform completely to the surfaces of the vertebral bodies with which they are connected, being slightly smaller in width than the vertebral bodies. The discs bulge anteriorly beyond the adjacent vertebrae. The NP in the cervical spine is located more anteriorly than in other portions of the spine (701).

It was controversial whether or not the cervical intervertebral discs received innervation. Cloward (702) stimulated cervical discs mechanically and electrically to verify that evoked pain originated in the discs themselves, rather than from irritation of adjacent structures. Cloward also proposed that disc pain is mediated through sinuvertebral nerves, which in the cervical region are very small and undetectable by conventional dissection methods. However, subsequent anatomical studies did visually identify cervical sinuvertebral nerves and confirmed Cloward's experimental observations and inferences. Now it is believed that intervertebral disc innervation in the cervical spine is analogous to that in the lumbar spine, with cervical discs receiving innervation posteriorly from the sinovertebral nerves, laterally from the vertebral nerve, and anteriorly from the sympathetic trunks (702-705).

6.2.1 Pathophysiology of Cervical Disc-Related Pain

Intervertebral disc-related pain can be caused by structural abnormalities, such as disc degeneration or disc herniation; correspondingly, biochemical effects such as inflammation (706) can also be the cause. The incidence of cervical disc herniation is less common than lumbar disc herniations (707-712). Clearly, the mechanical compression on the nerve root that is being irritated by the herniated disc material is an important factor in the production of neck and upper extremity pain. However, the mechanical, chemical, and inflammatory components produce ischemic neuropathy from alteration of blood flow patterns or defects in the neuronal transport mechanism of the nerve root itself (713). Radicular pain may occur in the absence of nerve root compression secondary to NP extrusion or inflammatory reaction to the chemicals (714,715).

Okada et al (707) showed progressive degeneration of cervical spine on MRI in over 81% of the patients during a 10-year period, with development of symptoms in 34% of subjects. Consequently, they concluded that aging of the cervical spine inevitably occurs in everyone. Advances in basic research on disc degeneration have revealed its possible mechanism including a decrease in proteoglycan contents and water concentration (708), involvement of inflammatory cytokines such as IL-1 (714) and iTNF-α (368), and some genetic factors (715). The cervical intervertebral disc is one of the tissues subject to the early aging process, starting as early as 20 years of age, and is often a source of cervical spinal disorders causing neck pain and related symptoms.

6.2.2 Diagnosis of Cervical Discogenic Pain

Imaging studies such as radiographs, myelography, CT, CT-myelography, and MRI are incapable of identifying a degenerated disc as painful (97,98,716-718). The referral patterns can only be used to suggest which segment is most likely to be the source of pain and, therefore the levels at which the investigation should focus (719). In addition, multiple studies have demonstrated that age-related changes of the cervical spine are widely present in asymptomatic healthy subjects (720-722). MRI findings of degenerative discs were recognized frequently in subjects 40 years and older despite the absence of symptoms on MRI (720). In another study, some abnormal findings were recognized in 62% of the subjects 40 years and older, whereas abnormal findings were rare in those younger than 40 years (721).

6.2.2.1 Cervical Provocation Discography

Cervical provocation discography, an image-guided procedure in which a contrast agent is injected into the NP of the intervertebral disc, includes disc stimulation and morphological assessment. It is intended to both identify a painful cervical intervertebral disc and depict internal derangements (716,719,723,724).

6.2.2.1.1 Rationale

Imaging studies such as radiographs, myelography, CT, CT-myelography, and MRI are incapable of identifying a degenerated disc as painful (97,98,717-719,723-729). Thus, cervical provocation discography is the test which can diagnose discogenic pain without disc herniation and radiculitis.

Over 50 years ago, Smith and Nichols (730,731) emphasized pain reproduction as the principal feature of cervical discography. Cloward (702,703,732) described 2 types of pain during cervical disc stimulation: pain arising from IDD (i.e., discogenic pain) and neurogenic pain that stems from a herniated disc fragment caus-

ing nerve root or dural irritation.

6.2.2.1.2 Validity

In a report published in 1964, Holt (733) questioned the validity and role of cervical discography, citing a high false-positive rate in asymptomatic subjects. He based this assumption on the contention that fissures and pain provocation were normal features in people without neck pain. Klafta and Collis (734,735) also found that cervical discography was less accurate than myelography in predicting surgical findings.

Studies conducted in cadavers and patients have re-examined Holt's conclusions (717,736-741). These studies have established fissures to be normal age-related findings that do not necessarily indicate symptomatology, and that demonstrating them with discography is immaterial (719,738). Supporting this assertion, Schellhas et al (717) found that pressurizing normal discs failed to provoke pain in both symptomatic and asymptomatic patients, whereas abnormal discs tended to produce concordant pain. Roth (739) and Kofoed (740) proposed the concept of analgesic discography.

The major obstacle confronting proponents of cervical discography is the lack of consensus as to what constitutes a positive response. Widespread variations in criteria exist not only for pain provocation (i.e., designation of concordance and threshold for a positive response), but also for morphological classification. While some investigators have interpreted certain patterns of contrast dispersion as being indicative of disc pathology, others have found a lack of correlation between morphology and pain reproduction (717,719,723,724,730,731,735-738,741-743).

Multiple questions have been raised regarding the utility of cervical discography, including the high reported false-positive rate; the lack of standardization; the discrepancies regarding the need for "control levels," pain concordance, and pain intensity threshold; and utilization (19,97,98,100,716,719,723,724,729,744,745).

Validity is exemplified by disc stimulation symptom mapping (98-100,717,746) in pain patients and asymptomatic volunteers. Ohnmeiss et al (747) found a significant relationship between imaging and symptom provocation, with 86% of normal-looking discs either producing no pain (60%) or atypical pain (26%). Conversely, 78% of disrupted discs were clinically painful on injection. Viikari-Juntura et al (748) demonstrated that discography provides additional information regarding structural changes not available by any other non-invasive and non-irradiative methods of examination. In general, nuclear signal changes observed on MRI in cadavers tended to underestimate the degree of pathology appreciated with discography or gross examination. Parfenchuck and Janssen (741) found that while certain MRI patterns correlated well with positive and negative cervical discography responses, many other patterns revealed equivocal responses. They concluded that MRI is a useful adjunct to cervical discography, but that some MRI patterns should not be considered pathologic, and discography is necessary to identify a painful disc(s).

The proportion of cervical discs identified as symptomatic varies among studies. Grubb and Kelly (737) found that 50% of discs are capable of producing concordant pain upon injection. Schellhas et al (717) reported that among 11 discs that appeared normal on MRI in pain patients, 10 proved to have annular tears discographically. Two of these 10 elicited concordant pain with an intensity rating exceeding 6/10. Discographically normal discs (n = 8) were never painful in either pain patients or an asymptomatic cohort, whereas intensely painful discs all exhibited tears of both the inner and outer annulus.

Hamasaki et al (749) retrospectively reviewed 15 cases of foraminal cervical disc herniations. Using MRI and CT-myelography, less than half of the cases were identified. In contrast, all were clearly noted on CT-discography. These findings are similar to those found by Lejeune et al (750) in a study evaluating the diagnosis and outcomes for foraminal lumbar disc herniation. The authors concluded that a majority of foraminal-type cervical disc herniations may be overlooked with conventional MRI or CT-myelography, but correctly diagnosed with CT discography.

Zheng et al (725) evaluated cervical discography results at 161 disc levels. There were 79 positive levels, yielding a per disc prevalence rate of 49%. Fifty-nine percent of small herniated and torn discs were discographically positive. The false-positive rate of MRI was calculated to be 51% and the false-negative rate was 27%. The most important criterion for determining a symptomatic disc was moderate or severe reproduction of the patient's typical pain. The presence of a control disc was not considered a diagnostic criterion in this study.

Holt's 1964 study (733) in asymptomatic prisoners reflected negatively on cervical discography. But these studies (502,733) have been repeatedly refuted and better overriding data have since been generated (503). Holt utilized an irritant contrast and failed to employ fluoroscopic guidance. Even aside from these significant flaws, the technique itself was suspect. Extravasation of contrast material was noted with every injection, which continued even after reducing the

volume. Furthermore, Holt considered "pain provocation" as being "without value."

6.2.2.1.3 Cost Effectiveness

There are no cost effectiveness studies of provocative discography available in the literature.

6.2.2.1.4 Safety and Complications

Complications related to cervical discography include discitis, subdural abscess, spinal cord injury, vascular injury, and epidural and prevertebral abscess (719,724,751-754).

6.2.2.1.5 Evidence Synthesis

Three systematic reviews were identified evaluating cervical discography (98-100). Of these, the recent systematic review of cervical discography utilized 3 studies with methodologic quality scoring (89,742,755). This systematic review also included various outcome studies comparing surgical outcomes.

6.2.2.1.6 Prevalence

Based on IASP criteria (723), the data show a prevalence rate ranging between 16% and 20% (89,742,755).

6.2.2.1.7 False-Positive Rate

The main criticism regarding studies attempting to quantify false-positive discography rates is that disc stimulation in asymptomatic volunteers may not reflect pain provocation in non-painful discs in subjects with spine pain (745). Moreover, the hallmark of a positive discogram has become concordant pain provocation, which is not possible in people devoid of spine symptoms. "False" pain provocation may be produced in markedly degenerative discs in the lumbar spine, especially in the elderly (745,756-759). Cohen and Larkin et al (277,760) estimated that 15% to 25% of degenerative discs failed to elicit concordant pain during disc stimulation in the lumbar spine.

Overall, false-positive results with cervical provocation discography are a serious concern, with cited prevalence rates exceeding 50%. But these rates vary as a function of the diagnostic criteria. The results of studies requiring the presence of a control disc(s) shows a prevalence rate between 16% and 20% (89,742).

False-positive responses to disc stimulation can arise if the threshold for reproduction of pain is set too low. A disc is not necessarily the source of a patient's pain if the pain that is reproduced is minor or trivial. Schellhas et al (717) compared the responses to discography in asymptomatic volunteers and patients with neck pain. They found that the numerical rating pain score produced by discography in asymptomatic subjects was significantly lower ($P \leq 0.0001$) than in patients with neck pain. It was unusual for volunteers to report pain greater than 5/10 and no asymptomatic subject experienced pain exceeding 6/10. Consequently, Schellhas et al (717) recommended adding an operational criterion whereby the patient must rate the intensity of produced pain as ≥ 7 on a 10-point numerical pain rating scale or an equivalent magnitude on another suitable scale. The emphasis then shifts from the baseline pain score to how intensely the patient rates the evoked pain. Bogduk (719) pointed out that this criterion guards against diagnosing a moderately painful disc that could nevertheless be asymptomatic. The downside of this argument is the intrinsic potential for contradictions. Theoretically, a functional patient with 10/10 baseline pain could be deemed "positive" if 7/10 pain is elicited (i.e., 70% of baseline pain was provoked), whereas a disabled patient with 4/10 pain in whom disc stimulation provokes 6/10 pain (i.e., 150% of baseline) would be designated as "negative." Thus, Manchikanti et al (100) recommended as a criterion standard to evaluate reproduction of at least 70% of the most severe pain the patient has experienced (i.e., 5 of 7) and lack of production of pain at all in 2 adjacent discs.

6.2.2.1.8 Level of Evidence

Based on the systematic review (100) utilizing 3 studies in the performance of cervical discography (89,742,755), the indicated level of evidence is Level II-2 based on the modified USPSTF criteria (153).

6.2.2.1.9 Recommendations

Based on the systematic review (100), IASP criteria (723), and ISIS criteria (719), the following recommendations are made:

1) Cervical discography is indicated to test the diagnostic hypothesis of discogenic pain of the cervical spine in individuals who have been properly selected and screened to eliminate other sources of cervical pain.
2) TThe discography should be performed utilizing appropriate criteria and results are considered positive only if the stimulation of the target disc produces concordant pain with an intensity of at least 7 on a 10-point pain measurement scale or reproduces at least 70% of the most severe pain the patient has

experienced (i.e., 5 of 7) and 2 adjacent discs with low volume contrast injection with low pressure discography do not produce any pain at all.

7.0 Thoracic Pain

The multiple structures which may be responsible for chronic thoracic pain include thoracic facet joints and intervertebral discs. Thoracic facet joints have been evaluated with controlled diagnostic techniques.

7.1 Thoracic Facet or Zygapophysial Joints

Similar to lumbar and cervical facet joints, thoracic facet joints are paired diarthrodial articulations between posterior elements of the adjacent vertebrae. The role of facet joints as a cause of chronic upper or mid back pain has received very little attention with only a few publications discussing these joints as the source of pain (761-763). However, the description of the involvement of thoracic facet joints as a cause of chronic mid back and upper back pain started in 1987 (764). Thoracic facet joint pain patterns were described in 1994 and 1997 (765,766).

Thoracic facet joints have been shown to have abundant nerve supply (37,91,172,173,177,765-773). The joints also have been shown to be capable of causing pain similar to that seen clinically, in normal volunteers with persistent mid back and upper back pain and referred pain into the chest wall (765,766). The joints also have been shown to be affected by osteoarthritis, rheumatoid arthritis, spondylitis, degeneration, inflammation, and injury leading to pain upon joint motion and restriction of motion (101,774).

7.1.1 Facet or Zygapophysial Joint Blocks

Diagnostic blocks of thoracic facet or zygapophysial joint provide valid information.

7.1.1.1 Rationale

The rationale for using thoracic facet joint blocks for diagnosis is based on the fact that facet joints are capable of causing pain and they have a nerve supply (101,765-773). They have been shown to be a source of pain in patients using diagnostic techniques of known reliability and validity (143,144,775). Conventional clinical and radiologic techniques are unreliable in diagnosing thoracic facet joint pain. Various patterns of referred pain described for thoracic facet joints in the spine are similar to other structures such as discs. In addition, any maneuver to stress the facet joint is also likely to stress several other structures simultaneously, especially the discs and muscles.

The value, validity, and clinical effectiveness of thoracic diagnostic facet joint nerve blocks was illustrated by application of therapeutic modalities based on the diagnosis with controlled, comparative local anesthetic blocks (94,121,125).

7.1.1.2 Validity

The face validity of medial branch blocks by injecting small volumes of local anesthetic and contrast material onto the target joints for these structures and by determining the spread of contrast medium has been established for lumbar and cervical medial branches (163,164,668). Construct validity of thoracic facet joint blocks to eliminate placebo effect as the source of confounding results has been demonstrated by controlled, comparative local anesthetic blocks. False-positive rates were evaluated in 3 separate studies (143,144,775).

7.1.1.3 Cost Effectiveness

Diagnostic thoracic facet joint nerve blocks were not evaluated for cost effectiveness systematically. However, multiple authors (88,242,274) have described the feasibility and cost-effectiveness of appropriately performed controlled local anesthetic blocks.

7.1.1.4 Safety and Complications

The safety of thoracic facet joint interventions with intraarticular injections and medial branch blocks has been demonstrated. Though rare and minor, the reported complications of facet joint injections or nerve blocks are related to needle placement and drug administration. These complications include hemorrhage, dural puncture, spinal cord trauma, infection, intraarterial or intravenous injection, chemical meningitis, neural trauma, paralysis, pneumothorax, radiation exposure, facet capsule rupture, hematoma formation, steroid side effects, and epidural, subdural or subarachnoid spread (6,91-93,101,231,245,246,249-252,256-263,270-272,687,761).

7.1.1.5 Evidence Assessment

Our search yielded 4 systematic reviews (91-94). The recent systematic review by Atluri et al (94) utilized 3 studies (143,144,775), meeting the inclusion criteria for methodologic quality assessment. Table 6 illustrates the prevalence and false-positive data.

7.1.1.6 Prevalence

Based on the systematic review by Atluri et al (94),

which included controlled local anesthetic blocks, the prevalence was shown as 34% to 48% with CIs ranging from 22% to 62%. The average prevalence was 40% (95% CI; 33% to 48%) (Table 6).

7.1.1.7 False-Positive Rate

Based on the systematic review by Atluri et al (94) false-positive rates of single local anesthetic blocks have been shown to range from 42% to 58% with CIs ranging from 26% to 78%. The average false-positive rate was 42% (95% CI; 33%–51%) (Table 6).

7.1.1.8 Level of Evidence

Based on the systematic review (94) the evidence for the diagnosis of thoracic facet joint pain with controlled comparative local anesthetic blocks is Level I or II-1 based on USPSTF criteria (153).

7.1.1.9 Recommendations

Common indications for diagnostic thoracic facet joint interventions include (94,776,777):

- Somatic or nonradicular upper back or chest wall pain.
- Duration of pain at least of 3 months.
- Average pain levels of greater than 6 on a scale of 0 to 10.
- Intermittent or continuous pain causing functional disability.
- Failure to respond to more conservative management, including physical therapy modalities with exercises, chiropractic management, and nonsteroidal anti-inflammatory agents.
- Lack of obvious evidence for thoracic discogenic pain, thoracic disc herniation, and evidence of thoracic radiculitis or intercostal neuritis.
- No contraindications with understanding of consent, nature of the procedure, needle placement, or sedation.
- No history of allergy to contrast administration, local anesthetics, or other drugs potentially utilized.
- Contraindications or inability to undergo physical therapy, chiropractic management, or inability to tolerate nonsteroidal anti-inflammatory drugs.
- A positive response is based on the following evidence:
  - Patient has met the above indications.
  - Patient responds positively to controlled anesthetic blocks either with placebo control or comparative local anesthetic blocks (< 1 mL) with appropriate response to each local anesthetic.
  - At least 80% relief as criterion standard with the ability to perform previously painful movements without deterioration of the relief (i.e., extension, flexion, lateral rotation, lateral flexion, etc.).
  - The patient's response should be recorded independently by an assessor – generally a registered nurse familiar with the patient or another physician.

7.2 Thoracic Intervertebral Disc

Similar to lumbar and cervical intervertebral discs, thoracic intervertebral discs are composed of 3 major components with the nucleus pulposus, annulus fibrosis, and vertebral endplates (277). Degeneration of the thoracic disc along with endplate irregularities and changes due to osteophyte formation are common findings (774,778). However, the contribution of disc and facet joints as sources of

Table 6. *Data of prevalence and false-positive rates of thoracic facet joint pain.*

Study	Methodological Quality Scoring (AHRQ)	Participants	Prevalence	False-Positive Rate
Manchikanti et al 2002 (775)	70	46	48% (95% CI 34%–62%)	58% (95% CI 38%–78%)
Manchikanti et al 2004 (144)	70	72	42% (95% CI 30%–53%)	55% (95% CI 39%–78%)
Manchukonda et al 2007 (143)	60	65	34% (95% CI 22%–47%)	42% (95% CI 26%–59%)
Combined Results (Average)	66.66	173	40% (95% CI 33%–48%)	42% (95% CI 33%–51%)

AHRQ=Agency for Healthcare Research and Quality; CI = confidence interval

Adapted from Atluri S et al. Systematic review of diagnostic utility and therapeutic effectiveness of thoracic facet joint interventions. *Pain Physician* 2008; 11:611-629 (94).

thoracic spinal pain have received only scant attention (93,121,125,143,144,764-766,775,779-787). The proportion of patients suffering from chronic upper or mid back pain secondary to thoracic disorders is relatively small compared to chronic low back and neck pain (6,788). Imaging studies including MRI, CT, myelography, and radiographs are incapable of identifying a degenerated disc as painful in the thoracic spine similar to the lumbar spine (97-99).

Thoracic discs are innervated structures and have been shown to elicit pain (290,292,302,303,306,308, 310,345,347,781). Further, thoracic discs have been shown to cause chronic upper back and mid back pain (449,780,781,786,787).

7.2.1 Diagnosis of Thoracic Discogenic Pain

Imaging studies including radiographs, myelography, CT, CT-myelography, and MRI are inaccurate in determining if a thoracic disc is responsible for a patient's pain complaints or the presence or absence of disc pathology (781). In addition, the patterns for thoracic discogenic pain are expected to be indistinguishable from those of thoracic facet joint pain, as in the lumbar and cervical regions (434,719).

Simmons and Segil (449), in 1975, described thoracic discography and nucleography in the evaluation of a man with mid-thoracic radicular pain with a diagnosis of a posterior annular tear that reproduced his thoracic symptoms. In 1994, Schellhas et al (786) published a retrospective review of 100 outpatient thoracic discographies performed on patients whose MRI findings revealed thoracic disc degeneration. In 1999, Wood et al (787) published a prospective study of MRI and thoracic discography in asymptomatic and symptomatic individuals. Over the past few decades, thoracic discography has been used as a safe procedure by skilled interventionalists, with its main purpose of precisely identifying and localizing the disc level or levels which are the source of chronic thoracic spinal pain.

7.2.1.1 Provocation Thoracic Discography

Thoracic discography continues to be in the nascent stages of clinical application and specifically in the arena of evidence-based medicine with the first descriptions of thoracic discography appearing in 1975 (449), approximately 30 years after the description of lumbar discography (324).

7.2.1.1.1 Rationale

Thoracic discs are innervated structures and elicit pain. Thoracic discs have been shown to cause chronic upper back and mid back pain. In addition, present clinical radiological evaluation does not lend to a diagnosis of thoracic discogenic pain.

7.2.1.1.2 Validity

The IASP Task Force (785) defined thoracic discogenic pain as thoracic spinal pain, with or without referred pain. The key diagnostic criteria of thoracic discogenic pain is that the patient's pain must be shown conclusively to stem from an intervertebral disc by provocation discography of the putatively symptomatic disc with reproduction of the patient's accustomed pain with provocation of at least 2 adjacent intervertebral discs clearly not reproducing the patient's pain, and provided that the pain cannot be ascribed to some other source innervated by the same segments that innervate the putatively symptomatic disc. The Task Force (785) cautioned that thoracic discography alone is insufficient to conclusively establish a diagnosis of discogenic pain because of the propensity for false-positive responses, either because of the apprehension on the part of the patient or because of the coexistence of a separate source of pain within the segment under investigation.

Wood et al (787) evaluated the validity of the concordant pain and the role of false-positive responses. They reported the mean pain response in the asymptomatic volunteers as 2.4/10 even though 3 discs exhibiting prominent endplate irregularities and annular tears typical of thoracolumbar Scheuermann's disease were intensely painful. Further, of the 48 discs studied, only 21 appeared normal on MRI and only 10 were judged as normal after provocation discography. The discs which exhibited concordant pain (24 of 48 or 50%) exhibited a pain response of 8.5/10, statistically higher pain levels than the 17 discs that exhibited non-concordant pain pressure with an average pain of 4.8/10, and 5 discs with no pain response at all.

Schellhas et al (786) evaluated concordant pain and also at least one nearby controlled level disc. They demonstrated clinical concordance in approximately 50% of the discs, with controlled levels being painless.

7.2.1.1.3 Cost Effectiveness

There are no cost effectiveness studies of thoracic provocation discography available in the literature.

7.2.1.1.4 Safety and Complications

Complications relating to thoracic discography include discitis, trauma to spinal cord, nerve root injury, epidural abscess, allergic contrast reaction, subarachnoid puncture, chemical meningitis, pneumothorax, and trauma to retroperitoneal structures including the kidney and the spleen (779).

7.2.1.1.5 Evidence Synthesis

While there were 3 systematic reviews evaluating thoracic discography (97-99), there was only one systematic review (99) evaluating thoracic discography as a diagnostic test separately. This study utilized IASP criteria and methodologic quality assessment criteria.

7.2.1.1.6 Prevalence

The prevalence of thoracic discography has not been determined.

7.2.1.1.7 False-Positive Rate

Utilizing the data by Wood et al (787), it appears that the false-positive rate with thoracic discograms is 0 if a pain response of 7 or above is considered as positive with concordant pain with negative contiguous discs. However, in patients with severe pathology, pain may be produced in 20% of the patients. Considering the clinical realities which dictate provocation thoracic discography to be performed only in symptomatic patients, utilizing the IASP criteria (785), and that these positive patients may have been dormant and fall within the range of the prevalence of discogenic pain, it is concluded that the false-positive rate with thoracic provocation discography is low.

7.2.1.1.8 Level of Evidence

Based on the systematic review by Singh et al (99) and the 2 studies meeting the inclusion criteria (786,787), the indicated level of evidence is Level II-3 for thoracic discography.

7.2.1.1.9 Recommendations

The recommendations based on IASP criteria (785), ISIS guidelines (779), systematic review (99), and this comprehensive review are as follows:

1) The thoracic discography is indicated to decide if an intervertebral disc is painful or not.
2) The discography should be performed utilizing appropriate criteria and results are considered positive only if the stimulation of the target disc produces concordant pain with an intensity of at least 7 on a 10-point pain measurement scale or reproduces at least 70% of the most severe pain the patient has experienced (i.e., 5 of 7) and 2 adjacent discs with low volume contrast injection with low pressure discography do not produce any pain at all.

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