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IPM Guidelines

An Update of Comprehensive Evidence-Based Guidelines for Interventional Techniques in Chronic Spinal Pain. Part II: Guidance and Recommendations

Laxmaiah Manchikanti, MD, Salahadin Abdi, MD, PhD, Sairam Atluri, MD, Ramsin M. Benyamin, MD, Mark V. Boswell, MD, PhD, Ricardo M. Buenaventura, MD, David A. Bryce, MD, Trish A. Burks, LPT, David L. Caraway, MD, Aaron K. Calodney, MD, Kimberly A Cash, RT, Paul J. Christo, MD, Steven P. Cohen, MD, James Colson MS, MD, Ann Conn, MD, Harold J. Cordner, MD, Sareta Coubarous, DO, Sukdeb Datta, MD, Timothy R. Deer, MD, Sudhir A. Diwan, MD, Frank J.E. Falco, MD, Bert Fellows, MA, Stephanie C. Geffert, MLIS, Jay S. Grider, DO, PhD, Sanjeeva Gupta, MD, Haroon Hameed, MD, Mariam Hameed, MD, Hans Hansen, MD, Standiford Helm II, MD, Jeffrey W. Janata, PhD, Rafael Justiz, MD, Alan D. Kaye, MD, PhD, Marion Lee, MD, Kavita N. Manchikanti, MD, Carla D. McManus, RN, BSN, Obi Onyewu, MD, Allan T. Parr, MD, Vikram Patel, MD, Gabor B. Racz, MD, Nalini Sehgal, MD, Manohar Sharma, MD, FRCA, FFPMRCA, Thomas T. Simopoulos, MD, Vijay Singh, MD, Howard S. Smith, MD, Lee T. Snook, MD, John Swicegood, MD, Ricardo Vallejo, MD, PhD, Stephen P. Ward, MD, FRCA, FFPMRCA, Bradley W. Wargo, DO, Jie Zhu, MD, and Joshua A. Hirsch, MD

From: American Society of Interventnional Pain Physicians

Additional author affiliations and conflicts of interest on PP. S209-S212.

Address Correspondence:
ASIPP
81 Lakeview Drive
Paducah, KY 42001
E-mail: asipp@asipp.org

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Objective: To develop evidence-based clinical practice guidelines for interventional techniques in the diagnosis and treatment of chronic spinal pain.

Methodology: Systematic assessment of the literature.

Evidence:

I. *Lumbar Spine*

- The evidence for accuracy of **diagnostic selective nerve root blocks** is limited; whereas for **lumbar provocation discography**, it is fair.
- The evidence for **diagnostic lumbar facet joint nerve blocks** and **diagnostic sacroiliac intraarticular injections** is good with 75% to 100% pain relief as criterion standard with controlled local anesthetic or placebo blocks.
- The evidence is good in managing disc herniation or radiculitis for **caudal, interlaminar,** and **transforaminal epidural injections**; fair for axial or discogenic pain without disc herniation, radiculitis or facet joint pain with **caudal, and interlaminar epidural injections**, and limited for **transforaminal epidural injections**; fair for spinal stenosis with **caudal, interlaminar, and transforaminal epidural injections**; and fair for post surgery syndrome with **caudal epidural injections** and limited with **transforaminal epidural injections.**
- The evidence for therapeutic facet joint interventions is good for **conventional radiofrequency**, limited for **pulsed radiofrequency,** fair to good for **lumbar facet joint nerve blocks**, and limited for **intraarticular injections.**
- For sacroiliac joint interventions, the evidence for **cooled radiofrequency neurotomy** is fair; limited for **intraarticular injections and periarticular injections**; and limited for both **pulsed radiofrequency** and **conventional radiofrequency neurotomy**.
- For **lumbar percutaneous adhesiolysis**, the evidence is fair in managing chronic low back and lower extremity pain secondary to post surgery syndrome and spinal stenosis.
- For intradiscal procedures, the evidence for **intradiscal electrothermal therapy (IDET)** and **biaculoplasty** is limited to fair and is limited for **discTRODE.**
- For percutaneous disc decompression, the evidence is limited for **automated percutaneous lumbar discectomy (APLD), percutaneous lumbar laser disc**

decompression, and **Dekompressor;** and limited to fair for **nucleoplasty** for which the Centers for Medicare and Medicaid Services (CMS) has issued a noncoverage decision.

II. ***Cervical Spine***

- The evidence for **cervical provocation discography** is limited; whereas the evidence for **diagnostic cervical facet joint nerve blocks** is good with a criterion standard of 75% or greater relief with controlled diagnostic blocks.
- The evidence is good for **cervical interlaminar epidural injections** for cervical disc herniation or radiculitis; fair for axial or discogenic pain, spinal stenosis, and post cervical surgery syndrome.
- The evidence for therapeutic cervical facet joint interventions is fair for **conventional cervical radiofrequency neurotomy** and **cervical medial branch blocks**, and limited for **cervical intraarticular injections.**

III. ***Thoracic Spine***

- The evidence is limited for **thoracic provocation discography** and is good for diagnostic accuracy of **thoracic facet joint nerve blocks** with a criterion standard of at least 75% pain relief with controlled diagnostic blocks.
- The evidence is fair for **thoracic epidural injections** in managing thoracic pain.
- The evidence for therapeutic **thoracic facet joint nerve blocks** is fair, limited for **radiofrequency neurotomy,** and not available for **thoracic intraarticular injections.**

IV. ***Implantables***

- The evidence is fair for **spinal cord stimulation (SCS)** in managing patients with failed back surgery syndrome (FBSS) and limited for **implantable intrathecal drug administration systems.**

V. ***Anticoagulation***

- There is good evidence for risk of thromboembolic phenomenon in patients with **antithrombotic therapy** if discontinued, spontaneous epidural hematomas with or without traumatic injury in patients with or without anticoagulant therapy to discontinue or normalize INR with warfarin therapy, and the lack of necessity of discontinuation of nonsteroidal anti-inflammatory drugs (NSAIDs), including low dose aspirin prior to performing interventional techniques.
- There is fair evidence with excessive bleeding, including epidural hematoma formation with interventional techniques when **antithrombotic therapy** is continued, the risk of higher thromboembolic phenomenon than epidural hematomas with discontinuation of antiplatelet therapy prior to interventional techniques and to continue phosphodiesterase inhibitors (dipyridamole, cilostazol, and Aggrenox).
- There is limited evidence to discontinue **antiplatelet therapy with platelet aggregation inhibitors** to avoid bleeding and epidural hematomas and/or to continue antiplatelet therapy (clopidogrel, ticlopidine, prasugrel) during interventional techniques to avoid cerebrovascular and cardiovascular thromboembolic fatalities.
- There is limited evidence in reference to newer **antithrombotic agents dabigatran (Pradaxa) and rivaroxan (Xarelto)** to discontinue to avoid bleeding and epidural hematomas and are continued during interventional techniques to avoid cerebrovascular and cardiovascular thromboembolic events.

Conclusion: Evidence is fair to good for 62% of diagnostic and 52% of therapeutic interventions assessed.

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Key words: Interventional techniques , chronic spinal pain, diagnostic blocks, therapeutic interventions, facet joint interventions, epidural injections, epidural adhesiolysis, discography, radiofrequency, disc decompression, spinal cord stimulation, intrathecal implantable systems

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The American Society of Interventional Pain Physicians (ASIPP) Interventional Pain Management (IPM) guidelines entitled, "An Update of Comprehensive Evidence-Based Guidelines for Interventional Techniques in Chronic Spinal Pain" are systematically developed statements, presenting best practice based on a thorough evaluation of the evidence from published studies on the outcomes of management (1-39). Part 1: Introduction and General Considerations (39) describes the process of developing trustworthy guidelines utilizing Institute of Medicine (IOM) criteria (40) and detailed methodology of guideline development. The reviews were developed based on contemporary practices of systematic review development including guidance from the IOM (1,9-40).

I. PREAMBLE

1.0 Chronic Pain

Chronic pain is defined as a complex and multifactorial phenomenon with pain that persists 6 months after an injury and/or beyond the usual course of an acute disease or a reasonable time for a comparable injury to heal, that is associated with chronic pathologic processes that cause continuous or intermittent pain for months or years, that may continue in the presence or absence of demonstrable pathology and may not be amenable to routine pain control methods with healing never occurring (8,41).

1.1 Interventional Pain Management

The National Uniform Claims Committee (NUCC) defined IPM as the discipline of medicine devoted to the diagnosis and treatment of pain and related disorders by the application of interventional techniques in managing subacute, chronic, persistent, and intractable pain, independently or in conjunction with other modalities of treatments (42).

1.2 Interventional Techniques

The Medicare Payment Advisory Commission (MedPAC) has described interventional techniques as minimally invasive procedures, such as needle placement of drugs in targeted areas, ablation of targeted nerves, and some surgical techniques, such as discectomy and the implantation of intrathecal infusion pumps and spinal cord stimulators (43).

1.3 Purpose

The updated evidence-based clinical practice guidelines for spinal interventional techniques in the management of chronic spinal pain are statements developed to improve the quality of care, patient access, treatment outcomes, the appropriateness of indicated and medically necessary care, efficiency and effectiveness, and to achieve cost containment by improving the cost-benefit ratio (3-8).

1.4 Objectives

The objectives of the updated ASIPP guidelines for spinal interventional techniques are to provide a set of recommendations that can support existing and future guidelines by:

- Providing strategies to manage chronic spinal pain and/or its consequences to improve the quality of clinical care.
- Providing recommendations that are generally acceptable to a wide range of specialties and agencies.
- Developing methods that are sound and transparent and highlighting the areas where further research is needed by noting deficiencies in knowledge.
- Utilizing a process which is valid, reliable, reproducible, clinically applicable, and flexible, providing clarity with a multidisciplinary process with documentation of the process in developing guidelines, along with a scheduled review.
- Systematically assessing the clinical and cost effectiveness of treatments and management strategies with an evidence-based approach through the use of systematic reviews, existing evidence-based guidelines, and individual clinical studies.
- Increasing compliance, dispelling misconceptions, contributing to appropriate patient expectations, and facilitating the improved relationship between patients, physicians, and payers.

1.5 Population and Preferences

The population covered by these guidelines includes all patients suffering with chronic spinal pain eligible to undergo commonly utilized and effective interventional technique(s). The treatment plan must take into consideration the evidence, patient preferences, and risk-benefit ratio.

1.6 Implementation and Review

The dates for implementation and review were established:

- Effective date – May 1, 2013
- Expiration date – December 31, 2015
- Scheduled review – April 2014

1.7 Application

While these guidelines may be applied by any specialty, they are specifically intended for use by interventional pain physicians. These guidelines do not constitute inflexible treatment recommendations. It is expected that a provider will establish a plan of care on a case-by-case basis, taking into account an individual patient's medical condition, personal needs, and preferences, and the physician's experience. Based on an individual patient's needs, treatment different from that outlined here could be warranted. Consequently, these guidelines do not represent a "standard of care."

The goal of these guidelines is to provide patients, practitioners, regulators, and payers information that may be used to determine whether the available evidence supports the notion of a "standard" for interventional techniques. "Standard" refers to what is applicable to the majority of patients, with a preference for patient convenience and ease of administration without compromising treatment efficacy or morbidity (44,45). It is essential to recognize the difference between "standard" and "standard of care," as utilized as a legal definition.

1.8 Rationale and Importance

The rationale for the update of the comprehensive evidence-based guidelines for interventional techniques of chronic spinal pain by ASIPP is based on the escalating prevalence, health care costs, and the various procedures performed to manage chronic spinal pain and its impact on society (46-101). IPM as an emerging specialty is growing significantly, attesting to the importance of managing chronic spinal pain using existing, proven, and emerging technology.

Many of the causes of spinal pain and other chronic pain conditions are considered to be acute recurrent problems characterized by periods of quiescence punctuated by flare-ups, or chronic diseases, like diabetes or hypertension, requiring long-term treatment with ongoing care. The importance of spinal interventional techniques in managing chronic spinal pain has been established on the basis of advances in imaging, neuroanatomic findings, the development of precision diagnostic and therapeutic injection techniques, and reported non-operative treatment successes. Many guidelines, systematic reviews, Cochrane Reviews, and other articles pertaining to IPM have been published (2-40,101-136). Most of these guidelines, however, are ambiguous and may not be applicable in managing chronic spinal pain utilizing contemporary IPM. Moreover, quality issues exist, including conflicts of interest and the inclusion or exclusion of significant literature of randomized trials and observational studies (101-116).

II. CHRONIC PAIN AND INTERVENTIONAL PAIN MANAGEMENT

The IOM report on relieving pain in America (46,56) noted that not only is the magnitude of pain in the United States astounding, with more than 100 million Americans afflicted with pain that persists for weeks to years, but that it also has estimated financial costs ranging from $560 billion to $630 billion per year with Americans constituting only 4.5% of the global population. Freburger et al (47), in a survey conducted in 1992 and repeated in 2006 in North Carolina, showed a rapid overall increase for low back pain of 162% from 3.9% in 1992 to 10.2% in 2006. Echoing the findings among multiple authors, Hoy et al (48) showed a variable prevalence of spinal pain with a significant recurrence of 24% to 80%. Studies of the prevalence of low back and neck pain and its impact in the general population have shown 23% of patients reporting Grade II to IV low back pain (50) with a high pain intensity and disability compared to 15% with neck pain (51) (Fig. 1). Furthermore, the prevalence of persistent pain is highly prevalent in the elderly and closely associated with functional limitations (61,62). Overall, chronic persistent low back and neck pain is seen in 25% to 60% of the patients one-year or longer after the initial episode (8,39,41,60).

However, chronic pain must not be confused with chronic pain syndrome (41) which is defined as a complex pain condition with physical, psychological, emotional, and social components. While chronic pain and chronic pain syndrome may appear similar and may at times coexist, chronic pain syndrome as opposed to chronic pain, encompasses the added components of certain recognizable psychological and socioeconomic influences, and psychological behavioral patterns. In addition, chronic pain is associated with significant economic, societal, and health outcomes (39,41,52-76). Further, along with enormous costs and disability associated with reduced functioning, overuse of opioids and related fatalities have been well described (78-92). Evidence illustrates that opioid prescriptions have been escalating at a rapid pace, along with related fatalities contributing to 60% of the deaths from appropriate prescriptions for chronic pain compared to 40% due to abuse, with all deaths exceeding the deaths due to motor vehicle injuries (91,92,101,137) (Fig. 2). Further, a direct correlation has been established with the increase in opioid-related deaths, treatments, and admissions, along with opioid related sales in the United States and across the globe (87,101,137).

Exploding health care costs are a major issue for the United States and the world (52-60,63-72), leading

to various measures of health care reform, regulations, and the imposition of guidelines often based on quasi evidence-based medicine and comparative effectiveness research. An abundance of criticism and argument have been advanced both for and against proposed reforms (53,63,93-134,138-160). The United States, as noted, is in the midst of this storm. Martin et al (53) estimated that treatment for back and neck pain problems accounted for $86 billion in health care expenditures in the United States in 2005. This was associated with a 65% increase in expenditures; a 49% increase in the number of patients seeking spine-related care from 1997 through 2006. This was the biggest contributor to the increase in expenditures. Rates of imaging, interventional techniques, drug use, and surgery for spine problems have increased substantially over the past decade (66,77,82,83,91,92,116,117,161-293). Thus, spinal interventional techniques are considered as being one of the major components in the escalation of health care costs among patients with chronic spinal pain, specifically in the United States (161-175).

As an emerging specialty, IPM encounters multiple problems of a disproportionate magnitude compared

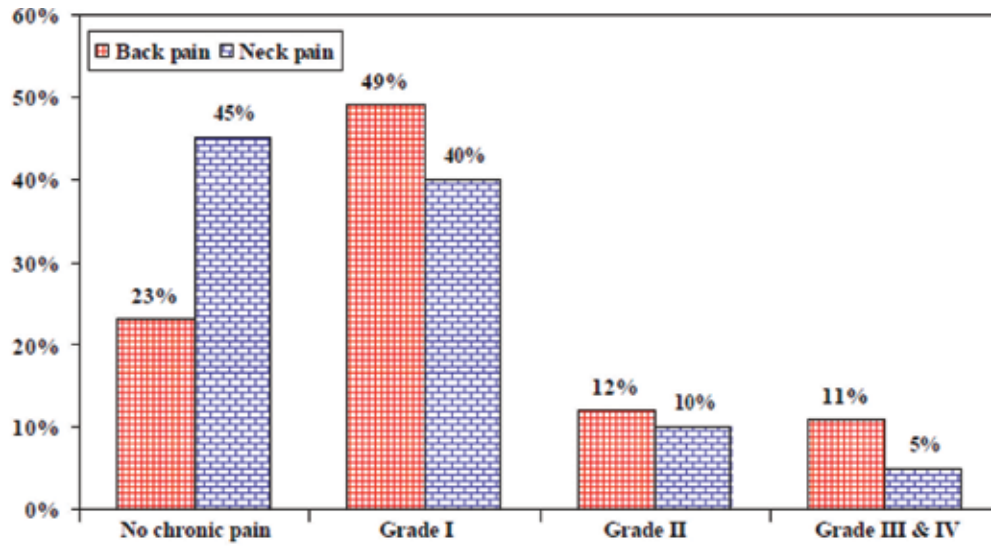


Fig. 1. *Severity of low back and neck pain (age standardized rate).*
Adapted and modified from: Cassidy JD et al. The Saskatchewan Health and Back Pain Survey. The prevalence of low back pain and related disability in Saskatchewan adults. *Spine (Phila Pa 1976)* 1998; 23:1860-1867 (50) and Côté P et al. The Saskatchewan Health and Back Pain Survey. The prevalence of neck pain and related disability in Saskatchewan adults. *Spine(Phila Pa 1976)* 1998; 23:1689-1698 (51).

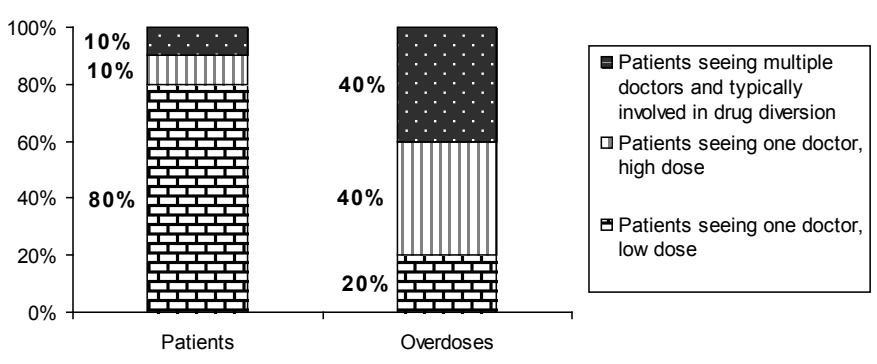


Fig. 2. *Percentage of patients and prescription drug overdoses, by risk group – United States.*
Source: Centers for Disease Control and Prevention. CDC grand rounds: Prescription drug overdoses – a U.S. epidemic. *MMWR Morb Mortal Wkly Rep* 2012; 61:10-13 (101).

to established medical specialties. The increasing utilization of major techniques considered to be inappropriate and occasionally unsafe is considered as potentially inappropriate care, even though significant advances have been provided in IPM supported by numerous guidelines (2-8,105,116-133), systematic reviews (3-38,111,112,116,129,135,191,217,294-323), and randomized and observational studies (226-293). However, the available evidence documents a wide degree of variance in the definition of the practice of medicine in general and IPM in particular (3-39,101-134). Specifically, the application of interventional techniques by physicians of different specialties and by nonphysicians is highly variable for even the most commonly performed procedures and treated conditions (161-175). In fact, Abbott et al (170), in a descriptive analysis of utilization patterns between 2003 and 2007, showed a variable number of procedures across all categories performed per patient during a 12 month inclusion period with high variability among the specialties. Manchikanti et al (169), in the analysis of utilization trends and Medicare expenditures from 2000 to 2008 in relation to the growth of spinal IPM techniques, showed that Medicare recipients receiving spinal interventional techniques increased 107.8% from 2000 through 2008 with an annual increase of 9.6%; whereas the number of spinal interventional techniques increased by 186.8%, an annual average increase of 14.1% per 100,000 beneficiaries. Even though this study showed an explosive increase in spinal interventional techniques from 2000 to 2008, there was a slowing of growth observed in later years. In an updated evaluation, Manchikanti et al (161), in an assessment of all interventional techniques, except for implantables, continuous epidurals, intraarticular injections, trigger point and ligament injections, peripheral nerve blocks, and vertebroplasty procedures, showed an overall increase of 228% from 2000 to 2011 for IPM services. They also showed an overall increase of 177% per 100,000 Medicare beneficiaries. Annual increases with geometric average calculations were 11.4%, ranging from a decrease of 1.4% to an increase of 30.3% year-to-year. There were significant variations and increases in procedures and specialties as illustrated in Figs. 3 and 4.

Multiple reports have been the subject of investigations scrutinizing inappropriate use and incomplete documentation (172-175). These instances may be exacerbated due to burdensome, difficult to follow, and expensive regulations, and empowerment of insurers, hospitals, and non-physician providers (93-100,105,111-133,161-175,191,217,324-326).

III. GUIDELINE DEVELOPMENT

The methodology of guideline development is described in detail in Part 1 of the Update of Comprehensive Evidence-Based Guidelines for Interventional Techniques of Chronic Spinal Pain (39). This document describes the essentials of guideline development including the guidelines from IOM, National Institute for Health and Clinical Excellence (NICE), National Health and Medical Research Council (NHMRC), and World Health Organization (WHO), along with Guidance from International Network (GIN) – a network of guideline developers composed of 93 organizations and 89 individual members representing 46 countries (327-330). Even though guidelines have become a key tool for comprehensively summarizing the available literature and placing it in a format accessible to IPM physicians, it has been shown that systematic reviews, specifically in emerging specialties are outdated after 2 to 3 years (331). It also has been demonstrated that the evidence for the methods has been provided to update systematic reviews along with surveillance, search techniques, and evidence that systematic reviews can be produced and published faster (332-335).

Towards these ends, ASIPP has updated the guidelines on a regular basis, incorporating the guidance for guidelines for systematic reviews from IOM and other organizations. Various factors hampering guideline development include bias due to a multitude of conflicts of interest, poor or inappropriate assessment of methodological quality, poor writing, and ambiguous presentation, all of which essentially project a view that these are not applicable to individual patients or are too restrictive with a reductions in clinician autonomy and that overzealous or inappropriate recommendations are not based on evidence. To avoid these factors, ASIPP has followed the guidance for the development of trustworthy guidelines with the 8 standards of IOM (1).

- Establishing transparency
- Management of conflict of interest
- Guideline development group composition
- Clinical practice guideline-systematic review intersection
- Establishing evidence foundations for and rating strength of recommendations
- Articulation of recommendations
- External review
- Updating

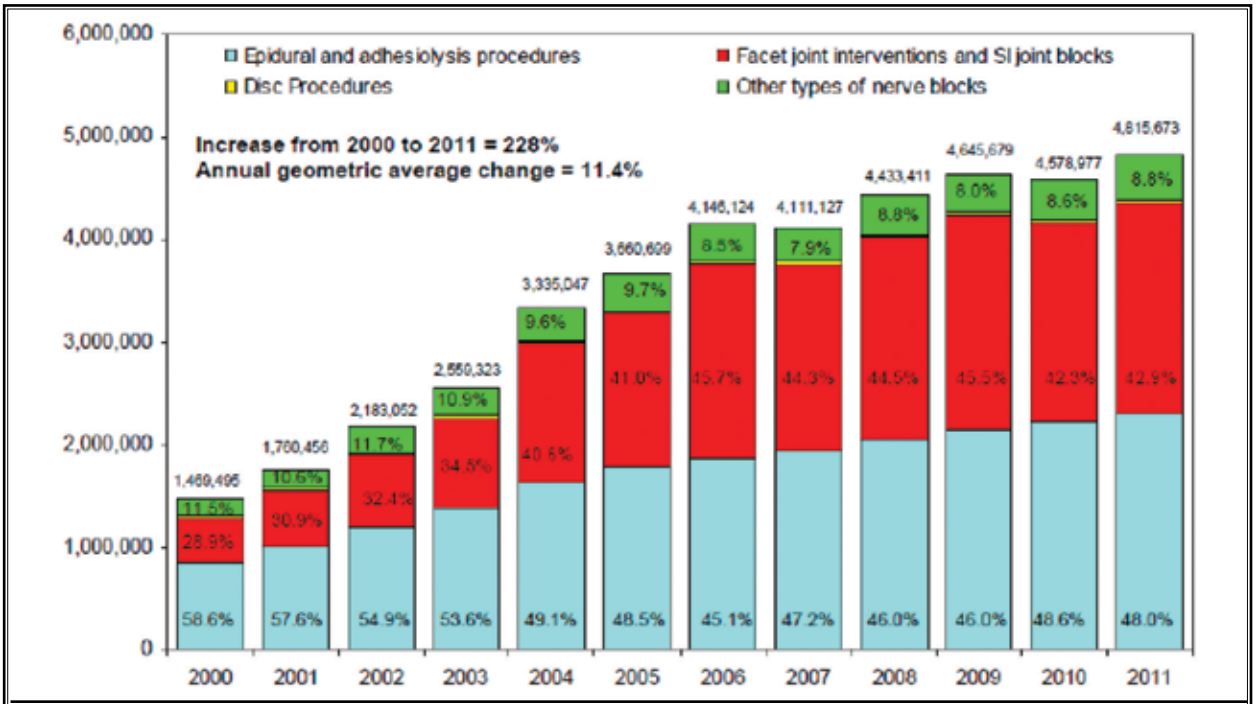


Fig. 3. *Illustration of distribution of procedural characteristics by type of procedures from 2000 to 2011.*
Source: Manchikanti L, et al. Utilization of interventional techniques in managing chronic pain in the Medicare population: Analysis of growth patterns from 2000 to 2011. Pain Physician 2012; 15:E969-E982 (161).

ASIPP also utilized guidance from GIN. ASIPP launched the development of practice guidelines for interventional techniques in the management of chronic pain and published the first guideline in 2000 (3). These guidelines were started to create a document to help practitioners by synthesizing the available evidence. The authors stated that these clinical practice guidelines for interventional techniques in the management of chronic pain were professionally developed utilizing a combination of evidence and consensus.

The synthesis of evidence, committee composition, and the development process have been revised, refined, and expanded with evaluation at least once every 3 years.

1.0 Development of ASIPP Guidelines

Recommendations of the IOM, which essentially incorporate all other guidance for guideline development, were applied in the preparation of ASIPP guidelines. All of the guidelines share a similar philosophy, thus, in this guideline process, we utilized the IOM's 8 proposed standards (1).

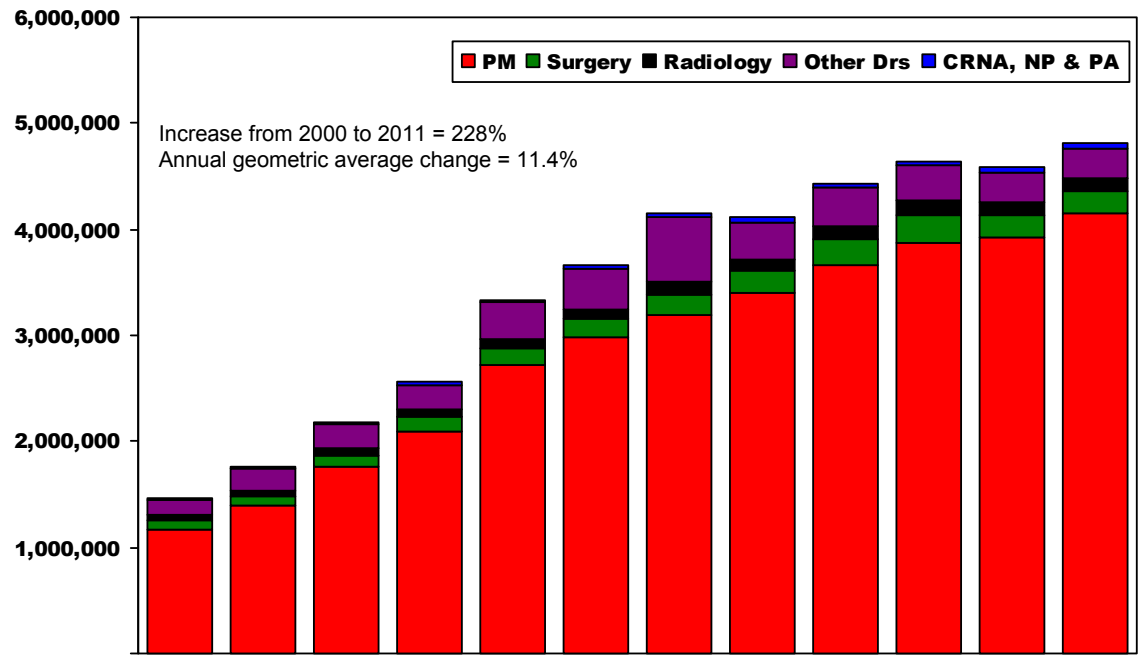
1.1 Transparency

The development process of guidelines for ASIPP is a project developed by the Board of Directors and membership of ASIPP, a not-for-profit organization, to provide a set of recommendations that can support existing and future guidelines to provide appropriate strategies to manage chronic spinal pain and improve the quality of clinical care. The membership consists of multiple specialties across the globe even though it is an American society. The majority of the specialists include interventional pain physicians derived from the primary specialities of anesthesiology, physical medicine and rehabilitation, and neurology and psychiatry.

There has been no external funding in the preparation of these guidelines. All the participation has been on a voluntary basis. No funding was received from any type of industry in the preparation of these guidelines. All the participants have been requested to provide their conflicts of interest.

1.2 Management of Conflict of Interest

Conflicts were managed by limiting involvement of the individuals with conflicts of interest and re-eval-



Specialty (%)	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Pain Management	80.1%	78.9%	80.4%	82.0%	81.5%	81.3%	77.1%	82.8%	82.8%	83.5%	85.6%	86.4%
Surgery	5.7%	5.6%	5.3%	4.9%	4.8%	4.8%	4.7%	5.0%	5.2%	5.7%	4.7%	4.1%
Radiology	2.8%	2.8%	2.9%	3.0%	2.8%	2.8%	2.7%	2.7%	2.6%	2.7%	2.6%	2.6%
Other Physicians	10.4%	11.6%	10.4%	9.2%	10.1%	10.3%	14.7%	8.5%	8.3%	7.2%	6.0%	5.6%
CRNA, NP & PA	1.0%	1.2%	1.1%	0.9%	0.8%	0.8%	0.9%	1.0%	1.0%	1.0%	1.1%	1.3%

Fig. 4. *Utilization of interventional pain management techniques by specialty from 2000 to 2011 in Medicare recipients.*
Source: Manchikanti L, et al. Utilization of interventional techniques in managing chronic pain in the Medicare population: Analysis of growth patterns from 2000 to 2011. Pain Physician 2012; 15:E969-E982 (161).

uating the evidence provided by those with conflicts of interest, even though there was no direct funding received for this project. Consequently, we have also undertaken extensive efforts to avoid direct, as well as indirect, internal and external conflicts of interest. Prior to selection of the guideline development group, all the individuals considered for membership declared all interests and activities potentially resulting in conflicts of interest with development group activity, by written disclosure. Disclosures reflected all current and planned commercial services, including services from which a clinician derives a substantial portion of income, non-commercial, intellectual, institutional, and patient/public activities pertinent to the potential scope of the clinical practice guidelines. There were no significant conflicts of interest among the members, thus, there was no necessity for divestment or exclusion. Even then, care was exercised to avoid any conflicts not disclosed by the usual disclosure procedure in decision-making.

1.3 Guideline Development

ASIPP convened a multidisciplinary panel of 51 experts in various fields to review the evidence and formulate recommendations for interventional techniques in managing chronic spinal pain. The panel was instructed to answer questions and develop evidence pertaining to important aspects of spinal interventional techniques. Members of the panel were also requested to develop comprehensive systematic reviews on various related subjects in preparation for spinal interventional techniques guidelines (9-32,82-84). Other independent systematic reviews were also considered. The panel convened in person on 3 occasions at ASIPP workshops in Memphis, Tennessee, and also had 6 webinars and/or

telephone conferences. The majority of the participants attended multiple meetings.

The committee provided a broad representation of academic and non-academic clinical practitioners, representing a variety of practices and geographic areas, all with interest and expertise in interventional techniques and chronic pain management. The committee formulized the elements of the guideline preparation process, including literature searches, literature synthesis, consensus evaluation, open forum presentations, and formal endorsement by the ASIPP Board of Directors and peer review. However, there were no patients, patient advocates, or patient/consumer organizations represented in the guideline development process, which may be considered as a deficiency.

The evidence synthesis and analysis resulted in multiple conclusions and recommendations based on evidence with overwhelming majority consent.

Of the 8 diagnostic techniques assessed, good evidence is available for only 4 or 50% of diagnostic interventions, with fair evidence for one intervention and limited evidence for the remaining 3 interventions. Of the 42 therapeutic interventions assessed, good evidence is available for 5 or 12% of interventions, fair evidence is available for 17 or 40% of interventions, with the remaining 20 interventions having limited and/or poor evidence. Overall, good to fair evidence is available for only half of the therapeutic interventions and 62% of the diagnostic interventions assessed.

Sixteen of the 51 authors provided information that they received funding from industry; however, of these, less than 5% were receiving funding from drug makers, only 2% were receiving from industry, and 2% were receiving funding for research or engaged in speaking from industry. Editorially, appropriate measures were taken to avoid any conflicting opinions from authors receiving funding from the industry.

1.4 Systematic Reviews

The IOM Committee concluded that systematic reviews should be used to inform health care decision-makers about what is known and not known about the effectiveness of health interventions (40). Patients expect that their doctors and other health care providers know what type of treatment to recommend. Yet the reality is that the evidence that informs current health care decisions often is incomplete and may be biased, and there are no standards in place to ensure that systematic reviews of the evidence are objective, transparent, and scientifically valid. Better quality systematic reviews have the potential to improve the decisions made by clinicians, to better inform patient choice, and to provide a more trustworthy basis for decisions by payers and policy makers.

1.5 Methodology

Evidence assessment for systematic reviews was based on methodological quality assessment criteria recommended for randomized trials, observational studies, and diagnostic studies (336-356). The methodology utilized in the systematic reviews followed the review process derived from evidence-based systematic reviews and meta-analyses of randomized trials, observational studies, and diagnostic accuracy studies (40,109,336-357); Consolidated Standards of Reporting Trials (CONSORT) guidelines for the conduct of randomized trials (358-362); Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (363-365); Cochrane guidelines (191,336); Standards for Reporting of Diagnostic Accuracy (STARD) studies (341-352); and American Pain Society (APS) and American Academy of Pain Medicine (AAPM) guidelines prepared by Chou and Huffman (105,293).

Apart from the description of various criteria for considering the studies for inclusion, appropriate literature search, data collection and analysis, and methodologic quality or validity assessment were performed.

The quality of each individual article used in this analysis was assessed by Cochrane review criteria as shown in Table 4 in Part I (39,336) for randomized trials, Newcastle-Ottawa Scale for observational studies as shown in Tables 5 and 6 in Part I (39,338), and Quality Appraisal of Reliability Studies (QAREL) checklist for diagnostic accuracy studies (339,344) as shown in Table 7 in Part I (39). Even though none of these instruments or criteria has been systematically assessed and the advantages and disadvantages of each system continue to be debated, they represent contemporary available tools and methodology. Furthermore, the systematic reviews for guideline preparation have utilized robust outcome measures.

Meta-analysis was performed appropriately when the predetermined minimum number of studies was available, and finally, analysis of evidence was based on the United States Preventive Services Task Force (USPSTF) criteria as illustrated in Table 8 in Part I (39,366), which has been utilized by multiple authors (9-38,105,191,293). The analysis was conducted using 3 levels of evidence, ranging from good, fair, and limited or poor, in all systematic reviews (9-38).

IV. SPINAL INTERVENTIONAL TECHNIQUES

Chronic spinal pain is a complex and multifactorial phenomenon. Consequently, the high prevalence of chronic spinal pain, the numerous modalities of treatments applied in management of the problem, and the growing social and economic costs continue to influence medical decision-making. Despite its commonality, both in primary care and tertiary care, it is often difficult to reach a definite diagnosis of the origin of spinal pain. Interventional techniques are based on the philosophy of a neurophysiologic basis, in that when present, a structural origin of pain is important with or without coexisting psychosocial abnormalities and comorbid conditions. A major source of exponential growth in treatment modalities is the inherent difficulty in obtaining an accurate diagnosis. In the search of a diagnosis, an inaccurate or incorrect diagnosis, may lead not only to expensive diagnostic ventures, but to treatment failures resulting in wasted health care dollars, and diversion of essential health care resources. Fundamental to proper treatment is an accurate diagnosis which is based on the reliability of the test used to make the diagnosis. There are no universally accepted gold standards for the diagnosis of spinal pain, regardless of the suspected source (3-8,11,13,15,17,33,36-39,41,101,105,111,112,115,283,291,293-320,367-414). In the diagnosis of pain due to intervertebral discs, facet joints, sacroiliac joint, muscles, and ligaments, an accurate diagnosis is made either by non-interventional techniques or interventional techniques (415-422). The majority of the pain problems are not related to an easily identifiable cause.

1.0 Controlled Diagnostic Interventional Techniques

Based on history, physical examination, imaging, and nerve conduction studies in non-radicular pain, a precise cause of pain may be identified in only approximately 15% of patients (184-189,367-504). However, it has been described that with application of controlled diagnostic interventional techniques, a diagnosis may become a reality in 85% of the patients rather than 15% (11,13,15,17,26,33,36-38,111,383,384).

Consequently, precision diagnostic blocks are used to clarify multiple challenging situations, in order to determine the pathophysiology of clinical pain, the site of nociception, and the pathway of afferent neural signals.

Various diagnostic techniques with proven accuracy include diagnostic facet joint nerve blocks, sacroiliac joint injections, and provocation discography.

The theoretical basis of controlled diagnostic blocks is that if a patient genuinely has pain from a particular target structure, complete or near complete relief of that pain should be obtained consistently whenever that structure is anesthetized, and repeating the diagnostic block can increase the diagnostic accuracy by testing for consistency of response and for the effect of different aesthetic agents.

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 and a physiological sense (383,384). If a particular structure is said to be the target, it must be shown that the structure is anesthetized and either does or does not produce a result within the distribution of that structure. Face validity can be tested and established either by a study whose results can be replicated or by testing for face validity in each and every case. The face validity may be established by radiographic imaging with injection of a contrast agent or by a physiological approach utilizing a detectable and testable function other than pain (e.g., distal extremity temperature monitoring with a sympathetic block).

Construct validity 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 (383,384).

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 (383) has developed testing for construct validity of diagnostic blocks by other means. Features such as the false-positive rates 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 rates are known, the specificity of the test can be derived as the complement of the false-positive rates.

One 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 struc-

ture 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 second approach, most commonly utilized in the United States because it is also a more pragmatic approach, is to use comparative local anesthetic blocks. The blocks are performed on separate occasions using local anesthetic agents with different durations of action (383,384,415-422). In this approach, the consistency of response and the duration of response are tested. Failure to respond to the second block constitutes inconsistency, and indicates that the first response was false-positive. A response concordant with the expected duration of action of the agent used strongly suggests a genuine, physiologic response.

2.0 Therapeutic Interventional Techniques

Multiple therapeutic spinal interventional techniques are applied in managing chronic spinal pain. The rationale includes the commonality and complexity of spinal pain problems and ability of diagnostic blocks to identify sources of chronic spinal pain. Facet joints, discs, and sacroiliac joints are proven sources of chronic spinal pain and are accessible to neural blockade (9-38). Removal or correction of structural abnormalities of the spine may fail to cure and may even worsen painful spinal conditions (3,8-38,82,139,177,195,196,202,207,232,260,261,295,367-374,505-551). The degenerative processes of the spine and the origin of spinal pain are complex without correlation of radiographic changes to the clinical picture and prognosis (8,413-504). The effectiveness of a large variety of therapeutic interventions used to manage chronic spinal pain has not been demonstrated conclusively. Finally there is increasing evidence supporting the use of spinal interventional techniques in managing chronic spinal pain (4-38).

Multiple therapeutic interventional techniques with reasonable evidence that are commonly applied are epidural injections including adhesiolysis, facet joint interventions, sacroiliac joint interventions, intradiscal therapies, mechanical disc decompression, and implantable therapies.

V. MANAGEMENT OF LOW BACK PAIN

Low back pain is the most common of all spinal, and even chronic, pain problems. Lumbar intervertebral discs, facet joints, sacroiliac joints, ligaments, fascia, muscles, and nerve root dura have been shown to be capable of transmitting pain in the lumbar spine with resulting symptoms of low back pain and lower extremity pain (8,10,11,13,17,33,36,374,551).

Lumbar disc herniation and spinal stenosis are diagnosed with physical examination, radiological assessment, and neurophysiological assessment (368,374,552-555). For chronic low back pain without disc herniation or radiculitis, the precision diagnostic blocks applied include lumbar facet joint nerve blocks, lumbar provocation discography, and sacroiliac joint blocks, and to a lesser extent, lumbosacral selective nerve root blocks or transforaminal epidural injections in the diagnosis of difficult radicular pain syndromes (11,17,33,36,374).

Low back pain is treated based on diagnosis with various modalities including epidural injections, percutaneous adhesiolysis, intradiscal therapy or annular thermal therapy, and mechanical disc decompression for disc-related pain, either discogenic or secondary to disc herniation, radiculitis, spinal stenosis, or post surgery syndrome. Facet joint interventions and sacroiliac joint interventions are utilized in managing facet joint and sacroiliac joint pain.

1.0 Disc-Related Pathology, Spinal Stenosis, and Radiculitis

Chronic, persistent low back, lower extremity pain, and radicular pain may be secondary to disc herniation, disc disruption, disc degeneration, spinal stenosis, or post lumbar surgery syndrome resulting in disc-related pain with or without radiculitis. Herniated lumbar disc is a displacement of disc material (nucleus pulposus or annulus fibrosis) beyond the intervertebral disc space. Over the past 78 years, voluminous literature has been published describing the epidemiology, diagnosis, and numerous treatment modalities for herniated disc pain, following the description of disc herniation by Mixter and Barr in 1934 (552). However, magnetic resonance imaging (MRI) findings of a herniated disc are not always accompanied by clinical symptoms (433). The prevalence of a symptomatic herniated lumbar disc is about 1% to 3% (554) with the highest prevalence among people aged 30 to 50 years (555), with a male to female ratio of 2:1 (556). In individuals aged 25 to 55

years, about 95% of herniated discs occur at the lower lumbar spine (L4/5 and L5/S1 level); disc herniation above this level is more common in people aged over 55 years (557,558). Lumbar disc displacement may present as internal disc disruption, disc prolapse, disc protrusion, disc extrusion, disc herniation, or simply discogenic pain. The estimated prevalence of lumbar radiculopathy or sciatica has been described as 9.8 per 1,000 cases (559), 5.1 in men and 3.7 in women (560). Lumbar radiculopathy secondary to disc herniation resolves spontaneously in 23% to 48% of patients, but up to 30% to 70% will still have pronounced symptoms after one year, with 5% to 15% of patients undergoing surgery (561-563). Even though first described by Wirshow in 1857, the pathophysiology and the mechanism of pain due to disc herniation remain controversial (564,565). However, the intervertebral disc has been implicated as a source of spinal pain based on decades of pre-clinical, clinical, and epidemiological research, though the precise mechanisms still continue to be debated as the literature evolves (36,374,379-381,566-598). Further, based on controlled evaluations, lumbar intervertebral discs showed the prevalence of internal disc disruption in 39% of a younger cohort of patients following injury (380), and 42% in a heterogenous population comprised of all age groups and all types of low back pain (331). Further, in a study that sought to determine the prevalence of discogenic pain without assessing internal disc disruption, the reported prevalence rate was 26% (378).

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 (374,599-603). Disc bulging, protrusion, and herniation 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. Central spinal stenosis is prevalent in 27.2% of the population (601,602).

Symptoms of central spinal stenosis may be related to a neurovascular mechanism such as arterial flow in cauda equina, venous congestion, and increased epidural pressure (603-611); nerve root excitation by local inflammation; or direct compression in the central canal (603,608). Thus, spinal stenosis is a multifactorial disorder, and clinical presentation can be variable with or without neurogenic claudication manifested by pain in the buttocks or legs when walking, which disappears with sitting or lumbar flexion (603,609,610).

Pain and disability in the low back and lower extremities following lumbar spine surgery has been hypothesized to be secondary to multiple causes including epidural fibrosis, sacroiliac joint pain, disc herniation, discogenic pain, spinal stenosis, arachnoiditis, and facet joint pain, along with inappropriate surgery (8,519,522-524,526,612-626). While the debate continues on epidural fibrosis as being the major cause of pain after lumbar spine surgery with multiple authors describing a lack of association (614-617), one study found that patients with extensive epidural fibrosis were 3.2 times more likely to experience recurrent radicular pain than those with less scarring (522). Further, experimental studies have provided electrophysiological evidence of neurologic disturbances caused by peridural scar formation (622). A multitude of other abnormalities including mechanical tethering of nerve roots secondary to epidural fibrosis in the vertebral canal (623,624), disturbances in blood flow (625), and expression of proinflammatory cytokines causing irritation of exposed dorsal root ganglion and triggering painful responses have been described (626). In addition, osteopontin has been shown to play a major role in the formation of epidural fibrosis and a mark-up dorsal root ganglia response to peridural scar formation (619). Additional experimental evidence has implicated paraspinal muscle spasms, tail contracture, pain behaviors, tactile allodynia, epidural and perineural scarring, and nerve root adherence to the underlying discs and pedicle in animal models (627,628).

In any type of disc-related pain, spinal stenosis, or radiculitis, radiographic evidence of disc herniation or spinal stenosis does not accurately diagnose low back or lower extremity pain. Diagnosis based on history, physical examination, and radiological imaging for other origins such as small disc herniations has low sensitivity and specificity in determining whether or not the disc or spinal stenosis are the primary sources of low back and lower extremity pain (11,17,33,36,235-237,244,255,260,261,374).

Open discectomy and decompression, with or without fusion, are the most common surgical interventions performed for disc herniation, spinal stenosis, and post surgery syndrome. However, absolute indications for surgery, even though rare, include altered bladder function and progressive muscle weakness (629). The usual indication for surgery is to provide for the rapid relief of pain and to address the possibility of impending disability in the majority of patients whose recovery is unacceptably low. While it appears that surgery provides good pain relief with improvement in functional status, specifically

on long-term follow-up, the role of surgical interventions in contained disc herniations has been limited. In fact, Carragee et al (550) showed poorer surgical outcomes in patients with massive annular defects and in those with an intact annulus and no identifiable fragment in a report of single level lumbar discectomies in 187 consecutive patients with a mean age of 37.5 years. Similarly, it was also shown that with sequestered or extruded lumbar disc herniations, the prognosis was better than with contained disc herniations with single level microdiscectomy (631). Patients with contained disc herniations, a predominance of back pain, and smoking are expected to have poorer outcomes and decreased return to duty rates. Similarly, lumbar spinal stenosis has been described as one of the most frequent indications for spine surgery in patients older than 65 years of age (176,182,632-640).

Management of symptomatic disc herniation, spinal stenosis, discogenic pain, or post surgery syndrome relies mainly on conservative care combining physiotherapy, structured exercise programs, analgesics, anti-inflammatory drugs, and opioids. Epidural injections including adhesiolysis and mechanical disc decompression with various modalities may be alternative techniques prior to surgery in patients with indications for surgery, in contained disc herniations, mild to moderate symptomatic spinal stenosis, and post surgery syndrome. Multiple systematic reviews with inappropriate assessment of interventional techniques have shown a lack of effectiveness of interventional techniques in managing disc-related pathology, spinal stenosis, radiculitis, and post surgery syndrome.

1.1 Diagnosis of Disc-Related Lumbar Pathology

The assessment of differential diagnosis is based on history, and physical examination which includes neurological examination, motor examination, sensory examination, reflex examination, and application of provocative maneuvers including straight leg raising test, crossed straight leg raising test, bowstring sign, and slump test. Deyo et al (641) showed that sciatica was highly sensitive for a clinically important herniated disc, as was old age for spinal stenosis and compression fractures. Subjective symptoms of numbness is considered reasonably sensitive (0.76), but not specific (0.33) as a sign of radiculopathy (642). Objective signs of numbness are reasonably sensitive, although numbness is not specific as a sign of radiculopathy. Radiation of pain needs to be carefully interpreted. Somatic referred pain in the buttock or lower limb can be expected. Somatic referred pain is mostly in the buttock or lower extremity with any type of pain generators in the lumbar spine and it should not be confused with radicular pain. The cardinal distinctions lie in the quality of pain and its behavior. Table 1 shows the differences between radicular and somatic pain.

Rubinstein and van Tulder (401), in a best evidence review of diagnostic procedures for neck and low back pain, showed that a number of factors can be identified which can assist the clinician in identifying sciatica due to disc herniation or serious pathology. However, they were unable to show any evidence based on history leading to a diagnosis not related to radicular pain. A neurologic and musculoskeletal examination may assist in the diagnosis of radiculopathy or radicular pain with identification of disc herniation at various levels. Figure 5 illustrates the clinical features of posterolateral lumbar intervertebral disc herniation. Straight leg raising or cross straight leg raising and motor examination may be crucial in the assessment of disc herniation. Table 2 shows the diagnostic features for various levels of nerve root involvement.

However, radiculitis may be seen not only with herniation of the nucleus pulposus, but also with central and foraminal spinal stenosis, nerve root entrapment in the lateral recess, and other causes such as spondylolisthesis, spondylolysis, facet joint cysts, and epidural fibrosis, internal disc disruption, or discogenic pain without involvement of other structures.

Central spinal stenosis resulting in lumbar radiculopathy is differentiated by pain on walking that is relieved by rest, the feeling that the legs are going to give away, a feeling of cold or numbness in the legs, a feeling that the legs are made of rubber and do not belong to the patient, and night pain that is relieved by walking. In addition, radiologic evaluation often differentiates this from disc herniation.

Lateral recess stenosis with nerve entrapment mostly presents without low back pain and rare muscle weakness. The pain may radiate into the ankle and occasionally into toes. Further, radiologic examination often differentiates it from lumbar radiculopathy from disc herniation.

1.1.1 Diagnostic Interventional Techniques

In difficult cases, without radicular symptoms, diagnostic interventions applied include diagnostic selective nerve root blocks and provocation lumbar discography.

1.1.1.1 Diagnostic Selective Nerve Root Blocks

Lumbosacral selective nerve root blocks and/or transforaminal epidural injections are used for the

Table 1. *Features of somatic and radicular pain.*

	Somatic or Referred Pain	Radicular Pain
Segment Causes	Posterior segment or element	Anterior segment
	Facet joint pain	Disc herniation
	Sacroiliac joint pain	Annular tear, discogenic pain
	Myofascial syndrome	Spinal stenosis
	Internal disc disruption	
Symptoms		
Quality	Dull, aching, deep	Sharp, shooting, superficial, lancinating
	Like an expanding pressure	Like an electric shock
	Poorly localized	Well localized
	Covers a wide area	Leg worse than back
	Back worse than leg	Paresthesia present
	No paresthesia	Well defined
	No radicular or shooting pain	Radicular distribution
Modification	Worse with extension	Worse with flexion
	Better with flexion	Better with extension
	No radicular pattern	Radicular pattern
Radiation	Low back to hip, thigh, groin	Follows nerve distribution
	Radiation below knee unusual	Radiation below knee common
	Quasi segmental	Radicular pattern
Signs		
Sensory Alteration	Uncommon	Probable
Motor Changes	Only subjective weakness	Objective weakness
	Atrophy rare	Atrophy possibly present
Reflex Changes	None	Commonly described, but seen only occasionally
Straight Leg Raises	Only low back pain	Reproduction of leg pain
	No root tension signs	Positive root tension signs

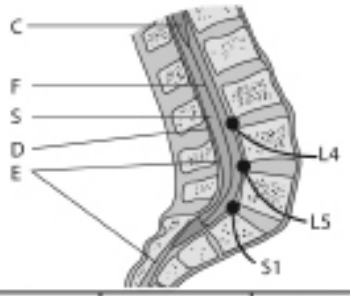
Adapted and modified from: Manchikanti L, et al. Low back and lumbar radicular pain. In: Manchikanti L, et al (eds). *Clinical Aspects of Pain Medicine and Interventional Pain Management: A Comprehensive Review*. ASIPP Publishing, Paducah, KY, 2011, pp 87-114 (374).

diagnosis and treatment of different disorders causing low back and lower extremity pain; however, a clear consensus on the use of selective nerve root injections as a diagnostic tool does not currently exist (33,643). In addition, the validity of this procedure as a diagnostic tool is not clear. The terms radicular pain and nerve root pain specifically apply to a single symptom – pain – that arises from one or more spinal nerve roots (33). The rationale for a diagnostic spinal nerve block is that if a particular spinal nerve is responsible for causing or mediating a patient's symptoms, then anesthetizing that nerve should theoretically temporarily relieve symptoms. Shah (643) questioned the anatomic selectivity and physiologic selectivity. There has been only one systematic review which is an update of a previous systematic review (33).

1.1.1.1.1 Evidence Assessment

The literature search provided one systematic review (33) - the update of a previous systematic review published in 2007 (644) and multiple studies (645-666). The systematic review (33) included 19 studies (645-656,659,661-666). Of these, 2 studies assessed contrast flow selectivity or flow patterns (647-649). One study assessed the distinct sensory effects of selective nerve root block (646). In addition, 15 studies evaluated diagnostic accuracy (650-656,659-666). Characteristics of the reported diagnostic accuracy studies are illustrated in Table 5 of the systematic review (33).

Diagnostic selective nerve root blocks have often been used to confirm the pain-generating nerve root. Despite its widespread use, the reported accuracy of these blocks at determining a symptomatic level varies



Herniation	L3–4	L4–5	L5–S1
Nerve root	L4	L5	S1
Pain			
	Low back ► hip ►antero-lateral thigh ► medial leg	Above S-1 joint►hip ► lateral thigh and leg ► dorsum of foot	Above S-1 joint►hip ► posterolateral thigh and leg ►heel
Numbness			
	Anteromedial thigh and knee	Lateral leg and first 3 toes	Back of calf ► lateral heel and foot ►toe
Atrophy	Quadriceps	Minor or non-specific	Gastrocnemius and soleus
Motor weakness	Extension of quadriceps	Dorsiflexion of great toe and foot	Plantar flexion of great toe and foot
Screening exam	Squat and rise	Heel walking	Walking on toes
Reflexes	Knee jerk diminished	None reliable	Ankle jerk diminished

Source: Manchikanti L, et al. Low back and lumbar radicular pain. In: Manchikanti L, et al (eds). C*linical Aspects of Pain Medicine and Interventional Pain Management: A Comprehensive Review.* ASIPP Publishing, Paducah, KY, 2011, pp 87-114 (374).
Originally modified from Wilkinson JL. *Neuroanatomy for Medical Students.* John Wright & Sons, Bristol, 1986, p. 46; Keim HA, Kirkaldy-Willis WH. Low back pain. Clin Symp 1987; 39:18; and Bigos S, et al. Acute low back problems in adults: Practice guideline, quick reference guide number 14: AHCPR Pub. No. 95-0643, Rockville, MD, 1994, US Department of Health and Human Services, Public Health Service, Agency for Health Care Policy and Research, 1994. Adapted from Giles LG. Diagnosis of mechanical low back pain with or without referred leg pain. In: *Clinical Anatomy and Management AU9 of Low Back Pain.* Vol. 1. Butterworth-Heinemann, Oxford, 1997, p 322).

C = Conus medullaris; D = dural tube; E = epidural space; F = filum terminale; S = subarachnoid space.

Fig. 5. *Clinical features of a posterolateral lumbar intervertebral disc herniation.*

Table 2. *Diagnostic features for various levels of nerve root involvement.*

Herniation	Nerve Root	Pain	Numbness	Atrophy	Motor Weakness	Screening Examination	Reflexes
L3-4	L4	Low back; hip; anterolateral thigh, medial leg	Anteromedial thigh and knee	Quadriceps	Extension of quadriceps	Squat and rise	Knee jerk diminished
L4-5	L5	Above S1 joint; hip; lateral thigh and leg; dorsum of foot	Lateral leg and first 3 toes	Minor or nonspecific	Dorsiflexion of great toe and foot	Heel walking	None reliable
L5-S1	S1	Above S1 joint; hip; posterolatera and thigh leg; heel.	Back of calf; lateral heel and foot; toe	Gastrocnemius and soleus	Plantar flexion of great toe and foot	Walking on toes	Ankle jerk diminished

Source: Manchikanti L, et al. Low back and lumbar radicular pain. In: Manchikanti L, et al (eds). *Clinical Aspects of Pain Medicine and Interventional Pain Management: A Comprehensive Review*. ASIPP Publishing, Paducah, KY, 2011, pp 87-114 (374).

from 31% to 100% (33). In addition to the wide range in accuracy, most of the studies have been retrospective in nature, have had a small sample size, and have failed to describe their methodologies in detail. In addition, in all the studies on the topic to date, the definition of a positive or negative result based on the degree of pain relief has either been arbitrarily set between 50% and 100% or has not been clearly defined. A majority of studies have analyzed the sensitivity, specificity, accuracy, and predictive values because they focus on the results of diagnostic selective nerve root block on the presumed lesion level alone, and many employed "control" injections at "unaffected roots." Consequently, the diagnostic accuracy of selective nerve root blocks continues to be questioned (33).

Only one controlled blinded study by Yeom et al (656) assessed the control root levels and defined a positive block as ≥ 70% pain relief, as determined by receiver-operator characteristic (ROC) analysis. They arrived at a sensitivity of 57%, a specificity of 86%, an accuracy of 73%, a positive predictive value of 77%, and a negative predictive value of 71%. They confirmed the findings of other investigators that false-positives were frequently the result of overflow of the injectate from the injected level into either the epidural space or to another level that was symptomatic. They also demonstrated that false-negative blocks were due to insufficient infiltration, insufficient spread of injectate, and intra-epineural injections. Multiple other studies have demonstrated difficulty in localizing injections without inadvertent spread to the epidural space or another level even when low volumes (i.e., 0.5 mL) are employed (647-649,655). In the study by Yeom et al (656), the evidence was shown to be only moderate, and the diagnostic value was relatively low compared with previous reports (650,652,655,659,661-664,665), most of which did not attempt to quantify false-positive results. In this and other studies, significant false-negative blocks occur concomitantly with false-positives. Almost all studies were characterized by significant limitations.

Overall, this systematic review (33) suggests that the diagnostic value of selective nerve root blocks in the lumbar spine is not high, confirming the hypothesis of Shah (643). The value may be improved by using a nerve stimulator and utilizing a meticulous injection technique with extremely low volume; however, this contention is based on only one high quality study (656).

Selective nerve root blocks can encompass many of the disadvantages of a diagnostic test. One of the major challenges is that unlike facet joint nerve blocks, sacroiliac joint nerve blocks, and even discography, selective nerve root blocks are not generally performed as dual blocks in a controlled atmosphere, which can serve to reduce false-positive results (11,13,15,17,36-38). Because of this, and the fact that no reference standard such as a tissue or biopsy diagnosis can confirm the results, the validity of selective nerve root blocks in the diagnosis of lumbosacral radiculitis has not been established. In addition, the influence of potential confounding factors such as psychological disorders, opioid usage, age, and obesity have on the results of selective nerve root blocks have not been studied (33).

Not only has the construct validity of selective nerve root blocks been questioned, but also the face validity. Local anesthetic injected accurately onto the targeted nerve root(s) should theoretically alleviate pain only in the distribution of the nerve(s). Yet, in addition to there being significant dermatomal overlap between adjacent nerve roots, even when the procedure is performed with low volumes under fluoroscopic visualization, the injec-

tate frequently extravasates to adjacent potential pain generators, which can undermine face validity.

Despite these obstacles, there is evidence that does support the validity of selective nerve root blocks. In an early study performed on 105 patients with radicular pain, 57% of whom had undergone previous surgery, Haueisen et al (652) compared the diagnostic accuracy of spinal nerve root injections with lidocaine to myelography and electromyography with regard to surgical findings and treatment outcomes. Among the 55 patients who underwent surgical exploration, selective nerve root injections were accurate in identifying the surgical pathology in 93% of patients, which favorably compared to accuracy rates of 24% for myelography, 58% for discography, and 38% for electrodiagnostic studies. At follow-up periods ranging from one to 5 years, 49% of patients had minimal or no pain vs. 16% of patients who were treated non-operatively. The authors concluded that in patients with surgically altered anatomy, selective nerve root blocks are helpful in making an accurate diagnosis.

Herron (655) examined the response to selective nerve root blocks as a means to confirm the spinal origin of pain. The surgical outcomes were as expected, with the best outcomes noted for lumbar disc herniation (83% good outcomes) and spinal stenosis (55% good results), while those with a history of prior surgery experienced the poorest results (29% good outcomes). The response to injection was helpful in narrowing potential surgical patients from 215 to 71.

In a study dating from 1980, Tajima et al (651) descriptively compared mechanical stimulation and anesthetic response to nerve root injections against myelography. Comparison to normal dye patterns in reference patients and cadavers was also used to clarify the role of radiculography as a diagnostic imaging tool. The disorders studied were diverse, but selective nerve root blocks were deemed helpful in determining the painful segment in the majority of patients, with corresponding abnormalities found on surgical repair. The authors also felt it was helpful in limiting surgical decompression to the area of primary pain generation.

A retrospective study by Schutz et al (662) reported on the accuracy of selective nerve root blocks in 23 patients. Among the 15 patients in whom an operation was performed at the level indicated by the selective nerve root block, 13 (87%) had findings that correlated with the results of the diagnostic block. Eighteen percent of blocks failed because of either intolerable pain during the procedure or failure to stimulate the desired root, most often at S1.

In reference to accuracy, it is generally measured in terms of sensitivity and specificity. Specificity is a relative measure of the prevalence of false-positives, whereas sensitivity is the relative prevalence of false-negative results. There are several factors that can lead to a false-positive selective nerve root block despite precautions, including the close proximity of numerous potential pain-generating structures that can be anesthetized by the aberrant extravasation of local anesthetic. Consequently, selective nerve root blocks are considered to have a higher degree of sensitivity than specificity.

The sensitivity and specificity of diagnostic selective nerve root blocks range from 45% to 100% (650,652,656,659-662,665,667). Schutz et al (662) reported finding a corroborative lesion at the time of surgery in 87% of patients with a positive diagnostic block. Krempen and Smith (665) reported 100% surgical confirmation following a positive block. Dooley et al (661) reported 3 out of 51 blocks to be false-positive, for a specificity of 94%, while Stanley et al (659) reported 95% specificity. Van Akkerveeken (650) attempted to establish the diagnostic value of selective nerve root injections by comparing 37 patients with confirmed lumbar radiculopathy to 9 patients with pain due to metastases. The author found the sensitivity for neuropathic spinal pain to be 100%, with the specificity, as determined by comparison to a normal level on imaging, around 90%. When calculating the positive predictive value, there was a 95% chance that patients with a positive selective nerve block would experience a good surgical outcome. If all patients who declined surgery were included in the analysis as surgical failures, the positive predictive value declined to 70%. Other reported specificities are 96% by Anderberg et al (660), 93% by Haueisen et al (652), and 85% by Dooley et al (661).

In a small prospective study comparing the specificity of 0.6 mL, 1.1 mL, and 1.7 mL, Anderberg et al (667) found that the use of lower volumes was associated with comparable "sensitivity," but increased specificity. A well-controlled prospective study by Yeom et al (656) showed a sensitivity of 57%, a specificity of 86%, a positive predictive value of 77%, and a negative predictive value of 71% based on 70% pain relief determined by receiver-operator characteristic analysis. Overall, the accuracy was determined to 73%.

Table 5 of the systematic review (33) shows the

Table 3. *Summary of diagnostic accuracy studies.*

Manuscript Author(s)	Methodological Quality Scoring	Number of Subjects	Results
Van Akkerveeken, 1993 (650)	8/11	46	P
Krempen & Smith, 1974 (665)	9/11	22	P
Tajima et al, 1980 (651)	9/11	106	P
Haueisen et al, 1985 (652)	9/11	105	P
Castro & van Akkerveeken, 1991 (653)	8/11	24	P
Kikuchi et al, 1984 (654)	8/11	62	P
Herron, 1989 (655)	9/11	78	P
Yeom et al, 2008 (656)	9/11	47	N
Wolff et al, 2001 (666)	9/11	29	N
Stanley et al, 1990 (659)	9/11	50	P
Dooley et al, 1988 (661)	9/11	62	P
Schutz et al, 1973 (662)	7/11	23	P
Sasso et al, 2005 (663)	8/11	101	N
Porter et al, 1999 (664)	7/11	56	N

P = positive; N = negative

characteristics of various studies meeting inclusion criteria.

Thus, based on the published evidence, it appears that even though evidence is emerging, the role of selective nerve root blocks in providing accurate diagnosis prior to surgical intervention is limited. Our literature search yielded no further studies.

1.1.1.1.2 Analysis of Evidence

The evidence was synthesized based on the relief criteria when selective nerve root injections were performed. Table 3 illustrates the summary of the results of the diagnostic accuracy studies.

The evidence is limited based on 10 of 15 studies providing positive evidence assessing the accuracy; however, none of the studies provided strong evidence.

1.1.1.1.3 Recommendations

Based on the present comprehensive evaluation of the available literature (33,650-656,659,661-666), diagnostic selective nerve root blocks may be recommended with limited evidence in the lumbar spine in patients with an equivocal diagnosis and involvement of multiple levels.

1.1.1.2 Lumbar Discography

Based on provocation discography, the prevalence of discogenic low back pain, with or without internal disc derangement, has been estimated between 26% and 42% of chronic low back pain sufferers without radicular symptoms (36,378,380,668).

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 low back pain (669,670). Implicitly, discography is an invasive diagnostic test that should only be applied to those chronic low back pain patients in whom one suspects a discogenic etiology and an appropirate treatment is available. Discography literally means the opacification of the nucleus pulposus of an intervertebral disc to render it visible under radiography (36,671,672). In addition, aging causes fissures and tears in the annulus. Further, there are also multiple types of chemical changes that occur in the degenerated discs with the release of inflammatory substances (571-580,583,669,670,673-686).

Basic and clinical studies have shown that the lumbar discs are innervated and can be a source of pain that has pathomorphologic correlates (581,673-680,686,687). 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 (36).

Proponents of discography are that the rationale is well established (36,379,391,688). Discography is helpful in patients with low back or lower extremity pain to acquire information about the structure and sensitivity of their lumbar intervertebral discs and to make informed decisions about treatment and modifications of activity. Although the clinical exam may demonstrate a favor-

able correlation with discography or disc-related pain (36,375,379,386-388,687-691), this information may not be sufficient to guide invasive treatment for discogenic pain.

Examinations of cadaver lumbar discs typically confirm the presence of annular tears and disc degeneration, as revealed by discograms (692-696). Lumbar discography was compared with myelography, computed tomography (CT), MRI, and results of surgical and conservative management. CT discography was reported to be more accurate than myelography. The assessment of the correlation of discography in a recent systematic review (36) with radiological studies showed 33 studies comparing lumbar discography with CT scanning or MRI in patients with degenerative disc disease. Of these, 13 showed a good correlation, 7 showed a fair correlation, and 13 showed a limited or poor correlation. Overall, 20 of 33 studies showed a good or fair correlation.

The technique of lumbar discography has been standardized by the International Association for the Study of Pain (IASP) criteria (671) and has been well studied (8,36,373,391,567,697-702). The definition of a positive discogram, per International Spine Intervention Society (ISIS) guidelines (672) is pain > 7/10, concordance, pressure < 50 psi above opening pressure, Grade III anular tear, and a painless control disc. ASIPP guidelines (8) have defined a positive discogram only if the target disc produces concordant pain with an intensity of at least 7 on a 10-point pain measurement scale or 70% of the highest reported pain (i.e., worst spontaneous pain of 7 = 7 x 70% = 5), and 2 adjacent discs with provocation discography do not produce any pain at all or only one disc in the case of L5/S1 with low volume and low pressure injection.

In an ideal situation, a gold standard or criterion is obtained by tissue confirmation of the presence or absence of a disease; however, surgical inspection of a degenerated disc cannot determine if discogenic pain is present or not. Thus, the greatest challenge concerning discography continues to be the "gold standard" dilemma and the treatments applied based on the results of the test (8,11,13,15,17,26,33,36-38,105,111,112,567,687,703-712). Consequently, opponents of discography contend that escalating numbers of unnecessary fusions have been performed in the United States each year for indications of discogenic pain (520,633,704,705,713-723). However, proponents argue that when properly utilized, discography screening can decrease the number of unnecessary operations. The discrepancy in opinions is based on the lack of positive outcomes with surgical interventions for discogenic pain.

Proponents of discography also argue that it is the only diagnostic modality that attempts to correlate pathology with symptoms. This point is reasonable given the fact that close to two-thirds of asymptomatic subjects have been found to have abnormal findings on MRI and CT scans of their lumbar spines, with many of the findings of a nonspecific nature (392,427,428,430,438,445,450,722-744). On the other hand, opponents of discography argue that the significance of discographic pathology is low, the validity of provoked symptoms is unproven, and fusion outcomes do not correlate with findings. These criticisms are further supported by the relative lack of specificity of discography, the inherent difficulty invalidating provoked symptomatology, and multiple studies showing false-positive discograms in patients without low back symptoms (395,396,670,723,745-752).

1.1.1.2.1 Evidence Assessment

The literature search provided 11 systematic reviews (36,105,111,112,116,217,375,379,567,697,700). All of the systematic reviews met the inclusion criteria. Shah et al (700), Buenaventura et al (697), and Manchikanti et al (567) performed a systematic assessment of the value of provocation discography utilizing West et al's Agency for Health care Research and Quality (AHRQ) criteria for systematic reviews. Hancock et al (375) focused on the diagnostic criteria comparing discography with other tests. Wolfer et al (379) evaluated false-positive rates.

Wolfer et al (379) utilized multiple studies with methodologic quality evaluation and scoring of lumbar discographic studies in their evaluations. The American College of Occupational and Environmental Medicine (ACOEM) guidelines (116) and Chou and Huffman (105) focused on several specific types of studies, rather heavily on Carragee's studies, and concluded that provocation discography was not a reliable diagnostic test. However, reassessment of the ACOEM guidelines (217) and a critical review of the APS clinical practice guidelines for interventional techniques by Manchikanti et al (111) repudiated these findings.

The recent systematic review by Manchikanti et al (36) with an extensive evaluation of 33 studies compared discography with other diagnostic tests, 30 studies assessed the diagnostic accuracy of discography, 22 studies assessed surgical outcomes for discogenic pain, and 3 studies assessed the prevalence of lumbar discogenic

pain. Tables 4 - 6 of the systematic review (36) illustrate various studies comparing lumbar discography with CT scan or MRI in patients with degenerative disc disease; list the characteristics of the diagnostic accuracies studies; and summarize the outcome data for lumbar disc replacement or fusion surgery based on preoperative discography screening. Table 10 of the systematic review (36) shows the summary of false-positive rates percent per patient and per disc for experimental studies in subjects asymptomatic of low back pain as described by Wolfer et al (379). The quality of the overall evidence supporting provocation discography based on the above studies appears to be fair. Thus, the latest systematic review by Manchikanti et al (36) was utilized in the evidence synthesis for the guidelines. Our literature search yielded one additional study (688) not included in discography systematic review by Manchikanti et al (36).

1.1.1.2.2 Prevalence of Lumbar Discogenic Pain

Table 4 describes the 3 studies assessing the prevalence of discogenic low back pain (378,380,668). Two of the studies focused on internal disc disruption (380,668) and reported prevalence as 39% (380) and 42% (668), respectively. The third study evaluated only discogenic pain and reported a prevalence of 26% (378). Descriptive characteristics are provided in Table 5 of the systematic review (36).

1.1.1.2.3 Diagnostic Accuracy

As shown in Table 5 of the systematic review (36), 30 studies evaluating the accuracy of discography were described. Of these, 25 studies evaluated provocation discography, 2 studies evaluated functional anesthetic discography, and 4 studies evaluated anesthetic discography. Among the 25 studies evaluating provocation discography, DePalma et al (668) reported subgroup analysis in multiple additional manuscripts (385,389,391). Of the 25 manuscripts assessed, 16 confirmed the validity of diagnostic discography. In contrast, 9 of the 25 manuscripts reported multiple confounding issues with provocation discography that could undermine its validity.

Recently, the use of anesthetic discography has generated significant interest as a means to reduce the high false-positive rates associated with provocation discography in certain patient subgroups. The rationale for this contention is extrapolated based on the reference standard used for other diagnostic spinal injections, such as facet and sacroiliac joint blocks (11,13,15,17,721). Currently, the ability of anesthetic discography used as either an adjunct or replacement for provocation discography, to enhance the accuracy of diagnosis, is mixed. One study by Alamin et al (698), conducted in 52 patients who underwent both procedures, found a 46% discordance rate between provocation and analgesic discography, with the large majority of discrepancies involving patients who were either found to be negative with analgesic discography after a positive provocation discogram (24%), or found to have only single-level disease on analgesic discography instead of 2-level involvement (16%). However, in a recent multi-center study performed with 251 patients using 4 different discography protocols and criteria, Derby et al (699) found no significant differences in prevalence rates between techniques involving pain provocation alone, pain provocation in combination with analgesic discography, or analgesic discography as a stand-alone test.

As illustrated by Wolfer et al (379), significant debate and controversy surrounds the accuracy of discography. Wolfer et al (379) demonstrated that, when using strict criteria, discography could provide valuable, accurate information regarding the intervertebral discs as potential pain generators. Notwithstanding the

Table 4. *Prevalence of lumbar discogenic pain utilizing IASP criteria.*

Study	Methodological Quality Scoring	Participants	Prevalence
Manchikanti et al, 2001 (378)	11/11	From a group of 120 patients with low back pain, 72 patients negative for facet joint pain underwent discography.	26% overall discogenic pain
Schwarzer et al, 1995 (380)	11/11	92 consecutive patients with chronic low back pain and no history of previous lumbar surgery referred for discography.	Internal disc disruption 39%
DePalma et al, 2011 (668)	11/11	Of the 156 patients, 71 underwent provocation discography. They also underwent other diagnostic blocks including facet joint nerve blocks and sacroiliac joint injections.	Internal disc disruption 42%

Adapted and modified from: Manchikanti L, et al. An update of the systematic appraisal of the accuracy of utility of lumbar discography in chronic low back pain. *Pain Physician* 2013; 16:SE55-SE95 (36).

work by Carragee et al who shed doubt on the utility of discography in patients with chronic pain or poorly controlled psychopathology, the present assessment shows at least fair evidence for diagnostic accuracy based on a total of 30 studies as listed in Table 5 of the systematic review (36) with 8 studies showing negativity, and the remaining 22 studies showing good to fair or positive evidence for accuracy.

In a recent study, Lopez et al (688) evaluated the clinical and radiological association with positive lumbar discography in patients with chronic low back pain. Their objectives were to find out if MRI findings and clinical risk factors associated with positive discography in patients with lumbar discogenic pain are caused by degenerative disc disease. They concluded that patients with a chief complaint of low back pain associated with sciatica, with more than 4 episodes of previous low back pain exacerbations and the presence of a high intensity zone (HIZ) on MRI have a higher rate of positive discography. However, these findings were not statistically significant, probably due to a small sample size. The authors also described that during discography, they noticed the end point resistance to be more prevalent in asymptomatic discs.

1.1.1.2.4 Correlation with Outcomes

There were a total of 22 studies of lumbar fusion and disc displacement surgery in patients with discogenic pain who were diagnosed using preoperative discography as shown in Table 6 of the systematic review (36). Of these, only 4 studies reported good results, with the remaining studies reporting limited effectiveness of provocation discography as a diagnostic tool. These 22 studies are shown in detail in Table 6 of the systematic review (36).

Given that very few fusion studies report significantly better outcomes following discography, there is limited evidence supporting the use of discography prior to surgical procedures. However, there is fair evidence supporting the management of discogenic pain with epidural injections (9,30,31). There is only limited evidence supporting the management of discogenic pain with intradiscal electrothermal therapy (IDET) and biacuplasty (25).

1.1.1.2.5 False-Positive Rates

A series of published studies specifically investigated the potential false-positive rates of lumbar discography (395,396,703,745,747,748,751,753-759). The Holt study (754) was performed on prisoners, with outdated techniques and noxious, irritating contrast dye (755). A false-positive rates meta-analysis by Wolfer et al (379) pooled all extractable data from high quality studies performed in subjects asymptomatic of low back pain and reported the following false-positive rates: 3% in subjects without confounding factors, 0% in the pain-free group, 10% in the low pressure positive chronic pain group, 15% in prior discectomy patients, and 12.5% in patients with residual pain after iliac crest bone harvesting. If all patients from all subgroups are combined, a total false-positive rate of 9.3% (95% confidence interval [CI], 3%, 16%) is obtained in contrast to the high false-positive rates of 40% to 83% described by Carragee et al (703,751).

1.1.1.2.6 Analysis of Evidence

The evidence for the prevalence of discogenic pain was available only with provocation discography utilizing IASP criteria evaluated in 3 high-quality studies (378,380,668).

The prevalence of internal disc disruption was estimated to be 39% in a younger cohort of patients following injury (380), and 42% in a heterogenous population comprised of all age groups and all types of low back pain (668). In a study that sought to determine the prevalence of discogenic pain without assessing internal disc disruption, the reported prevalence rate was 26% (378).

Thus, the evidence for provocation discography is fair based on 3 well-performed accuracy studies. Due to ongoing debate on the accuracy of this test and the lack of outcome parameters in patients undergoing surgical interventions, the evidence is subject to other interpretation.

There is limited evidence supporting functional anesthetic discography or provocation discography with local anesthetic injection.

The correlation between discography and various diagnostic tests was moderate to strong in 13 out of 33 evaluations, yielding limited to fair accuracy for lumbar discography compared to other non-invasive modalities of assessment.

Outcomes assessing the value of surgery in managing discogenic pain are shown in Table 6 of the systematic review (36). Based on the paucity of studies illustrating significantly better outcomes with fusion following discography, the evidence is limited supporting the use of discography prior to surgical procedures.

There is fair evidence supporting the management of discogenic pain with epidural injections (9,30,31). The evidence is fair supporting IDET and biaculoplasty (25).

1.1.1.2.7 Complications

Complications related to discography include discitis, subdural abscess, spinal cord injury, vascular injury, annular strains, epidural and paravertebral abscess, and local anesthetic toxicity (36).

1.1.1.2.8 Recommendations

The recommendations for lumbar provocation discography 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, only when a treatment is available.

1.2 Therapeutic Interventions of Lumbar Discogenic Pathology

Disc herniation, discogenic pain, spinal stenosis, radiculitis, and post surgery syndrome are managed with various types of percutaneous interventional techniques including epidural injections, percutaneous adhesiolysis, intradiscal therapies, and percutaneous disc decompression.

1.2.1 Epidural Injections

Access to the epidural space is available by caudal, interlaminar, and transforaminal approaches (8,28,30,31). The literature described substantial differences with the technique and outcomes among the 3 approaches (8,28,30,31). Thus, due to the inherent variations, differences, advantages, and disadvantages applicable to each technique (including the effectiveness and outcomes), caudal epidural injections, interlaminar epidural injections, and transforaminal epidural injections are considered as separate entities. Further, since the response to epidural injections for various pathological conditions (disc herniation and/or radiculitis, discogenic pain without disc herniation, spinal stenosis, and post surgery syndrome) is variable, outcomes are assessed based on pathology for each approach.

1.2.1.1 Caudal Epidural Injections

Several systematic reviews have evaluated the effectiveness of epidural steroids including caudal epidural injections (30,105,112,116,135,191,217,760-771). The majority of these systematic reviews, including those performed for Cochrane review (105,116,129,135,191,217,337,760-764,769-771), which evaluated caudal and interlaminar techniques in combination and erroneously included transforaminal and failed to separate various pathologies, have arrived at erroneous conclusions. In contrast, Abdi et al (765,766), Boswell et al (767), Bogduk et al (768), Conn et al (772), and Parr et al (30) evaluated caudal epidural injections as separate procedures for various pathologies, reaching opposite conclusions, illustrating the effectiveness of caudal epidural injections in managing low back and lower extremity pain. Parr et al (30), in a systematic review, reaffirmed the conclusions of Conn et al (772) with review of 73 available studies. Randomized trials and fluoroscopic observational studies (773-780) meeting methodological criteria were included in the analysis by Parr et al (30). Due to the availability of 7 randomized trials, for guideline synthesis, only randomized trials were utilized. Our literature search yielded 2 additional trials (233,781).

Pinto et al (135) in a recent systematic review and metaanalysis of epidural corticosteroid injections in the management of sciatica, included all types of studies, caudal, interlaminar, transforaminal, and fluoroscopic as well as blind, with inappropriate analysis considering active control trials as placebo control and utilizing physiotherapy criteria. They arrived at the conclusion that based on the available evidence corticosteroid injections offer only short-term relief of leg pain and disability for patients with sciatica. The long-term effects were also positive; however, they were smaller size and not statistically significant.

1.2.1.1.1 Disc Herniation and Radiculitis

As shown in Table 5, there were a total of 7 randomized trials (233,773,775-781), with one trial with 3 publications (233,773,777), meeting the inclusion criteria evaluating caudal epidural injections in managing disc herniation or radiculitis (30), of these, only 4 trials were performed utilizing fluoroscopy. Tables 14 and 15 of the systematic review (30) show the descriptive characteristics. There were 2 newly identified studies (233,781). Of these, the study by Manchikanti et al (233) was a 2-year follow-up of previously published results of a one year follow-up (773). In the remaining randomized study (781), the authors evaluated 102 patients either with conservative treatment, including medication and physiotherapy, or blind caudal epidural steroid injection. The follow-up was performed at 6 months. They showed complete relief at 6 months in 86% of the patients in the caudal epidural steroid group and 24% in the conservative management group. No relief was seen in 28% in conservative management group and 2% in caudal epidural steroid injection group. There was also partial relief noted in both groups, in 48%

Table 5. *Results of randomized trials of effectiveness of caudal epidural injections in managing disc herniation or radiculitis.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Interventions**	**Outcome Measures**	**Pain Relief and Function**			**Results**			**Comment(s)**
								Long-Term		
				3 mos.	**6 mos.**	**12 mos.**	**Short-term ≤ 6 mos.**	**> 6 mos.**	**≥ 12 mos.**	
Fluoroscopic Trials										
Manchikanti et al, 2012,2011,2008 (233,773,777) RA, AC, F 10/12	Total = 120	Lidocaine vs. lidocaine mixed with steroid Number of injections = 1 to 5	NRS, ODI, employment status, opioid intake	77% vs. 80%	77% vs. 82%	70% vs. 77%	P	P	P	Positive double-blind randomized trial.
Ackerman & Ahmad, 2007 (775) RA, AC, F 7/12	Total = 90 Caudal = 30 Interlaminar = 30 Transforaminal = 30	Methylprednisolone + saline Number of injections = 1 to 3	Numeric pain score (0-10), rating of pain relief, ODI, BDI, contrast dispersion pattern	Caudal = 57% Interlaminar = 60% Transforaminal = 283%	Caudal = 57% Interlaminar = 60% Transforaminal = 83%	NA	P	P	NA	Positive mid-term results.
Dashfield et al, 2005 (776) RA, AC, F 9/12	Total = 60 Caudal = 30 Endoscopy = 30	Lidocaine with triamcinolone Number of injections = 1	Pain relief, SF-MPQ, HAD scores	SI	SI	NA	P	P	NA	Positive mid-term results.
Makki et al, 2010 (780) RA, AC, F 7/12	Total = 57	Position: supine vs side of leg pain	VPS, ODI	SI in lateral group	NA	NA	P	NA	NA	Small study with positive short-term results.

Table 5 (cont.). *Results of randomized trials of effectiveness of caudal epidural injections in managing disc herniation or radiculitis.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Interventions**	**Outcome Measures**	**Pain Relief and Function**			**Results**			**Comment(s)**
								Long-Term		
				3 mos.	**6 mos.**	**12 mos.**	**Short-term ≤ 6 mos.**	**> 6 mos.**	**≥ 12 mos.**	
Ultrasound Trials										
Iversen et al, 2011 (778) RA, PC, UL 6/12	Total = 116	Saline or triamcinolone acetonide with saline Number of injections = 2	ODI, EQLS, VAS	N	N	N	U	U	U	Negative results in a study with numerous deficiencies with flawed design and without local anesthetic.
Blind Trials										
McCahon et al, 2011 (779) RA, AC, B 11/12	Total = 33	Methylprednisolone 40 mg vs. 80 mg with bupivacaine	ODI, VAS, HADS	SI in 40 mg group	NA	NA	P	NA	NA	Very small study with positive short-term results.
Murakibhavi & Khemka, 2011 (781) RA, AC, B 7/12	Group A = 50 control conservative management Group B = 52 caudal epidural steroid injections Total = 102 patients	Conservative management or caudal epidural steroid injections	VAS, ODI, BDI, NPI	Group A = 32% Group B = 92%	Group A = 24% Group B = 86%	NA	P	P	NA	Positive short-term results in a moderate quality study.

RA = Randomized; PC = Placebo Control; AC = Active Control; UL = Ultrasound; F = Fluoroscopy; B = Blind; P = Positive; N = Negative; NA = Not Applicable; U = Unclear; SI = Significant Improvement; VAS = Visual Analog Scale; NRS = Numeric Rating Scale; VPS = Visual Pain Scale; ODI = Oswestry Disability Index; HADS = Hospital Anxiety and Depression Scale; EQLS = European Quality of Life Scale; BDI = Beck Depression Inventory; SF-MPQ = Short-Form McGill Pain Questionnaire; NPI = Numerical Pain Intensity

Adapted and modified from: Parr AT, et al. Caudal epidural injections in the management of chronic low back pain: A systematic appraisal of the literature. *Pain Physician* 2012; 15:E159-E198 (30).

in the conservative management group and 12% in the caudal epidural steroid group. The study showed positive results; however, the follow-up was only for 6 months. Further, blinding was not possible because of the conservative management group.

There was only one study by Iversen et al (778), which was of moderate quality, utilizing a placebo design, however, without fluoroscopy, but with ultrasound and injection of steroid without local anesthetic. The study was highly deficient in multiple aspects with substantial criticism advanced (782-787). This study illustrates numerous flaws. As a first concern, the selection criteria are overtly broad. A significant proportion of patients (n = 17) did not even have to undergo randomization because their symptoms improved between assessment and randomization indicating the inclusion of short-term or subacute pain. In addition, after the randomization, 5 patients had spontaneous improvement before the first injection. A large proportion of patients were excluded due to neurologic compression, including cauda equina syndrome. They also attributed most of their results to natural course. Patient selection appears to be quite inappropriate. In chronic pain settings with long-lasting pain, patients undergoing various modalities of treatments would already have responded to a natural course or placebo effect. Further, while MRI was utilized as the criteria for disc herniation, ultimately the authors included clinically proven radiculopathy for inclusion criteria. Multiple flaws with the procedure include ultrasound identification of caudal epidural space, which the authors claim is appropriate for caudal even though they concede it was not appropriate for transforaminal. Ultrasound identification is appropriate for neither caudal nor for transforaminal (788-796). Further, the injection was not only non-targeted with an unproven technique, namely ultrasound, but also included large volumes of sodium chloride solution without local anesthetics and relatively small volumes of triamcinolone. It also appears, somewhat surprising, that only 17 patients of the 345 declined to participate in the study, even though it is a placebo-control study. Thus, overall the study failed to take into consideration multiple issues, unlike the study of transforaminal epidural injection under fluoroscopy (797). Ghahreman et al (797), have designed and evaluated a true placebo for transforaminal epidural injections and have shown that not only is sodium chloride the true placebo for intramuscular injection, but also intramuscular steroids were ineffective.

Thus, questions with regards to appropriate placebo must be dispelled. Further, the role of placebo substances into active spaces must be realized. The evidence shows that when injected into active structures, sodium chloride solution and local anesthetics are not placebos, but generate significant activity (96,97,111,112,115,129,236,237,244,250-255, 257,798-820). There has been substantial literature on the effects of placebo and nocebo and the use of impure placebos for clinical purposes (96,97,111,112,115,129,236,237,244,250-255,809,821-829).

Among the randomized trials, there were only 2 studies which included greater than 100 participants (233,773,777,778). There was only one pseudo-placebo-controlled trial (778) and the remaining studies were active-control trials (773,775-777,779,780). The placebo-controlled trial was flawed (778), even though the accompanying editorial (830) somewhat supported the study. Further, active-control trials that ranged from comparison of local anesthetic versus local anesthetic with steroid, types of steroids, dose response, and finally, caudal were also compared with interlaminar and transforaminal epidural injections.

The populations evaluated in all the included studies were consistent with the inclusion criteria for patients with disc herniation and leg pain. Only the proportion of patients utilized for disc herniation were included (when described) as shown in Table 5, even though, some studies included patients with other conditions.

Among the 7 randomized controlled trials (RCTs) (233,773,775-781), one study (778) utilized placebo injection into epidural with ultrasound guidance showing negative or unclear results with steroids, but without local anesthetic. The newly added study (781) compared conservative management with caudal epidural steroid injections, however, with a blind approach, with positive results for improvement at 6 months. Among the remaining 5 active-control trials (233,773,775-777,779,780), only one trial compared lidocaine with or without steroids (233,773,777) yielding similar results in the short-term and long-term. The second study (776) utilized lidocaine with triamcinolone without a lidocaine only group. One study (775), with inclusion of 30 patients in the caudal group, utilized sodium chloride solution with steroid without a local anesthetic group. Thus, in this evaluation, the evidence from only one properly conducted study of lidocaine with or without steroid showed equal results (233,773,777). Previously, experimental studies (831,832) and multiple other studies have illus-

trated no significant difference with or without local anesthetic (8,236,237,244,250,255,257,773,777,798-804,833-835). In one study (780), utilizing a mixture of 10 mL of normal saline, 10 mL of 0.5% bupivacaine, and 40 mg of methylprednisolone, the effect of a supine position was compared with a lateral decubitus position after injection, illustrating better results when the patients were positioned in the lateral decubitus position. However, this study has not evaluated the effectiveness of any drug. Rather this study evaluated the effectiveness of post procedure positioning. A pilot study of the dose-response of caudal methylprednisolone with levobupivacaine in chronic low back pain evaluated 40 mg and 80 mg of methylprednisolone and concluded that 40 mg appear to be superior to 80 mg when injected in 20 mL levobupivacaine (779).

Parr et al (30) excluded multiple studies not meeting the inclusion criteria based on various issues. Among these, 3 studies (836-838) were excluded due to the inclusion of a majority of patients with acute disc herniation. The review of these manuscripts shows that the results by Sayegh et al (836) were positive assessing 183 patients for short-term and long-term relief. Results were also positive in the studies by Zahaar et al (838) and Mathews et al (837). However, of importance, these studies are not optimal in chronic pain management.

In a high quality study, Sayegh et al (836) evaluated the efficacy of caudal epidural injections containing steroid versus nonsteroid preparations when treating patients suffering from low back pain and sciatica. They concluded that caudal epidural injections containing local anesthetic and steroids or water seem to be effective when treating patients with low back pain and sciatica. Caudal epidural injections containing steroid preparations demonstrated better and faster efficacy. In contrast, Mathews et al (837) evaluated back pain and sciatica assessing controlled trials of manipulation, traction, sclerosant, and epidural injections. The number of patients included in this study was small, confounding the results further.

1.2.1.1.1.1 Evidence Assessment

Of the 7 randomized trials meeting inclusion criteria evaluating caudal epidural steroid injections (233,773,775-780), only 4 of them evaluated long-term results (773,775-778).

The 4 randomized trials evaluating long-term outcomes (233,773,775-778) with 87 patients receiving local anesthetic with steroids (233,773,776,777) and 60 patients receiving local anesthetic only (233,773,777) showed positive results. One study (775) utilizing 19 mL sodium chloride solution with 40 mg of methylprednisolone showed positive results. The randomized trial with placebo performed under ultrasound guidance showed negative or unclear results (778) utilizing 37 patients in the steroid group with saline. Thus, 3 of the 4 studies evaluating the long-term follow-up showed positive results (233,773,775-777) and one study showed negative or unclear results (782). Of these, 2 studies were considered as high quality (233,773,776,777). One medium quality study showed negative or unclear results (778), and the second medium quality study showed positive results (776). Both of them studied mixtures of sodium chloride solution with steroid rather than local anesthetic (775,778). The number of patients included in the positive studies was 177, whereas in the single negative or unclear study, 39 patients received steroids mixed with sodium chloride solution with similar results whether steroid was injected into the epidural space or over the sacral hiatus.

Among the short-term evaluations, there were 3 additional studies (779-781), all of which utilized local anesthetic and steroids and showed positive results.

1.2.1.1.2 Axial or Discogenic Pain

Results of caudal epidural injections for axial or discogenic pain are illustrated in Table 6 (232,237,834,839), with one study having 3 publications (232,237,834). However, there was only one randomized trial (232,237,834) and one observational study (839) which met the inclusion criteria. The new study by Manchikanti et al (232) is a publication of the 2-year results of previous publications (237,834).

1.2.1.1.2.1 Evidence Assessment

The randomized trial by Manchikanti et al (232,237,834) as illustrated in Table 6 assessed the effectiveness of caudal epidural injections in axial or discogenic pain without disc herniation and without facet joint or sacroiliac joint pain showing good long-term results of 2 years. This study, utilizing 120 patients, 60 of them receiving local anesthetic and the other 60 receiving local anesthetic with steroid, followed a practical approach repeating the procedures only when the pain had returned and it was necessary with appropriate and practical outcome parameters. Further, this study also utilized controlled comparative local anesthetic blocks, and excluded facet joint pain and sacroiliac joint pain prior to starting epidural injections. Thus, it is presumed

Table 6. *Results of randomized and observational studies of effectiveness of caudal epidural injections in managing discogenic or axial pain with or without disc herniation or protrusion, without radiculitis, facet joint pain or SI joint pain.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment(s)
				3 mos.	6 mos.	12 mos	Short-term ≤ 6 mos.	Long-Term		
								> 6 mos.	≥ 12 mos.	
Manchikanti et al, 2012, 2011, 2008 (232,237,834) RA, AC, F 10/12	Total = 120 Lidocaine = 60 Lidocaine with steroids = 60	Lidocaine vs. lidocaine mixed with steroid Number of injections = 1 to 5	NRS, ODI, employment status, functional status, opioid intake	87% vs. 88%	89% vs. 93%	84% vs. 85%	P	P	P	Positive randomized double-blind trial.
Southern et al, 2003 (839) RE, F 7/13	Total = 97	Betamethasone and lidocaine Number of injections = 2 to 4	Roland-Morris Disability, visual numeric pain scale, and patient satisfaction scores	NA	NA	23%	NA	NA	N	A negative retrospective evaluation.

RA = Randomized; AC = Active Control; F = Fluoroscopy; RE = Retrospective; P = Positive; N = Negative; NA = Not Applicable
Adapted and modified from: Parr AT, et al. Caudal epidural injections in the management of chronic low back pain: A systematic appraisal of the literature. *Pain Physician* 2012; 15:E159-E198 (30).

that the pain is not related to the posterior structures and it is related to the disc.

The non-randomized study was negative (839). This study evaluated the results only at the end of one year after providing patients with 2 to 4 epidural injections in the beginning without any repeat injections and without short-term or mid-term follow-up. Even then, 23% of the patients showed improvement.

1.2.1.1.3 Spinal Stenosis

The results of the effectiveness of randomized and observational studies evaluating caudal epidural injections in managing central spinal stenosis are illustrated in Table 7 (30,235,236,840-842), with one study with 3 publications (235,236,840). Apart from the 3 studies Parr et al (30) included in the systematic review (236,840-842), the update of central spinal stenosis by Manchikanti et al with 2 year results was identified (235).

1.2.1.1.3.1 Evidence Assessment

The only RCT (235,236,840) included 100 patients with 50 patients in the local anesthetic group and 50 patients in the local anesthetic and steroids group, and showed positive results for both the short-term and long-term over a period of 2 years.

One retrospective evaluation (841) of one to 3 injections, with limited results available only at one year, which is not expected to provide positive results, showed improvement in 35% of the patients, which may be considered positive even though it does not meet the positive criteria of this evidence synthesis.

The second non-randomized study (842) showed positive results both in short-term and long-term utilization of local anesthetic and steroids.

1.2.1.1.4 Post Surgery Syndrome

Table 8 illustrates the results of studies evaluating the effectiveness of caudal epidural injections in managing post surgery syndrome (234,798,835,843). The studies meeting the inclusion criteria were 2 randomized trials (234,798,835,843), including one study with 3 publications (234,798,835).

One study was excluded (844). One study (234), which was not published at the time of Parr et al's systematic review (30), is a 2 year follow-up of the study by Manchikanti et al (798,835), with the previous publications included in the systematic review by Parr et al (30).

1.2.1.1.4.1 Evidence Assessment

Of the 2 randomized trials, one study (234,798,835) included 140 patients and was performed utilizing CONSORT guidelines as an active-control trial. The study also utilized a practical approach in a chronic pain management setting, repeating the injection therapy only with the return of pain. The study showed the results to be superior in patients who were judged to be positive initially. This well conducted study, performed under fluoroscopy (234,798,835), included 140 patients with a 2-year follow-up, and showed positive results for both local anesthetic alone and local anesthetic with steroid.

In contrast, the second study (843) was of low quality utilizing forceful caudal injections with rather high volumes, which may not only be uncomfortable, but may also be associated with side effects.

1.2.1.1.5 Analysis of Evidence

Based on the USPSTF criteria, the evidence was considered at 3 levels – good, fair, and poor.

1.2.1.1.5.1 Lumbar Disc Herniation

For lumbar disc herniation with radiculitis, based on 3 of 4 positive long-term randomized studies (233,773,775-777), and one negative or unclear study

Table 7. *Results of randomized and observational studies of effectiveness of caudal epidural injections in managing spinal stenosis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Results: Pain Relief and Function			Results: Long-Term		Comment(s)
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	> 6 mos. ≥ 12 mos.	
Manchikanti et al, 2012, 2012, 2008 (235,236,840) RA, AC, F 11/12	Total = 100 Lidocaine = 50 Lidocaine + steroid = 50	Lidocaine 0.5% vs. lidocaine mixed with steroid Number of injections = 1 to 5	NRS, ODI, employment status, opioid intake	66% vs. 62%	58% vs. 56%	48% vs. 46%	P	P P	Double-blind design in a practical setting with positive response.
Barre et al, 2004 (841) RE, F 7/13	Total = 95	Triamcinolone and preservative free lidocaine Number of injections= 1 to 3	VNS, RMDQ, NASS patient satisfaction index, and subsequent surgery	NA	NA	35%	NA	NA N	Negative retrospective evaluation.
Lee et al, 2010 (842) NR, RE, F 7/13	Total = 216	Local anesthetic and steroids. Number of injections = 1 to 16	NASS patient satisfaction scale of pain relief	86%	69%	46%	P	P P	A large observational study with positive results.

RA = Randomized; AC = Active Control; NR = Non-randomized; RE = Retrospective; F = Fluoroscopy; P = Positive; N = Negative; NA = Not applicable; VNS = Visual Numeric Scale; RMDQ = Roland-Morris Disability Questionnaire; NASS = North American Spine Society

Adapted and Modified from: Parr AT, et al. Caudal epidural injections in the management of chronic low back pain: A systematic appraisal of the literature. *Pain Physician* 2012; 15:E159-E198 (30).

Table 8. *Results of randomized trials of effectiveness of caudal epidural injections in managing post surgery syndrome.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment(s)
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-Term		
								> 6 mos.	≥ 12 mos.	
Manchikanti et al 2012, 2010, 2008 (234,798,835) RA, AC, F 11/12	Total = 140 Lidocaine = 70 Lidocaine + steroid = 70	Lidocaine vs. lidocaine mixed with non particulate betamethasone Number of injections = 1 to 5	NRS, ODI, employment status, opioid intake	Pain relief 60% vs 69% Function 56% vs 57%	Pain relief 60% vs. 66% Function 56% vs 63%	Pain relief 56% vs. 61% Function 54% vs 61%	P	P	P	A large high quality randomized trial with positive results.
Revel et al, 1996 (843) RA, AC, B 5/12	Total = 60	Prednisolone acetate and saline or prednisolone alone Number of injections = 6	Pain relief, Functional Score, straight leg raising, use of analgesics	NA	19% vs 45%	NA	NA	P	NA	A small low quality study with positive results.

RA = Randomized; AC = Active Control; B = Blind; F = Fluoroscopy; P = Positive; NA = Not Applicable
Adapted and Modified from: Parr AT, et al. Caudal epidural injections in the management of chronic low back pain: A systematic appraisal of the literature. *Pain Physician* 2012; 15:E159-E198 (30).

(778), the evidence is considered good for short-term and long-term relief with local anesthetics with steroids.

The sole well conducted randomized trial comparing local anesthetic with steroids (233,773,777) showed positive results, yielding fair evidence for short- and long-term relief with local anesthetic only.

1.2.1.1.5.2 Axial Pain

Based on one randomized trial (232,237,835), the evidence is fair for caudal epidural injections in discogenic or axial pain without disc herniation, radiculitis, facet joint pain, or sacroiliac joint pain.

1.2.1.1.5.3 Spinal Stenosis

Available evidence is fair based on one long-term randomized trial (235,236,840) with positive results with local anesthetic with or without steroids, supported by 2 non-randomized studies (841,842).

1.2.1.1.5.4 Post Surgery Syndrome

The evidence for post lumbar surgery syndrome is fair based on one high quality randomized double-blind trial (234,798,835) and one low quality randomized double-blind study (843).

1.2.1.1.6 Summary of Evidence

In summary, the evidence is good for radiculitis secondary to disc herniation with local anesthetics and steroids and fair with local anesthetics only, whereas it is fair for spinal stenosis with local anesthetics and steroids, for axial pain without disc herniation, and post surgery syndrome with local anesthetic with or without steroids.

1.2.1.1.7 Complications

Complications related to caudal epidural injections are rare. However, occasional complications may become worrisome. The common complications are related to either the needle placement or related to the drug activity. These include infection, either local or epidural; abscess; discitis; intravascular injection either intervenous or intraarterial with hematoma formation; spinal cord infarction;

extra epidural placement with subcutaneous injection; subdural injection, dural puncture with post lumbar puncture headache, nerve damage, intracranial air injection or increased intracranial pressure; pulmonary embolism; and adverse effects of steroids (8,30,105,191,217,236,237, 239,244,247,250,253,254, 271, 272,279,286,287,768,773-777,798-802,833-835, 839,840,844-905).

Less common complications include transient blindness (861), retinal hemorrhage and necrosis (862,863), serous chorioretinopathy (864,865), persistent recurrent intractable hiccups (866), flushing (867,868), chemical meningitis (869), arachnoiditis (870), discitis (871), epidural abscess (873), and other complications.

Other complications of corticosteroid administration include suppression of pituitary-adrenal axis, hypercorticism, Cushing's syndrome, osteoporosis, avascular necrosis of bone, steroid myopathy, epidural lipomatosis, weight gain, fluid retention, and hyperglycemia (874-878). The most commonly used steroids in neural blockade in the United States, methylprednisolone acetate, triamcinolone acetonide, betamethasone acetate, and phosphate mixture, have all been shown to be safe at epidural therapeutic doses in both clinical and experimental studies (878-887). The radiation exposure is also a potential problem with damage to eyes, skin, and gonads (889). However, some publications have shown a lack of effect on weight (217,250,774-777,799-802,833-835,839,840,847-860,890,891).

1.2.1.2 Interlaminar Epidural Injections

Multiple systematic reviews provided negative opinions for lumbar interlaminar epidural injections (30, 31,105,112,135,191,337,763,764,768,769,906), except for the recent systematic review by Benyamin et al (31). The old systematic reviews have shown highly variable evidence for lumbar interlaminar epidural injections, which ranged from indeterminate to moderate (105,112,135,191,337,763,768,769,906).

Bogduk et al (768) concluded that the results of lumbar interlaminar epidural steroids strongly refute the utility of epidural steroids in acute sciatica. Bogduk (894) updated the recommendations in 1999, recommending against epidural steroids by the lumbar route because effective treatment required too high a number for successful treatment. In 1995, Koes et al (763) reviewed 12 trials of lumbar and caudal epidural steroid injections (combined together) and reported positive results from only 6 studies, concluding that there was no evidence for epidural steroids in managing lumbar radicular pain. Their updated review (769) with 15 trials arrived at similar conclusions that there was no evidence that epidural steroid injections are effective in patients with chronic back pain without sciatica.

Watts and Silagy (762), in a meta-analysis of the efficacy of epidural corticosteroids in the treatment of sciatica, utilized 11 studies considered of good quality, involving a total of 907 patients, and concluded that quantitative evidence from meta-analysis of pooled data from randomized trials illustrated that epidural administration of corticosteroids was effective in the management of lumbosacral radicular pain

Staal et al (191,337), in an updated Cochrane Review of injection therapy for subacute and chronic low back pain, concluded that there was insufficient evidence to support the use of epidural injections in managing chronic low back pain. However, they concluded that it cannot be ruled out that specific subgroups of patients may respond to a specific type of injection therapy. Armon et al (764) in an assessment of the use of epidural steroid injections to treat radicular lumbosacral pain, in a poorly performed evaluation, concluded that in general, epidural steroid injections for radicular lumbosacral pain do not impact the average impairment of function, need for surgery, or provide long-term pain relief beyond 3 months with a negative recommendation (105,905).

Parr et al (906) reviewed the effectiveness of lumbar interlaminar epidural injections in managing chronic low back and lower extremity pain. The results showed that the available literature included only blind epidural injections without fluoroscopy. Consequently, the evidence was determined as poor.

The APS guidelines by Chou and Huffman also showed negative results for lumbar interlaminar epidural injections except for radicular pain on a short-term basis (105,112). ACOEM guidelines (116) also showed negative evidence for epidural injections. Rho and Tang (857) in describing the efficacy of lumbar epidural steroid injections, which also included all 3 approaches, showed strong evidence for transforaminal epidural steroid injections, but the evidence showed only short-term efficacy of interlaminar epidural steroid injections and caudal epidural injections in the management of low back and radicular pain. They concluded that lumbar epidural steroids can be an effective tool in the conservative management of low back pain with radicular symptoms. Pinto et al (135) in a recent systematic review and meta-analysis of epidural corticosteroid injections in the management of sciatica, included all types of studies, caudal, interlaminar, transforaminal, and fluo-

roscopic, as well as blind, with inappropriate analysis considering active control trials as placebo control and utilizing quality assessment criteria for physical therapty. They arrived at the conclusion that based on the available evidence corticosteroid injections offer only short-term relief of leg pain and disability for patients with sciatica. The long-term effects were also positive; however, they were of smaller size and not statistically significant. Landa and Kim (907) in assessing outcomes of interlaminar and transforaminal epidural injections showed positive results for short-term relief of less than 6 months, even though the majority of the studies they included were without fluoroscopy.

A recent evidence synthesis by Benyamin et al (31), with proper selection criteria and assessment for various pathologies assessing the evidence through December 2011, identified 82 lumbar interlaminar trials with 15 randomized trials and 11 nonrandomized studies meeting inclusion criteria for the analysis. Analysis was derived mainly from fluoroscopically guided randomized trials and non-randomized studies (908-927). They showed that the evidence is good for radiculitis secondary to disc herniation with local anesthetics and steroids, fair with local anesthetic only, fair for spinal stenosis with local anesthetic and steroids, and fair for axial pain without disc herniation with local anesthetic with or without steroids, with fluoroscopically guided epidural injections. Since December 2011, we identified 4 more published studies (928-931). They were included in this analysis.

1.2.1.2.1 Disc Herniation and Radiculitis

There were a total of 17 randomized trials meeting the inclusion criteria evaluating lumbar interlaminar epidural injections in managing disc herniation or radiculitis (239,242,775,799,807,908-919,921) with one duplicate publication (242,799) (Table 9). Among these, 7 randomized trials were performed under fluoroscopy (239,242,775,799,908,918,919,921) and 10 trials performed without fluoroscopy (807,909-917).

None of the 3 new studies (929-931), assessing effectiveness in disc herniation, met inclusion criteria. Cohen et al (931), in a randomized, multicenter, placebo-controlled trial, assessed 84 patients with lumbosacral radiculopathy administered with 2 epidural injections of steroid, etanercept, or saline, mixed with bupivacaine and separated by 2 weeks. Results showed epidural steroid injections to provide modest short-term pain relief for some adults with lumbosacral radiculopathy. The disadvantages of the study include short-term follow-up and a small number of patients. Even though the conclusion reached showed epidural steroid injection may provide modest short-term pain relief, review of the results shows 75% of the patients treated with epidural steroids reported 50% or greater leg pain relief and a positive global perceived effect at one month, but it was only 50% for those who received saline and 42% for those who received etanercept. However, placebo in this study is not a true placebo since sodium chloride solution was injected into the epidural space. They concluded that epidural steroid injections may provide modest short-term pain relief for some adults with lumbosacral radiculopathy, but larger studies with longer follow-up are needed to confirm their benefits. The remaining 2 studies were observational, one being a retrospective evaluation of 65 patients (930), the second (929), a pain DETECT questionnaire and lumbar epidural steroid injection for chronic radiculopathy comparing transforaminal and interlaminar epidural injections with a series of 3 injections at 2 week intervals. Both of them showed positive results.

1.2.1.2.1.1 Evidence Assessment

Among the moderate and high quality fluoroscopically guided studies (239,242,775,799,908,918,919,921), there were no placebo-controlled trials. Among the studies using a blind technique without fluoroscopy, 5 were placebo controlled (807,910,912,914,917). Placebo control was inappropriate in some studies, and most importantly in the widely quoted Carette et al's study (807). Dilke et al (910), Arden et al (914), and Ridley et al (917) used appropriate placebo-controlled designs either with interspinous injection or intramuscular injection of saline. Others utilized epidural saline, which may not be appropriate, intramuscular steroid injections, or local anesthetic and considered them as placebo controlled. Placebo effect in clinical studies and their misinterpretations have been extensively discussed (96,97,111,112,129,236,237,244,250-255,257,798-829).

Among the fluoroscopically guided studies, 2 utilized a total of 100 or more patients (239,242,799). Further, only one study (242,799) was carried out utilizing a randomized, active-controlled design, providing treatments as needed based on a robust measure of significant improvement considered as 50% improvement in pain and function with 120 patients with one- and 2-year follow-up with the number of injections ranging from one to 5 for one year, with significantly better results in the successful group, and performed in contemporary interventional pain management settings. The second study (239) included 200 patients; however, they compared 80 mg of triamcinolone

Table 9. *Results of randomized trials of effectiveness of lumbar interlaminar epidural injections in managing disc herniation or radiculitis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-term		
								> 6 mos.	≥ 12 mos.	
Fluoroscopic Trials										
Manchikanti et al, 2012, 2010 (242,799) RA, AC, F 10/12	Total = 120 Local anesthetic = 60 Local anesthetic and steroids = 60	Xylocaine or Xylocaine with non-particulate Celestone Number of injections = 1 to 5	NRS, ODI, employment status, opioid intake, significant improvement 50% or greater of NRS scores and ODI scores	72% vs. 82%	63% vs. 85%	67% vs. 85% or 80% vs. 86% in successful group	P	P	P	Positive randomized trial with long-term follow-up
Lee et al, 2009 (918) RA, AC, F 7/12	Total = 93 IL = 34 TF = 59	Lidocaine with triamcinolone Number of injections = 1 to 3	NRS, PSI	SI in both groups	SI in both groups	SI in both groups	P	NA	NA	Positive randomized trial with short-term follow-up
Rados et al, 2011 (919) RA, AC, F 8/12	Total = 64 IL = 32 TF = 32	Lidocaine with methylprednisolone Number of injections = 1 to 3	VAS, ODI	53% vs. 63%	53% vs. 63%	NA	P	P	NA	Positive results with short follow-up period
Kim & Brown, 2011 (921) RA, AC, F 9/12	Total = 60 Depo-Medrol = 30 Dexamethasone = 30	Methylprednisolone or dexamethasone with bupivacaine Number of injections = 1 to 2	VAS, pain medication intake, and emergency room visits	NA	NA	U	NA	NA	NA	Relatively small study, with undetermined results
Amr, 2011 (239) RA, AC, F 10/12	Total = 200 Steroid = 100 Steroid + Ketamine = 100	Triamcinolone plus preservative free ketamine and 0.9% saline Number of injections = 1	Pain scores, Oswestry low back pain disability questionnaire	SI in ketamine group	SI in ketamine group	SI in ketamine group	P	P	P	Positive randomized trial with long-term follow-up
Candido et al, 2008 (908) RA, AC, F 7/12	Total = 57 Parasagittal interlaminar = 29 Transforaminal =28	Number of injections = 1-3	Contrast medium spread	NA	NA	NA	NA	NA	NA	Small study without applicable results
Ackerman & Ahmad, 2007 (775) RA, AC, F 7/12	Total = 90 Caudal = 30 Interlaminar = 30 Transforaminal = 30	Steroid and saline with local anesthetic. Number of injections = 1 to 3	Pain relief	P	P	NA	P	P	NA	Positive mid-term results

Table 9 (cont.). *Results of randomized trials of effectiveness of lumbar interlaminar epidural injections in managing disc herniation or radiculitis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-term		
								> 6 mos.	≥ 12 mos.	
Blind Trials										
Buchner et al, 2000 (909) RA, B, AC 7/12	Total = 36 Methylprednisolone group = 17 Control group = 19	Rehabilitation program vs. epidural injections with methylprednisolone and bupivacaine Number of injections = 3 in 14 days	VAS and Hannover Functional Ability Questionnaire	P	P	NA	P = steroids N = local anesthetic	P = steroids N = local anesthetic	NA	Positive results in mid-term
Dilke et al, 1973 (910) RA, B, PC 8/12	Total = 100 Epidural = 50 Interspinous = 50	Methylprednisolone in normal saline or interspinous ligament Number of injections = 1-2	Pain relief, analgesic consumption, changes in straight leg raising, or neurological signs	P	NA	NA	P	NA	NA	Placebo control trial with positive responses
Rogers et al, 1992 (911) RA, B, AC 10/12	Total = 30 Steroid epidural = 15 Non-steroid epidural = 15	Lignocaine with or without methylprednisolone Number of injections = 1	Follow-up pain score, work status, analgesic consumption, straight leg raising	P	NA	NA	P	NA	NA	Small short-term study with positive results
Kraemer et al, 1997 (912) RA, B, PC, AC 7/12	Total = 133 Perineal = 47 Epidural = 40 Intramuscular = 46	Triamcinolone and local anesthetic Number of injections = 3	Pain relief, return to work, avoidance of surgery	68% vs. 53.3% vs. 34.8%	NA	NA	P	NA	NA	Short-term positive results
Pirbudak et al, 2003 (913) RA, B, AC 10/12	Total = 92 Epidural = 46 Epidural + amitriptyline = 46	Betamethasone and bupivacaine or with addition of amitriptyline Number of injections = 1 to 3	VAS, ODI	SI in both groups	SI in both groups	SI in both groups	P	P	P	Active control trial with positive results
Arden et al, 2005 (914) RA, B, PC 11/12	Total = 228 Steroid group = 120 Placebo group = 108	Triamcinolone and bupivacaine or normal saline into interspinous ligament Number of injections = 3	ODQ, pain relief, VAS, SF-36	NSI	NSI	NSI	N	N	N	Negative results

Table 9 (cont.). *Results of randomized trials of effectiveness of lumbar interlaminar epidural injections in managing disc herniation or radiculitis.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Interventions**	**Outcome Measures**	**Pain Relief and Function**			**Results**			**Comment**
				3 mos.	**6 mos.**	**12 mos.**	**Short-term ≤ 6 mos.**	**Long-term**		
								> 6 mos.	**≥ 12 mos.**	
Carette et al, 1997 (807) RA, B, PC 11/12	Total = 158 Methylprednisolone = 78 Placebo 80	Normal saline vs. depo methylprednisolone and procaine Number of injections = 1 to 3	VAS and ODI	NSI	NSI	NSI	N	N	N	Inappropriate blind placebo trial with negative results
Cuckler et al, 1985 (915) RA, B, AC 8/12	Total = 36 Steroid group = 22 Local anesthetic group - 14	Procaine or methylprednisolone acetate combined with procaine. Number of injections = 1 to 2	75% improvement	NSI	NSI	NSI	N	N	N	A small study in acute disc herniation with negative results
Wilson-MacDonald et al, 2005 (916) RA, B, AC 10/12	Total = 60 Intramuscular = 34 Epidural = 26	Intramuscular injection or epidural bupivacaine with methylprednisolone Number of injections = 1 to 2	Oxford Pain Chart and ODI	SI in the treatment group	U	U	P	U	U	Small study with positive short-term results
Ridley et al, 1988 (917) RA, B, PC 9/12	Total = 35 Active group = 19 Placebo group = 16	Interspinous saline vs. epidural methylprednisolone and physiological saline Number of injections = 1	VAS, SLR	SI	U	U	P	U	U	A small study without injection of local anesthetic with positive short-term results

RA = Randomized; PC = Placebo control; AC = Active-control; F = Fluoroscopy; B = Blind; IL = Interlaminar; TF = Transforaminal; SI = Significant improvement; NSI – No significant improvement; P = Positive; N = Negative; NA = Not applicable; U = Unclear; NRS = Numeric Rating Scale. ODI = Oswestry Disability Index; PSI = Patient Satisfaction Index; VAS = Visual Analog Scale; ODQ = Oswestry Disability Questionnaire; SLR = Straight Leg Raising; SF-36 = Short-form 36

Adapted and Modified from: Benyamin RM, et al. The effectiveness of lumbar interlaminar epidural injections in managing chronic low back and lower extremity pain. Pain Physician 2012; 15:E363-E404 (31).

Table 10. *Results of randomized and observational studies of effectiveness of lumbar interlaminar epidural injections in managing discogenic or axial pain without disc herniation, radiculitis, facet joint pain or SI joint pain.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-term		
								> 6 mos.	≥ 12 mos.	
Manchikanti et al, 2012, 2010 (243,800) RA, AC, F 10/12	Total = 120 Local anesthetics = 60 Local anesthetics and steroids = 60	Lidocaine alone or with Celestone Number of injections = 1 to 5	NRS, ODI, employment status, opioid intake, significant improvement 50% or greater of NRS scores and ODI scores	83% vs. 73%	72% vs. 75%	77% vs. 67%	P	P	P	Positive results in a large active control trial.
Buttermann, 2004 (922) NR, F 7/13	Epidural patients = not known	Betamethasone Number of injections = 1-2	VAS pain scale, pain drawing, Oswestry Disability Index, use of pain medication, and opinion of treatment success	U	U	U	U	U	U	Confusing design with inaccurate therapy in nonrandomized study.
Lee et al, 2010 (923) NR, F 6/13	Total = 81	Triamcinolone with saline and bupivacaine Number of injections = 1 to 3	50% relief, NASS satisfaction index	78%	77.5%	U	P	P	U	Positive mid-term results.

RA = Randomized; AC = Active-control; F = Fluoroscopy; NR = Non-randomized; P = Positive; U = Unclear; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; VAS = Visual Analog Scale; NASS = North American Spine Society

Adapted and Modified from: Benyamin RM, et al. The effectiveness of lumbar interlaminar epidural injections in managing chronic low back and lower extremity pain. *Pain Physician* 2012; 15:E363-E404 (31).

with 30 mg of preservative-free ketamine or 3 mL of 0.9% sodium chloride solution, illustrating significant improvement in both groups.

Among the non-fluoroscopic evaluations, there were 4 studies with more than 100 patients undergoing interventions (807,910,912,914). Tables 7 and 8 of the systematic review (31) show characteristics of the included studies.

Based on the evaluations separating fluoroscopically guided versus non-fluoroscopic evaluations, the results were positive for short-term relief in 5 trials performed under fluoroscopy (239,242,775,799,918,919); whereas, they were undetermined or not applicable in 2 trials (908,921). Consequently all of the trials are considered positive on a short-term basis. Among the trials evaluating long-term relief, there were 4 trials evaluating relief of 6 months or longer (239,242,775,799,919) and 2 trials evaluating outcomes for longer than one year (239,242,799). Among these, 4 trials showed positive results (239,242,775,799,919); whereas, in one trial, the results were undetermined or not applicable (921). Among the studies evaluating at least a one year follow-up, 2 trials showed positive results (239,242,799); whereas, one trial showed results that were undetermined or not applicable (921).

In contrast, with blind randomized trials, the results were highly mixed due to various issues involved. Some of the issues related to providing only one injection or providing injections of 3 in a series and following through with a one-year follow-up. With one injection, one could expect relief of 3 to 4 weeks, however, no more than 3 months. Thus, the follow-up after 3 months does not indicate improvement except for the rare patients who show long-term relief. Some of the studies also had flawed selection criteria. Overall, of 10 randomized trials with at least moderate methodological quality, 7 of them showed short-term positive results (909-

913,916,917) and the remaining 3 showed either undetermined or negative results (807,914,915). However, the results were uniformly negative after 3 months or not able to be determined in all the studies except one (913), which showed positive results comparing prednisone with local anesthetic with or without amitriptyline.

1.2.1.2.2 Axial or Lumbar Discogenic Pain

The results of lumbar interlaminar injections for axial or lumbar discogenic pain are illustrated in Table 10. There were 3 studies meeting the inclusion criteria (243,800,922,923), with one duplicate (243,800). Only one study was randomized, active-controlled performed under fluoroscopy (243,800). It included 120 patients with one year follow-up showing positive results, both with local anesthetic and steroids performed in a contemporary interventional pain management practice. The other 2 studies (922,923) were non-randomized; however, they were performed under fluoroscopy. There were no placebo-controlled trials evaluating axial or discogenic pain. The only randomized trial also excluded facet joint or sacroiliac joint pain prior to epidural injections (243,800). This trial showed positive results with 60 patients in both groups after exclusion of facet joint or sacroiliac joint pain. This was a large trial in a contemporary interventional pain management practice with an active-controlled design showing positive results. Among the 2 non-randomized trials, one study (923) showed positive results at 3 and 6 months; however, the results were unable to be determined at 12 months due to the injections being performed one to 3 not based on return of pain. In the second non-randomized study (922), the results were confusing; thus, they were classified as undetermined.

1.2.1.2.2.1 Evidence Assessment

Of the one randomized trial (243,800) and 2 non-randomized studies (922,923), the randomized trial and one non-randomized study showed positive results for both short-term and long-term. The third study (922), which was non-randomized, showed undetermined results with a confusing design. Only one study evaluated the 120 patients at 24 months (243,800). This study was positive both in the short-term and long-term.

1.2.1.2.3 Spinal Stenosis

Table 11 shows the results of randomized and observational studies of the effectiveness of lumbar interlaminar epidural injections in managing spinal stenosis (244,915,916,918,925,927). We identified one new study (928) not included in the latest systematic review by Benyamin et al (31). This was a subgroup analysis of the SPORT study. The analysis was performed poorly based on an incorrect hypothesis. There were only 69 patients receiving epidural steroid injection; thus, the results may not be applied to contemporary interventional pain management settings. Consequently, the study failed to meet inclusion criteria.

There were 5 randomized trials (244,915, 916,918,925) and one non-randomized study (927), with at least moderate methodologic quality, evaluating the effectiveness of lumbar interlaminar epidural injections in spinal stenosis. However, none of the well conducted studies utilized 100 or more patients. There were 2 randomized trials performed under fluoroscopy (244,918). The study by Manchikanti et al (244) was a preliminary report showing positive results with local anesthetic as well as steroids for central stenosis in a contemporary interventional pain management practice. The other randomized fluoroscopically guided trial (918) showed short-term positive results. The one non-randomized fluoroscopically guided study (927) showed short-term positive results. On a long-term basis, the results were also positive for 6 months or longer in one study (244). However, the results were mixed in the groups using a blind technique. One study (916) utilized the intermuscular injection for control with steroids and considered it also as a placebo. Short-term results were positive with blind epidural for spinal stenosis with a small number of patients in one trial (916).

1.2.1.2.3.1 Evidence Assessment

There were 2 randomized trials (244,918) evaluating spinal stenosis under fluoroscopy with both of them showing positive results. However, only one study by Manchikanti et al (244) evaluated long-term follow-up with positive results. The non-randomized trial, also performed under fluoroscopy (927), was positive in the short-term. Tables 7 and 8 of the systematic review (31) show the characteristics of the included studies.

Among the randomized trials without fluoroscopy, only the study with a small number of patients by Wilson-McDonald et al (916) was positive for short-term relief.

1.2.1.2.4 Analysis of Evidence

Based on the USPSTF criteria, the evidence is considered at 3 levels – good, fair, or limited.

Table 11. *Results of randomized and observational studies of effectiveness of lumbar interlaminar epidural injections in managing spinal stenosis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-term		
								> 6 mos.	≥ 12 mos.	
Fluoroscopic Trials										
Manchikanti et al, 2012 (244) RA, AC, F 10/12	Total = 60 Local anesthetic = 30 Local anesthetic and steroids = 30	Local anesthetic or local anesthetic with non-particulate Celestone Number of injections = 1 to 5	NRS, ODI, employment status, opioid intake, significant improvement 50% or greater of NRS scores and ODI scores	77% vs. 63%	67% vs. 67%	70% vs. 60%	P	P	P	High quality randomized controlled trial with positive long-term follow-up
Lee et al, 2009 (918) RA, AC, F 7/12	Total = 99 IL = 42 Bilateral TF = 57	Lidocaine and triamcinolone Number of injections = 1 to 3	NRS, PSI	SI in both groups	NA	NA	P	NA	NA	Positive short-term results.
Kapural et al, 2007 (927) NR, F 7/13	Total = 719	Epidural steroid injection Number of injections = 1 to 3	VAS, opioid use	P	NA	NA	P	NA	NA	Positive short-term results in a retrospective evaluation
Blind Trials										
Fukasaki et al, 1998 (925) RA, B, AC, PC 9/12	Total = 53 Epidural saline = 16 Mepivacaine = 18 Mepivacaine and methylprednisolone = 19	Saline or mepivacaine ora combination of mepivacaine and methylprednisolone Number of injections = 1-3	Walking distance Excellent > 100 m Good 20-100 m	6.5% vs. 5.6 %vs. 5.3%	NA	NA	N	NA	NA	A small study with short-term follow-up and negative results
Cuckler et al, 1985 (915) RA, B, AC 8/12	Total = 37 Steroid group = 20 Local anesthetic group - 17	Procaine with or without methylprednisolone Number of injections = 1 to 2	75% improvement	NSI	NSI	NSI	N	N	N	A small negative study.
Wilson-MacDonald et al, 2005 (916) RA, B, AC 10/12	Total = 50 Epidural = 21 Intramuscular injection (control) = 29	Intramuscular injection in the epidural area or epidural with bupivacaine or methylprednisolone Number of injections = 1	Oxford Pain Chart and ODI	SI in treatment group	U	U	P	U	U	A small study with short-term positive results.

RA = Randomized; AC = Active-control; NR = Non-randomized; PC = Placebo controlled; B = Blind; F = Fluoroscopy; P = Positive; N = Negative; NA = Not applicable; U = Unclear; SI = Significant improvement; NSI = No significant improvement; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; PSI = Patient Satisfaction Index; VAS = Visual Analog Scale.
Adapted and Modified from: Benyamin RM, et al. The effectiveness of lumbar interlaminar epidural injections in managing chronic low back and lower extremity pain. Pain Physician 2012; 15:E363-E404 (31).

1.2.1.2.4.1 Lumbar Disc Herniation

For lumbar disc herniation with radiculitis, based on 5 of 7 positive randomized trials for short-term relief and 4 of 6 positive randomized trials performed under fluoroscopy, the evidence is good for short-term and long-term relief with steroids and fair with local anesthetic.

Considering the blind trials (without fluoroscopy), the evidence continues to be good for short-term relief with positive results in 8 of the 10 studies with local anesthetic and steroids. However, for long-term relief, the results in the majority of the studies are negative or undetermined, with positive results in only 2 trials (909,913) with poor evidence.

1.2.1.2.4.2 Axial or Lumbar Discogenic Pain

For axial or lumbar discogenic pain, based on one positive randomized trial (243,800) and one observational study (923) performed under fluoroscopy, the evidence is considered fair for short-term and long-term relief with steroids or with local anesthetic.

1.2.1.2.4.3 Spinal Stenosis

For spinal stenosis, based on 2 positive randomized trials with fluoroscopy (244,918) and one positive non-randomized study performed under fluoroscopy (927), the evidence is considered fair for short-term and long-term relief with local anesthetic and steroids.

1.2.1.2.5 Summary of Evidence

In summary, the evidence is good for radiculitis secondary to disc herniation with local anesthetics and steroids, fair with local anesthetic only, fair for spinal stenosis with local anesthetic and steroids, and fair for axial pain without disc herniation and with local anesthetic with or without steroids.

1.2.1.2.6 Complications

The commonly described complications of interlaminar epidural injections are related either to the needle placement or drug administration (8,116,131,760-762,763,764,769,773,845,856-885,887-894,897-906,932-965). Multiple infectious complications including epidural abscess, meningitis, and osteomyelitis/discitis have been reported (869-873,932-937). One potentially serious complication of the epidural injection is epidural hematomas in patients with or without evidence of any bleeding tendency, anticoagulation, or traumatic needle insertion (938-944). Neurological injuries, though rare, could be devastating and are related to needle trauma, intraarticular injection, toxic effects of steroids, bleeding, and infection (879-882,945,947-951). Other complications include increased pain, seizures, chemical meningitis, dural puncture, disc puncture, subdural air, pneumocephalus, transient blindness, retinal necrosis, chorioretinopathy, hiccups, flushing, and arterial gas embolism (845,861-865,867-869,874,952-961). The major theoretical complications of corticosteroid administration include suppression of pituitary adrenal axis, hypercorticism, Cushing's syndrome, osteoporosis, avascular necrosis of the bone, steroid myopathy, epidural lipomatosis, weight gain, fluid retention, and hyperglycemia (870,878,899,934,962).

Manchikanti et al (899), in evaluating 10,000 fluoroscopically guided epidural injections, showed intravascular and return of blood in 0.5%, profuse bleeding and dural puncture in 0.8%, local hematoma and transient nerve root irritation in 0.28%, postlumbar puncture headache in 0.07%, and facial flushing in 0.13% with lumbar interlaminar epidural injections.

Finally, radiation exposure is also a potential problem with damage to eyes, skin, and gonads (889,966).

1.2.1.3 Lumbar Transforaminal Epidural Injections

Despite increasing utilization of lumbar transforaminal epidural injections, significant debate continues regarding their effectiveness (161-175,966-969). Chou and Huffman (105) in APS guidelines evaluated 3 higher quality, placebo-controlled trials assessing the transforaminal approach reporting mixed results (970-972), and concluded that for low back pain with sciatica, the evidence for the efficacy of epidural steroid injection by the transforaminal approach was mixed, with 2 of 3 higher quality trials showing no benefit compared to controlled injections.

In a critical evaluation of APS guidelines, Manchikanti et al (112) concluded that the evidence appears to be fair, based on a grading of good, fair, and poor, in managing lumbar nerve root pain with transforaminal epidural injections. Favorable evidence has also been described in other manuscripts (114,856,857,973-977). Buenaventura et al (968) also showed limited evidence for transforaminal epidural injections for lumbar radicular pain in post surgery syndrome (808,968-971). There were no studies evaluating transforaminal epidural injections in spinal stenosis meeting the inclusion criteria (968). Depalma et al (973) showed that there was moderate evidence in support of selective nerve root blocks in treating painful radicular syndromes. European guidelines (131) for the management of chronic nonspecific low back pain also provided a favorable

level of evidence for transforaminal epidural steroid injections, while providing negative evidence for other modalities.

While debate continues, Benny and Azari (976) examined 8 RCTs (775,808,912,918,969-971,978). They showed positive outcomes in both short-term and long-term results, concluding that there was strong evidence for transforaminal injections in the treatment of lumbosacral radicular pain for both short-term and long-term relief. In another evidence-based radiology review (856), the authors concluded that there was moderate to strong evidence supporting the use of transforaminal therapeutic epidural injections for lumbar nerve-root compression. In a systematic review, Roberts et al (974) concluded that there was fair evidence supporting transforaminal epidural injections as superior to placebo for treating radicular symptoms, there was good evidence that they should be used as a surgery-sparing intervention, and that they were superior to interlaminar epidural steroid injections and caudal epidural steroid injections for radicular pain. Rho and Tang (857), in an evaluation of the efficacy of lumbar epidural steroid injections, concluded that there was strong evidence to support the use of lumbar transforaminal epidural steroid injections in patients with acute to subacute unilateral radicular pain caused by a herniated nucleus pulposus or spinal stenosis. They also concluded that a lumbar transforaminal epidural steroid injection is an effective surgery-sparing procedure that should be a part of conservative care in the management of low back pain and radiculopathy.

Quraishi (975), in a recent systematic review and meta-analysis, concluded that when appropriately performed, transforaminal epidural steroid injections should result in an improvement in pain, but not disability. Three RCTs were included that followed patients for 3 months, with results illustrating no benefit by adding steroids.

Manchikanti et al (28) in a systematic review with a literature search spanning up to December 2011, identified 70 studies of which 25 studies met inclusion criteria for methodological quality assessment, with 15 randomized trials and 10 nonrandomized studies (774,775,797,808,858,908,918,919,969-972,979-993) with 2 duplicate publications (808,970,987,989), and 3 studies (990,993,994) failing to meet inclusion criteria. They showed the evidence for lumbar disc herniation is good for transforaminal epidural with local anesthetic and steroids, whereas it is fair for local anesthetics alone and the ability of transforaminal epidural injections to prevent surgery. For spinal stenosis, the available evidence is fair for local anesthetic and steroids. The evidence for axial low back pain and post lumbar surgery syndrome is poor, inadequate, limited, or unavailable.

In a recent comprehensive review with systematic analysis of the published data, Macvicar et al (967) assessed 39 publications on the effectiveness of lumbar transforaminal injection of steroids. The primary outcome sought was the success rate for relief of pain. The results showed that for disc herniation, the evidence is sufficiently abundant to show that lumbar transforaminal epidural injection of steroids is not universally effective but, nevertheless, benefits a substantial portion of patients, and is not a placebo. Success rates were higher in patients with contained herniations that cause only low-grade compression of the nerve. For other conditions, the available evidence was shown to be limited and was neither compelling nor conclusive. They concluded that in a substantial proportion of patients with lumbar radicular pain caused by contained disc herniations, lumbar transforaminal injection of corticosteroids is effective in reducing pain, restoring function, reducing the need for other health care, and avoiding surgery. The authors felt that the evidence supporting their conclusion was revealed by comprehensive review of all published data and found to be much more compelling than it would have been if the literature review had been of the limited scope of a "traditional systematic review" of RCTs only.

Pinto et al (135) in a recent systematic review and metaanalysis of epidural corticosteroid injections in the management of sciatica, included all types of studies, caudal, interlaminar, transforaminal, and fluoroscopic as well as blind, with inappropriate analysis considering active control trials as placebo control and utilizing physiotherapy criteria. They arrived at the conclusion that based on the available evidence corticosteroid injections offer only short-term relief of leg pain and disability for patients with sciatica. The long-term effects were also positive; however, they were smaller size and not statistically significant.

The search for further studies after December 2011 yielded 6 studies (285,995-999).

1.2.1.3.1 Disc Herniation and Radiculitis

A total of 14 randomized trials (775,797,808, 908,918,919,969,970,972,982-985,987,989,995) with 2 duplicate publications (808,970,987,989) met inclusion criteria as shown in Table 12.

There were 2 studies (797,808,987) evaluating with a placebo control; however, only the study by Ghahre-

man et al (797) was a true placebo evaluation study with 2 control groups and 3 treatment groups. The second study by Karppinen et al (808,987) utilized sodium chloride solution transforaminally in patients with subacute radiculopathy. Even then, the study results showed that the differences were significant compared to the baseline; however, there were no differences between the steroid group and the saline group. Thus, the study has been judged as negative (105,116,135), and has been extensively criticized (8,112,968,1000-1003). Further, subgroup analysis also showed cost-effectiveness in one study (987). Karppinen's study (808,987) failed to take into consideration that injecting sodium chloride solution into the transforaminal epidural space is not a true placebo. Significant arguments have been made for and against what is an actual true placebo in interventional pain management. Finally, Ghahreman et al (797), for the first time, have designed and evaluated a true placebo for transforaminal epidural injections and have shown that sodium chloride intramuscular injection is not only a true placebo, but also that intramuscular steroids were ineffective. Misinterpretation of placebo and nocebo effects has been well described (39,821-829).

Thus, questions regarding appropriate placebo must be dispelled. Further, the role of placebo substances injected into active spaces must be realized. The evidence by Ghahreman et al (797) illustrates that when injected into active structures, sodium chloride solution and local anesthetics are not placebos, rather they generate significant activity (96,97,111,112,114,129,236,237,250,255,257,773,798-802,804,806,807,809-818,1004,1005).

Among the randomized trials, there were 5 studies which included more than 100 participants (797,808,918,969,983,987). There were only 2 placebo-controlled trials and the remaining were active-control trials. However, there was only one properly conducted placebo-controlled trial (797), whereas the second one was inappropriately described as placebo-controlled; they also treated acute low back pain patients (808,987). The active-control trials included comparing local anesthetic versus local anesthetic with steroid, technical variations (preganglionic versus postganglionic), types of steroids (long-acting vs. short-acting), and finally, transforaminals were also compared with interlaminar, caudal, and in one study, with plasma disc decompression (nucleoplasty).

Park et al (995) assessed the short-term benefits of the Kambin triangle vs. the supraneural approach for the treatment of lumbar radicular pain. Their results showed that for both groups, the verbal numeric pain scale and Oswestry Disability Index (ODI) scores improved 2 weeks after the injections, and this improvement was maintained through the 12-week follow-up. They concluded that the Kambin triangle approach can be used instead of the supraneural approach in cases where it is difficult to place the needle at the anterior epidural space.

The populations evaluated in all the included studies were consistent with the inclusion criteria with patients with disc herniation and leg pain. Even though studies combined spinal stenosis, discogenic pain, and post lumbar surgery syndrome, for this subject of evaluation – disc herniation - only the proportion of patients utilized for disc herniation in randomized trials were included (when described) as shown in Table 12.

Multiple studies illustrated significant improvement while comparing the baseline improvement with an appropriate follow-up period, and some have shown significantly better improvement when steroid was added (772,774,775,797,858,908,919,969,970,983,984,986,989), whereas others have illustrated no significant improvement (972,985) with addition of steroid, even though similar evidence was also illustrated in an experimental study (834). However, only 4 studies compared bupivacaine to corticosteroids (797,970,972,985,989). All of them showed positive results when local anesthetics were combined with steroids, with 2 studies showing positive results (797,970,989), and 2 studies showing equally effective results with bupivacaine alone compared to bupivacaine with steroids (972,985). None of the studies utilized lidocaine in comparing local anesthetic alone or with steroids.

Multiple studies also illustrated patients avoiding surgery when treated with transforaminal epidural injections (774,970,981,989,990).

Further results also illustrated transforaminal epidural injections may be superior to interlaminar epidural injections but inferior to plasma disc decompression, and some have provided equivalent results between interlaminar and caudal injections, but not inferior results.

1.2.1.3.1.1 Evidence Assessment

Of the 14 randomized trials meeting inclusion criteria for evaluating lumbar transforaminal epidural steroid injections, 5 trials evaluated only short-term results (797,918,972,983,995), and 7 trials evaluated long-term results (775,797,908,919,969,970,982,985,989) with one duplicate publication (970,989). Tables 12

Table 12. *Results of randomized trials of transforaminal epidural injections in managing disc herniation or radiculitis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment(s)
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-Term > 6 mos	Long-Term ≥ 12 mos.	
Ghahreman et al, 2010 (797) RA, PC 12/12	Total = 150 5 groups with 28, 37, 27, 28, 30	Steroids with saline vs local anesthetic vs Intramuscular steroids vs Intramuscular saline Number of injections = 1 to 3	At least 50% pain relief	Transforaminal saline = 19% Transforaminal local anesthetic = 7% Transforaminal epidural = 54%	NA	NA	P = steroids N = local anesthetic & saline	NA	NA	This study was the first of its nature with a true placebo evaluation with positive short-term efficacy.
Karppinen et al, 2001, 2001 (808,987) RA, PC 11/12	Total = 160 Methylprednisolone-bupivacaine = 80 Saline = 80	Sodium chloride solution, or methylprednisolone (40 mg) and bupivacaine (5 mg) Number of injections = 1	VAS, ODI, Nottingham Health Profile, cost, physical examination	NA	SI in both groups	SI in both groups	U	U	U	An ineffective or inappropriate placebo design, without applicable results.
Jeong et al, 2007 (969) RA, AC 9/12	Total = 193 Ganglionic (G) = 104 Preganglionic (PG) = 89	0.5 mL of bupivacaine hydrochloride and 40 mg of 1 mL of triamcinolone Number of injections = 1	VAS	PG = 88.4% G = 70.9%	PG = 60.4% G = 67.2%	NA	P	P	NA	Moderate quality study with mid-term positive results.
Gerszten et al, 2010 (982) RA, AC 7/12	Total = 90 PDD = 46 TF = 44	Plasma disc decompression or transforaminal Number of injections = 2	VAS, SF-36	NA	VAS and ODI 21% and PDD -49%,. versus 32%, and 15%	VAS and ODI - 18%. PDD -44%,vs 25%, and 10%	U	N	N	The study evaluated 2 dissimilar modalities of treatments with results not applicable.
Riew et al, 2000, 2006 (970,989) RA, AC 8/12	Total = 55 Bupivacaine = 27 Bupivacaine + steroid = 28	Bupivacaine 0.25% or bupivacaine with 6 mg of betamethasone Number of injections = 1 to 4	North American Spine Society Outcome Instrument and operative treatment considered as failure of injection treatment	NA	NA	33% vs 71% (avoided surgery)	P = steroids Unsure = local anesthetic	P = steroids Unsure = local anesthetic	P = steroids Negative = local anesthetic	Positive results in avoiding surgery in 33% of bupivacaine group and 71% in the steroid group.
Ng et al, 2005 (972) RA, AC 11/12	Total = 49 Bupivacaine = 26 Bupivacaine + steroid = 23	bupivacaine only, or bupivacaine with methylprednisolone. Number of injections = 1	VAS, ODI, change in walking distance, claudication, satisfaction of the outcome	Bupivacaine = 4 7.5% Bupivacaine + steroid = 41.5%	NA	NA	P = steroids Negative = local anesthetic	NA	NA	Positive results in a small study with short-term follow-up

Table 12 (cont.). *Results of randomized trials of transforaminal epidural injections in managing disc herniation or radiculitis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment(s)
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-Term		
								> 6 mos	≥ 12 mos.	
Lee et al, 2009 (918) RA, AC 7/12	Total = 93 IL = 34 TF = 59	Interlaminar vs transforaminal epidural injections. 4 mL (TF) Number of injections = 1 to 3	NRS, PSI	Roland Pain Score Transforaminal = 3.34 to 1.59 Interlaminar = 3.25 to 1.57	NA	NA	P	NA	NA	Positive results in short-term follow-up.
Ackerman & Ahmad, 2007 (775) RA, AC 7/12	Total = 90 Caudal = 30 Interlaminar = 30 Transforaminal = 30	Steroid and saline with local anesthetic Number of injections = 1 to 3	Pain relief	Caudal = 57% Interlaminar = 1 60% Transforaminal = 83%	Caudal = 57%) Interlaminar = 60% Transforaminal = 83%	NA	P	P	NA	Positive mid-term results.
Candido et al, 2008 (908) RA, AC 7/12	Total = 60 TF = 30 PIL = 30	lateral parasagittal interlaminar epidural or transforaminal epidural Number of injections = 1 to 3	Contrast medium spread	no significant difference between the groups 42.93 versus 46.6	Improvement in VAS scores from baseline but no differences between the groups	NA	P	P	NA	Positive mid-term results.
Park et al, 2010 (983) RA, AC 7/12	Total = 1 06 Dexamethasone = 5 3 Triamcinolone acetate = 53	Dexamethasone or triamcinolone acetate with lidocaine. Number of injections = 1	VAS, Short MPQ, ODI	Dexamethasone = 40% Triamcinolone = 71%.	NA	NA	P**	NA	NA	Positive short-term results with triamcinolone compared to dexamethasone.
Burgher et al, 2011 (984) RA, AC 12/12	Total = 26 Clonidine = 11 Triamcinolone = 15	Lidocaine with clonidine, or 4 triamcinoloneNumber of injections = 1 to 3	NRS, RMDQ, ODI	SI in both groups	NA	NA	U	NA	NA	Small study without applicable results.
Rados et al, 2011 (919) RA, AC 8/12	Total = 64 IL = 32 TF = 32	Interlaminar vs transforaminal Number of injections = 1 to 3	VAS scores, ODI, Disability scores	TF = 53% IL = 75%	TF = 53% IL = 75%	NA	P	P	NA	Positive mid-term results.
Tafazal et al, 2009 (985) RA, AC 10/12	Total = 76 Bupivacaine = 34 Bupivacaine + steroid = 42	Bupivacaine with methylprednisolone Number of injections = 1 to 3	VAS, ODI, LBOS, modified somatic perception questionnaire, MZD	VAS and ODI change Bupivacaine = 24.3 and 13.8 Bupivacaine + steroid = 27.4 and 13.6	NA	NA	P	NA	NA	Positive short-term results.

Table 12 (cont.). *Results of randomized trials of transforaminal epidural injections in managing disc herniation or radiculitis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Results					Comment(s)
				Pain Relief and Function			Long-Term		
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	> 6 mos	≥ 12 mos.	
Park et al, 2012 (995) RA, AC 9/12	Total = 100 Kambin triangle = 50 Supra-neural = 50	Local anesthetic with steroid	Verbal numeric pain rating scale, ODI	Positive in both groups	NA	NA	P	NA	NA	Positive short-term results in a small study.

RA = Randomized; PC = Placebo-control; AC = Active-control; F = Fluoroscopy; IL = Interlaminar TF = Transforaminal; P = Positive; N = Negative; NA = Not applicable; U = Unclear; G = Ganglionic; PG = Preganglionic; PDD = Plasma disc decompression; PIL = Parasagittal interlaminar; SI = significant improvement; VAS = Visual Analog Scale; ODI = Oswestry Disability Index; NRS = Numeric rating scale; PSI = Patient Satisfaction Index; MPQ = McGill Pain Questionnaire; RMDQ = Roland Morris Disability Questionnaire; SF-36 = Short Form-36 Health Survey; MZD = Modified Zung Depression; MSPQ = Modified Somatic Perception Questionnaire; LBOS = Low Back Outcome Score; NASS = North American Spine Society.

Adapted and Modified from: Manchikanti L, et al. Effectiveness of therapeutic lumbar transforaminal epidural steroid injections in managing lumbar spinal pain. *Pain Physician* 2012; 15:E199-E245 (28).

and 13 of the systematic review (28) show the characteristic features of the included studies.

Short- and long-term relief was evaluated in 14 randomized trials (775,797,808, 908,918,919,969,970,972,982-985,987,989,995), of which 11 trials (775,797,908,918,919,969,970, 972,983,985,989,995) showed positive short-term results, and long-term positive results were shown in 6 trials (775,908,919,969,970,985,989). One randomized trial showed negative results (982) utilizing 44 patients in the steroid group. Negative results for local anesthetics were seen in 3 trials (797,970,972,989). Further, 2 randomized trials (808,984,987) showed results which could not be determined: these included 15 patients receiving local anesthetic and steroids, 80 patients receiving sodium chloride solution and steroids, and 80 patients receiving sodium chloride.

Overall, long-term relief was illustrated in 6 of the 8 randomized trials evaluating long-term follow-up (775,908,919,969,970,985,989), one trial showed results which were undetermined (808,987), and one trial showed negative results (982). A total of 538 patients were included in the positive studies and a total of 90 patients were included in the study with negative results.

1.2.1.3.2 Axial or Discogenic Pain

There were 2 non-randomized studies (979,980) evaluating the role of transforaminal epidural injections in patients without disc herniation, radiculitis, and facet joint or sacroiliac joint pain.

1.2.1.3.2.1 Evidence Assessment

Rosenberg et al (979) and Berger et al (980) studied the role of transforaminal epidural injections in managing discogenic pain without radiculitis or disc herniation. However, these studies included a small number of patients. Thus, there was no data was available for assessment of the evidence.

1.2.1.3.3 Spinal Stenosis

Table 13 illustrates the characteristics of the included studies for spinal stenosis. There were a total of 4 randomized trials (918,969,972,985) and 5 non-randomized studies (858,979,986,991,992) which met the inclusion criteria based on quality assessment evaluating the role of transforaminal epidural injections in managing spinal stenosis. Of these, one trial (918) included 99 patients, and one study (858) included 138 patients suffering with spinal stenosis.

Table 13. *Results of randomized and observational studies of effectiveness of transforaminal epidural injections in managing spinal stenosis.*

Study Study Characteristics Methodological Quality Scoring	**Participants**	**Interventions**	**Outcome Measures**	**Pain Relief and Function**			**Results**			**Comment (s)**
				3 mos.	**6 mos.**	**12 mos**	**Short-term ≤ 6 mos.**	**Long-Term**		
								> 6 mos	**≥ 12 mos.**	
Jeong et al, 2007 (969) RA, AC 9/12	Total=46 Ganglionic=23 Preganglionic = 23	Bupivacaine with triamcinolone Number of injections=1	An outcome of 50% or more pain relief.	89.1%	56.5%	NA	P	P	NA	Small study with positive mid-term results.
Ng et al, 2005 (972) RA, AC 11/12	Total=32 Bupivacaine = 15 Bupivacaine + steroid=17	Bupivacaine only, or bupivacaine with methylprednisolone. Number of injections = 1-2	Oswestry, VAS for back and radicular pain, change in walking distance, and patient's satisfaction level.	Pain and ODI Bupivacaine = 47.5% and 41.5%	NA	NA	P	NA	NA	A small study with positive short-term results.
Lee et al, 2009 (918) RA, AC 7/12	Total=99 IL=42 Bilateral TF=57	Lidocaine with triamcinolone Number of injections=1 to 3	NRS, PSI, and the Roland 5 point pain score.	Transforaminal = 3.34 to 1.59 Interlaminar = 3.25 to 1.57	NA	NA	P	NA	NA	Positive short-term results.
Tafazal et al, 2009 (985) RA, AC 10/12	Total = 48 Bupivacaine= 25 Bupivacaine + steroid = 23	Bupivacaine or bupivacaine with methylprednisolone Number of injections=1 to 3	VAS, ODI, LBOS	VAS and ODI change Bupivacaine = 20.4 and 6.5 Bupivacaine + steroid = 19.4 and= 1.5	NA	NA	N	N	N	Negative study.
Park & Lee, 2011 (991) NR, PR 5/13	Total=55	Triamcinolone and lidocaine Number of injections=1	VAS scores	Significant improvement	NA	NA	P	NA	NA	Positive short-term results.
Lee et al, 2009 (858) NR, RE 5 6/10	Total = 138 Interlaminar = 33 Caudal = 40 Transforaminal = 49	Lidocaine with triamcinolone Number of injections=1	VAS, PSI	Transforaminal = 53% Interlaminar = 57.6% Caudal=30%	NA	NA	P	NA	NA	Positive short-term results.
Cooper et al, 2004 (992) NR, RE, CC 6/13	Total=61	Triamcinolone with lidocaine	NRS, NASS Scale, pain medication usage, function and pain status assessment	44.2%	NA	37.2%	P	NA	N	Negative study
Rosenberg et al, 2002 (979) NR, RE 6/13	Total=26	Methylprednisolone with 1 mL of 1.5% lidocaine with epinephrine Number of injections=1 to 4	Pain relief	54%	19%	35%	P	N	N	Postive short-term results.

Table 13 (cont.). *Results of randomized and observational studies of effectiveness of transforaminal epidural injections in managing spinal stenosis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment (s)
				3 mos.	6 mos.	12 mos	Short-term ≤ 6 mos.	Long-Term > 6 mos	Long-Term ≥ 12 mos.	
Ng & Sell, 2004 (986) NR, PR 7/13	Total=62	Bupivacaine and methylprednisolone. Number of injections= Unclear	VAS, ODI, MZDS, MSPQ	Mean change of VAS of 1.2, ODI change of at least 10% in 37%.	NA	NA	N	NA	NA	Negative study

RA = Randomized; AC = Active-control; NR = Non-randomized; RE = Retrospective; PR = Prospective; CC = Case-control; P = Positive; N = Negative; NA = Not applicable; VAS = Visual Analog Scale; ODI = Oswestry Disability Index; IL = Interlaminar; TF = Transforaminal; NRS = Numeric rating scale; PSI = Patient Satisfaction Index; MPQ = McGill Pain Questionnaire; RMDQ = Roland Morris Disability Questionnaire; SF-36 = Short Form-36 Health Survey; MZDS = Modified Zung Depression Scale; MSPQ = Modified Somatic Perception Questionnaire; LBOS = Low Back Outcome Score; NASS = North American Spine Society.
Adapted and Modified from: Manchikanti L, et al. Effectiveness of therapeutic lumbar transforaminal epidural steroid injections in managing lumbar spinal pain. Pain Physician 2012; 15:E199-E245 (28).

1.2.1.3.3.1 Evidence Assessment

Of the 4 randomized active-controlled trials (918,969,972,985), 3 trials, which included 46 patients, 17 patients, and 57 patients receiving local anesthetic with steroids, showed positive results for short-term relief (918,969,972), with one trial showing long-term positive results (969). One randomized trial (985), with 23 patients receiving bupivacaine with steroids, had negative results for steroids.

Among the non-randomized studies, 4 studies (858,979,991,992) showed positive results for short-term improvement and one study (986) showed negative results for short-term improvement. For long-term improvement, only one RCT showed positive results (969). However, one randomized trial (985) and one non-randomized study (979) showed negative results. Results were not available in the remaining studies.

1.2.1.3.4 Postsurgery Syndrome

There was only one randomized trial with adequate data for describing and evaluating the role of transforaminal epidural steroid injections in post surgery syndrome (993).

1.2.1.3.4.1 Evidence Assessment

Devulder et al's study (993) was an active-control trial of 60 patients with a history of spinal surgery for disc herniation who had an electromyogram (EMG) to confirm chronic nerve pathology and imaging to confirm nerve fibrosis. Patients were treated with bupivacaine and hyaluronidase; bupivacaine and methylprednisolone; or bupivacaine, hyaluronidase, and methylprednisolone. There were no statistically significant differences among the groups. Overall, pain relief was most prominent after one month, but decreased at 3 and 6 months.

1.2.1.3.5 Analysis of Evidence

Based on the USPSTF criteria, the evidence is considered at 3 levels – good, fair, and poor.

1.2.1.3.5.1 Lumbar Disc Herniation

For lumbar discherniation with radiculitis, based on 11 positive randomized trials (775,797,908,918,919,969,970, 972,983,985,989,995) with one duplicate publication (970,989), one negative study (982), and 2 studies with undetermined conclusions (808,984,987), the evidence is considered good for short-term and long-term relief with local anesthetics with steroids. Evidence is superior in contained disc herniation (967).

Of the 4 randomized trials comparing local anesthetic with steroids (797,970,972,985,989), 2 of them showed positive results (972,985), whereas 2 of them showed negative results (797,970,989), yielding fair evidence for short- and long-term relief with local anesthetic only.

There was fair evidence that transforaminal epidural injections will prevent surgery in a reasonable proportion of patients (774,970,981,989,990).

1.2.1.3.5.2 Axial or Discogenic Pain

The available literature does not illustrate significant evidence for transforaminal epidural steroid injections in patients with axial or discogenic pain without radiculitis, disc herniation, or spinal stenosis. Consequently, the evidence is limited for transforaminal epidural injections in patients with axial or discogenic pain without radiculitis, disc herniation, or spinal stenosis.

1.2.1.3.5.3 Spinal Stenosis

For spinal stenosis, the available evidence is fair for short-term based on 4 randomized trials (918,969,972,985), with 3 of them showing positive results (918,969,972). Of the 5 non-randomized studies (858,979,980,986,992), 4 studies showed positive results in the short term (858,979,980,992). The evidence is limited for long-term improvement based on one positive active-control trial (971) and one negative active-control trial (987) for transforaminal epidural with local anesthetic and steroids in managing spinal stenosis.

1.2.1.3.5.4 Post Surgery Syndrome

The evidence for post lumbar surgery syndrome is poor based on one moderate quality RCT (993), which was an active-control trial with indeterminate conclusions.

1.2.1.3.6 Summary of Evidence

In summary, the evidence is good for radiculitis secondary to disc herniation with local anesthetics and steroids and fair with local anesthetic only, fair for spinal stenosis with local anesthetic and steroids, and limited for axial pain and post surgery syndrome with local anesthetic with or without steroids for short-term and long-term relief.

1.2.1.4 Complications

The most common and worrisome complications of transforaminal epidural steroid injections in the lumbar spine, though rare, are related to neural trauma, vascular trauma, intravascular injection, and infection (269,867,868,872,877,878,889,904,934,966,1004-1032). None of the studies included in an effectiveness analysis showed any major complications.

However, transforaminal injections have been reported with complications including spinal cord injury and infarction and paraplegia (1008,1009).

Side effects related to the administration of steroids are generally attributed either to the chemistry or to the pharmacology of steroids (878). The major theoretical complications of corticosteroid administration include the suppression of pituitary adrenal axis, hypocorticism, Cushing syndrome, osteoporosis, avascular necrosis of the bone, steroid myopathy, epidural lipomatosis, weight gain, fluid retention, and hyperglycemia (877). Radiation exposure is also a potential problem with damage to eyes, skin, and gonads (889,966).

1.2.1.5 Recommendations

The evidence is good for caudal epidural, interlaminar epidural, and transforaminal epidural injections with or without steroids in managing disc herniation or radiculitis.

For axial or discogenic pain, the evidence is fair for either caudal epidural or lumbar interlaminar epidural injections with or without steroids. The evidence is limited for transforaminal epidural injections.

For spinal stenosis the evidence is fair for caudal and interlaminar injections and limited for transforaminal epidural injections with or without steroids.

For post surgery syndrome the evidence is fair for caudal epidural injections with or without steroids.

Thus, for disc herniation, one of the 3 approaches may be used; for axial or discogenic pain, either lumbar interlaminar or caudal epidural injections are recommended; for spinal stenosis any of the 3 approaches may be performed, however with transforaminal, there is limited evidence; and for post surgery syndrome, the preferred modality of treatment is with caudal epidural with or without steroids.

1.2.2 Lumbar Epidural Adhesiolysis

The purpose of percutaneous epidural lysis of adhesions is to minimize the deleterious effects of epidural scarring, which can physically prevent direct application of drugs to nerves and other spinal tissues and to treat chronic back pain (1033-1035). Epidural lysis of adhesions and direct deposition of corticosteroids in the spinal canal can also be achieved with a 3-dimensional view provided by epiduroscopy or spinal endoscopy.

Due to limited evidence and rare use of spinal epidural endoscopic adhesiolysis, it is not discussed herewith. However, systematic reviews for both techniques have been performed by Helm et al (19,20) with updated evidence.

1.2.2.1 Percutaneous Adhesiolysis

Percutaneous adhesiolysis with a reinforced or Racz catheter is proven to be effective in post lumbar surgery syndrome and spinal stenosis. Its effectiveness for other causes is unknown or limited. Adhesiolysis has been the subject of several systematic reviews (112,116,128,977,1033-1041).

The 2007 ACOEM guidelines found that adhesiolysis was not recommended for the treatment of low back pain because of insufficient evidence (116). Manchikanti et al (977) have criticized the ACOEM guidelines for methodological shortcomings. Chou and Huffman (105), in the 2007 APS guidelines, in discussing therapies for post lumbar surgery syndrome, commingle adhesiolysis with "forceful epidural injections," which appear to be high volume caudal injections. Chou and Huffman's review does not present specific evaluations of a treatment, rather, it rates the individual studies, along with editorial comments regarding the quality of the studies. Belozer and Wang (1033), writing a Health Technology Assessment in 2004 for the Washington State Department of Labor and Industries, reviewed the then-available literature, but did not make any policy recommendations. Racz et al (1040) found that the procedure was effective, that it did provide relief in patients who had failed epidural injections, that hyaluronidase did not improve outcomes, that the role of hypertonic saline was unclear, and that it was a safe procedure. Van Boxem et al (305), in an article reviewing treatment of radicular pain, found that adhesiolysis was an investigational procedure. Tran et al (1039), in a review of treatment for spinal stenosis, citing one article (1042), noted that adhesiolysis provided lower pain and ODI scores and longer duration of relief than did fluoroscopically guided epidural injections.

In a recent systematic review, Helm et al (19) assessed the evidence with a search of the relevant publications through June 2012, with strict inclusion criteria and methodological quality assessment. They identified 15 studies, and 5 of the RCTs and 2 of the observational studies met inclusion criteria. They assessed the evidence as fair for percutaneous adhesiolysis in relieving low back and/or leg pain caused by post lumbar surgery syndrome and central spinal stenosis (1041-1047). There were 3 new studies identified (260,261,1048). Of these, 2 studies (260,261) were updates of previously published studies with 2 year follow-up (1041,1042). The third study (1048) was a retrospective chart review without a control group of the effectiveness of percutaneous adhesiolysis using NaviCath for the management of chronic pain due to lumbosacral disc herniation. This was only a 3 month follow-up, even though the results were positive. Our literature search yielded no additional studies, except for updates of 2 previously published studies (260,261).

1.2.2.1.1 Evidence Assessment

Tables 14 and 15 illustrate the results of randomized studies of the effectiveness of percutaneous adhesiolysis in post lumbar surgery syndrome and lumbar spinal stenosis (260,261,1041,1042,1044-1047). There were 3 high quality studies in assessing post lumbar surgery syndrome and there was one high quality study in assessing lumbar central spinal stenosis. There was also one observational study meeting the inclusion criteria in lumbar spinal stenosis.

Manchikanti et al (261,1042) in an assessment of the effectiveness of percutaneous adhesiolysis and caudal epidural injections in managing post lumbar surgery syndrome published 2-year results. In this evaluation they included 120 patients assigned to 2 groups, with Group I receiving caudal epidural injections with catheterization up to S3 with local anesthetic 2% (5 mL), nonparticulate betamethasone 6 mg (1 mL), and 6 mL of 0.9% sodium chloride solution without adhesiolysis. In contrast, Group II (intervention group, n = 60), received percutaneous adhesiolysis of the targeted area with targeted delivery of lidocaine 2% (5 mL), 10% hypertonic sodium chloride solution (6 mL), and nonparticulate betamethasone (6 mg). The authors utilized multiple outcome measures including numeric pain rating scale, ODI 2.0, employment status, and opioid intake with assessment at various levels during the follow-up. They defined the primary outcome as 50% improvement in pain and ODI scores. Utilizing a robust outcome criteria, significant improvement with at least 50% relief with pain and improvement in functional status was illustrated in 82% of the patients at the 2-year follow-up in the adhesiolysis group compared to 5% in the control group receiving caudal epidural injections. The average number of procedures over a period of 2 years in the adhesiolysis group was 6.4 ± 2.35 with overall total relief of approximately 78 weeks out of 104 weeks. The authors concluded that the

Table 14. *Results of randomized studies on the efficacy of percutaneous adhesiolysis in post lumbar surgery syndrome.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain Relief and Function	Results at 12 mos.	Comments
Manchikanti et al, 2012, 2009 (261,1042) RA, AC 10/12	120 60 adhesiolysis 60 caudal epidural steroid	NRS, ODI, employment status, opioid intake. A significant reduction was 50% for NRS and 40% for ODI.	73% of adhesiolysis group had >50% relief at 12 months; 12% of caudal group did. 3-4 adhesiolysis procedures/year	P	High quality trial showing good evidence of effectiveness.
Heavner et al, 1999 (1044) R, AC 10/12	59	VAS, MPQ, VAS rated mild (0-29), moderate (30-54) or severe (55-100) Improvement was a 10 point change in VAS.	83% of the patients showed significant improvement compared to 49% at 3 months, 43% at 6 months, and 49% at 12 months.	P	High quality trial with positive results.
Manchikanti et al, 2004 (1045) RA, AC 10/12	75 25 caudal epidural steroid injection 25 1-day adhesiolysis with normal saline 25 1-day adhesiolysis with hypertonic saline	VAS, ODI, work status, opioid intake, ROM, and psychological evaluation using P-3. Significant pain relief was >50% relief.	72% of hypertonic saline and 60% of normal saline patients had >50% relief at 12 months, versus 0% of caudal injections.	P	High quality trial with positive results.
Veihelmann et al, 2006 (1046) RA, AC 7/12	47 1 –day adhesiolysis 52 physical therapy	VAS for back and leg pain, ODI, Gerbershagen score	There was a significant decrease in VAS and Oswestry scores at 1, 3, 6, and 12 months. 28 adhesiolysis patients were able to decrease Gerbershagen grade compared to 2 PT patients.	I	Moderate quality trial with indeterminate results.

RA = Randomized; AC = Active-control; P = Positive; VAS = Visual Analog Scale; I = Indeterminate; MPQ = McGill Pain Questionnaire; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; ROM = Range of motion; P-3 = Pain Patient Profile; PT = Physical Therapy.
Adapted and Modified from: Helm II S, et al. Percutaneous adhesiolysis in the management of chronic low back pain in post lumbar surgery syndrome and spinal stenosis: A systematic review. *Pain Physician* 2012; 15:E435-E462 (19).

Table 15. *Results of randomized and observational studies on the effectiveness of percutaneous adhesiolysis in lumbar central spinal stenosis.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain relief and Function	Results at 12 months	Comments.
Manchikanti et al, 2013, 2009 (260,1041) RA, AC 10/12	25 adhesiolysis 25 caudal epidural steroid	NRS ODI Opioid intake, employment, work status	76% of adhesiolysis patients had >50% relief at 12 months; 4% of the epidural group did. Average of 3-4 adhesiolysis procedures per year.	P	High quality trial with positive results.
Park et al, 2011 (1047) PR 7/13	66, all had adhesiolysis	5 point satisfaction scale	66% had improvement at 6 months	NA	Moderate quality study with positive results.

RA = Randomized; AC = Active-control; PR = Prospective; P = Positive; N = Negative; NA = Not applicable; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index.
Adapted and Modified from: Helm II S, et al. Percutaneous adhesiolysis in the management of chronic low back pain in post lumbar surgery syndrome and spinal stenosis: A systematic review. *Pain Physician* 2012; 15:E435-E462 (19).

results of this study showed significant improvement in 82% of patients over a period of 2 years with an average of 6 to 7 procedures of one-day percutaneous adhesiolysis in patients with failed back surgery syndrome (FBBS). This is a well performed active-control randomized trial with a long-term follow-up; however, the criticism has been that Group I, or the caudal group which functioned as a control group in this case, had an unblinding or withdrawal rate of 62% at the end of one year, whereas the adhesiolysis group had only a 3% unblinding rate. It is quite understandable that patients with a chronic condition who have already failed conservative management, epidural injections, and surgical interventions, basically having to contend with continued pain problems and increasing disability for 2 years is an impossible task. Considering the strict inclusion criteria and outcome parameters, the results of this study are of importance in managing post lumbar surgery syndrome.

Heavner et al (1044) in 1999 showed that neither hypertonic saline nor hyaluronidase was critical for a successful outcome. Manchikanti et al (1043) showed that the procedure could be done in one day, instead 3 days. Manchikanti et al (1045) also showed that hypertonic saline was not critical to the procedure. The common factor which differentiates percutaneous adhesiolysis from an epidural steroid injection, whether done through a needle or using a non-wire bound catheter, is the use of a wire-bound, steerable catheter to deliver appropriate volumes of saline, steroid, and local anesthetic into the target area. Veihelmann et al (1046) noted the importance of placing the catheter at the ventrolateral aspect of the epidural space and the desirability of replicating the patient's pain complaints. Thus, there is a variety of factors which clearly differentiate adhesiolysis from other injections, including catheter placement, volumes injected and, most clearly, the use of a wire-bound catheter.

In the assessment of spinal stenosis (260,1041,1047), there were 2 studies, one of which was a randomized double-blind study with a preliminary publication (1041), followed by an observational phase of 2 years (260), and another observational study (1047). For the observational study (1047), results were available only at 6 months. There were no results available at one year. The high quality randomized double-blind study which was continued into the observational phase (260,1041) was conducted in an interventional pain management practice, a specialty referral center in the United States by Manchikanti et al. They included 70 patients with only central spinal stenosis with chronic low back and lower extremity pain having failed conservative management along with fluoroscopically directed epidural injections. The initial phase of the study was randomized, double-blind with a comparison of percutaneous adhesiolysis with caudal epidural injections (1041). In the randomized phase, there were 25 patients in the adhesiolysis group and 25 patients in the caudal epidural steroid injection group, which was a control group. The results showed significant improvement in 76% of the patients undergoing percutaneous adhesiolysis compared to 4% in the epidural group at one year follow-up in the randomized phase. The authors used robust outcomes assessment criteria with 50% improvement in pain and functional status. The 2 year follow-up (1041) was performed with percutaneous adhesiolysis and appropriate placement of the Racz catheter, followed by an injection of 5 mL of 2% preservative-free lidocaine with subsequent monitoring in the recovery room with injection of 6 mL of 10% hypertonic sodium chloride solution and 6 mg of non-particulate betamethasone, followed by an injection of 1 mL of sodium chloride solution and removal of the catheter. Overall, a primary outcome, or significant pain relief and functional status improvement of at least 50% was seen in 71% of the patients at the end of 2 years. The overall number of procedures over a period of 2 years was 5.7 ± 2.73. This study may be criticized for the high withdrawal rate after one year in the control group; however, considering the major issue with recruitment into a randomized double-blind trial, even though it was an active-control trial, it proved to the authors to be extremely difficult, not only to recruit, but to keep the patients without unblinding, ethically with controlling their pain appropriately. The authors have described that this is the first study of many randomized, double-blind controlled trials they have conducted with difficulty in recruiting the patients.

Park et al (1047), in a prospective observational study, sought to determine the relationship between the severity of spinal stenosis and the participants' response to adhesiolysis, and to evaluate the mid-term effectiveness of adhesiolysis. Their results showed improvement (including reports of slightly improved, much improved, and no pain) was observed in 49 participants (74.2%) at 2 weeks and 45 participants (66.7%) at 6 months after the procedure. The dural sac cross-sectional area did not differ between participants who reported improvement and those who did not. There was no statistically significant correlation between pain relief and dural sac cross-sectional area, age, or participant

gender. They concluded that percutaneous adhesiolysis was shown to be effective for the treatment of lumbar spinal stenosis, with mid-term results, without affecting dural sac cross-sectional area.

1.2.2.1.2 Analysis of Evidence

Based upon the 3 high quality RCTs (261,1042,1044,1045) with positive results and one moderate quality randomized trial (1046) with indeterminate results, using the USPSTF criteria, the evidence is fair that adhesiolysis is effective in the treatment of chronic low back and leg pain due to post lumbar surgery syndrome.

Based upon one high quality RCT (260,1041) and one moderate quality observational study (1047), using the USPSTF criteria, the evidence is fair that adhesiolysis is effective in the treatment of chronic low back and leg pain due to spinal stenosis.

1.2.2.1.3 Complications

Complications of percutaneous epidural adhesiolysis have been extensively reviewed (853,868,887,956,1035,1037,1038,1049-1084). The most commonly noted complication was dural puncture, which in and of itself can lead to post lumbar puncture headache and possibly the need for a blood patch.

A secondary consequence of lumbar puncture is the possibility of local anesthetic spinal blockade and, if hypertonic saline is injected into the subarachnoid space, neural damage (1055). It is to prevent the occurrence of neural damage that Racz's protocol for adhesiolysis includes monitoring the patient for 30 minutes prior to the injection of hypertonic saline to ensure that there is no evidence of subarachnoid or subdural injection of local anesthetic.

Transient neurologic deficits have been reported. Veihelmann et al (1046) reported 15 cases of transient sensory deficit out of 47 patients. Their higher incidence of sensory deficit may be related to their focus on placement of the catheter at the ventral aspect of the epidural space. Ho and Manghnani (1056) reported a case of transient (less than 5 weeks) monoplegia involving L4, L5, and S1 in a patient with pre-existing neurologic deficits in the same area. The patient was given 5 mL of normal saline and 5 mL of 0.1% bupivacaine, indicating that the authors' suggestion that the injection of a large volume of fluid led to the deficit seems unlikely. The accompanying fluoroscopic images suggest that injection into an area of scarring (a loculation) leading to a localized area of compression of the nerve root with attendant deficits also seems unlikely. One is left to hypothesize that there was an unrecognized subarachnoid injection with persistent local anesthetic blockade of the damaged nerve roots, while sparring the lower sacral roots, but this explanation of the observed deficit is speculative.

Aldrete et al (1059) attributed incidences of arachnoiditis following epidural adhesiolysis with hypertonic saline to subarachnoid leakage of hypertonic saline. However, the technique utilized in these cases was criticized (1060-1062).

Catheter shearing has also been reported. Usually, the catheter is left in situ as the risks of removing it are greater than the risks of leaving it. Veihelmann et al (1046) reported one case of catheter shearing, which was easily removed via an incision at the sacrum under local anesthetic. Perkins et al (1052) reported a case in which an MRI was successfully obtained with a retained sheared Racz catheter being present. In this case, the MRI had a metallic artifact and a CT myelogram was necessary to identify a filling defect by the S1 nerve root. A laminectomy found the retained catheter in the epidural space by the S1 root; removal of the catheter resolved the radiculopathy which had occurred since the shearing of the catheter.

Manchikanti and Bakhit (1058) reported a torn Racz catheter in the lumbar epidural space. This case report illustrated a difficult situation with a sheared and retained epidural catheter which could not be removed utilizing standard techniques, but was successfully removed without any residual problems using arthroscopy forceps.

The most widespread cause of catheter shearing is advancing an RK needle without the stylet being fully inserted, allowing the long lip of the needle to be bent up and catch the catheter causing it to shear. One commentator stated that sheared catheters seemed "to occur every time we have a new group of pain fellows" (1057), suggesting that the complication is related to user experience. The current recommendation to use a Coude needle rather than an RK needle minimizes the risk of this complication.

As with any procedure, there is a risk of infection or hematoma. Wagner et al (1051) reported a case of meningitis. Gerdesmeyer et al (1084), in their series of 61 cases, did report one case of epidural infection successfully treated with antibiotics and refer to 2 additional cases reported in the literature. Manchikanti et al (1043) reported one case of infection out of 232 patients. This infection did require drainage but was not

an epidural abscess. Talu and Erdine (1049) reported 3 cases of epidural abscess in a study of 250 patients.

No cases of epidural hematoma have been reported. There are no reported cases of serious neurologic deficits after adhesiolysis, including arachnoiditis, paralysis, weakness, or bowel or bladder dysfunction.

The incidence of complications from percutaneous adhesiolysis is low and the complications are generally minimal and self-limited. The procedure should be considered to be low risk for serious adverse events when performed by well trained physicians.

1.2.2.1.4 Recommendations

Based on the present evidence, percutaneous adhesiolysis is recommended in patients with post lumbar surgery syndrome and lumbar central spinal stenosis after failure of conservative management of physical therapy, chiropractic, drug therapy, structured exercise program, and fluoroscopically directed epidural injections.

1.2.3 Thermal Annular Procedures

Thermal annular procedures (TAPs) have been the subject of several reviews (119,309,1085-1091). The United Kingdom's National Institute for Clinical Excellence (1087) published a review of percutaneous intradiscal radiofrequency thermocoagulation (PIRFT) in 2004, finding that IDET should be restricted. On similar lines, the Centers for Medicare and Medicaid Services (CMS) described these procedures as thermal intradiscal procedures and provided a noncoverage decision due to lack of evidence (119). Gibson and Waddell (511), in a review published in 2005 concerning the surgical treatment of degenerative disc disease, found that limited evidence on the IDET procedure suggested that the procedure was ineffective. This review was criticized by Andersson et al (1090) at the time of its publication for methodological shortcomings. They said there was a lack of critical assessment of the reviewed studies as well as a mischaracterization of the procedure. Andersson et al published a systematic review in 2006 (509), finding that IDET had the same symptom amelioration as fusion without the complications of fusion. Appleby et al (510), in a manufacturer-sponsored meta-analysis of the data supporting IDET, found that although there were variations in the results of the various studies, "the pooled results provide compelling evidence of the relative efficacy." Freeman (1086), in a review published in 2006, found that the evidence for IDET was weak. Freeman updated his conclusions in a book chapter in 2010 (1091). The American Pain Society (APS) guidelines, authored by Chou and Huffman (105), found that there was conflicting evidence regarding IDET's efficacy and that the quality of the evidence was poor. Chou and Huffman (105) also looked at PIRFT, but used this term to refer to either Coblation®, a technology which used radiofrequency to decompress the nucleus, or to the application of radiofrequency energy within the nucleus (1092). Neither procedure treated the annulus, so they are not germane to the current discussion.

Urrútia et al (1088) also looked at both IDET and PIRFT, again defining PIRFT as having the catheter "placed in the center of the disc rather than the annulus." Urrutia et al (1088), however, also included a study by Kapural et al (1093) that compared IDET with discTRODE, so that they, like Chou and Huffman (105), appear to be comparing dissimilar procedures. Urrútia et al (1088) found that the evidence did not support the effectiveness of IDET. The 2009 review by the Helm et al (1085) of TAPs found that IDET provided functionally significant relief in approximately one-half of appropriately selected patients, but that there was minimal evidence to support the use of discTRODE or biacuplasty. Levin (811), publishing a review of prospective, double blind, placebo controlled trials in 2009, found that IDET is modestly effective in carefully selected patients. Chou and Huffman (105), responding in the same issue as Levin published in, clarified the APS position as being that there is insufficient evidence to judge whether IDET (or the other TAP procedures) is effective.

Kabbara and Hayek (1089) found that IDET may be useful in a selected group of patients, but evidence did not exist for a wider use of IDET. Kallewaard et al (309), as a part of the evidence-based medicine reviews published in *Pain Practice*, authored a review of the treatment of discogenic low back pain. They found insufficient evidence to support either IDET or biacuplasty. Interestingly, an older therapy, radiofrequency ablation of the gray ramus communicans, was recommended.

These reviews have significant treatment implications and have been used to support denial of coverage of these procedures (1094,1095). The use of an insufficient evidence determination to support denied coverage is disquieting (1096). Carragee et al (1097), in an article co-authored by Urrútia et al (1088), used Urrútia et al's study of IDET as an example of a technology which was initially popular and which was later shown to be ineffective. Freeman and Merdian (1098) concluded that IDET was not effective.

Henschke et al (771), writing in the *European Spine Journal* in 2010, found that there was low quality evidence that IDET is more effective than placebo at relieving pain, but not functional status, at 6 months. Because IDET is the most widely studied of the 3 technologies evaluated here, it was the focus of these reviews.

Helm et al (25) performed a systematic review of effectiveness of TAPs in treating discogenic low back pain with evidence spanning through December 2011. They identified 3 RCTs and one observational study which met the inclusion criteria. They concluded that the evidence is fair for IDET and limited or poor for discTRODE and biacuplasty, which is also being evaluated in 2 ongoing RCTs. A literature search yielded one additional study of biaculoplasty (1099).

1.2.3.1 Evidence Assessment

Table 16 illustrates the results of 4 RCTs (1099-1102), the one moderate quality observational study (1103), and 5 low quality studies (1104-1108).

Of the 5 studies that met the current criteria relating to study size and quality for inclusion (1099-1103), only Pauza et al (1100) showed efficacy for the IDET procedure. There was a statistically significant (P = .037) improvement in visual analog scale (VAS) scores between the treated and the controlled, with 40% of the control group getting more than 50% relief. At the same time, 33% of the placebo group had more than 50% relief and the change in the VAS, while significant between the control and placebo group, was less than 3. Thus, while Pauza et al's study does show efficacy of the procedure, the extent of the relief is modest. There are an additional 4 observational studies (1104,1105,1107,1108) which showed positive results for IDET.

Freeman et al (1101) have been soundly criticized. We have already noted that the control and treated groups were dissimilar. There is also the methodological flaw that a 2-point improvement in VAS is listed as an outcome under the Methodology section, but no VAS scores are provided (1109). Further, Kapural and Mekhail (1110) criticized it for its failure to control for factors known to be associated with adverse outcomes, such as multilevel disease, workers' compensation status, and obesity. However, these criticisms pale in light of the failure to have a placebo effect. The importance of this failure is best described by Carragee (1111). Carragee is a strong and eloquent supporter of the position that various back interventions are ineffective. Thus, his opinions on the importance of the lack of response in the control group are of great significance. He feels that no effect on the sham group is a major flaw: "Decades of detailed research on patients with [low back pain] have consistently shown at least some improvement after any nonspecific intervention on the basis of natural history, regression to the mean, and the placebo effect. Yet we see no effect of the sham injection at all. A failure to see this nonspecific effect is troublesome" (1111). Freeman et al's (1101) article should be excluded for unidentified structural flaws that led to a lack of response in the placebo group. In comparison, Pauza et al (1100) found that one out of 3 in the placebo groups got 50% relief. In like manner, Kvarstein et al's (1102) data show that about 30% of the sham treated groups had 50% relief. The data suggest that Freeman et al's study (1101) is an outlier.

Kvarstein et al (1102) showed no benefit from the discTRODE procedure. These findings are supported by a lower quality study by Kapural et al (1093), which showed that discTRODE had a less favorable outcome than IDET.

There is a third technology, cooled biacuplasty, for which there is one high quality publication (1099,1112). A controlled, prospective, randomized, placebo-controlled efficacy study showed positive results. The principal outcome measures were physical function, pain, disability, and opioid usage. Patients in the intradiscal biacuplasty group exhibited statistically significant improvements in physical function (P = 0.029), pain (P = 0.006), and disability (P = 0.037) at 6-month follow-up as compared to patients who received sham treatment. Treatment patients reported a reduction of 16 mg daily intake of opioids at 6 months; however, the results were not statistically different from sham patients. The results suggest that the clinical benefits observed in this study are the result of non-placebo treatment effects afforded by intradiscal biacuplasty. Intradiscal biacuplasty may be recommended to select patients with chronic discogenic low back pain.

1.2.3.2 Analysis of Evidence

The results of the analysis of evidence as to whether TAPs provide relief from discogenic low back pain are shown in Table 16. Level of evidence is based on USPSTF criteria stratified as good, fair, or limited (or poor).

1.2.3.2.1 IDET

Based on the above evidence of one positive randomized trial (1100), 4 positive observational studies meeting the inclusion criteria (1104,1105,1107,1108),

Table 16. *Results of randomized and observational studies on the effectiveness of thermal annular procedures.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain Relief and Function	Results at 6 months	Results at > one-year	Comments
Pauza et al, 2004 (1100) RA, PC, DB 10/12	37 IDET/27 sham	VAS, SF-36, ODI 25%, 50% and 75% relief at 6 months	No significant change in mean VAS.. 40% of treated had ≥ 50% relief; 33% of control had ≥ 50% relief.	P	NA	High quality trial showing weak evidence of effectiveness.
Freeman et al, 2005 (1101) RA, PC, DB 8/12	38 IDET/19 sham	VAS, LBOS, ODI, SF-36, ZDI, MSPQ Blinded assessment	No improvement in treated or placebo.	N	NA	Randomized trial w/ flawed methodology.
Derby et al, 2004 (1103) RE 8/11	74 IDET/35 injection therapy	VAS Patients' subjective impression of improvement	Neither group showed > 3 point improvement in VAS or 50% improvement in VAS or 40% improvement in functional scores.	U	U	Retrospective evaluation w/ indeterminate results.
Tsou et al, 2010 (1104) P 6/11	93 IDET	Percent improvement – 100%, > 50%, < 50%, no change increase	3 months (62%), 6 months (74%), one year (63%), 2 years (60%), 3 years (48%).	P	P	Prospective evaluation, positive results.
Assietti et al, 2011 (1105) P 6/11	50 IDET	VAS, ODI	68% improved at 24 months	P	P	A small prospective evaluation, positive results.
Davis et al, 2004 (1106) RE 6/11	60 IDET	Surgical treatment for back pain after IDET	NA	N	NA	A small poorly conducted evaluation, negative results.
Derby et al, 2004 (1107) RE 6/11	99 IDET	VAS	64%	P	P	A retrospective evaluation w/ large number of dropouts, positive results.
Nunley et al, 2008 (1108) RE 6/11	53 IDET	VAS, ODI	VAS reduction 62% ODI reduction 69%	P	P	A prospective evaluation in workers' compensation patients, positive results.
Kvarstein et al, 2009 (1102) RA, PC, DB 10/12	20, 10 discTRODE/10 sham	VAS, w/ reduction of 2 significant, verbal rating scale of pain, BPI, SF-36, ODI, patient specific functional scale	No improvement in treated or sham.	N	NA	High quality trial showing lack of efficacy for discTRODE.
Kapural et al, 2012 (1099) RA, PC, DB 10/12	Biaculoplasty 27 active 30 sham	NRS, ODI, SF-36	SI in pain, function, disability	P	NA	High quality randomized trial w/ positive results

RA = Randomized; PC = Placebo control; RE = Retrospective; P = Prospective; IDET – Intradiscal Electrothermal Therapy; VAS=Visual Analog Scale; ODI = Oswestry Disability Index; SI = Significant improvement; SF-36 = Short Form-36; NRS = Numeric Rating Scale; HUQ = Health Care Utilization Questionnaire; BPI= Brief Pain Inventory; MSPQ = Modified Somatic Perception Questionnaire; ZDI=Zung Depression Index; LBOS = Low Back Outcome Score. Adapted and Modified from: Helm II S, et al. Effectiveness of thermal annular procedures in treating discogenic low back pain. *Pain Physician* 2012; 15:E279-E304 (25).

negative evidence from one poorly performed randomized trial (1101) and an observational study (1106), and undetermined results from another observational study (1103), the evidence supporting the efficacy of IDET is limited to fair.

1.2.3.2.2 discTRODE

There was only one study evaluating discTRODE (1102) which showed no benefit from the procedure; therefore, the evidence is limited (or poor).

1.2.3.2.3 Biacuplasty

There is limited to fair evidence for the effectiveness of biacuplasty for treating low back pain, based on one randomized trial with modest results (1099).

1.2.3.3 Complications

While some serious complications of TAPs have been reported, they are rare and temporary (1101-1122). Discitis, osteonecrosis, and the development of Grade 1 anterolisthesis and cauda equina syndrome have been reported (1106,1114-1116,1119). Orr and Thomas (1117) reported a case in which the catheter broke off and was left in the annulus resulting in the catheter migrating to the intradural sac. This led to radiculopathy and surgical removal of the catheter fragment. Derby et al (1120) reported a review of 1,675 IDET procedures and 35,000 medical device reports from the US Food and Drug Administration (FDA). There were 6 nerve root injuries, 5 of which were related to the placement of the introducer needle. They resolved spontaneously. Six cases of disc herniation were reported, 2 of which required discectomy. Nineteen cases of catheter breakage were reported.

There are no published cases of complications from discTRODE, but adverse events may be underreported and may include possible permanent ablation of traversing motor roots (1121). There are no reported complications from biacuplasty (1122).

1.2.3.4 Recommendations

Based on the evidence synthesis, there is limited to fair evidence for IDET and biaculoplasty and limited evidence for discTRODE. Consequently, IDET and biaculoplasty may be performed in a select group of patients (1123) with discogenic pain nonresponsive to conservative modalities including epidural injections.

1.2.4 Percutaneous Disc Decompression

Lumbar disc prolapse, protrusion, and extrusion account for less than 5% of all low back problems, but are the most common causes of nerve root pain and surgical interventions (21-24,555,1124-1129). The typical rationale for traditional surgery is an effort to provide more rapid relief of pain and disability (552,629,1124,1125). The majority of patients are expected to recover with conservative management (561-563). The primary rationale for any form of surgery for disc prolapse associated with radicular pain is to relieve nerve root irritation or compression due to herniated disc material (629). The primary modality of treatment continues to be either open discectomy or microdiscectomy, but several alternative techniques to open discectomy including automated percutaneous lumbar discectomy (APLD), percutaneous lumbar laser disc decompression, mechanical disc decompression with Dekompressor®, and nucleoplasty have been described. Herniated discs are of 2 basic types: contained and non-contained. Contained herniated discs have an outer annulus with displaced disc material being held within the outer annulus of the contained herniated disc. However, in a non-contained herniated disc there is a localized displacement of the disc material beyond the intervertebral disc space and a breech in the outer annulus (21-24,555,629,1124-1131). Mechanical disc decompression has the ability to avoid many of the major complications related to FBBS. Multiple reviews have been published in reference to mechanical disc decompression (21-24,1124-1126); however, there appears to be a significant paucity of high quality literature even though APLD and percutaneous lumbar laser discectomy were introduced several decades ago.

1.2.4.1 Automated Percutaneous Mechanical Lumbar Disc Decompression

Automated percutaneous mechanical lumbar disc decompression, or APLD, is performed with a pneumaticaly driven, suction-cutting probed in a cannula with a 2.8 mm outer diameter with removal of 1 to 3 grams of disc material to reduce the intradiscal pressure and decompress the nerve roots (23,1124,1125,1131-1137).

Diagnostic and Therapeutic Technology Assessment (DATTA) published in the *Journal of the American Medical Association* (JAMA) in 1989 (1138) concluded that percutaneous discectomy, particularly the automated procedure, using Onik Nucleotome, is a promising treatment for herniated lumbar discs wherein the nuclear bulge is contained by the nucleus. They concluded that further studies were needed to establish the safety and effectiveness of this procedure for this indication. The

majority of the DATTA panelists also concluded that when a herniated lumbar disc has nuclear material outside the annulus but still contiguous with the nucleus, either that the risk/benefit ratio was unfavorable or that evidence was insufficient for a definitive decision regarding the application of percutaneous discectomy. A year later in the analysis in 1991, the same organization, DATTA (1139), after reconsideration of APLD, concluded that it was a safe procedure when used for patients with protruding lumbar discs who have failed conservative therapy. However, there was no consensus on the effectiveness APLD for this indication, as the majority of the responses fell in either the promising or investigational category. However, a consensus of the panelists considered that APLD was an inappropriate treatment in terms of both safety and effectiveness for a lumbar disc in which the nuclear material protruded outside the annulus without any free sequestered fragment, an opinion similar to the previous one (1138). There was no consensus on the effectiveness of APLD for this indication as the majority of the responses fell in either the promising or investigational category. Since then, no diagnostic and therapeutic technology assessments have been published.

The recent systematic review by Manchikanti et al (23) included 19 studies (1137,1140-1158) with none of the randomized trials meeting the inclusion criteria (1159-1162). Based on this review, the indicated evidence for APLD is limited for short- and long-term relief.

Lühmann et al (1163) in a systematic review of minimally invasive surgical procedures for the treatment of lumbar disc herniation showed that the evidence base to assess safety, efficacy, and effectiveness of minimally invasive lumbar disc surgery procedures was rather limited. In reference to APLD, they found 2 RCTs, one case series, and 2 economic analyses. They concluded that among all minimally invasive procedures, chemonucleolysis was the only one of which efficacy may be judged on the basis of results from high quality RCTs. They described that the only RCT comparing the results of APLD to those of microdiscectomy showed clearly superior results of microdiscectomy (1161). This study was excluded from the present systematic review as it failed to meet the inclusion criteria. They also concluded that the results of the 5 economic analyses evaluating various types of minimally invasive lumbar disc decompressions were, due to conceptual and methodological problems, of no value for decision-making in the context of the German health care system, which may be applied to other health care systems too.

Our literature search yielded no further studies.

1.2.4.1.1 Evidence Assessment

The evidence synthesis included 19 observational studies as shown in Table 17 with inclusion of 5,515 patients undergoing APLD with all of them judged to have positive results ranging from 58% to 90%, with an average result of 80%. Four randomized trials failed to meet inclusion criteria.

Even though multiple randomized trials (1159-1162) studies are available, none met the inclusion criteria. Among the many observational studies, 19 of them met inclusion criteria. There have not been many recent studies. One study was published in 2010, however the data were collected from 2000 to 2002 (1140). The 4 randomized trials conducted are met with multiple flaws. The study by Chatterjee et al (1161), an assessment of a controlled clinical trial comparing APLD and microdiscectomy in the treatment of contained lumbar disc herniation published in 1995, has been met with not only criticism but also skepticism. This was based on the results which showed an unreasonably low success rate with APLD of 29% which may be even less than placebo, along with poor patient selection. This is an active-control trial comparing 2 modalities of treatment with no control group. Chatterjee et al (1161) have been criticized for poor selection criteria and not describing the response in patients with broad based disc protrusions which Chatterjee et al (1161) described as only a very small percentage of patients with lumbar disc herniation.

The study performed by Haines et al (1160) titled "Discectomy Strategies for Lumbar Disc Herniation: Results of the LAPDOG Trial" also has been criticized. The study generally may have been used to invalidate APLD but this study does not offer any proof. The study was terminated before it accumulated enough data to reach statistical conclusions. The authors were unable to recruit a targeted number of patients from a potential of almost 6,000 patients screened; only 36 patients were included in the study. In addition, 25% of the treated patients were lost to follow-up, even before 6 month data could be collected, raising questions in reference to the quality and validity of the study. In addition, almost 40% of the APLD patients were involved in litigation, which has been described as a complicating factor.

The third study by Revel et al (1159) compared APLD with chemonucleolysis. They included 141

patients of which 69 were treated with APLD. The success rate shown was 43%, which was significantly lower than the majority of the observational studies. In this evaluation sample size required 80 patients in each group; however, it was not met. The follow-up also was described as one year, even though it is only 6 months. Selection criteria may be inappropriate. The requirement of the contained, non-extruded disc for inclusion is not specified in the study protocol. At discography, 39% of the tested discs showed epidural leakage. The protocol allowed migration up to 5 mm beyond the disc space and the publication lists 71% of APLD patients in this category; thus, it appears that 29% of the patients had migration beyond 5 mm of the disc space. It has been a major concern that some of these cases had large extrusions of free fragments which was also reinforced by bilateral lower extremity pain in 8% of the patients, large volume herniations in 14%, and inclusion of patients with a positive crossed straight leg raising test. Further, the protocol or the publication does not specify the exclusion of the discs with diffuse annular bulging for which APLD is not effective and is therefore contraindicated. The results show a 16% incidence at discography of severely degenerated discs, and 9% with marked disc space narrowing and descriptions of 2 cases as technical failures after it was impossible to introduce the probe into the disc space. An additional criticism has been that there was no requirement that leg pain has to be greater than back pain for inclusion, even though the publication insists that only sciatica patients were included in the study. Apparently the study shows that 21% of patients had severe back pain, with no correlation to leg pain being available. Due to multiple abnormalities as discussed here, the Revel et al study (1159) may not be applicable to clinical settings. Since we were able to find only 6 month follow-up results, the study was excluded.

Table 17. *Summary results of eligible studies of automated percutaneous mechanical lumbar discectomy.*

Study	Methodological Quality Scoring	Number of Participants	Significant Pain Relief	Results
			> 12 mos.	Long-term > 12 mos.
Liu et al, 2010 (1140)	7/13	104 APLD 101 MED	76%	P
Degobbis et al, 2005 (1141)	7/12	50	76%	P
Marks, 2000 (1142)	7/12	103	63%	P
Hanaoka et al, 1996 (1143)	7/12	63	81%	P
Teng et al, 1997 (1144)	7/12	1,474	83%	P
Rezaian & Ghista, 1995 (1145)	7/12	285	88%	P
Grevitt et al, 1995 (1146)	7/12	115	45%	P
Shapiro, 1995 (1147)	7/12	57	58%	P
Gill & Blumenthal, 1993 (1148)	7/12	109	79%	P
Sakou & Masuda, 1993 (1152)	7/12	117	80%	P
Bonaldi et al, 1991 (1149)	7/12	234	75%	P
Gill & Blumenthal, 1991 (1150)	7/12	62	79%	P
Davis et al, 1991 (1151)	7/12	518	85%	P
Onik et al, 1990 (1154)	7/12	506	75%	P
Mooney, 1989 (1155)	7/12	64	75%	P
Davis & Onik, 1989 (1156)	7/12	200	78%	P
Swiecicki, 1989 (1157)	7/13	100 patients each = 3 groups	84%	P
Maroon & Allen, 1989 (1158)	7/12	1054	85%	P
Morris, 1988 (1153)	7/12	479	74%	P
TOTAL		5,515	80%	P

APLD = Automated Percutaneous Lumbar Discectomy; MED = Microendoscopic Discectomy; P = Positive
Adapted and modified from: Manchikanti L, et al. An updated review of automated percutaneous mechanical lumbar discectomy for the contained herniated lumbar disc. *Pain Physician* 2013; 16:SE151-SE184(23).

Krugluger & Knahr (1162) also performed a small assessment comparing APLD with chemonucleolysis. In this study, the level of the surgeon's experience has been questioned. In addition, there were extremely uncommon technical failures which occur in an estimated 0.005% of cases accounting for 10% of total failures in the APLD group in this study. Further, the authors also acknowledged a 7% to 20% occurrence in post op syndromes from open surgery, and attributed failures to central and lateral stenosis, fibrosis, and adhesions. Further, for some unknown reason, the hospital stay of the patients was an average 6 days after the procedure which is most often an outpatient procedure. In addition, the comparator which was used in this study, chemonucleolysis, is not utilized in the United States. Even though the results are considered positive, this study is unreliable. Consequently, it is excluded.

Among the 19 observational studies, none of them provided recent data. The recently published 2010 assessment was from data derived from 2000 to 2002 (1140). Overall, there were only 3 studies since 1997, with one in 2000 (1142), one in 2005 (1141), and one in 2010 (1140) meeting the inclusion criteria, all with positive short- and long-term results; however, Marks (1142) in 2000 published the study on the role of APLD in internal disc derangement rather than disc herniation even though the results were positive. Internal disc derangement is not an indication even discussed. Thus, it appears there were only 2 studies after 2000, both showing positive results in a total of 179 patients (1140,1141). In a multi-institutional study to assess automated percutaneous discectomy in the treatment of lumbar disc herniation, Onik et al (1154), from 1984 through 1987, included 506 APLDs by 18 different surgeons. Of the 327 patients who were followed for one-year or longer within the protocol, the success rate was 75.2%. The authors emphasized APLD is not appropriate for all patients with a herniated disc and should be used only for those patients with a contained disc herniation, that is, with the annulus and/or posterior longitudinal ligaments still intact and without evidence of migration from the disc space. They also showed that nearly 70% of patients in whom the treatment failed and subsequently had surgery had unrecognized sequestration of free disc fragments. Maroon and Allen (1158) in a large study of 1,054 patients undergoing APLD procedures from January 1987 to February 1988 at 35 U.S. hospital facilities reported an 82.9% successful result, both by the treating physician and the patient. They showed no significant correlation between the disc level and success; however, the primary cause of the failure was the preoperative non-discernible presence of free disc fragments. They removed an average of 2.5 grams of nucleus pulposus material from the disc ranging from 1 gram to 8 grams with no correlation with the outcomes. Teng et al (1144) also reported the results of 1,582 APLD procedures in a prospective study in 10 independent hospitals from 1992 to 1994, with a success rate of 83% at one year. They also reported good results in post surgical patients. They reported multiple contraindications including extrusion/sequestration type of herniation, long-term duration of the symptoms, old age, calcification of longitudinal ligaments, and previous surgical discectomy. In contrast to the common philosophy, they reported that patients who had only low back pain with little or no leg pain had significantly better results than those with classical sciatica.

Davis et al (1151) reported results of 518 patients with APLD performed on an outpatient basis, with an 85% success rate. Their results also showed that in 427 non-compensation cases, there was an 87% success rate with a 13% failure rate, whereas in 91 compensation patients, the success rate was 74%. Of the 79 patients considered failures, 33 were found to have extruded disc fragments outside the interspace with subsequent microdiscectomy and successful results. Five patients also had spinal stenosis sufficient to deny pain relief from the percutaneous discectomy, and later, surgery was successfully performed. Davis et al (1151) reported a 70% return to work rate in less than 2 weeks for compensation patients.

Bonaldi et al (1149) evaluated 234 patients treated by percutaneous discectomy showing an overall success rate of about 75% with follow-up between 11 months and 3 years. They also reported that in a subgroup of 112 of these patients who were continuously followed, the clinical results remained consistently good even 24 months after surgery. They also reported a good success rate even in patients with only low back pain.

Liu et al (1140) in the most recently published evaluation, assessing the results from 2000 to 2002, evaluated 104 patients with percutaneous lumbar discectomy and 82 patients with microendoscopic discectomy in a comparative evaluation. Utilizing appropriate outcome parameters, they reported a success rate of 75.96% in the percutaneous lumbar discectomy group and 84.15% in the microendoscopic discectomy group with excellent or good results, respectively. The costs for percutaneous discectomy were lower and there were no

long-term complications, whereas in microendoscopic discectomy 2 patients or 2.44% reported complications. The authors concluded that both percutaneous lumbar discectomy and microendoscopic discectomy show an acceptable long-term efficacy for treatment of lumbar disc herniation. However, while long-term satisfaction was slightly lower in the percutaneous lumbar discectomy patients, complications, hospitalization duration, and costs in the percutaneous lumbar discectomy group were also lower.

1.2.4.1.2 Analysis of Evidence

The indicated level of evidence for automated percutaneous mechanical lumbar disc decompression based on USPSTF criteria of good, fair and limited or poor, is limited for short- and long-term relief based on all observational studies.

1.2.4.2 Percutaneous Lumbar Laser Disc Decompression

Percutaneous lumbar laser disc decompression is performed by delivery of laser energy to the nucleus pulposus by means of a laser fiber (1164-1174). The fiber is inserted through a thin needle via a posterolateral percutaneous approach under local anesthesia. The absorption of the applied laser energy leads to vaporization of the water content of the nucleus pulposus and a change in its protein structure. The subsequent volume reduction causes a disproportionate decrease in intradiscal pressure, which in turn should theoretically decompress an entrapped nerve root. The first clinical percutaneous lumbar laser disc decompression was performed in Europe by Choy and colleagues in 1986 (1164). The FDA approved percutaneous laser disc decompression (PLDD) for use in the United States in 1991 (1174).

Percutaneous lumbar laser disc decompression is an attractive treatment because of its minimally invasive nature and the corresponding decreased risk of structural damage to the muscles, bone, ligaments, and nerves, which in turn may result in a lower prevalence rate of FBBS. In addition, the patients are expected to have less back pain, shorter hospitalization stays, and shorter recovery periods than following conventional surgery. The actual resolution of sciatica may be longer than after conventional surgery, though immediate resolution of symptoms does occur (1174). However, considerable skepticism persists regarding the technology. Despite several published cohort studies and FDA approval, no randomized trial has been performed to date comparing percutaneous lumbar laser disc decompression with conventional surgical procedures. The cohort studies demonstrate safety and suggest potential benefits that may be afforded by percutaneous lumbar laser disc decompression. Brouwer et al (1174) have designed a prospective RCT to assess the effectiveness of percutaneous lumbar laser disc decompression versus conventional open discectomy in the treatment of lumbar disc herniation. The results of this assessment are not available yet. The lack of high grade evidence is reflected in reviews on the subject. Schenk et al (1166) concluded that despite the fact that percutaneous lumbar laser disc decompression has been around for almost 20 years, scientific evidence of its efficacy still remains relatively poor, though the potential medical and economic benefits of percutaneous lumbar laser disc decompression are too high to justify discarding it on the sole basis of insufficient scientific proof.

In a Cochrane Collaboration review, Gibson and Waddell (629) presented the results from 40 RCTs and 2 quasi-randomized controlled trials (QRCTs) evaluating surgical interventions for lumbar disc prolapse. This review concluded that the indications for non-traditional forms of discectomy remain unresolved. Trials of percutaneous discectomy and laser discectomy suggest that clinical outcomes following treatment are at best fair and, certainly worse, than after microdiscectomy, although the importance of patient selection is acknowledged. Gibson and Waddell (629) concluded that while conventional discectomy provides faster relief from the acute attack of sciatica than other treatments, the unintended consequences on the long-term natural history of the underlying disease are unclear.

In a technology assessment report (512), no randomized published studies of percutaneous lumbar laser disc decompression were identified. However, the majority of the observational studies evaluating percutaneous lumbar laser discectomy showed positive evidence. In a systematic review of percutaneous lumbar laser disc decompression that evaluated 33 publications, none of which were controlled, Singh et al (1127) concluded that based on USPSTF criteria, the indicated level of evidence for percutaneous lumbar laser disc decompression was II-2 for short- and long-term relief. In 2009, a non-inferiority study design (1174) was published to assess the effectiveness of percutaneous lumbar laser disc decompression versus conventional open discectomy in the treatment of lumbar disc herniation. The protocol asserted that because there was a broad consensus that conventional surgery is the

gold standard for surgical intervention for sciatica, percutaneous lumbar laser disc decompression had to be compared to conventional surgery in order to assess its cost-effectiveness.

The underlying treatment principle of percutaneous lumbar laser disc decompression is based on the concept that the intervertebral disc is contained in a closed hydraulic system, so that only contained herniations would be expected to retract in response to a reduction in intradiscal pressure (1166). Consequently, the presence of a frank disc extrusion or sequestered herniation is considered to be an exclusion criterion for percutaneous lumbar laser disc decompression. For practical and clinical reasons, patients with critically (< 50%) diminished disc height, significant spinal stenosis, serious neurologic symptoms such as cauda equina syndrome or other conditions that require acute surgical intervention, are not generally considered candidates for percutaneous lumbar laser disc decompression.

The recent systematic review by Singh et al (22) with inclusion of 17 observational studies with a total of 3,171 patients showed an average relief of 75% on a long-term basis of greater than one year.

Our literature search yielded no further studies.

1.2.4.2.1 Evidence Assessment

The available literature included 15 observational studies (1167,1168,1173,1175-1189), with one study with 3 publications (1167,1168,1187), as shown in Table 18, with inclusion of 3,171 patients with overall relief of 75% on a long-term basis of greater than one year. Even though numerous studies are available, none of them were randomized. All of them evaluated disc herniation. Thus, without randomized trials, the percutaneous lumbar laser disc decompression procedure has been labeled as experimental (629). At present, it is believed the potential medical and economic benefits of percutaneous lumbar laser disc decompression are too high to justify discarding it as experimental or ineffective on the sole basis of insufficient scientific proof (1127,1166).

Schenk et al (1166) included 16 clinical studies representing a total of 1,579 patients. However, since it was a narrative review, the criteria were different. They included studies if they provided enough information on techniques used in the procedure (laser type, parameters used, etc.) and no additional techniques such as endoscopy were used. In this systematic review we also excluded studies if endoscopy was used except with laser-assisted spinal endoscopy (LASE). Schenk et al (1166) also included only trials when they addressed the outcome of percutaneous lumbar laser disc decompression. In the present systematic review and the review by Schenk et al (1166), the basic technique of percutaneous lumbar laser disc decompression appears to be the same for all trials. However, in the different studies, while basic principles remain the same, it appears there is a considerable degree of variation in the way percutaneous lumbar laser disc decompression is performed. Differences can be found in the choice of laser type and laser parameters used. While most studies used fluoroscopy some also used additional CT imaging or even MRI. In our previous systematic review (1127), 10 clinical studies were included representing 2,447 patients. In contrast to APLD (23), there were multiple studies after 2000. Eight of the 15 studies were published after 2000, with all of them showing positive results (1175-1182,1187). The most recent study by Duarte and Costa published in 2012 (1175) was a prospective, open, uncontrolled, and planned evaluation lasting from June 2006 through July 2009. This included 205 patients with 67% of the patients showing good results based on MacNab criteria.

Menchetti et al's (1176) study, published in 2011, was a multicenter retrospective of percutaneous lumbar laser disc decompression. This study utilized MacNab criteria reporting a 70% success rate at mean follow-up of 5 years (2 to 6 years) with a very low complication rate.

Iwatsuki et al (1177) in 2007 published an observational descriptive report of percutaneous lumbar laser disc decompression. This study utilized MacNab criteria showing percutaneous lumbar laser disc decompression was effective for 80% of patients with Lasègue's sign, but ineffective for those without positive Lasègue's sign.

Tassi (1178,1180) published 2 reports in 2004 and 2006 of the assessment of percutaneous lumbar laser disc decompression and microdiscectomy. This study utilizing MacNab criteria reported 83.8% of the patients with a good or excellent outcome in the percutaneous lumbar laser disc decompression group and 85.6% of the patients had a good or excellent outcome in microdiscectomy group. Complications occurred in 2.2% in the microdiscectomy group and 0% in the percutaneous lumbar laser disc decompression group

Zhao et al (1179) in 2005 published a cohort controlled study of percutaneous lumbar laser disc decompression with reports of excellent response in 45.3% or 63 patients and good results in 36.7% or 51 patients in the good indication group; whereas in the poor indication group, excellent results were seen in 32.4% or 11 patients, and good results in 23.5% or 8 patients.

Overall good results were seen in 82% of the patients.

Choy (1187) in 2004 published a review of 17 years of experience by the inventors of percutaneous lumbar laser disc decompression utilizing MacNab criteria. They reported an overall success rate of 83%. The complication rate was 0.4%. The recurrence rate was 5%.

Grönemeyer et al (1181) in 2003 published an observational report of percutaneous lumbar laser disc decompression under CT/fluoroscopic guidance. Outcome measures were no sensory motor impairment, clear reduction of impairment, mild reduction of impairment, and no reduction of improvement. They reported that in 84.5% of the patients, pain was eliminated or reduced. Forty-three percent of the patients reported to be pain free. The relief lasted for an average of 3 ± 2 years.

Knight and Goswami (1182) in 2002 published an observational report with percutaneous lumbar laser disc decompression. Outcome measures were patient target achievement scores and patient satisfaction scores. At the end of the first year, 60% of the patients demonstrated good to excellent results with back and leg pain, while another 20% demonstrated a satisfactory response. By the end of the third year, the good to excellent response was limited to 51% with 22% showing satisfactory response with back and leg pain. Four patients developed aseptic discitis. Disc prolapse occurred at the same level in 2% of the patients. Seventeen percent of the patients required further surgical interventions.

1.2.4.2.2 Analysis of Evidence

Table 18 illustrates the results of 15 observational studies (1167,1168,1173,1175-1189), with one study with 2 publications (1178,1180) and one study with 3 publications (1167,1168,1187) of the effectiveness of percutaneous lumbar laser disc decompression in managing disc herniation.

The evidence, based on all available observational studies, is limited for percutaneous lumbar laser disc decompression in managing disc herniation. However, the results of a randomized, double-blind controlled trial have not been published yet.

1.2.4.3 Mechanical Lumbar Disc Decompression with Nucleoplasty

Nucleoplasty, a minimally invasive procedure, uses radiofrequency energy to remove nuclear material and to create small channels within the disc

Table 18. *Results of observational studies of the effectiveness of percutaneous lumbar laser disc decompression.*

Study	Methodological Quality Scoring	Number of Participants	Significant Pain Relief	Results
			> 12 mos.	Long-term > 12 mos.
Duarte & Costa, 2012 (1175)	8/12	205	67%	P
Menchetti et al, 2011 (1176)	8/12	585	78%	P
Iwatsuki et al, 2007 (1177)	8/12	+ Lasegue's Sign = 25	80%	P
Tassi, 2006, 2004 (1178,1180)	8/12	500	83.8%	P
Zhao et al, 2005 (1179)	8/12	173	76.8%	P
Choy et al, 1992, 1998, 2004(1167,1168*,1187)	8/12	350	75%	P
Grönemeyer et al, 2003 (1181)	8/12	200	73%	P
Knight & Goswami, 2002 (1182)	8/12	310	60%	P
Nerubay et al, 1997 (1188)	8/12	50	74%	P
Gangi et al, 1996 (1183)	8/12	119	76.5%	P
Bosacco et al, 1996 (1189)	8/12	61	66%	P
Siebert, 1989 (1173)	8/12	180	72.8%	P
Casper et al, 1996 (1184)	8/12	100	80%	P
Casper et al, 1995 (1185)	8/12	223	84%	P
Botsford, 1994 (1186)	8/12	90	73.3%	P
TOTAL		3,171	75%	P

numbers reported from Choy et al, 1998 (1168) P = Positive

Adapted and modified from: Singh V, et al. Percutaneous lumbar laser disc decompression: An update of current evidence. *Pain Physician* 2013; 16:SE229-SE260 (22).

(24,227,1099,1129,1190-1193). With Coblation technology, radiofrequency energy is applied to a conductive medium, creating the formation a highly focused plasma field to form around the energized electrodes (24,1099,1129,1190-1193). The plasma field is composed of highly ionized particles (1193). The created channel is thermally treated, producing a zone of thermal coagulation. Thus, nucleoplasty combines coagulation and tissue ablation (patented Coblation technology) to form channels in the nucleus and decompress the herniated disc. Claims have been made over the past few years that nucleoplasty can produce satisfactory results with fewer serious complications. However, these claims continue to be debated (25,105,227,1099,1129,1190-1193).

Gibson and Waddell (629) in the Cochrane Collaboration review presented the results from 40 RCTs and 2 QRCTs of surgical interventions for lumbar disc prolapse including 17 new trials since the first issue of the review. This review indicated that the place for alternative forms of discectomy other than traditional open discectomy is unresolved. They noted that as of January 2007 there were no RCTs examining Coblation as a treatment for disc prolapse.

Gibson and Waddell (629) concluded that there is considerable evidence that surgical discectomy provides effective clinical relief for carefully selected patients with sciatica due to lumbar disc prolapse that fails to resolve with conservative management. They noted that the choice of micro- or standard discectomy at present probably depends more on the training and expertise of the surgeon and the resources available than on scientific evidence of efficacy. In addition, they concluded that at present, unless or until better scientific evidence is available, multiple minimally invasive decompression techniques including Coblation therapy should be regarded as research techniques.

The CMS (119) has issued a non-certification for intradiscal procedures. The CMS refers to multiple procedures collectively as thermal intradiscal procedures, including percutaneous or plasma disc decompression, or Coblation, along with other intradiscal therapies. However, in a systematic review of nucleoplasty for lumbar disc herniation (1129), there was limited evidence in managing predominantly lower extremity pain due to contained disc herniation. In another evidence-based systematic review (1191), it was concluded that based on the observational studies, nucleoplasty is a potentially effective, minimally invasive treatment for patients with symptomatic disc herniation who are refractory to conservative therapy. However, in another review (1098), the authors showed that there were no published RCTs assessing Coblation or nucleoplasty. They also concluded that none of the minimally invasive techniques including automated percutaneous discectomy were effective.

In a recent systematic review, Manchikanti et al (24) showed fair evidence for nucleoplasty in managing radicular pain due to contained disc herniation based on the results from one randomized trial and 14 observational studies which met inclusion criteria for methodologic quality assessment.

In a recent letter to the editor updating the systematic review of RCTs with nucleoplasty, König et al (32) showed the results of their systematic review of the literature. Once again they emphasized that there were no RCTs comparing nucleoplasty with open surgical procedures. They concluded that nucleoplasty significantly reduces pain in patients with symptomatic contained disc herniation and also increases their functional capacity. Further, they opined that according to currently available data from RCTs it can be confirmed that nucleoplasty is an effective, safe, and minimally invasive treatment option in cervical, thoracic, and lumbar contained disc herniations. However, this research was funded by an unrestricted scientific grant from Arthrocare, the manufacturer of the nucleoplasty probe.

We identified one additional manuscript (1192).

1.2.4.3.1 Evidence Assessment

For the evidence synthesis a total of 37 studies were considered for inclusion (982,1194-1229). One randomized trial and 14 observational studies met inclusion criteria for methodologic quality assessment (982,1202,1204-1206,1208,1211,1212,1215-1217,1220-1223). Study characteristics of the published reports of mechanical lumbar disc decompression with nucleoplasty are shown in Table 7 of the systematic review (24). Table 19 shows the results of eligible studies of mechanical lumbar disc decompression with nucleoplasty, with the addition of one new study (1190).

Contrary to previous evaluations, in this evaluation we were able to assess one randomized trial (982) and 15 observational studies (1190,1202,1204-1206,1208,1211,1212,1215-1217,1220-1223) meeting methodological quality assessment criteria. This shows significant progress in the evidence. Among these, the only available randomized trial by Gerszten et al (982), published in 2010, evaluated clinical outcomes of nucleoplasty compared with standard care using fluoroscopically guided transforaminal epidural steroid injection over the course of 2 years. They concluded

that patients who had radicular pain associated with a contained lumbar disc herniation, treated with nucleoplasty, had significantly reduced pain and better quality of life scores than those treated using repeated transforaminal epidural steroid injection. In addition, significantly more nucleoplasty patients than transforaminal epidural steroid injection patients avoided having to undergo a secondary procedure during the 2-year study follow-up. Furthermore, a significantly higher percentage of patients in the nucleoplasty group showed a minimum of clinically important changes. This is the best study thus far assessing nucleoplasty in a randomized fashion. This is, however, not a true placebo-control study. It is an active-control study with transforaminal epidural steroid injection procedures and nucleoplasty. Some may consider that the sample size as too small; however, the sample size calculations were appropriate. The authors utilized extensive outcomes assessment. The major disadvantage is that the randomized, controlled portion of the trial was limited to a 6-month follow-up. There is also criticism that transforaminal epidural is not really comparable to disc decompression as one is known to provide short-term relief and the other one is expected to provide long-term relief of greater than one year or so. Overall, the study is considered moderate quality.

Among the other studies, which are noteworthy, is the study by Alexandre et al (1223). In this study, they evaluated 1,390 patients with chronic lumbar pain with or without radicular pain, lasting more than 3 months after the failure of medically and physically conservative treatments. In addition, inclusion criteria also included a positive provocative discography level and a negative control level. Contraindications included the presence of neurological deficit, infection, and coagulopathies. They utilized rather strict outcome measures with results being classified as excellent with total resolution of the clinical picture and full re-uptake of daily activities; good with total resolution of pain and relatively good quality of life; scanty with insignificant pain resolution and inability to take up normal daily activities; and none with no results both on pain and clinical field. They showed striking results with over 80% of patients, with 55.8% with excellent results and 24.9% with good results. They also illustrated that MRI and/or CT performed 6 months after the procedure showed that bulging discs were eliminated in 34%, significantly reduced in 48%, and unvaried in 18% of cases.

Table 19. *Summary results of eligible studies of mechanical lumbar disc decompression with nucleoplasty.*

Study	Methodological Quality Scoring	Number of Participants	Significant Pain Relief	Results
			> 12 mos.	Long-term > 12 mos.
Gerszten et al, 2010 (982)	7/12	90	56%	P
Kallás et al, 2013 (1190)	7/12	396	75%	P
Bokov et al, 2010 (1202)	7/12	138	74%	P
Shabat et al, 2012 (1204)	7/12	87	65%	P
Azzazi et al, 2011 (1205)	7/12	50	80%	P
Masala et al, 2007 (1206)	7/12	72	79%	P
Karaman et al, 2011 (1208)	7/12	56	66%	P
Sinan et al, 2011 (1211)	7/12	82	77%	P
Lemcke et al, 2010 (1212)	7/12	128	SI	P
Mirzai et al, 2007 (1215)	7/12	52	88%	P
Al-Zain et al, 2008 (1216)	7/12	96	58%	P
Singh et al, 2002 (1217)	7/12	67	80%	P
Singh et al, 2003 (1220)	7/12	80	75%	P
Marin, 2005 (1221)	7/12	64	80%	P
Gerszten et al, 2006 (1222)	7/12	67	54%	P
Alexandre et al, 2005 (1223)	7/12	1,390	55.8%	P
TOTAL		2,787	64%*	P

P = Positive; SI = Significant improvement *Lemcke et al (1212) was not included as data was not available
Adapted and modified from: Manchikanti L, et al. An update of the systematic assessment of mechanical lumbar disc decompression with nucleoplasty. Pain Physician 2013; 16:SE25-SE54 (24).

Kallás et al (1190), in a retrospective analysis, assessed 396 patients with lumbar disc herniation related pain and no improvement after previous conservative clinical treatment. The results showed that among all patients, 26% presented with 100% or complete pain relief and paresthesia, whereas, 13% had 90% pain improvement, 15% had 80% pain improvement, and overall 75% showed at least 50% pain improvement in the VAS.

In a cadaveric study, Kasch et al (1213) assessed 52 discs from T8 to L1 from 26 pigs separated into thoracic T8-T11 and thoracolumbar T12-L1. In this assessment of volumetry, they found that average preinterventional nucleus volume was 0.799 mL, whereas postinterventional volume reduction in the nucleoplasty group was significant at 0.052 mL, or 6.3% in thoracic discs, and 0.082 mL, or 7.25%, in thoracolumbar discs. They concluded that nucleoplasty achieved volume reductions of 14.72% in thoracic and 11.6% in thoracolumbar compared to the placebo group. Consequently, nucleoplasty seems to demonstrate a pathophysiologic, clinical, and biologic basis for disc decompression.

Limitations still include scant literature. There was only one randomized trial, which was of moderate quality (982), although with positive results. The remaining evidence is dependent on observational studies. The number of observational studies meeting inclusion criteria has increased to 14 with one large study including 1,390 patients (1223). Inclusion criteria were rather strict, in that at least 50 patients and one-year follow-up was required. Thus, multiple studies were excluded even though these have been included in other systematic reviews.

1.2.4.3.2 Analysis of Evidence

Based on one randomized trial (982), which is of moderate quality, and 15 moderate quality observational studies (1190,1202,1204-1206,1208,1211,1212,1215-1217,1220-1223), the evidence for nucleoplasty is limited to fair.

1.2.4.4 Mechanical High RPM Device

The Dekompressor probe is a mechanical high rotation per minute device designed to extract the nuclear material through an introducer cannula using an auger-like device that rotates at high speeds (21,1128,1131).

The Dekompressor system is a single-use probe intended for percutaneous discectomies under fluoroscopic imaging. The device removes a predetermined amount of disc material from the herniated disc, reducing pressure in the disc and the surrounding area. Using a cannula placement similar to that used for a standard discography, less pertinent scarring and less postoperative fibrosis may be expected with this device (1230). The Dekompressor has been described as a minimally invasive technique with advantages over other techniques (1231).

A systematic assessment of the efficacy of PLDD utilizing Dekompressor demonstrated limited evidence for both short-term and long-term relief (21).

A review of the current literature focusing on percutaneous mechanical disc decompression using the Dekompressor device (1232) identified 3 nonrandomized studies and a single case series. All studies were reasonably rigorous in reporting pain relief and the use of analgesics. Data related to physical functioning were scarce. The results suggested that, even though the investigators reported pain relief, there was a lack of rigor with respect to other outcome measures, such as the use of other health care resources and physical functioning.

Our literature search yielded no additional studies.

1.2.4.4.1 Evidence Assessment

In this guideline preparation, only one systematic review (21) and one comprehensive review (1232) were assessed. The total number of studies evaluated was 3, compared to 2 in previous systematic evaluations (1230,1233,1235). There has been only one new study since the previously published evaluation. The available literature on Dekompressor illustrates the common shortcomings of observational studies of interventions. Even though Dekompressor may be considered a new interventional modality, the early studies were published approximately 8 years ago. Consequently, one would expect that the technique's continued use would be supported by more recent, high quality evaluations. Even though all the studies are of moderate quality, they lack scientific rigor because of their observational, albeit prospective, design. Further, these studies do not include sufficiently large numbers of patients.

Alo et al (1231,1233) published 2 papers based on a single randomized prospective clinical trial evaluating the efficacy of treating disc herniations with the Dekompressor in an initial cohort of 50 consecutive patients with chronic radicular pain. Data were collected at 6-month follow-up. Outcomes were assessed using the VAS, analgesic usage, self-reported functional improvement, and overall satisfaction. The findings may have been more objective if the assessment had included some form of functional improvement measure.

After 6 months, 74% of the patients reported reducing their analgesic intake, 90% reported improvement in functional status, and 80% reported overall satisfaction with the therapy. At the one-year follow-up, results were published for 42 patients (54 treatment levels). The authors noted a 65% average reduction in the preoperative VAS pain score, as well as a 79% reduction in analgesic intake. Functional improvement was observed in 91% of the patients.

Lierz et al (1230) evaluated percutaneous lumbar discectomy at 76 lumbar levels in 64 patients using the Dekompressor system under CT guidance. Follow-up data at 12 months were obtained for all patients. The average reported pain level, as measured by VAS, was 7.3 at baseline and 2.1 at 12 months. Before the procedure, 61 patients (95%) regularly used opioid or nonopioid analgesics; after one year, 51 patients (80%) were able to reduce analgesic use. None of the patients reported procedure-related complications. The authors concluded that, when standardized patient selection criteria are used, treating patients with radicular pain associated with contained disc herniation using Dekompressor can be a safe and efficient procedure.

Amoretti et al (1235) published results of a clinical follow-up of 50 patients treated by percutaneous lumbar discectomy using Dekompressor. Although not a blinded and randomized study, the data collection methodology was considered good and was based on clearly defined inclusion and exclusion criteria. Patients were included if they presented with "lumbar sciatica of disco-lumbar origin" secondary to a herniated disc documented by an MRI. Patients had undergone medical therapies such as "CT-guided infiltration" (presumably a corticosteroid injection). There was no change in disc height and the discs were satisfactorily hydrated, as documented by a T2 signal on MRI. Patients were excluded if they presented with extruded herniations and inconsistency between MRI and clinical findings. Other exclusion criteria included infection and coagulopathy, as well as pre-operative treatment with morphine and anti-inflammatory drugs.

Using Dekompressor under CT or fluoroscopic guidance, the authors performed disc decompression primarily on L4-5 and L5-S1 discs, as well as on some L3-4 discs. Eleven patients did not respond satisfactorily to the treatment, but 39 patients were either able to suspend or reduce their medications (n = 31 and n = 8, respectively). Pain reduction was reported to stabilize after about 7 days in most patients. Of the patients who responded favorably, 36 out of 50 experienced > 70% relief. More importantly, the authors noted > 70% improvement in 79% of patients with posterolateral hernias, as compared to only 50% of patients with posteromedial hernias. However, this study failed to meet inclusion criteria, as the follow-up was limited to only 6 months.

Overall, these studies suggest that Dekompressor treatment improves pain and function and also reduces health care utilization, as described in Table 20. However, no validated instruments were used to arrive at those conclusions. Proponents state that these studies consistently demonstrate that significant numbers of patients achieve marked improvements that are sustained for 6 or 12 months, without significant decay in the response. However, there are multiple flaws in this analysis. Only one study reported complete relief in 14% of patients (1231,1233). Other studies reported only the proportion of patients reporting significant pain relief, without corroboration by outcome measures (1232). Because of their observational nature, the studies also lack a control group and randomization, and are potentially biased by the investigators. Consequently, the true effectiveness of Dekompressor may be less than reported and also raises questions. Although the study by Alo et al (1231,1233) rigorously reported pain-related data, it was sponsored by the device manufacturer and involved the inventor of the device, again raising questions about potential bias (1232).

In spite of the limited evidence, the Dekompressor is appealing because of its simplicity, relative safety, and the fact that it destroys minimal tissue, which suggests that disc height is maintained, or decreases more slowly, thus allowing the body time to adapt. The Dekompressor may be considered prior to open discectomy for patients with leg pain and a contained disc herniation. Considering the multiple challenges related to surgical interventions and the other treatment modalities (e.g., interventional techniques and other conservative modalities) which these patients have basically failed prior to considering Dekompressor, they have no other option except for high-dose opioid therapy. Consequently, percutaneous disc decompression by any of the modalities may still be an attractive option for patients with persistent pain (87,90-92,1236-1238).

1.2.4.4.2 Analysis of Evidence

Based on 3 prospective studies evaluating the effectiveness of Dekompressor (1230,1231,1233,1235), with one duplicate publication (1231,1233), the evidence for percutaneous disc decompression with Dekompressor is limited.

Table 20. *Study characteristics of published reports of mechanical lumbar disc decompression with Dekompressor.*

Study/Methods Study Characteristics Methodological Quality Assessment	Participants	Intervention(s)	Outcome Measures	Result(s)	Conclusion(s) Short term relief ≤6 mos. Long-term relief >6 mos.
Alo et al, 2004, 2005 (1231,1233) Prospective 7/12	50 patients with radicular pain of greater than 6 months with disc herniation of less than 6 mm after having failed conservative care, including positive response to spinal nerve block were included.	Percutaneous disc decompression with Dekompressor	Pain relief and follow-up at 6 months and 12 months with mean pain scores and proportion of patients with response	16% were lost to follow-up. Mean reduction of pain was 65%. Over two-thirds of the patients achieved at least 50% relief of pain at 12 months, with 14% achieving complete relief, and a further 8% achieving greater than 80% pain reduction, while 58% of patients maintained VAS scores of less than 4 at 12 months.	Positive short-term and long-term results
Lierz et al, 2009 (1230) Prospective 7/12	64 patients with radicular pain of greater than 6 months with disc herniation of less than 6 mm after having failed conservative care and positive response to transforaminal epidural injection were studied.	Percutaneous disc decompression	Follow-up at 6 months and 12 months with mean pain scores and proportion of patients with response	Significant proportion of patients with improvement of pain, function and opioid use.	Positive short-term and long-term results
Amoretti et al, 2006 (1235) Prospective 7/12	50 patients were studied with radicular pain of unclear duration or at least 3 weeks with preserved disc height and failure to respond to conservative care.	Percutaneous disc decompression	Pain relief at 6 months	Very good pain relief was reported with greater than 75% reduction of pain in a significant proportion of patients.	Positive short-term and long-term results

Adapted and modified from: Manchikanti L, et al. Percutaneous lumbar mechanical disc decompression utilizing Dekompressor®: An update of current evidence. *Pain Physician* 2013; 16:SE1-SE24 (21).

1.2.4.5 Summary of Evidence

The indicated level of evidence based on USPSTF criteria of good, fair, and limited or poor, is limited for APLD, percutaneous lumbar laser disc decompression, DeKompressor, and limited to fair for nucleoplasty.

1.2.4.6 Complications

Percutaneous discectomy is associated with the same multiple complications and side effects as those associated with intradiscal procedures with a large cannula (1194). These complications associated with intradiscal procedures include hematoma; infection, either superficial or associated with abscess; allergic reaction to radiographic contrast or antibiotic; bleeding; and direct needle trauma to spinal nerve with transient or persistent paresthesia and spondylodiscitis (21,22,142,512,521,552, 1137,1140,1149,1154,1158,1162,1165,1166, 1168-1173,1188,1189,1237-1249).

Nerve injury can occur from several sources including direct root injury during needle insertion or from the decompression process if improperly performed. This should be avoidable by ensuring a responsive patient during the entire procedure and listening carefully for radicular/paresthesia complaints throughout. Infection risk can be lowered by the use of a meticulously sterile technique and intravenous or intradiscal antibiotics. Other complications include damage to the adjacent endplate, the development of spinal instability, and/or the potential for disc space collapse with associated progressive degenerative changes. Other complications include cauda equina syndrome.

Complications of percutaneous lumbar laser discectomy are classified into intraoperative and postoperative complications (1166,1168-1173,1188,1189,1239-1248). The most frequently described complication of percutaneous disc decompression is (spondylo) discitis (1168,1170,1173,1241,1242,1243), both aseptic and septic. The reported frequency of discitis varies from 0% (1188,1189,1240,1244) to 1.2% (1242). Aseptic discitis is the result of heat damage to either the disc or adjacent vertebral endplates (1248). The goal of percutaneous lumbar laser disc decompression is to leave the annulus fibrosis and surrounding tissues

unaffected, at the same time, selectively to decrease the amount of nucleus pulposus tissue. Consequently, the extent of heat penetration is to be kept as low as possible (44). Septic discitis can occur as a result of infection during needle placement (29,932,1165,1238,1249). Another complication is thermal nerve root damage due to heating of the cannula, which represented a total complication frequency of 8% (1166,1188,1239). It has also been described that the high complication rate for CO_2 lasers can be attributed to the use of the fixed cannulae, so this rate is not representative for percutaneous lumbar laser disc decompression in routine clinical practice (1166). Ohnmeiss et al (1165), in a series of 164 laser discectomies, reported the tip of the instrument bent in one case, 12 patients complained of postoperative dermatomal dysesthesia, which resolved in 5 cases, and 2 patients had signs of reflex sympathetic dystrophy. Mayer et al (1171) in a retrospective analysis of 658 cases treated at 9 different centers observed 1.1% intraoperative complications and 1.5% postoperative complications. They reported radicular deficits in 4 patients (0.5%), L5 nerve root injury in 3 cases, vascular injuries in 2 cases, sigmoid artery injury in one patient, anomalous iliolumbar artery injury in one patient, and transverse process injury in one patient. In a report of 10 cases, complications were present in 1.5% of the total number of cases, which were reported to have spondylodiscitis (1245). In another report, after percutaneous lumbar laser disc decompression a patient developed subacute cauda equina syndrome (1247).

Gerges et al (1191) reported that the majority of reviewed studies reported no significant complications related to nucleoplasty (1214,1222,1225). However, the study by Cohen et al (1226) reported that 2 of 16 patients experienced new-onset "neurologic" symptoms following nucleoplasty. Bhagia et al (1224), in a quantitative analysis of the incidence of complications following nucleoplasty, reported that the most common side effects at 24 hours following nucleoplasty were soreness at the needle insertion site (76%), new numbness and tingling (26%), increased intensity of preprocedure back pain (15%), and new areas of back pain (15%). New numbness and tingling were present in 15% of patients and 4% of patients had an increased intensity of preprocedure back pain after 2 weeks (1224). Gerszten et al (982), in a randomized trial of 90 patients, of which 45 underwent nucleoplasty, reported procedure-related adverse events in 5, or 11% of patients. These adverse-related events were higher in the transforaminal group than in the nucleoplasty group.

The complications of percutaneous disc decompression with Dekompressor are similar to complications occurring for other percutaneous disc decompression modalities involving the passage of an instrument into the disc. One critical failure of the Dekompressor probe was reported while performing a discectomy at the L4/5 level on a 54-year-old patient (1236). When the probe was removed after operating the instrument for one to 2 minutes, 4 inches of the tip broke off and remained embedded in the patient. The tip was removed surgically, and the patient recovered without any major complication. Similar instances have been previously reported by 2 other authors. One was thought to be caused by a bent cannula, which may have contributed to tip breakage.

1.2.4.7 Recommendations

Even though, APLD and percutaneous lumbar laser disc decompression have been around for a long time and have been performed in a large proportion of patients, due to the lack of randomized trials, the evidence continues to be limited. Based on individual experience and large amount of literature, this may be performed when indicated. In contrast, among the 2 newly emerging procedures, nucleoplasty, even though disallowed by CMS (119), is with limited to fair evidence. Finally, DeKompressor is with limited evidence.

2.0 Lumbar Facet Joint Pain

Lumbar facet joints are pairs of joints that stabilize and guide motion in the spine. Controlled studies have established intervertebral discs, facet joints, and sacroiliac joints as potential sources of low back and lower extremity pain (8,11,13,17,36,111,375,377, 378,401,1250). Thus, lumbar facet joints are a well recognized source of low back and referred pain in the lower extremity in patients with chronic low back pain (8,11,375,377,378,401,1250). Facet joints are well innervated by the medial branches of the dorsal rami (11,1251-1260). Neuroanatomic, neurophysiologic, and biomechanical studies have demonstrated free and encapsulated nerve endings in lumbar facet joints, as well as nerves containing substance *P* and calcitonin gene-related peptide (1260-1273).

A multitude of factors have been shown to induce facet joint pain. Both mechanical injury and inflammation of the facet joint have been shown to produce persistent pain in otherwise normal rats (1274-1276). In addition, mechanical injury of the facet joint increases cytokine messenger RNA in the dorsal root ganglion

(DRG) (1275) and intraarticular injection of NSAID agents alleviates injury-induced pain in the same model (1275), suggesting that inflammation has a role in the pain response after mechanical joint insult. However, despite increasing suggestions that mechanical joint injury can initiate inflammatory responses in the context of pain, the molecular mechanisms of facet joint injury-induced pain remain poorly defined. Inflammatory mediators, such as cytokines, prostaglandins, and neuropeptides, increase within the joint and the DRG in joint inflammation and arthritis (1276-1281). Specifically, prostaglandin E2 (PGE2) has been identified as a key mediator of inflammation-induced behavioral sensitivity and increased neuronal excitability (1282-1286).

Kalichman et al (1287) evaluated facet joint osteoarthritis and low back pain in the community-based Framingham Heart Study. They concluded that there is a high prevalence of facet joint osteoarthritis in the community-based population with a prevalence of 59.6% in males and 66.7% in females. The prevalence of facet joint osteoarthritis increased with age and reached 89.2% in individuals 60 to 69 years old with the highest prevalence of facet joint osteoarthritis found at the L4/5 spinal level. Furthermore, they showed that individuals with facet joint osteoarthritis identified by a CT scan at any spinal level showed no association with low back pain. Eubanks et al (1288) in a study of 647 cadaveric lumbar spines found that facet joint osteoarthritis is a universal finding. Characteristic features of osteoarthritis emerge early on in the life cycle, with more than half of adults younger than 30 years demonstrating arthritic changes in the facets, with the most common arthritic level being L4/5. The relationship between lumbar facet joint osteoarthritis and back pain is not clear. Gong et al (1262) explored a rat model of lumbar facet joint osteoarthritis associated with facet-mediated mechanical hyperalgesia induced by an intraarticular injection of monosodium iodoacetate (MIA). The results showed that progressive cartilage degeneration and changes in subchondral bone were observed after injection. A biphasic pattern of mechanical hyperalgesia was noted in the hind paw. They concluded that with the establishment of an experimental lumbar facet joint osteoarthritis model associated with facet-mediated mechanical hyperalgesia with an intraarticular injection of MIA, this model might provide a useful tool for further study to ascertain the complex mechanism of facet joint pain.

Henry et al (1261) with the objective of developing a novel animal model of persisting lumbar facet joint pain showed that in a rat model, lumbar facet joint compressive injury induces lasting changes in local structure, nociceptive scores, and inflammatory mediators. They concluded that the compression of a facet joint induces a novel model of local cartilage loss accompanied by increased sensitivity to mechanical stimuli and increases in inflammatory mediators. The results of this study showed a site-specific loss of cartilage, tactile hypersensitivity, and increases in proinflammatory cytokines.

Once the appropriate diagnosis is made, lumbar facet joint pain may be managed by either facet joint nerve blocks or neurolysis of facet joint nerves and intraarticular injections.

2.1 Diagnosis of Lumbar Facet Joint Pain

Fundamental to an accurate diagnosis is the reliability of the test used to make the diagnosis (8,11,13,110,339-342,344,375,401,1250). Attempts have been made to improve the accuracy of diagnostic lumbar facet joint pain by multiple means, including history, pain patterns, physical examination, imaging techniques, and controlled local anesthetic blocks (8,11,13,375,377,378,388,401,406,407, 441,618, 641,1250,1289-1330).

The published radiological 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 scanning, single photon emission computed tomography (SPECT), and radionuclide bone scanning (48,1250,1289-1317). Specifically, the association between degenerative changes in the lumbar facet joints and symptomatic low back pain remains unclear and is a subject of ongoing debate.

Conventional clinical features are unreliable in diagnosing lumbar zygapophysial (facet) joint pain. The distinguishing features of somatic or referred pain secondary to facet joints and radicular pain secondary to disc pathology are described in Table 1. Figure 6 shows pain diagrams of facet joint pain which may be similar to discogenic pain and/or disc herniation.

Hancock et al (375) performed a systematic review of tests to identify the disc, sacroiliac joint, and facet joint as the source of low back pain. They found that none of the tests for facet joint pain were found to be informative. Consequently, controlled local anesthetic blocks of the facet joint or its nerve supply are routinely employed to diagnose facet joint pain.

There is, however, no universally accepted gold standard for the diagnosis of low back pain, regardless of whether the suspected source is the facet joint(s),

intervertebral disc(s), or sacroiliac joint(s). The recommended reference standards typically involve anesthetic or provocative injections. Multiple arguments have been made in favor of and against the diagnostic accuracy of controlled local anesthetic blocks, but controlled local anesthetic blocks continue to be the best available tool to identify intervertebral disc(s), facet joint(s), or sacroiliac joint(s) as the source of low back pain. Yet, these reference standards are invasive, expensive, and often difficult to interpret, and therefore may not be suitable for routine clinical use as a primary diagnostic modality.

2.1.1 Diagnostic Lumbar Facet Joint Blocks

Controlled diagnostic blocks of a lumbar facet or zygapophysial joint can be performed by anesthetizing the joint via injection of local anesthetics intraarticularly or in close proximity to the medial branches of the dorsal rami that innervate the target joint.

The rationale for using facet joint blocks for diagnosis is based on the fact that lumbar facet joints are capable of causing pain and they have a nerve supply (1251-1256,1319-1324). Facet joints have been shown to be a source of pain in patients using diagnostic techniques of known reliability and validity (377,378). The value, validity, and clinical effectiveness of diagnostic facet joint nerve blocks has also been illustrated by the application of therapeutic modalities based on the diagnosis with controlled comparative local anesthetic blocks (8,11,12,1325-1327).

The face validity of lumbar medial branch or facet joint nerve 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 the posteroanterior and lateral radiographs (8,11,383,384,1253,1254). Construct validity of facet joint blocks is important to eliminate placebo effect as the source of confounding results and to secure true-positive results (8,11,383,384,420-422). The hypothesis that testing a patient first with lidocaine and subsequently with bupivacaine provides a means of identifying the placebo response has been tested and proven (383,384,415-421).

The specificity of the effect of lumbar facet joint blocks was demonstrated in controlled trials (11,1253,1254). Provocation response of facet joint pain was shown to be unreliable in one study (1328). However, the relevance of 8% unrecognized intravascular

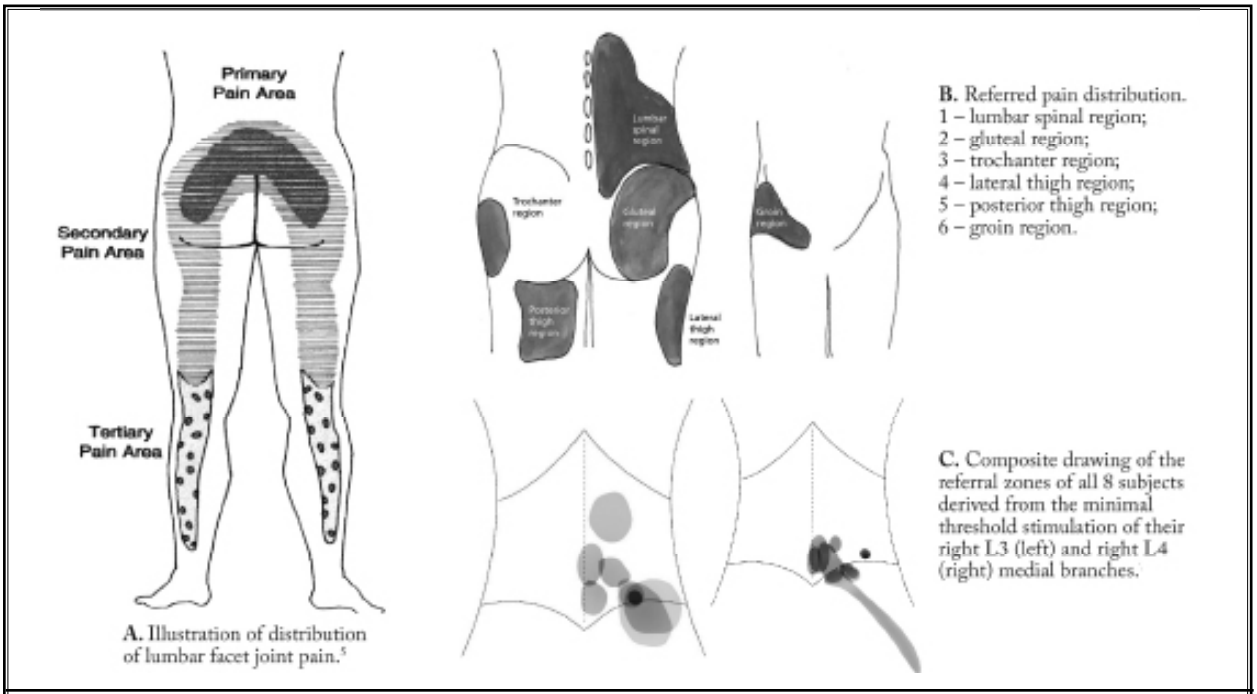


Fig. 6. ***Patterns of lumbar facet joint pain based on descriptions of multiple authors.***
Source: Manchikanti L, et al. Low back and lumbar radicular pain. In: Manchikanti L, (et al) (eds). *Clinical Aspects of Pain Medicine and Interventional Pain Management: A Comprehensive Review.* ASIPP Publishing, Paducah, KY, 2011, pp 87-114 (374).

injection of lidocaine has been questioned. Considering that 2 nerves have to be blocked for each joint, the potential unrecognized intravascular injection of local anesthetic may not be significant. Multiple larger studies have assessed the intravascular injection; however, they were unable to identify the influence of such intravascular injection and false-negative results arising from such response (11,255,282,711,712,1253,1331-1333). The false-negative rate of diagnostic facet joint blocks was shown to be 8% due to unrecognized intravascular injection of local anesthetic (1253).

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 application of another appropriate reference standard (long-term follow-up) as described in the literature (711,712,1326,1327).

Rubinstein and van Tulder (401) also provided a best-evidence review of diagnostic procedures for neck and low back pain. They commented that it is quite remarkable that while many named orthopedic tests of the neck and low back are often illustrated in orthopedic textbooks, there is 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 that arise during the history. The placebo-controlled technique is considered the gold standard, but has limited clinical utility due to cost implications and to the ethical and logistical issues of designing a true placebo.

The rationale for controlled diagnostic blocks is that an anesthetic blockade of a painful joint will abolish pain arising from that joint for the duration of the anesthetic effect, while an anesthetic blockade of a non-painful joint will not alter the pain report.

Chou and Huffman (105) found that the diagnostic blocks were not valid. However, their methodology has been criticized (111). In contrast, Falco et al (11) in a recent systematic review of the diagnostic accuracy of lumbar facet joint nerve blocks with application of modified IASP criteria and also single blocks evaluated the prevalence and false-positive rates in patients with chronic low back pain, with the inclusion of 25 diagnostic accuracy studies (377,378,381,388,618,668,712,1327,1334-1350). They utilized pain relief of at least 50% from the baseline pain as the criterion standard with the ability to perform previously painful movements, either with a single block or dual blocks. They showed the best evidence with a criterion standard of 75% to 100% pain relief with dual blocks with good evidence illustrating a prevalence of 25% to 45% in heterogenous populations with false-positive rates of 17% to 66%. Our assessment yielded 3 additional manuscripts (1329,1330,1351).

Among these manuscripts, Cohen et al (1329) provided a comprehensive review of facet joint pain with advances in patient selection and treatment. Cohen et al (1330) also published a prospective correlational study in reference to establishing an optimal cutoff threshold for diagnostic lumbar facet blocks. In the third manuscript, Derby et al (1351) correlated lumbar medial branch neurotomy results with diagnostic medial branch block cutoff values to optimize therapeutic outcomes.

2.1.1.1 Evidence Assessment

Our search yielded 3 systematic reviews (11,116,375) and 25 manuscripts as utilized by Falco et al (377,378,381,388,618,668,712,1327,1334-1350). Falco et al (11) assessed relief categorized as at least 50% from baseline pain and the ability to perform previously painful movements. They also divided them into single blocks and dual blocks along with relief of 50% to 74% and 75% to 100% into different categories.

There was one study utilizing single blocks with 50% to 74% relief (377), and 4 studies utilizing single blocks with 75% to 100% relief (388,712,1334,1335). There were 5 studies utilizing 50% to 74% relief with controlled blocks (377,712,1337-1339) and one publication with false-positive rates (1254), with one duplicate publication (1341), and 13 studies utilizing 75% to 100% relief with controlled blocks (378,618,712,1327,1342-1349) with one duplicate publication (1350). Table 4 of the systematic review (11) describes the characteristic features of the diagnostic accuracy studies.

There were 3 studies assessing the influence of age (596,1348,1349,1352), 2 studies assessing psychological variables (1353,1354), 2 studies assessing the influence of body mass index (596,1349), 5 studies assessing the influence of surgery (227,390,618,1355,1356), 2 studies assessing gender/smoking related factors (596,1357), 3 studies assessing the influence of sedation (1095,1358,1359), and 7 studies assessing the influence of diagnostic blocks on therapeutic outcomes (711,712, 1326,1330,1351,1360,1361).

Among the 3 new manuscripts identified (1329,1330,1351), Cohen et al (1330) attempted to establish an optimal cutoff threshold for diagnostic lumbar facet blocks in a prospective correlational study. In this multicenter study, 61 consecutive patients

undergoing lumbar facet radiofrequency denervation after experiencing significant pain relief after medial branch blocks were enrolled. A positive outcome was defined as greater than 50% reduction in back pain at rest or with activity coupled with a positive satisfaction score lasting longer than 3 months. The relationship between pain relief after the blocks and denervation outcomes was evaluated. Their results showed no significant differences in radiofrequency outcomes based on any medial branch block pain relief cutoff over 50%. A trend was noted whereby those patients who obtained less than 50% pain relief reported poorer outcomes. Consequently, they were unable to calculate an optimal threshold for designating a diagnostic block as positive, above 50% pain relief.

Derby et al (1351) in a retrospective analysis assessed the percentage of subjective pain relief following a medial branch block, confirmed by numeric rating scale in aggravating positions before and 45 minutes after medial branch block. The percentage of overall pain relief following a medial branch block was compared with multiple outcome variables. They assessed a total of 211 patients undergoing medial branch blocks with 111 patients with positive relief greater than 50% with a single block and 40 patients with a dual block. Subsequently, 38 patients in the one block group completed radiofrequency neurotomy, whereas, 13 patients in the 2 block group completed radiofrequency neurotomy. The results showed that patients reporting 70% or greater pain relief following medial branch blocks showed a statistically favorable outcome for percentage of pain relief, duration of pain relief, patient satisfaction, and pain medication reduction. In the single medial branch block group, patients reporting 80% or greater pain relief following medial branch blocks had favorable outcomes for improvement in activity level and patient satisfaction. They concluded that the dual medial branch block protocol correlated better with favorable medial branch neurotomy outcomes compared with a single medial branch block protocol. Using a double medial branch block protocol, a 70% cutoff value for reported subjective pain relief post-medial branch block best predicted overall outcome following medial branch neurotomy. Without a confirmatory medial branch block, an 80% cutoff value was the optimal value.

In a comprehensive review, Cohen et al (1329) described advances in patient selection and treatment. They concluded that even though physical signs, such as paraspinal tenderness, might be weakly associated with facetogenic pain, the best means to identify a painful facet joint is the use of diagnostic blocks. Further, they opined that double blocks might reduce the rate of false-positive diagnosis and enhance radiofrequency treatment success rates, but will lower the overall success rate by increasing false-negative diagnosis and eliminating placebo responders.

Our literature search yielded no further studies.

2.1.1.2 Prevalence of Lumbar Facet Joint Pain

There was only one study evaluating 50% to 74% relief as criterion standard with a single block with prevalence of 48% (377), 4 studies evaluated 75% to 100% relief as the criterion standard with a single block with a prevalence of 31% to 61% (388,712,1334-1336), 5 studies evaluated 50% to 74% relief as the criterion standard with controlled diagnostic blocks with a prevalence of 15% to 61% (381,712,1336-1341), and 13 studies evaluated 75% to 100% relief as the criterion standard with controlled blocks with a prevalence of 25% to 45% in heterogenous populations (378,618,712,1327,1342-1350) (Table 21).

The evidence is good for utilization of 75% to 100% pain relief with controlled diagnostic blocks as the criterion standard with a prevalence of 25% to 45% with false-positive rates of 25% to 49% in a heterogenous population (377,618,668,712,1327,1342-1349). The evidence is fair for controlled diagnostic blocks utilizing 50% to 74% relief as the criterion standard with a prevalence of 15% to 61% with false-positive rates of 17% to 66% in a heterogenous population (712,1336-1340). The evidence is poor utilizing 50% to 74% or 75% and limited for greater pain relief with a single diagnostic block with prevalence ranging from 33% to 61% (377,388,712,1334,1335).

The outcomes of facet joint interventions, to a great extent, may depend on the diagnosis. Multiple authors have evaluated the factors related to accuracy of the diagnosis and its influence on the outcomes. It is well known that facet joint nerve blocks are inherently non-specific, even when low volumes are injected under fluoroscopic guidance. Thus, a strong case can be made for increasing the criteria to a more stringent 75% pain relief. A study by Dreyfuss et al (1253) found that using 0.5 mL low volume facet joint nerve block using conventional landmarks resulted in contrast spread into the epidural space or intervertebral foramen in 16% of cases, and between the cleavage plain of the multifidus and longissimus muscles in all injections. Kaplan et al (1254) also demonstrated the ability of lumbar medial

branch blocks to anesthetize the zygapophysial joint. Consequently, 75% or higher relief with controlled diagnostic blocks has been recommended. The rationale behind using 50% relief as criteria to proceed to a therapeutic radiofrequency neurotomy was outlined by Schwarzer et al (1337) who cite the high evidence of concurrent spinal pathology occurring with lumbar facet joint degeneration as the primary reason. Further, Fujiwara et al (463) found that even though lumbar degenerative disc disease frequently occurs in absence of lumbar facet joint degeneration, patients with severe lumbar facet joint arthritis virtually always have radiologic evidence of degenerative disc disease and/or other spinal pathology. The role of 50% or 75% relief on the diagnostic accuracy has been evaluated (711,712). In these studies, it was illustrated that the prevalence specifically with a single block with 50% criterion standard is inordinately high (73%), along with proof that the diagnosis was sustained in 50% of patients at the end of 2 years when it was made by controlled diagnostic blocks with 50% minimum relief criteria. In contrast, when the diagnosis was made by 80%, the diagnosis of facet joint pain was sustained in 89.5% of patients at the end of 2 years (709). In addition, 80% pain relief also has shown a lack of confounding when sedation was administered, either with midazolam or fentanyl (1095,1358). Even though dual blocks with 80% relief as a criterion standard appears to be the best, some have argued that there is no difference between the outcomes, specifically with radiofrequency neurotomy (1362). In fact, the results were also significant when patients were selected without any diagnostic blocks, in a study by Civelek et al (256), even though the study by Cohen et al (1361) showed inferior results.

Cohen et al (1360) emphasized that one reason double blocks were not used for their study on the success of lumbar zygapophysial joint radiofrequency denervation as a function of diagnostic block relief was that the use of controlled blocks was not cost-effective. Manchikanti and Singh (1363) commented that the whole concept of single blocks resulting with 50% or more relief followed by radiofrequency denervation creates many questions regarding the reliability of diagnostic blockade, increased health care costs, and coverage for facet joint nerve blocks and radiofrequency neurotomy. Schwarzer et al (1337), using 50% relief of pain as a standard, showed the prevalence of lumbar zygapophysial joint pain in 15% of patients. They (1338) also showed 40% prevalence in another study with 90% pain relief as the criterion standard with placebo control. In addition, they showed a false-positive response in 38% of the patients (1340). Most publications agree that 2 diagnostic blocks must be performed before radiofrequency denervation, and many payers are requiring 80% or more pain relief. Further, Cohen et al (1361), in an RCT, investigated costs and outcomes of radiofrequency treatment using 3 different medial branch blocks treatment paradigms, including radiofrequency, without the use of a screening block, radiofrequency if the patient obtained significant relief after a single diagnostic block with 50% relief, and radiofrequency denervation only if a patient has an appropriate response with a positive response of 50% or more relief with 2 confirmatory blocks. By 3 months after radiofrequency treatment, the proportion of successful outcomes of each individual cohort was highest in the group where patients received radiofrequency treatment after 2 diagnostic blocks with 64% of the patients reporting relief. However, by utilizing the total number of patients, Cohen et al (1361) confused the entire data and misinterpreted the results, concluding that it was more cost-effective to perform radiofrequency neurotomy without any type of diagnostic blocks. This misinformation and inappropriate evaluation will lead to unnecessary interventions with radiofrequency neurotomy, increasing health care costs (17,101). Consequently, a single block will definitely increase the costs of care as the single diagnostic block will lead to an increase in the number of radiofrequency denervations, which are more expensive and time consuming. The cost effectiveness of controlled, comparative, local anesthetic facet joint nerve blocks has been evaluated and found to be superior to an algorithmic approach starting with discography in axial pain (378).

Recently, Cohen et al, in 2 different manuscripts (1329,1330), showed the evidence for diagnostic blocks even through they were unable to decide exactly the percent of relief; however, they also indicated that relief below 50% was inappropriate. In contrast, Derby et al (1351) correlated medial branch block relief with radiofrequency neurotomy and concluded that the best results were obtained with a double medial branch protocol with a 70% cutoff value for reported subjective pain relief, whereas with a single block cutoff value relief was at least 80%.

Multiple evaluations have been performed assessing the role of confounding factors in the diagnosis of facet joint pain and its prevalence (227,283,381,385,389, 391,618,711,1095,1326,1348,1349,1352-1361). There were 3 studies evaluating the influence of age on

Table 21. *Data of prevalence of lumbar facet joint pain by diagnostic blocks.*

Study	Methodological Criteria Score	Number of Subjects	Prevalence Estimates with 95% Confidence Intervals	False-Positive Rates with 95% Confidence Intervals
Single Blocks with 50%-74% Relief				
Pang et al, 1998 (377)	9/12	100	48%	NA
Single Blocks with ≥75%-100% Relief				
Revel et al, 1992 (1334)	8/10	51	33%	NA
Revel et al, 1998 (1335)	8/10	80	31%	NA
Young et al, 2003 (388)	11/12	102	61%	NA
Manchikanti et al, 2010 (712)	11/12	491	53% (67%-80%)	NA
Controlled Blocks with 50%-74% Relief				
Schwarzer et al, 1994 (381,1337,1340)	11/12	176	15%	38% (30% – 46%)
Schwarzer et al, 1995 (1338,1341)	12/12	57 of 63	40% (27% – 53%)	NA
Manchikanti et al, 2000 (1336)	12/12	200	42% (35% – 42%)	37% (32% – 42%)
Manchikanti et al, 2010 (712)	11/12	181	61% (53% – 81%)	17% (10%- 24%)
Schütz et al, 2011 (1339)	11/12	60	NA	66%
Controlled Blocks with ≥75%-100% Relief				
Manchikanti et al, 2001 (378)	11/12	120	40% (31% – 49%)	47% (35% – 59%)
Manchikanti et al, 1999 (1327)	11/12	120	45% (36% – 54%)	41% (29% – 53%)
Manchikanti et al, 2000 (1343)	12/12	180	36% (29% – 43%)	25% (21% – 39%)
Laslett et al 2004, 2006 (1342,1350)	12/12	151	24.2%	NA
Manchikanti et al, 2003 (1344)	11/12	300 I: Single region II: Multiple regions	I: 21% (14%-27%) II: 41% (33%-49%)	I: 17% (10% – 24%) II: 27% (18% – 36%)
Manchikanti et al, 2002, (1345)	11/12	120	40% (31% – 49%)	30% (20% – 40%)
Manchikanti et al, 2004 (1346)	11/12	397	31% (27% – 36%)	27% (22% – 32%)
Manchukonda et al, 2007 (1347)	11/12	303	27% (22% – 33%)	45% (36% – 53%)
Manchikanti et al, 2007 (618)	11/12	117	16% (9% – 23%)	49% (39% – 59%)
Manchikanti et al, 2010 (712)	11/12	491	31% (26% – 35%)	42% (35% – 50%)
DePalma et al, 2011 (668)	11/12	156	31% (24% – 38%)	NA
Manchikanti et al, 2001 (1348)	11/12	100 I: (< 65 years) = 50 II:(> 65 years) = 50	I: 30% (17% – 43%) II: 52% (38% – 66%)	I: 26% (11%-40%) II: 33% (14%-35%)
Manchikanti et al, 2001 (1349)	11/12	100 I: (BMI < 30) = 50 II: (BMI > 30) = 50	I: 36% (22%, 50%) II: 40% (26%, 54%)	I: 44% (26%, 61%) II: 33% (16%, 51%)

NA = Not available

Adapted and modified from: Falco FJE, et al. An update of the systematic assessment of the diagnostic accuracy of lumbar facet joint nerve blocks. *Pain Physician* 2012; 15:E869-E907 (11).

prevalence and false-positive rates of facet joint injections (385,1348,1352), with only limited evidence showing that the prevalence of facet joint pain is higher in the elderly. Two studies assessing the influence of psychological factors (1353,1354) showed no significant correlation with psychopathology and prevalence of facet joint pain or false-positive rates. A study of body mass index showed limited evidence that obese patients may have a higher prevalence of facet joint pain (385,1349). In patients with post-laminectomy syndrome and fusion, the prevalence of facet joint pain has been shown to be lower than in non-surgical patients (227,391,618,1355,1356). In reference to smoking, there has not been any significant difference noted, while in reference to gender, it appears that the prevalence of facet joint pain may be higher in women (385,1357). The influence of sedation was also evaluated in 3 different studies (1095,1358,1359) on the diagnostic ac-

curacy, although these studies were by the same group of authors.

2.1.1.3 False-Positive Rates

False-positive rates of 17% to 66% are noted in the group with 50% to 74% pain relief as the criterion standard, and 17% to 49% in the group when 75% to 100% pain relief was used as the criterion standard (Table 21).

2.1.1.4 Analysis of Evidence

There is good evidence for diagnostic facet joint nerve blocks with 75% to 100% pain relief as the criterion standard with dual blocks based on 13 controlled diagnostic block studies (378,618,668,712,1327,1342-1350), with fair evidence with 50% to 74% relief based on 5 studies (381,712,1336-1341), with limited evidence for 75% to 100% pain relief as the criterion standard with a single block based on 4 studies (388,712,1334,1335), and poor based on a single study with 50% to 74% pain relief as the criterion standard with a single block (377).

There is limited evidence showing lack of influence of multiple factors on the diagnostic accuracy including age, post surgery syndrome, multiple psychological factors, sedation, gender, smoking, and occupational injury.

2.1.1.5 Recommendations

Based on the present comprehensive evaluation the evidence is good for accuracy. Diagnostic lumbar facet joint nerve blocks are recommended in patients with suspected facet joint pain.

2.2 Therapeutic Lumbar Facet Joint Interventions

Facet joint pain may be managed by intraarticular injections, facet joint nerve blocks, and neurolysis of facet joint nerves. Conflicting results have been reported regarding the effectiveness of these different treatment modalities in systematic reviews (12,101,105,112,113,115,191,217,321-323,1250,1364,1365). Datta et al (1250), in a systematic review of therapeutic facet joint interventions, presented moderate evidence for therapeutic lumbar facet joint nerve blocks and radiofrequency thermoneurolysis. Geurts et al (322) determined that there was moderate evidence that radiofrequency lumbar facet denervation was more effective for chronic low back pain than placebo. But, they included medial branch neurotomy, intraarticular neurotomy, and dorsal root denervation in their systematic review. Manchikanti et al (321) in their review assessed medial branch neurotomy for managing chronic spinal pain, including randomized and observational reports. They concluded that there was strong evidence for short-term relief and moderate evidence for long-term relief of facet joint pain. The evidence from the Cochrane Reviews, the ACOEM guidelines, and APS guidelines for these interventions has been negative (101,105,112,115,191,1250) and marred by controversy (101,105,112,113,115).

Falco et al (12) in the most recent systematic review identified over 120 studies. However, they analyzed the evidence based on 11 randomized trials and 4 observational studies which met inclusion criteria for methodologic quality assessment. They concluded that there is good evidence for the use of conventional radiofrequency neurotomy, and fair to good evidence for lumbar facet joint nerve blocks for the treatment of chronic lumbar facet joint pain resulting in short-term and long-term pain relief and functional improvement. However, the evidence is limited for intraarticular facet joint injections and pulsed radiofrequency thermoneurolysis. Falco et al (12), in the previous systematic review, utilized as a selection criteria the confirmed diagnosis with diagnostic facet joint nerve blocks. However, in preparation of these guidelines and systematic reviews, due to previous criticism and continuing debate in reference to the need for diagnostic blockade, multiple therapeutic modalities without diagnostic blocks were also assessed.

As described in the diagnostic facet joint interventions section, our assessment yielded 4 additional manuscripts (1329,1330,1351,1366). One manuscript was a review (1329) and 3 of the manuscripts (1330,1351,1366) described the role of diagnostic blocks and also outcomes of radiofrequency neurotomy.

2.2.1 Radiofrequency Neurotomy

Radiofrequency lesioning is performed utilizing either a heat lesion or pulsed mode radiofrequency. A thermal radiofrequency neurotomy lesion for facet denervation is performed at 80° to 85°C. Clinically, a higher temperature allows for a larger lesion to be made. The size of the lesion is influenced by the vascularity of the surrounding tissue: the greater the vascularity of the tissue, the smaller the lesion. Overall, the mechanism of radiofrequency neurotomy is described as denaturing of the nerves. Consequently, with radiofrequency, the pain returns when the axons regenerate requiring repetition of the radiofrequency procedure. The pulsed mode radiofrequency is an application of

a strong electric field to the tissue that surrounds the electrode and the temperature of the tissue surrounding the tip of the electrode does not exceed 42°C and heat is dissipated during the silent period.

Among the 8 systematic reviews (12,321-323,1250,1364,1365,1367) of medial branch radiofrequency neurotomy available only 2 systematic reviews (12,1250), which included inclusion criteria of controlled local anesthetic blocks and appropriate outcome parameters, were included in this review. The description of multiple systematic reviews is provided briefly to illustrate the deficiencies.

Geurts et al (322) concluded that there was moderate evidence that radiofrequency lumbar facet denervation was more effective for chronic low back pain than placebo. Niemesto et al (323), within the framework of the Cochrane Collaboration Back Review Group, concluded that there was conflicting evidence of short-term effect on chronic low back pain. Slipman et al (1367) concluded that the evidence for radiofrequency denervation is Level III or moderate. The systematic reviews by Manchikanti et al (321), Boswell et al (1364,1365), Slipman et al (1367), and Datta et al (1250) concluded that the evidence for pain relief with lumbar radiofrequency neurotomy of medial branch nerves was moderate to strong.

The APS guidelines underwent a critical review by Manchikanti et al (111,112). The APS guidelines relating to therapeutic interventions were reassessed by Manchikanti et al (112) wherein a literature search was completed and manuscripts were assessed using the same criteria used by the APS guidelines. The conclusions from the APS guidelines were compared to the critical assessment by Manchikanti et al (112) using the same grading system developed by the USPSTF (366). The results of this analysis using the APS criteria and the same grading system showed fair evidence for therapeutic lumbar facet joint nerve blocks and radiofrequency neurotomy. When incorporating current literature that was absent in the analysis used for the APS guidelines, therapeutic lumbar facet joint nerve blocks improved from fair to good. This critical analysis demonstrated that the APS guidelines assessed multiple studies incorrectly, excluded studies of high quality, failed to include current literature, and utilized flawed methodology. Similar to the above analysis, Van Zundert et al (1368) reassessed the evidence by Chou and Huffman (105). They described that the review by Chou et al (1003) concludes that there is insufficient (poor) evidence from randomized trials (conflicting trials, sparse and lower quality data, or no randomized trials) to reliably evaluate a variety of interventional therapies for spine-related pain. Van Zundert et al (1368,1369) further state that even though the title of the above manuscript (1003) states that it is a systematic review, it looks more like a narrative review because the authors did not comply with the general guidelines for writing a systematic review of RCTs, the Quality of Reporting of Meta-analysis (QUOROM) (354), and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement (332). Van Zundert et al (1368) considered that the main problem was the lack of structured overview of the results. They criticized that Chou et al (1003) discussed the value of treatment based on previous reviews and did not present the outcomes of the trials in a structured way. Chou et al's (1003) conclusions were based on 6 trials. Several of those 6 trials had shortcomings. Van Zundert et al (1368) criticized that 3 studies did not report the standard errors of the change in time (1370-1372). One study also did not do an intention-to-treat analysis (1372), and in another study, flaws were detected in the assessment of the diagnostic block (1373). Consequently, Van Zundert et al (1368) performed a meta-analysis including all 6 trials (1370-1372,1374-1376), which showed a significantly better effect of radiofrequency compared to placebo. Furthermore, when they excluded the trials with shortcomings, the analysis of the only 2 included studies (1374,1375), showed even significantly better results for radiofrequency neurotomy. Thus, they concluded that the results of these 2 different analyses indicate that radiofrequency treatment of the facet joints is significantly more effective than placebo.

Cohen et al (1329), in a comprehensive review, opined the reference treatment for facetogenic pain is radiofrequency denervation of the medial branch nerves innervating the joint, which can provide up to 12 months of benefit. They also cautioned that multiple technical steps can be taken to improve the success rate of radiofrequency denervation. They opined that even though physical signs might be weakly associated with facetogenic pain, the best means to identify a painful facet joint is the use of diagnostic blocks.

Bogduk et al (1377) in a narrative review of lumbar medial branch neurotomy for the treatment of back pain sought to demonstrate how the rationale and efficacy of lumbar medial branch neurotomy depends critically on the correct selection of patients and use of a surgically correct technique. They opined that sys-

tematic reviews have not recognized the importance of patient selection and correct surgical technique when appraising the literature. As a result, they felt, negative conclusions about procedures have been drawn because the lack of efficacy of one procedure has been misattributed to other, cognate, but different procedures. Their results showed that only 2 descriptive studies (1253,1378) and 3 controlled studies (1371,1374,1375) used valid or acceptable techniques and consistently showed that lumbar medial branch neurotomy had positive effects on pain and disability. They also showed that all valid, RCTs showed medial branch neurotomy to be more effective than sham treatment.

2.2.1.1 Evidence Assessment

For evidence synthesis, 7 randomized trials and 11 observational studies were utilized (256,1330,1351,1361,1365,1370,1371,1374,1375,1378-1386). A randomized, double-blind controlled trial comparing the efficacy of continuous versus pulsed radiofrequency in the treatment of lumbar facet syndrome (1376) was excluded since the study included patients with duration of low back pain of only one month. Of the 7 randomized trials, 6 of them were positive (256,1361,1371,1374,1375,1379). Among these studies, only one showed definite negative results (1370). The strong positive results were illustrated by Nath et al (1374) using triple blocks for the diagnosis with 80% pain relief as the criterion standard for diagnosis. van Kleef et al (1375) used a single block with 50% relief showing positive results which may be considered as moderate results. Tekin et al (1371) compared sham lesioning after local anesthetic injection with pulsed and conventional radiofrequency and showed moderately strong results with conventional radiofrequency. Cohen et al (1361) and Dobrogowski et al (1379) also studied radiofrequency neurotomy after diagnosis with dual blocks with 50% pain relief as the criterion standard, showing positive results by Cohen et al and weakly positive results by Dobrogowski et al. Cohen et al (1361) also evaluated single block diagnosis with 50% pain relief as the criterion standard and radiofrequency neurotomy; they reported weakly positive results in 39% of their patients, which is considered negative.

Civelek et al (256) and Cohen et al (1361) evaluated without diagnostic blocks and the results were positive by Civelek et al; whereas Cohen et al, even though published as positive, had results that were negative with only 33% showing positive results after radiofrequency.

The observational study by Macvicar et al (1366) evaluated a total of 106 patients, selected on the basis of complete relief of pain following controlled, diagnostic, medial branch blocks. They were treated with conventional radiofrequency neurotomy according to the guidelines of the ISIS (672). They defined a successful outcome as complete relief of pain for at least 6 months, with complete restoration of activities of daily living, no need for any further health care, and return to work. Patients who failed to meet any of these criteria were deemed to have failed treatment. Considering that this is very strict criteria, in the 2 practices, 58% and 53% of patients achieved a successful outcome. Relief lasted 15 months from the first radiofrequency neurotomy and 13 months for repeat treatments. They concluded that lumbar radiofrequency neurotomy can be very effective when performed in a rigorous manor in appropriately selected patients.

Cohen et al (1330) attempted to correlate an optimal cutoff threshold for diagnostic lumbar facet blocks. In this assessment, they evaluated 61 consecutive patients undergoing lumbar facet radiofrequency denervation after experiencing significant pain relief after medial branch blocks of at least 50% reduction of pain. Of the 61 patients, only 6 patients had less than 50% relief. In the remaining groups positive outcomes varied from 65.4% to 69.2% with no significant difference between groups obtaining 50% to 66% relief, 67% to 83% relief, or greater than 84% relief. In contrast, Derby et al (1351) correlated lumbar medial branch neurotomy results with diagnostic medial branch block cutoff values to optimize therapeutic outcomes. In this assessment they evaluated 51 patients with radiofrequency neurotomy either with a single block or double blocks. They demonstrated 63.2% positive results with the single block group with radiofrequency neurotomy, whereas, they showed 84.6% positive results with double blocks.

Thus, among the 11 observational studies, 10 reported positive results (1330,1351,1366,1378,1380-1382,1384-1386) and one reported undetermined results (1383).

The detailed descriptions of various studies, results, strengths, weaknesses, and conclusions have been described in detail in the systematic review (12) in Tables 7 and 8.

The results of the effectiveness of conventional and pulsed lumbar radiofrequency neurotomy, which included both randomized trials and observational studies, are illustrated in Table 22.

ACOEM practice guidelines for the treatment of low back pain (116) and APS guidelines for the evalua-

tion and management of low back pain (105) were unable to provide any clear rationale for conclusions that did not recommend radiofrequency neurotomy or facet joint nerve blocks for treatment of patients with chronic low back pain because they were based on insufficient evidence. Both the ACOEM and APS guidelines lack a systematic approach to evaluating the literature; use assessment tools that are not considered standard; present their analysis in a disorganized fashion; are deficient of any input from pain medicine physicians; and make conclusions that are often inconsistent, are based on an incomplete review of the literature, and/or rely on outdated research while ignoring more recent high quality published studies (8,101,111,112,1003).

2.2.1.2 Analysis of Evidence

Based on 6 positive randomized trials (256,1361,1371,1374,1375,1379) and 10 positive observational studies (1330,1351,1365,1378,1380-1382,1384-1386), the evidence for conventional radiofrequency neurotomy in managing chronic low back pain of facet joint origin in the lumbar spine is good for short- and long-term relief.

Based on one randomized trial (1371) and one observational study (1386) meeting inclusion criteria, the evidence is limited for pulsed radiofrequency neurotomy for managing chronic low back pain of facet joint origin.

2.2.2 Therapeutic Facet Joint Nerve Blocks

Lumbar facet joint nerve blocks are well known for their diagnostic capability and are utilized prior to radiofrequency neurotomy. However, they have been shown to be effective for long-term therapy. The exact mechanism of the therapeutic effect of lumbar facet joint nerve blocks is not known. Lumbar facet joint nerve blocks may be repeated to reinstate the pain relief when it returns without any deleterious effects, similar to radiofrequency in which pain returns when the axons regenerate, requiring repetition of the radiofrequency procedures.

Five systematic reviews (12,191,1250,1364,1366) evaluating the effectiveness of lumbar therapeutic medial branch injections were available. These included an update (12) of a previous publication (1250). These publications were current with application of strict methodologic inclusion criteria, with controlled diagnostic blocks as a prerequisite, along with assessment of 6 months of relief as short-term and longer than 6 months as long-term. However, Staal et al (191) utilized more than 6 weeks of relief as long-term, whereas others (12) utilized over 6 months of relief as long-term. Staal et al (191) included one study by Manchikanti et al (1387) and concluded that there was no difference between placebo and treatment group, even though they failed to take into consideration the design of the study – an active-control trial versus a placebo-control trial.

2.2.2.1 Evidence Assessment

There were 3 randomized trials (255,256,1387-1389), with 2 duplicate publications (255,1388,1389), evaluating the role of facet joint nerve blocks, 2 were of high quality (255,256,1388,1389) and one was of moderate quality (1387). All 3 studies reported positive results with or without steroids. However, only one study was appropriately conducted and of high quality (255,1388,1389), reporting appropriate and positive results in 85% of patients receiving local anesthetic only and 90% of the patients receiving local anesthetic and steroids, with approximately 5 or 6 procedures on average over a period of 2 years.

The second study (256), which was high quality, compared local anesthetic blocks and radiofrequency neurotomy; both procedures had positive results. In essence, they showed at the end of one year, 90% of the patients in the radiofrequency group and 69% of the patients in the facet joint nerve block group showed significant improvement. They also showed that at 6-month follow-up, 92% in the radiofrequency group and 75% in the facet joint nerve block group were positive. However, they did not use any diagnostic blocks for selection, even though they used strict selection criteria. The third study (1387), by the same authors as the high quality study (255,1388,1389), was of moderate quality, and also showed positive results with multiple procedures as needed after assessment with proper selection criteria and dual diagnostic blocks.

The results of the effectiveness of therapeutic lumbar facet joint nerve blocks are illustrated in Table 23.

2.2.2.2 Analysis of Evidence

Based on the available evidence of 2 high quality studies (255,256,1388,1389) and one moderate quality study (1387), the evidence for lumbar facet joint nerve blocks using local anesthetics with or without steroid for managing chronic low back pain of facet joint origin is fair to good for short- and long-term improvement.

2.2.3 Intraarticular Injections

The oldest and most common modality of treat-

Table 22. *Effectiveness of conventional and pulsed lumbar radiofrequency neurotomy.*

Study Study Characteristics Methodological Quality Scoring	Patients	Interventions	Outcome Measures	Pain Relief and Function			Results			Comments
				3 mos.	6 mos.	12 mos.	Short-Term ≤ 6 mos.	Long-Term		
								> 6 mos.	≥ 12 mos.	
Nath et al, 2008 (1374) RA, DB, Sham control 12/12	40	Radiofrequency = 20 Sham = 20	NRS, global functional improvement, reduced opioid intake, employment status.	NA	Significant proportion of patients in interventional group	NA	P for radiofrequency N for sham or active	P for radiofrequency N for sham	NA	Positive short and long-term
van Kleef et al, 1999 (1375) RA, DB, sham control 12/12	31	Radiofrequency = 15 Sham = 16	VAS, pain scores, global perceived effect, ODI	60% vs. 25%	47% vs. 19%	47% vs. 13%	P for radiofrequency N for sham or active	P for radiofrequency N for sham	P for radiofrequency N for sham	Positive short and long-term results
Civelek et al, 2012 (256) RA, AC 9/12	100	CRF = 50 Facet joint nerve blocks = 50	Visual Numeric Pain Scale, North American Spine Society patient satisfaction questionnaire, Euro-Qol Group 5-dimension self report questionnaire, ≥ 50% pain relief	NA	92% vs. 75%	90% vs. 69%	NA	P	P	Positive long-term results
Cohen et al, 2010 (1361) RA, DB 8/12	"0" block = 51 One block = 20 Two blocks = 14	CRF	Greater than 50% pain relief coupled with a positive global perceived effect persisting for 3 months	"0" group = 33% One block = 39% Two blocks = 64%	NA	NA	P in two block group	NA	NA	Positive short-term results with dual blocks
Tekin et al, 2007 (1371) RA, AC and sham, DB 12/12	60	CRF = 20 PRF = 20 Control = 20	VAS, ODI, global perceived effect	NA	SI with CRF	SI with CRF	NA	P for radiofrequency N for sham	P for radiofrequency. N for sham	Positive long-term results
van Wijk et al, 2005 (1370) RA, DB, Sham control 12/12	81	Radiofrequency = 40 Sham = 41	Pain relief, physical activities, analgesic intake, global perceived effect, Short form-36, quality of life measures	27.5% vs. 29.3%	27.5% vs. 29.3%	27.5% vs. 29.3%	N	N	N	Negative results
Dobrogowski et al, 2005 (1379) RA, AC 10/12	45	CRF	VAS, minimum of 50% reduction of pain intensity, patient satisfaction score	NA	60%	NA	NA	P	NA	Positive short and long-term results

Table 22 (cont.). *Effectiveness of conventional and pulsed lumbar radiofrequency neurotomy.*

Study Study Characteristics Methodological Quality Scoring	Patients	Interventions	Outcome Measures	Pain Relief and Function			Results			Comments
				3 mos.	6 mos.	12 mos.	Short-Term ≤ 6 mos.	Long-Term		
								> 6 mos.	≥ 12 mos.	
Cohen et al, 2012 (1330) O 7/12	55	CRF	NRS, ODI	67%	NA	NA	P	NA	NA	Positive short-term results
Derby et al, 2012 (1351) O 7/12	51	CRF	NRS, degree of subjective pain relief, duration of relief, patient satisfaction, activity level, no other doctor's visits, reduction in medication use	Double blocks = 85% Single blocks = 63%	Double blocks = 85% Single blocks = 63%	Double blocks = 85% Single blocks = 63%	P	P	P	Positive short and long-term results
Macvicar et al, 2012 (1366) P 8/12	106	CRF	Complete relief of pain for at least 6 months with complete restoration of activities of daily living, no need for any further health care, and return to work.	58% vs. 53%	58% vs. 53%	58% vs. 53%	P	P	P	Positive short and long-term results with strict criteria
Masala et al, 2012 (1386) O 7/12	92	PRF	Beck Depression Inventory II, VAS, ODI	NA	100%	100%	NA	P	P	Positive short and long-term results
Tomé-Bermejo et al, 2011 (1380) P 7/12	86	CRF	Pain relief, VAS, ODI, and satisfaction assessment	89%	66%	50%	P	P	P	Positive short and long-term results
Speldewinde, 2011 (1381) P 7/12	151	CRF	NRS, functional rating index, 4 active days of daily living scale, general health questionnaire, depression, anxiety, and stress scale, duration of pain relief.	69%	69%	69%	P	P	P	Positive short and long-term results
Yilmaz et al, 2010 (1384) O 7/12	50	CRF	VAS, health related quality of life state, EuroQol Group-5 Dimension Self-Report Questionnaire measures of pain, disability, and treatment satisfaction.	NA	NA	86%	NA	NA	P	Positive short and long-term results

Table 22 (cont.). *Effectiveness of conventional and pulsed lumbar radiofrequency neurotomy.*

Study Study Characteristics Methodological Quality Scoring	Patients	Interventions	Outcome Measures	Results					Comments
				Pain Relief and Function			Short-Term ≤ 6 mos.	Long-Term	
				3 mos.	6 mos.	12 mos.		> 6 mos.	≥ 12 mos.	
Son et al, 2010 (1385) O 7/12	60	CRF	Duration and quantity of pain relief by VAS	NA	60%	60%	NA	P	P	Undetermined short and long-term results
Gofeld et al, 2007 (1378) O 7/13	174	CRF	Pain relief	NA	68.4%	96.4%	P	P	P	Positive short and long-term results
Martinez- Suárez et al, 2005 (1382) O 6/12	252	CRF	Pain relief	NA	NA	75%	NA	NA	P	Positive short and long-term results
Tzaan & Tasker, 2000 (1383) O 7/12	69	CRF	Pain relief	NA	41%	NA	NA	U	NA	Positive short and long-term results

RA = Randomized; DB = Double-blind; AC = Active control; RE = Retrospective; O = Observational; P = Prospective; SI = Significant improvement; CRF = Conventional radiofrequency neurotomy; PRF = Pulsed radiofrequency neurotomy; P = Positive; N = Negative; NA= Not applicable; U = Undetermined; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; VAS = Visual Analog Scale.
Adapted and Modified from: Falco FJE, et al. An update of the effectiveness of therapeutic lumbar facet joint interventions. Pain Physician 2012; 15:E909-E953 (12).

ment for facet joint pain has been injection of intraarticular steroids or other substances into the facet joints. The basis for intraarticular injections has been the inflammation of the joint, consequently injection of anti-inflammatory substances into the joint.

Staal et al (191) included the studies by Carette et al (806) and Lilius et al (1390) in their analysis and qualified one as high quality (806) and one as low quality (1390), comparing the effects of facet joint injections with corticosteroids to placebo injections. They concluded that there was moderate evidence with 2 trials including 210 patients and that facet joint injections with corticosteroids are not significantly different from placebo injections for short-term pain relief and improvement of disability. Datta et al (1250) considered 5 randomized trials and 15 observational studies for inclusion and concluded that none of them met inclusion criteria with appropriate diagnosis and duration of follow-up. Datta et al (1250), in their systematic review showed limited evidence for intraarticular injections. Falco et al (12), utilizing 2 randomized trials (806,1318) and 6 nonrandomized studies (1391-1396), showed limited evidence. Among the 2 randomized trials meeting the inclusion criteria (806,1318), the results were negative for the high quality randomized, double-blind, placebo- or active-control trial by Carette et al (806) at 6 months, and the moderate quality study by Fuchs et al (1318) was weakly positive or undetermined for a high number of injections. Among the 6 nonrandomized studies meeting the inclusion criteria for intraarticular injections (1391-1396), 5 studies reported positive results (1391-1395), whereas in one study (1392), the results were negative.

Bogduk, in a narrative review of intraarticular corticosteroid injections for low back pain (1397) in 2005, found 10 observational studies meeting inclusion criteria and 2 controlled trials (806) with one controlled trial reported in 3 forms by Lilius et al (1390). He concluded that the results indicated that intraarticular steroids have no attributable effect when used for low back pain without a diagnosis of lumbar zygapophysial joint pain being made. Whatever benefit occurs is indistinguishable from the effect of simply performing a sham injection. He also described that only one study by Carette et al (806) has assessed the outcome of intraarticular injection of steroids in patients diagnosed as having lumbar zygapophysial joint pain. In this study, to be eligible for treatment, they had to report at least 50% relief of their pain when the targeted joint had been anesthetized. This study was judged to be negative, even though at 6 months, the authors showed

a significantly greater proportion of patients reporting marked improvement in their pain and function. However, Bogduk also noted that if only the patients who had significant improvement at one month were considered, the proportion of patients with continued responses at 6 months were not significantly different in the saline group versus steroid group. Consequently, Bogduk concluded that the apparent efficacy of lumbar intraarticular steroids is no greater than that of sham injection. He also opined that there is no justification for the continued use of lumbar intraarticular corticosteroid injections.

2.2.3.1 Evidence Assessment

Two randomized trials (806,1318) and 5 observational studies (1391,1395) met inclusion criteria. The results of the effectiveness of lumbar intraarticular injections are illustrated in Table 24.

Carrette et al (806) performed what appeared to be the optimal and perfect controlled trial of corticosteroid injections into facet joints for chronic low back pain. In this study, they randomly assigned patients either to receive methylprednisolone acetate 20 mg in 49 patients or isotonic saline in 48 patients in the same facet joints that responded with immediate relief of pain after injection of local anesthetic into the facet joints. They followed 95% of the patients for 6 months. The results showed that after one month, none of the outcome measures evaluating pain, functional status, and back flexion differed clinically or statistically between the 2 study groups. Forty-two percent of the patients who received methylprednisolone and 33% of those who received placebo reported marked or very marked improvement. The results were similar after 3 months; however, at the 6-month evaluation, the patients treated with methylprednisolone reported more improvement, less pain on the VAS, and less physical disability. The differences were reduced, however, when concurrent interventions were taken into consideration. Further, only 11 patients or 22% in the methylprednisolone group and 5 patients or 10% in the placebo group had sustained improvement from the first month to the sixth month. However, Carette et al (806) failed to exclude placebo responders, which may account for the relatively high incidence of patients in their study with presumed facet joint pain. They showed an incidence of 58% prevalence of facet joint pain based on inclusion criteria of phase 1 of their study. Failure to exclude placebo responders may have diluted the findings of true responses, making detection of differences between the study and the control group difficult. The patients in the methylprednisolone group received a greater proportion of concurrent interventions. This factor alone will reduce the quality of study since concurrent interventions were not provided equally even though the study has been touted in multiple systematic reviews as a high quality evaluation. Consequently, even though 42% of the patients in the steroid group showed a benefit compared to 50% in the sodium chloride solution group, they concluded that there was no significant difference between the groups. In contrast, Staal et al (337) concluded that the methylprednisolone group was positive compared to the sodium chloride solution group.

Fuchs et al (1318) conducted a study comparing intraarticular hyaluronic acid versus glucocorticoid injections for nonradicular pain in the lumbar spine. Sixty patients were included in this randomized, controlled, blind-observer clinical study and randomly assigned to 2 groups to receive 10 mg of sodium hyaluronate or 10 mg of triamcinolone acetonide per facet joint. The facet joints on both sides at levels L5-S1, L5-L4, and L4-L3 were treated once per week under CT guidance. The study visits were timed to permit assessment of the immediate effect as well as possible carryover effects at 3 and 6 months after completion of treatments. Changes in pain were assessed with a VAS and changes in function and quality of life were assessed by the Roland-Morris questionnaire (RMQ), the Oswestry Disability questionnaire (ODQ), the Low Back Outcome Score (LBOS), and the Short-Form 36 (SF-36). Patients reported lasting relief, better function, and improved quality of life with both treatments.

However, the disadvantages of the study include a lack of appropriate diagnosis with controlled diagnostic blocks, thus failing to exclude placebo responders which may have increased the possibility of inclusion of patients without facet joint pain. Furthermore, pain relief of 50% or greater was achieved only in the triamcinolone group with a reduction of 51.7% despite a series of injections bilaterally at 3 levels, whereas the reduction was 45.1% in the sodium hyaluronate group. RMQ scores, ODQ scores, and LBOS showed reduction in sodium hyaluronate of 43.2%, 39.1%, and 43.9%, whereas in the triamcinolone group the reduction was 33.4%, 29.5%, and 34.8%. Considering that no controlled diagnostic blocks were used, and no mention was made of at least an 80% relief of pain following a diagnostic block, this study was excluded from the final evaluation.

Table 23. *Effectiveness of therapeutic lumbar facet joint nerve blocks.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comments
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-Term > 6 mos.	Long-Term ≥ 12 mos.	
Civelek et al, 2012 (256) RA, AC 9/12	100	LA with steroid = 50 CRF = 50	Visual Numeric Pain Scale, North American Spine Society patient satisfaction questionnaire, Euro-Qol in 5 dimensions and ≥ 50% relief	NA	75% vs. 92%	69% vs. 90%	NA	P	P	Positive long-term results
Manchikanti et al, 2010, 2008 (255,1389) RA, DB, AC 11/12	120	LA with steroid = 60 LA = 60	NRS, ODI, employment status, and opioid intake.	82% vs. 83%	93% vs. 83%	85% vs. 84%	P	P	P	Positive with local anesthetic with or without steroids
Manchikanti et al, 2001 (1387) RA, AC 8/12	73	LA with steroid = 41 LA = 32	Numeric pain rating scale, Functional status, opioid intake, employment status	SI	SI	SI	P	P	P	Positive short and long-term results

RA = Randomized; DB = Double-blind; AC = Active control; CRF = Conventional radiofrequency; LA = Local anesthetic; P = Positive; NA = Not applicable; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index.
Adapted and Modified from: Falco FJE, et al. An update of the effectiveness of therapeutic lumbar facet joint interventions. *Pain Physician* 2012; 15:E909-E953 (12).

2.2.3.2 Analysis of Evidence

Based on the one moderate quality study with weakly positive or undetermined results (1318) and 5 observational studies (1391-1395), the evidence for intraarticular injections is limited.

2.2.4 Summary of Evidence

The evidence for conventional radiofrequency neurotomy is good for short- and long-term improvement, the evidence for pulsed radiofrequency neurotomy is limited, the evidence for lumbar facet joint nerve blocks is fair to good for short- and long-term improvement, and the evidence for intraarticular injections is limited.

2.2.5 Complications

Complications from facet joint nerve blocks, intraarticular injections, or radiofrequency neurolysis in the lumbar spine are exceedingly rare (8,249,255,256,282,321, 323,377, 378,385,806,856,875, 890,891,932,944, 959,1250,1333,1336-1338,1367,1398-1456). The most common complications of lumbar facet joint interventions are twofold: complications related to the placement of the needle and complications related to the administration of various drugs and the application of heat, cryo, or laser. Most problems, such as local swelling, pain at the site of the needle insertion, and pain in the low back, are short-lived and self-limited.

More serious complications may include dural puncture, spinal cord trauma, subdural injection, neural trauma, injection into the intervertebral foramen, and hematoma formation; infectious complications including epidural abscess and bacterial meningitis; and side effects related to the administration of steroids, local anesthetics, and other drugs (8,249,255,256,282,321,323,377, 378,385,806,856,875,890,891,932,944,959,1250, 1333,1336-1338,1367,1398-1456).

Other minor complications include lightheadedness, flushing, sweating, nausea, hypotension, syncope, pain at the injection site as described earlier, and non-postural headaches.

Side effects related to the administration of steroids are generally attributed to the chemistry or to the pharmacology of the steroids (875). The major theoretical complications of corticosteroid administration include suppression of the pituitary-adrenal axis,

Table 24. *Effectiveness of lumbar intraarticular injections.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment(s)
				3 mos	6 mos	12 mos	Short-term ≤ 6 mos.	Long-Term		
								> 6 mos	≥ 12 mos.	
Carette et al, 1991 (806) RA, DB, PC or AC Single block confirmed 11/12	97	Methylprednisolone acetate = 49 Isotonic saline = 48 patients	VAS, McGill Pain Questionnaire, mean sickness impact profile	33% vs. 42%	22% vs. 10%	NA	N	N	NA	Negative results
Fuchs et al, 2005 (1318) RA, DB, AC 8/12	60	Hyaluronic acid versus glucocorticoid with 6 injections	VAS, Rowland-Morris Questionnaire, ODI, low back outcomes score, Short Form-36	Significant proportion of patients	Significant proportion of patients	NA	U	U	NA	Undetermined
Murtagh, 1988 (1391) P 7/12	100	Local anesthetic and steroids	Pain relief	54%	NA	NA	P	NA	NA	Positive short-term results
Destouet et al, 1982 (1392) O 7/12	54	Local anesthetic and steroids	Pain relief	54%	38%	38%	P	N	N	Positive short-term with a single block
Lippitt, 1984 (1393) RE 7/12	99	Local anesthetic and steroids	Pain relief and return to work	51%	NA	NA	P	NA	NA	Positive short-term with a single block
Celik et al, 2011 (1394) P 7/13	80	Conservative vs. local anesthetic and steroid	VAS, ODI	Significant proportion of patients in treatment group	Significant proportion of patients	NA	P	P	NA	Positive short-term and long-term results
Anand & Butt, 2007 (1395) P 7/12	57	Local anesthetic and steroids	Pain relief	53%	68%	NA	P	P	NA	Positive short-term and long-term results
Bani et al, 2002 (1396) RE 7/12	230	Local anesthetic and steroids	Pain relief	NA	NA	18.7%	NA	NA	N	Negative

RA = Randomized; DB = Double-blind; AC = Active control; PC = Placebo control; RE = Retrospective; O = Observational; P = Prospective; P = Positive; N = Negative; NA = Not applicable; U = Undetermined; ODI = Oswestry Disability Index; VAS = Visual Analog Scale.
Adapted and Modified from: Falco FJE, et al. An update of the effectiveness of therapeutic lumbar facet joint interventions. Pain Physician 2012; 15:E909-E953 (12).

hyperadrenocorticism, Cushing syndrome, osteoporosis, avascular necrosis of bone, steroid myopathy, epidural lipomatosis, weight gain, fluid retention, and hyperglycemia.

A study by Manchikanti et al (282) included over 7,500 episodes, or 43,000 spinal facet joint nerve blocks, with 3,162 lumbar facet joint nerve blocks performed under fluoroscopic guidance in an ambulatory surgery center by one of 3 physicians. The complications encountered during each procedure and postoperatively were prospectively evaluated. The results showed no major complications. Multiple side effects and complications observed in lumbar facet joint nerve blocks included intravascular penetration in 4% of the procedures, local bleeding in 73%, and oozing in 10%. Local hematoma was seen in only 0.1%. Profuse bleeding, bruising, soreness, nerve root irritation, and all other effects, such as vasovagal reactions, were observed in 1% or less.

Toxicity of local anesthetic with or without steroids has been extensively discussed (1430-1456). Local anesthetics relieve pain by inhibiting sensitization of nerve endings (1430) and by reducing proinflammatory cytokine production (1431-1433). Among the local anesthetics, bupivacaine has been one of the most commonly used for injection therapy, and is considered one of the safest drugs in terms of its potential for nerve or tissue toxicity (1430). A number of *in vitro* studies have demonstrated a dose- and time-dependent chondrotoxic effect of bupivacaine, especially at clinically applied concentrations from 0.1% to 1% (1431-1437). In evaluations of the effects of bupivacaine on cell viability, studies have shown that bupivacaine may be toxic to intervertebral disc cells (1438-1441). Some (1442), but not all (1443), studies have demonstrated synergistic toxic effects when steroids are combined with local anesthetic *in vitro*.

Reported complications of radiofrequency thermoneurolysis include a worsening of the usual pain, burning or dysesthesias, decreased sensation and allodynia in the paravertebral skin or the facets denervated, transient leg pain, persistent leg weakness, and inadvertent lesioning of the spinal nerve or ventral ramus resulting in motor deficits, sensory loss, and possible deafferentation pain. A spinal cord lesion can lead to paraplegia; loss of motor, proprioception, and sensory function; bowel and bladder dysfunction; Brown-Séquard syndrome; and spinal cord infarction.

2.2.6 Recommendations

Based on the available evidence it appears that the best response is obtained after confirmation of the diagnosis of facet joint pain with controlled diagnostic blocks preferably with 75% pain relief as the criterion standard with dual blocks. Based on the present evidence, there is good evidence for conventional radiofrequency neurotomy and fair to good evidence for lumbar facet joint nerve blocks for the treatment of chronic lumbar facet joint pain both in short-term and long-term. However, the evidence is limited for intraarticular facet joint injections and pulsed radiofrequency thermoneurolysis. Consequently, the recommended treatment is with radiofrequency neurotomy or therapeutic facet joint nerve blocks.

3.0 Sacroiliac Joint Pain

The sacroiliac joint is accepted as a potential source of low back and/or buttock pain with or without lower extremity pain (17,18,378,1457-1472). The sacroiliac joint receives innervation from the lumbosacral nerve roots (1462-1467,1473-1482). Neurophysiological studies have demonstrated both nociceptive and proprioceptive afferent units in the sacroiliac joint (1270,1473,1477,1479). Referral patterns based on sacroiliac joint provocation and analgesic response to local anesthetics in asymptomatic volunteers (1459) and patients with pain (1263,1483-1485) have been published.

3.1 Diagnosis of Sacroiliac Joint Pain

There is no universally accepted gold standard for the diagnosis of low back pain stemming from sacroiliac joints. 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 (375) 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.

A systematic review by Szadek et al (397) 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 (399) performed a systematic literature review evaluating the diagnostic value of scintigraphy in assessing sacroiliitis and ankylosing spondylitis. They concluded that scintigraphy is at best of limited value in establishing a diagnosis of ankylosing spondylitis.

Referral patterns based on sacroiliac joint provocation and analgesic response to local anesthetics, though illustrated in asymptomatic volunteers and patients with pain (1459,1483-1485), are not diagnostic. Radiographic assessment, and history and physical examination may only provide partial diagnostic information (17,18,378,1462-1467,1471,1486-1536).

3.1.1 Diagnostic Sacroiliac Joint Blocks

Due to the inability to make the diagnosis of sacroiliac joint-mediated pain with non-invasive tests, sacroiliac joint blocks appear to be the evaluation of choice to provide appropriate diagnosis. The sacroiliac joint is well innervated (1462-1467,1473-1482) with nociceptors and proprioceptors, even though the pattern of innervation is the subject of considerable controversy (57,101,103,104,109-114,139-142,157-160). Controlled studies have established sacroiliac joints as a potential source of low back and lower extremity pain (8,17,375, 377,378,401,403,1460,1461,1471,1472,1487,1537-1539). Based on the controlled diagnostic blocks, the sacroiliac joint has been implicated as the primary source of pain (8,17,375,401,403,1461,1463,1464,1471).

The face validity of sacroiliac joint blocks has been established by injecting small volumes of local anesthetic with contrast into the joint and determining contrast spread. Construct validity of sacroiliac joint blocks has been established by determining the false-positive rates of single, uncontrolled, sacroiliac joint injections of 20% to 54% (378,1488,1537,1538). Positive responses may occur with extravasation of an anesthetic agent out of the joint due to defects in the joint capsule (1489). Negative results may occur from faulty needle placement, intravascular injection, or inability of the local anesthetic to reach the painful portion of the joint due to loculations (372,1461,1462,1466,1468-1470,1481,1490-1492).

Hancock et al (375) suggested that a combination of sacroiliac joint pain provocative maneuvers appears to be useful in pinpointing the sacroiliac joints as the principal source of symptoms in patients with pain below the fifth lumbar vertebra.

Rubinstein and van Tulder (401), in a best evidence review of diagnostic procedures for low back pain, concluded that there is moderate evidence for the diagnostic accuracy of sacroiliac joint injections in evaluating spinal pain.

Simopolous et al (17), in recent systematic review utilizing multiple studies and at least 50% relief as the criterion standard, estimated the prevalence of sacroiliac joint pain to range between 10% and 62% based on the setting; whereas the majority of analyzed studies suggest a point prevalence of around 25%, with a false-positive rate of uncontrolled blocks of approximately 20%. They showed good evidence for diagnostic sacroiliac joint pain utilizing controlled comparative local anesthetic blocks, fair evidence for provocative testing to diagnose sacroiliac joint pain, and limited evidence for the diagnostic accuracy of imaging in identifying painful sacroiliac joint.

Our literature search showed no additional studies published since the publication of the systematic review by Simopoulous et al (17).

3.1.1.1 Evidence Assessment

Sacroiliac joint blocks were assessed in 3 systematic reviews. The evidence was synthesized, modified from a systematic review by Simopoulos et al (17), based on the relief criteria when sacroiliac joint injections were performed.

Only one study (1493) was performed with a single block with 50% to 74% pain relief; however, prevalence was not assessed.

There were 2 studies evaluating 50% to 74% relief with dual blocks (1489,1538). The prevalence rate in the 50% to 74% dual block category was 38% with 50% relief and 26.6% with 70% relief. When 50% relief with dual blocks was utilized as the criterion standard, the prevalence rate was shown to be 38% with a false-positive rate of 21% (1489). Irwin et al (1538), in a large retrospective evaluation, found a prevalence rate of 26.6% using 70% pain relief.

There were a total of 8 studies meeting the inclusion criteria evaluating sacroiliac joint pain using a cutoff threshold between 75% and 100% relief following a single block (377,388,1460,1487,1494,1495, 1539,1540). The prevalence in this group ranged from a low of 10% to a high of 62%. The 53% and 62% prevalence rates reported by Dreyfuss et al (1487) and Slipman et al (1494), respectively, were found in highly selected populations. Dreyfuss et al (1487) employed a reference standard of greater than 90% pain relief during the blocks, and enrolled study patients who had pain predominantly below L5. Slipman et al (1494) used 80% pain relief as the criterion standard,

and studied a population who had a positive response to 3 sacroiliac joint pain provocation tests. Overall, a single block using 75% to 100% pain relief as the reference standard appears to yield a prevalence of around 35%.

There were a total of 7 studies meeting the inclusion criteria with 75% to 100% relief with dual blocks (283,378,389,391,668,1488,1537,1541), with 2 duplicate publications (283,668). Using between 75% and 100% pain relief with dual blocks as the criterion standard has been advocated by some as the most rigorous means for diagnosing sacroiliac joint pain (8,712,1250,1341,1471). In a small study that included only 20 patients, Manchikanti et al (41) found a low prevalence rate of 10%. In contrast, Laslett et al (1488) showed a prevalence rate of 25.6% in a study involving 48 subjects. The false-positive rate was 22% (378). Laslett et al (1488) have not estimated the false-positive rates, but looking at the data, it appears to be 0%. Others have shown prevalence of 18.5% with false-positive rate of 20% (1537), 40.4% and 26% (1541), and only prevalence of 18.2% (283,389,391,668).

3.1.1.2 Prevalence

Table 25 illustrates the prevalence of diagnostic studies for sacroiliac joint pain (283,377,378,388,389,391, 668,1460,1487,1488,1489, 1494,1495,1537-1541).

Based on the available studies, the prevalence ranged from 10% to 44.4% with 75% to 100% relief with dual blocks and 10% to 62% with 75% to 100% relief with a single block. The prevalence was 26.6% or 38% with 50% to 74% relief with a dual block with only 2 studies available.

3.1.1.3 False-Positive Rates

False-positive rates were determined with dual blocks in a total of 4 studies (378,1489,1537,1541). The illustrated false-positive rates were similar with both types of dual blocks with 2 different criteria ranging from 20% to 26% (Table 25).

3.1.1.4 Analysis of Evidence

Based on this comprehensive assessment, the evidence is good with utilization of either single block or dual blocks with 75% to 100% pain relief as the criterion standard (283,377,378,388,389,391, 668,1460,1487 ,1488,1494,1495,1537, 1539-1541). The evidence is fair due to the limitation of the number of studies with 50% to 74% relief with a dual block with only 2 studies available (1489,1538).

Even though pain patterns may be helpful in identifying patients who might benefit from diagnostic injections, they are not pathonomic (1263,1459,1483-1485).

Based on multiple studies that utilized evaluating provocative testing and clinical evaluation (388,1460,1487,1488,1489,1493,1495-1499,1537,1539), the review of provocative testing and clinical examination findings illustrates that 6 commonly performed provocative tests may be useful to select patients for further study provided 3 or more of them are positive. These include the distraction, compression, thigh thrust, Gaenslen's test, and sacral thrust test (1495). The evidence is fair for provocative testing.

Based on numerous evaluations (388,398, 1289,1483,1494,1495,1500-1536,1539,1540), the evidence for diagnostic accuracy of a painful sacroiliac joint with imaging is limited.

3.1.1.5 Recommendations

Controlled sacroiliac joint blocks with placebo or controlled comparative local anesthetic blocks are recommended when indications are satisfied with suspicion of sacroiliac joint pain, except when required by regulation or guidance, a positive response is considered ≥ 75% relief (good evidence) or with ability to perform previously painful movements.

3.2 Therapeutic Sacroiliac Joint Interventions

Sacroiliac joint pain may be managed by intraarticular injections or neurolysis of the sacroiliac joint (1461,1468,1469). Four systematic reviews have been conducted to evaluate the effectiveness of sacroiliac joint interventions (18,1461,1468,1469). All of them illustrated either lack of evidence or limited evidence for both intraarticular sacroiliac joint injections and radiofrequency neurotomy of the nerve supply of the sacroiliac joint. Rupert et al (1461) evaluated the role of intraarticular injections and radiofrequency neurotomy with inclusion criteria of a diagnosis of sacroiliac joint pain by controlled diagnostic blocks and outcome parameters of 6 months or longer. There was limited evidence (Level II-3) for radiofrequency neurotomy.

Hansen et al (18) in the recent systematic review reached the conclusion that there was fair evidence for cooled radiofrequency neurotomy, however, with limited evidence for intraarticular injections, conventional radiofrequency neurotomy, and pulsed radiofrequency neurotomy.

Table 25. *Data of prevalence of sacroiliac joint pain by controlled diagnostic blocks.*

Study	% Relief Used	Methodological Criteria Score	Number of Subjects	Prevalence Estimates	False-Positive Rates
50%-74% RELIEF WITH A DUAL BLOCK					
Irwin et al, 2007 (1538)	70%	8/11	158	26.6%	NA
van der Wurff et al, 2006 (1489)	50%	9/11	60	38%	21%
75%-100% RELIEF WITH A SINGLE BLOCK					
Pang et al, 1998 (377)	90%	8/11	104	10%	---
Dreyfuss et al, 1996 (1487)	90%	8/11	85	53%	---
Slipman et al, 1996 (1494)	80%	8/11	50	62%	---
Laslett et al, 2005 (1495)	80%	8/11	48	33%	---
Young et al, 2003 (388)	80%	8/11	81	39%	---
Stanford & Burnham, 2010 (1539)	80%	6/11	34	32%	---
Schwarzer et al, 1995 (1460)	75%	9/11	43	30%	---
Maigne & Planchon, 2005 (1540)	75%	8/11	40	35%	---
75%-100% RELIEF WITH DUAL BLOCKS					
DePalma et al, 2012, 2011 (283,668)	75%	8/11	156	18.2%	NA
Manchikanti et al, 2001 (378)	80%	9/11	20	10%	22%
DePalma et al, 2011 (389)	75%	8/11	27	18.2%	NA
DePalma et al, 2011 (391)	75%	8/11	170	18.2%	NA
Maigne et al, 1996 (1537)	75%	8/11	54	18.5%	20%
Laslett et al, 2003 (1488)	80%	8/11	43/48	25.6%	NA
Liliang et al, 2011 (1541)	75%	8/11	52	40.4%	26%

NA = Not available
Adapted and modified from: Simopoulos TT, et al. A systematic evaluation of prevalence and diagnostic accuracy of sacroiliac joint interventions. *Pain Physician* 2012; 15:E305-E344 (17).

3.2.1 Intraarticular Injections

Intraarticular injections are the most commonly used modality of treatment in managing sacroiliac joint pain. Thus far, 4 systematic reviews have shown a lack of significant evidence for intraarticular injections in managing chronic sacroiliac joint pain without spondyloarthropathy. However, in the recent assessment, Hansen et al (18) showed emerging evidence for intraarticular injections, even though there are no well conducted high quality randomized trials published yet showing their effectiveness.

Our search criteria since the publication of the systematic review showed no additional studies evaluating intraarticular injections of sacroiliac joint.

3.2.1.1 Evidence Assessment

As per the systematic review by Hansen et al (18), there were a total of 4 studies (1499,1540,1542,1543) performed evaluating intraarticular injections. The characteristics of these studies are shown in Table 26. Only one study was randomized using an active-control design (1542). This study by Kim et al (1542) compared prolotherapy to steroid injections. The authors found no significant differences at 3 months; however, on a long-term basis, prolotherapy was more effective. In a large retrospective study, Hawkins and Schofferman (1499) reported positive results with intraarticular injections performed appropriately under fluoroscopy. Liliang et al (1544) showed short-term effectiveness for intraarticular steroid injections. Borowsky and Fagen (1543) compared intraarticular injections with a combination of intra- and periarticular injections. The results were suboptimal with both techniques, but were somewhat better in the combined injection group. Among the excluded studies, there were positive results illustrated by Maugars et al (1545) in patients with spondyloarthropathy. In addition, Murakami et al (1546), in a short-term follow-up, showed the superiority of periarticular injections over intraarticular injections.

Table 26. *Results of randomized and observational studies of effectiveness of intraarticular sacroiliac joint injections.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-Term		
								> 6 mos.	≥ 12 mos.	
Hawkins & Schofferman, 2009 (1499) NR, F 7/13	155	Local anesthetic and steroids Number of injections = 1 to 4	Significant pain relief of 50% or more	77%	77%	77%	P	P	P	Positive study
Liliang et al, 2009 (1544) NR, F 8/13	150	Local anesthetic and steroids Number of injections = 1 to 3	Pain recurrence within 6 weeks after the block was considered treatment failure and no further blocks were performed on these patients. VAS, ODI	66.7%	NA	NA	P	NA	NA	Positive study
Kim et al, 2010 (1542) RA, AC, F 11/12	50 Prolotherapy group = 24 Steroid group = 26	25% dextrose solution with levobupivacaine or levobupivacaine with triamcinolone Number of injections = 3	NRS, ODI, significant improvement 50% relief	Prolotherapy = 77.6% vs. Steroids = 70.5%	Prolotherapy = 63.6% vs. Steroids = 27.2%	Prolotherapy = 58.7% vs. Steroids = 10.2%	P*	N = steroids P* = local anesthetic	N = steroids P* = local anesthetic	Positive for prolotherapy
Borowsky & Fagen, 2008 (1543) NR, F 6/10	120	Intraarticular or with extraarticular injection. Number of injections = 1	Percent change in VAS pain scores Patient self-reported activities of daily living	12.5 % vs. 31.25%	NA	NA	N	N	N	Negative study

*Prolotherapy

NR = Non-randomized; F = Fluoroscopy; RA = Randomized; AC = Active-control; P = Positive; N = Negative; NA = Not Applicable; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; VAS = Visual Analog Scale.

Adapted and Modified from: Hansen H, et al. A systematic evaluation of the therapeutic effectiveness of sacroiliac joint interventions. *Pain Physician* 2012; 15:E247-E278 (18).

3.2.1.2 Analysis of Evidence

There is limited evidence for the effectiveness of intraarticular steroid injections.

3.2.2 Periarticular Injections

In addition to intraarticular injections, another popular treatment has been periarticular injections, which has been believed to provide better relief due to blockade of the ligaments and the neural supply. However, the literature is scant in reference to periarticular injections. The only systematic review assessing the role of periarticular injections is by Hansen et al (18) which showed poor evidence. Our search criteria yielded no other studies published since the publication of systematic review by Hansen et al (18).

3.2.2.1 Evidence Assessment

Periarticular injections were evaluated in 3 randomized trials (1547-1549) and one observational study (1543) as shown in Table 27.

The study by Lee et al (1547) was a randomized trial, whereas Borowsky and Fagen (1543) retrospectively compared intraarticular injections to a combination of intraarticular and periarticular injections. In the randomized trial by Lee et al (1547), the authors showed that a periarticular injection of botulinum toxin was effective in a significant proportion of patients at 3 month follow-up. Borowsky and Fagen (1543) showed that patients receiving intraarticular and periarticular injections fared better than the patients receiving intraarticular injections only; however, only 31.25% of patients who received the combination of injections experienced relief at 3 months. Luukkainen et al evaluated the role of periarticular injections in 2 randomized trials (1548,1549). Both the studies showed periarticular injection of local anesthetic with steroids to be superior, though only in a short-term follow-up. The characteristics of these studies are described in Table 11 of the systematic review by Hansen et al (18).

3.2.2.2 Analysis of Evidence

Based on the limited results, there is limited evidence for periarticular injections of local anesthetic and steroid or botulinum toxin (Table 27).

3.2.3 Conventional Radiofreqency Neurotomy

Conventional radiofrequency has been used frequently in managing pain of sacroiliac joint origin (18,1461,1550,1551). Systematic reviews assessing conventional radiofrequency neurotomy showed limited evidence (18,1461).

Our literature search yielded no further studies.

3.2.3.1 Evidence Assessment

As described by Hansen et al (18) there was only one study evaluating conventional radiofrequency neurotomy that met the inclusion criteria (1550) (Table 28). Our literature search identified one new study comparing cooled radiofrequency neurotomy with conventional radiofrequency neurotomy (1551).

Cohen et al (1550) retrospectively evaluated 77 patients with refractory, injection-confirmed sacroiliac joint pain who underwent sacroiliac joint denervation at 2 academic institutions. Forty patients (52%) obtained a positive outcome. In multivariate analysis, preprocedure pain intensity, age older than 65 years, and pain radiating below the knee were significant predictors of failure. A trend was noted whereby patients receiving regular opioid therapy were more likely to experience a negative outcome. The use of cooled radiofrequency, rather than conventional radiofrequency, was also associated with a higher percentage of positive outcomes. The authors concluded that although several factors were found to possibly influence outcomes, no single clinical variable reliably predicted treatment results. The use of more stringent selection criteria was not associated with better outcomes.

Cheng et al (1551) showed comparative outcomes of conventional versus cooled radiofrequency ablation of the lateral branches for sacroiliac joint pain. They collected the retrospective data on 88 patients from 2006 to 2009. Among the 88 patients, 30 were treated with traditional radiofrequency neurotomy and 58 were treated with cooled radiofrequency neurotomy. They were unable to find a significant univariable relationship between each technique and duration of pain relief, either before or after adjusting for the potentially confounding variables. Both cooled and traditional radiofrequency ablations provided greater than 50% pain reduction for 3 to 6 months in the majority of the patients. They concluded that this study did not reveal evidence that cooled radiofrequency ablation of the lateral branches provided longer relief of sacroiliac joint pain as compared with conventional radiofrequency ablation.

Table 28 illustrates the effectiveness of radiofrequency (conventional, cooled, and pulsed) neurotomy of sacroiliac joint (1550,1551-1556).

3.2.3.2 Analysis of Evidence

Based on 2 observational studies (1550,1551), the

Table 27. *Results of randomized and observational studies of effectiveness of periarticular sacroiliac joint injections.*

Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Results					Comment
				Pain Relief and Function			Long-Term		
				3 mos.	6 mos.	12 mos	Short-term ≤ 6 mos	> 6 mos	≥ 12 mos.	
Luukkainen et al, 2002 (1548) RA, B, AC 11/12	24	Methylprednisolone with local anesthetic vs. sodium chloride solution Number of injections = 1	VAS, pain index	Significant improvement in steroid group	NA	NA	P	NA	NA	Positive for steroids with local anesthetic
Lee et al, 2010 (1547) RA, AC, F 12/12	39 patients Botox Group (n=20) Steroid Group (n=19)	Number of injections = 1	NRS, ODI	Botox = 88.2% vs. Steroid = 26.7%	NA	NA	N = steroids P** = local anesthetic	NA	NA	Positive for Botox
Luukkainen et al, 1999 (1549) RA, B, AC 11/12	20	Methylprednisolone with local anesthetic vs. sodium chloride solution Number of injections = 1	VAS, pain index	Significant improvement in steroid group	NA	NA	P	NA	NA	Positive for steroid
Borowsky & Fagen, 2008 (1543) NR, F 6/10	120	Intraarticular and periarticular Number of injections = 1	Percent change in VAS pain scores Patient self-reported activities of daily living	12.5 % vs. 31.25%	NA	NA	N	N	N	Small study with negative results

** Botulinum Toxin

RA = Randomized; B = Blind; F = Fluoroscopy; AC = Active-control; NR = Non-randomized; P = Positive; N = Negative; NA = Not Applicable; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; VAS = Visual Analog Scale.

Adapted and Modified from: Hansen H, et al. A systematic evaluation of the therapeutic effectiveness of sacroiliac joint interventions. P*ain Physician* 2012; 15:E247-E278 (18).

evidence for the effectiveness of conventional radiofrequency neurotomy of sacroiliac joint innervation is limited.

3.2.4 Cooled Radiofrequency Neurotomy

Cooled radiofrequency neurotomy has been recently employed in managing sacroiliac joint pain. Two RCTs (1553,1554) evaluated the efficacy of cooled radiofrequency neurotomy using a placebo control design, as assessed by Hansen et al (18). Although there were some potential shortcomings with the control group, both studies illustrated the effectiveness of cooled radiofrequency neurotomy.

Our literature search yielded 3 additional studies (1551,1552,1555) with 2 observational studies (1551,1552) and a case report (1555).

3.2.4.1 Evidence Assessment

There were 2 RCTs (1553,1554) and 2 observational studies (1551,1552) evaluating the effectiveness of cooled radiofrequency neurotomy of sacroiliac joint innervation that met inclusion criteria (Table 28).

Cohen et al (1553) evaluated lateral branch radiofrequency denervation for sacroiliac joint pain in a randomized placebo-controlled study. They included 28 patients with diagnostic injection-diagnosed sacroiliac joint pain. Fourteen patients were treated with L4/5 primary dorsal rami and S1 to S3 lateral branch radiofrequency denervation using cooling probe technology after a local anesthetic block, and 14 patients received the local anesthetic block, followed by placebo denervation. At 3 and 6 months after the procedures, 64% and 57% radiofrequency-treated patients experienced pain relief of 50% or greater and significant functional improvement. In contrast, none of the patients receiving sham denervation experienced significant improvement at 3 month and 6 month follow-up even though 14% experienced relief at one month follow-up. The authors concluded that these results

Table 28. *Effectiveness of radiofrequency (conventional, cooled, and pulsed) neurotomy of sacroiliac joint.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment
				3 mos.	6 mos.	> 12 mos.	Short-term ≤ 6 mos.	Long-Term		
								> 6 mos.	≥ 12 mos.	
CONVENTIONAL RADIOFREQUENCY										
Cohen et al, 2009 (1550) NR, F 8/13	77	Conventional or cooled radiofrequency from L4/5 to S3/4	VAS pain scores, quality of life, medication usage	NA	66.7% improvement	NA	P	P	NA	Positive study
Cheng et al, 2013 (1551) O 10/13	Conventional = 30 Cooled = 58	Conventional radiofrequency neurotomy vs. cooled radiofrequency neurotomy	NRS	T = 60% C = 50%	T = 40% C = 40%	NA	T = P C = P	T = P C = P	NA	Positive study
COOLED RADIOFREQUENCY										
Cohen et al, 2008 (1553) RA, DB, PC 11/12	Total: 28 Placebo = 14 Radiofrequency = 14	Cooled radiofrequency or sham	NRS pain scores, Oswestry Disability Index, reduction in analgesic medications, positive global perceived effect	Treatment group: 64% success rate Control group: 14%	Treatment group: 57% success rate Control group: 0%	Treatment group: 14% in open-label follow-up	P = RF N = Sham	P = RF N = Sham	N	Positive trial
Patel et al, 2012 (1554) RA, DB, PC 11/12	51 (34 treatment, 17 control)	Cooled radiofrequency versus sham	SF-36, Oswestry Disability Index, Quality of Life, NRS	Treatment group: 47% success rate Control group: 12%	Treatment group: 38% success rate Control group: NA	NA	P = RF N = Sham	P = RF N = Sham	NA	Positive trial
Cheng et al, 2013 (1551) O 10/13	Conventional = 30 Cooled = 58	Conventional radiofrequency neurotomy vs. cooled radiofrequency neurotomy	NRS	T = 60% C = 50%	T = 40% C = 40%	NA	T = P C = P	T = P C = P	NA	Positive study
Stelzer et al, 2013 (1552) O 10/13	97	Cooled radiofrequency neurotomy		86%	71%	48%	P	P	P	Positive results

Table 28 (cont.). *Effectiveness of radiofrequency (conventional, cooled, and pulsed) neurotomy of sacroiliac joint.*

Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment
				3 mos.	6 mos.	> 12 mos.	Short-term ≤ 6 mos.	Long-Term		
								> 6 mos.	≥ 12 mos.	
PULSED RADIOFREQUENCY										
Vallejo et al, 2006 (1556) O 10/13	126	Pulsed radiofrequency	VAS and quality of life measures	55%	32% had between 17 and 32 weeks worth of relief	NA	P	P	NA	Positive study

RA = Randomized; NR = Non-randomized; DB = Double-blind; PC = Placebo control; F = Fluoroscopy; P = Positive; N = Negative; RF = Radiofrequency; NA = Not applicable; T = Traditional radiofrequency; C = Cooled radiofrequency;
Adapted and Modified from: Hansen H, et al. A systematic evaluation of the therapeutic effectiveness of sacroiliac joint interventions. *Pain Physician* 2012; 15:E247-E278 (18).

provided preliminary evidence that L4 and L5 primary dorsal rami and S1 to S3 lateral branch radiofrequency denervation may provide intermediate term pain relief and functional benefit in selected patients with suspected sacroiliac joint pain. However, the authors used a single diagnostic block and patients in the placebo group also received local anesthetic blocks which have been shown to have prolonged effect (236,237,244,250,255-257,773,777,798-804,834,836-838,1387-1389).

Patel et al (1554) in another randomized placebo-controlled study assessed the efficacy of lateral branch neurotomy for chronic sacroiliac joint pain. In this study, 51 subjects were randomized on a 2:1 basis to lateral branch neurotomy and sham groups with follow-ups being conducted at 3, 6, and 9 months. Lateral branch neurotomy was performed with cooled radiofrequency technology from S1 to S3 lateral branches and L5 dorsal ramus. The sham procedure was identified as identical to the active treatment, except that radiofrequency energy was not delivered. The results showed statistically significant changes in pain, physical function, disability, and quality of life at 3 month follow-up with 47% of treated patients showing improvement compared to 12% of the sham patients with treatment success. At 6 and 9 months, 38% and 59% of treatment subjects achieved treatment success, respectively. There was a significant number of crossovers in the sham group at 3 months. Patients in both groups received local anesthetic blocks. Twelve percent of the patients in the sham group reported success at 3 months. At 6 and 9 months 38% and 59% showed a successful outcome. It is also concerning that treatment success of 47% at 3 months declined to 38% at 6 months and increased to 59% at 9 months. The authors concluded that the treatment group showed significant improvements and the duration and magnitude of relief was consistent with previous studies. The disadvantages also include that the study was limited to only 9 months.

Among the newly identified studies meeting inclusion criteria, Stelzer et al (1552) reported a larger case series in a retrospective evaluation in 97 patients. Outcomes were reported up to 20 months after the procedures. Cooled radiofrequency involved lesioning of the L5 dorsal ramus and lateral to the S1, S2, and S3 and posterior sacral foramina apertures. When stratified by time to final follow-up, the results showed 86%, 71%, and 48% of the patients experiencing greater than 50% reduction in VAS pain scores at 4 to 6 months, 6 to 12 months, and after 12 months. Also 96%, 93%, and 85% reported their quality of life as much improved or improved. In addition, they also showed that 100%, 62%, and 67% of opioid users stopped or decreased use of opioids at 4, 6, and after 12 months. They concluded

that the results showed promising, durable improvements in pain, quality of life, and medication usage in a large European study population.

Cheng et al (1551) showed comparative outcomes of cooled versus conventional radiofrequency ablation. Among the 88 patients reviewed, 58 were treated with cooled radiofrequency neurotomy and 30 were treated with conventional radiofrequency neurotomy. Both cooled and traditional radiofrequency ablations provided greater than 50% pain reduction for 3 to 6 months in the majority of the patients, with no significant differences.

3.2.4.2 Analysis of Evidence

The evidence for cooled radiofrequency neurotomy in managing sacroiliac joint pain is fair based on 2 randomized, double-blind placebo-controlled trials (1553,1554) and 2 observational studies (1551,1552).

3.2.5 Pulsed Radiofrequency Neurotomy

There was only one study by Vallejo et al (1556) evaluating pulsed radiofrequency neurotomy.

Our literature search yielded no further studies.

3.2.5.1 Evidence Assessment

Vallejo et al (1556) evaluated the effectiveness of pulsed radiofrequency denervation for the treatment of sacroiliac joint syndrome. They selected patients based on greater than 75% pain relief after 2 consecutive injections. They performed pulsed radiofrequency neurotomy after failure of conservative management in 22 patients. Sixteen patients, or 73%, experienced good relief with greater than 50% reduction in VAS score, or excellent relief with greater than 80% reduction in VAS pain relief following pulsed radiofrequency neurotomy. Duration of pain relief ranged from 17 to 32 weeks in 7 patients (32%), 10 to 16 weeks in 5 patients (23%), and 6 to 9 weeks in 4 patients (18%). Quality of life scores improved significantly in all measured categories. However, 6 patients (26.1%) did not respond to pulsed radiofrequency denervation and had less than 50% improvement. Though this is an observational study with no control groups, the selection criteria were strict and results provided positive preliminary evidence.

3.2.5.2 Analysis of Evidence

Based on one non-randomized prospective evaluation (1556), the evidence for pulsed radiofrequency is limited.

3.2.6 Summary of Evidence

The evidence is fair for cooled radiofrequency neurotomy; limited for short-term and long-term relief from intraarticular steroid injections; limited for periarticular injections with steroids or botulinum toxin; and limited for both pulsed radiofrequency and conventional radiofrequency neurotomy.

3.2.7 Complications

Complications from sacroiliac joint interventions (intraarticular injections, radiofrequency neurotomy, or periarticular injections) are exceedingly rare. The most common complications of intraarticular injections and periarticular injections are 2-fold relating to the needle placement or administration of various drugs. Most side effects such as local swelling, pain at the site of the needle insertion, and pain in the extremities are short-lived and self-limited. More serious complications may include neural trauma, injection into the intervertebral foramina, hematoma formation, and sciatic nerve injury. Infectious complications including intraarticular abscess, systemic infection, and even meningitis have been reported (893). The side effects related to the administration of steroids and local anesthetics are similar to other interventions and have been described (870,874-878,934,962). In addition, minor complications such as lightheadedness, flushing, sweating, nausea, hypotension, syncope, have been reported.

Reported complications of radiofrequency thermoneurolysis include a worsening of the usual pain, burning or dysesthesias, decreased sensation, and allodynia in the skin over the denervated area, transient leg pain, persistent leg weakness, and inadvertent lesioning of the nerve supply including the sciatic nerve resulting in motor deficits, sensory loss, and possible deafferentation pain.

3.2.8 Recommendations

Based on the comprehensive review of the literature, there is good evidence that diagnostic blockade with controlled blocks provides better selection criteria than without diagnostic blocks. In addition, based on the comprehensive review of the literature for therapeutic purposes, the only effective modality with fair evidence appears to be cooled radiofrequency neurotomy after appropriate diagnosis confirmed by diagnostic sacroiliac joint injections. However, evidence is emerging for intraarticular injections, even though it is limited at the present time, which may be used in selected cases with or without periarticular injections.

VI. MANAGEMENT OF NECK PAIN

Chronic neck pain in the general population with or without sprain or injury is common (49,51-56,65,73,1557-1584). Annual estimates of the prevalence of neck pain among adults ranges from 12.1% to 71.5% with most estimates showing an annual prevalence of between 30% and 50% (49,51-55,1557-1571). Côté et al (51) illustrated various grades of chronic neck pain with 5% of patients suffering with grades III and IV neck pain associated with high pain intensity and disability (Fig. 1).

While it is well known that neck pain is a common, human phenomenon, what is not known is whether neck pain is likely to improve, reoccur, persist, or worsen. Most of the evidence indicates that between 50% to 75% of people who initially experience neck pain will also report neck pain one to 5 years later (1567,1578-1583). Furthermore, the evidence also indicates that in adults, recovery from whiplash associated disorder (WAD) is prolonged, with approximately 50% of those affected reporting neck pain symptoms one year after the injury (1583-1587).

Although less prevalent than low back pain, neck pain is very common and may cause persistent pain and disability. Neck pain may originate from intervertebral discs, facet joints, atlantoaxial and atlantooccipital joints, ligaments, fascia, muscles, and nerve root dura. Cervical intervertebral discs, facet joints, and nerve root dura have been shown to be capable of transmitting pain in the cervical spine with resulting symptomatic neck pain, upper extremity pain, and headache (13).

1.0 Disc-Related Pathology, Spondylosis, Spinal Stenosis, and Radiculitis

Chronic, persistent neck and upper extremity pain and radicular pain may be secondary to disc herniation, discogenic pain, spondylosis, spinal stenosis, or post cervical surgery syndrome resulting in disc related pain with or without radiculitis.

1.1 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 (1588) can also be the cause. The incidence of cervical disc herniation, however, is less common than lumbar disc herniations (466,1589-1591). 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. The mechanical, chemical, and inflammatory components produce ischemic neuropathy due to the alteration of blood flow patterns or defects in the neuronal transport mechanism of the nerve root itself. Radicular pain may occur in the absence of nerve root compression secondary to nucleus pulposus extrusion or inflammatory reaction to the chemicals.

Okada et al (466) showed progressive degeneration of the cervical spine on MRI in over 81% of patients during a 10-year period, with 34% developing symptoms. 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.

Advances in basic research on disc degeneration have revealed its possible mechanism, including a decrease in proteoglycan contents and water concentration, the involvement of inflammatory cytokines such as interleukin-1 (iL-1) and iTNF-a, and some genetic factors.

1.2 Cervical Radicular Pain

The most common causes of cervical radicular pain and cervical radiculopathy are disc protrusion and cervical spondylosis. Other rare causes include facet joint pathology; vertebral body pathology; meningeal pathology; and pathology from the involvement of blood vessels, nerve sheaths, and nerves (1592). Multiple studies have shown the unique properties of spinal nerves and inflammatory mechanisms, explaining various mechanisms other than mechanical compression and compression affecting dorsal root ganglion (8,1471,1593-1607). In fact, herniated cervical intervertebral discs have been shown to produce metalloproteinases, nitric oxide, interleukin-6, and prostaglandin E2 (1593). These substances are considered to be potential irritants of spinal nerves or inflammation.

1.2.1 Cervical Spondylosis and Radiculopathy

Degenerative changes of the cervical spine reach a prevalence of nearly 95% by age 65. These changes are associated with disc protrusion, neuroforaminal narrowing, and spinal cord contour changes in up to 78% of asymptomatic individuals (1608,1609).

Cervical disc herniation occurs in the younger population with traumatic origin and compresses the nerve roots; whereas, spondylosis is a chronic degenerative condition of the cervical spine associated with

the formation of osteophytes and compression of the spinal cord.

In most symptomatic cases, spondylosis is associated with aging and with compression of the spinal cord, producing either central or neuroforaminal stenosis in patients older than 55 (1610).

Spondylosis refers to degenerative changes of the spine involving the intervertebral discs, uncovertebral joints of Luschka, facet joints, ligaments, and connective tissue of the cervical vertebrae. Degenerative changes of the cervical spine are seen in approximately 10% of individuals by age 25 and in 95% by age 65. The levels most commonly affected by both disc herniation and chronic spondylosis are C6/C7 followed by C5/C6 as these are the cervical segments where the most extension and flexion occurs.

Cervical spondylotic myelopathy refers to clinically evident spinal cord dysfunction with the presence of long-track signs due to compression of the spinal cord. Weakness or stiffness in the legs with unsteady gait, together with weakness or clumsiness in the hands, is pathonomic of cervical spondylotic myelopathy. The progression of weakness may be gradual in some patients or sudden in others following minor trauma. Some patients may complain of hesitancy on urination, even though loss of sphincter control or urinary incontinence is rare and considered a late sign of myelopathy.

1.2.2 Cervical Disc Herniation and Radiculopathy

While the most common cause of cervical radiculopathy in 70% to 75% of cases is foraminal encroachment of the spinal nerve due to a combination of factors, including decreased disc height and degenerative changes of the uncovertebral joints anteriorly and zygapophyseal joints posteriorly, herniation of the nucleus pulposus is responsible for radiculopathy in approximately 20-25% of cases (1611,1612).

Cervical disc herniations occur most often between the C5/6 and C6/7 cervical vertebral bodies (466,1589-1591). Disc herniations can result from degeneration or are precipitated by traumatic incidents such as lifting, etc. As the disc ages, the disc material loses hydration and the annulus weakens, thus increasing the potential for extrusion and herniation. When the disc material protrudes, it is mostly expelled to the lateral side of the spinal canal because of the posterior longitudinal ligament directly compressing the exiting nerve root, which leads to cytokine release and chemical irritation of the nerve tissue.

1.2.3 Cervical Spinal Stenosis

Cervical spinal stenosis is a common disease that results in considerable morbidity and disability (536-538,1613). Degenerative change is the most common cause of cervical stenosis and can be due to disc herniation, osteophyte formation, or a combination of both, namely disc-osteophyte complex (536). Tandem spinal stenosis is a degenerative disease that describes a double stenotic lesion involving the cervical and lumbar spine (539,540). Historically, tandem spinal stenosis accounts for between 5% and 25% of all cases of stenosis (539,540). However, cervical spinal stenosis is less common than lumbar spinal stenosis. With increasing age, a large proportion of the population exhibits radiological signs of discopathy or spondylosis, leading to constriction of the spinal canal (537). Thus, cervical spinal stenosis has been detected in 26% of older asymptomatic individuals (541).

Cervical spinal stenosis may also cause myelopathy which is broadly defined as a symptomatic dysfunction of the cervical spinal cord caused by compressive etiologies (1613-1615). However, cervical myelopathy can occur because of cord compression resulting from one of several physiological factors including spondylolysis/congenital stenosis, disc herniation, ossification of the posterior longitudinal ligament, hypertrophy of the ligamentum flavum, and degenerative subluxation. For the past 4 decades, there have been several attempts to correlate the clinical severity of spinal stenosis with the degree of spinal cord compression on MRI (1616-1624). However, no methodology has been validated. In a recent manuscript, Karpova et al (1613) assessed the reliability of quantitative MRI methods in the assessment of spinal canal stenosis and cord compression in cervical myelopathy. They concluded that the measurements of maximum canal compromise, maximum spinal cord compression, and compression ratio were reliable and correlated well with the clinical severity of cervical myelopathy.

1.2.4 Cervical Post Surgery Syndrome

Cervical post surgery syndrome represents a cluster of symptoms following cervical spine surgery wherein the expectations of the patient and spine surgeon are not met. Animal models of post lumbar laminectomy syndrome demonstrated paraspinal muscle spasms, tail contractures, pain behaviors, tactile allodynia, epidural and perineural scarring, and nerve root adherence to the underlying disc and pedicle (614-616,619,622,625-628,1625-1627). It also has been postulated that there may be a final common pathway with all the described

etiologies, which results in peripheral and central facilitation potentiated by inflammatory and nerve injury mechanisms (614-616,619,622,625-628,1626-1628).

In a recent manuscript, Seichi et al (1628) explored the mechanism of post operative axial neck pain which is a common complication (1629-1631) even though neurological recovery after laminoplasty is excellent (1632-1634). They described that even though multiple factors, including surgical trauma to the posterior cervical muscles and the period of external immobilization, have been suggested as causative factors for the development of pain (1629-1631), the precise mechanism underlying the development of post operative axial pain remains unclear (1630). They described that post operative axial pain is multifactorial in nature with soft tissue injuries, such as those that occur due to intraoperative damage of the posterior extensor musculature, are considered to be a major mechanical factor in the development of post operative axial pain (1635,1636). In addition to muscle damage, nerve tissue injuries sustained during surgery also have been suggested as a causative factor of post operative axial pain (1629,1630).

1.3 Diagnosis of Cervical Discogenic Pathology

An assessment of differential diagnosis is based on a patient's history and an extensive physical examination which includes a neurological examination; motor examination; sensory examination; reflex assessment; application of provocative maneuvers, including Spurling's neck compression test, shoulder abduction test, neck distraction test, Lhermitte sign, Hoffman sign, and Addison's test (1637).

The distinguishing features of cervical radicular pain and somatic referred pain are illustrated in Table 29. While pain secondary to either the disc or facet joints is limited to the neck, upper back, and head associated with referred pain into the upper extremity, discogenic pain may present as radicular pain and facet joint pain may present as pain below the elbow with referred pain patterns. Radicular pain is most likely to travel below the elbow, and somatic referred pain is most often limited to above the elbow, but radicular pain may be restricted to the upper back or shoulder girdle, and somatic pain may radiate below the elbow. Symptoms may be confusing because radicular and somatic pain may coexist. In contrast to the lumbar spine, paresthesia is considered to be more valid than the distribution of pain. The distribution of paresthesia in the hand is also considered more valid than the distribution of paresthesia in the forearm. In addition, paresthesia, with or without pain, occurs in 90% of patients with surgically proven radiculopathy due to disc prolapse (1638). Approximately 45% of patients are unable to vocalize the paresthesia to a distinct region; and they present with diffuse, nondermatomal symptoms. In general, paresthesia affecting the thumb or index finger is attributed to the C6 dermatome; the middle finger, with or without involvement of the index finger, is assigned to the C7 dermatome; and the little finger is assigned to the C8 dermatome (Fig. 7).

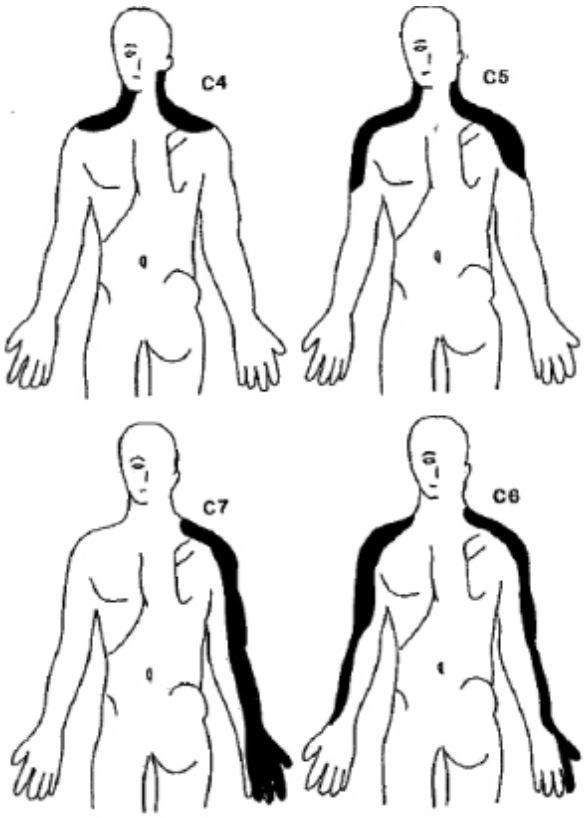
Table 30 shows signs and symptoms of nerve root compression in the cervical region. Overall a patient's history may not be reliable in assessing cervical spine pathology in reference to diagnostic procedures. Rubinstein and van Tulder (401), in a best evidence review, showed that a positive Spurling's, traction/neck distraction, and Valsalva can be used to establish a diagnosis of cervical radiculopathy (1639). The existing literature appears to indicate high specificity, low sensitivity, and good to fair interexaminer reliability for Spurling neck compression test, the neck distraction test, and should abduction (relief test) when performed as described. For Hoffman's sign, the existing literature does not address interexaminer reliability, but appears to indicate fair sensitivity and fair to good specificity (1637). Numbness in the upper limb is a reasonably reliable sign (1640), even though it is not a universal feature in patients with radiculopathy. The prevalence rate of numbness has varied significantly from 24% to 48%, and 60% to as high as 86% (1641). Numbness is most often seen in the C6 and C7 dermatomes, indicating the most frequent involvement of these nerve roots. The predictive validity of numbness was calculated to be 0.7.

Consequently, Wainner and Gill (1642) stated that with regard to cervical radiculopathy, many investigators believe that, "Given the paucity of evidence, the true value of the clinical examination… is unknown at this time."

In reference to imaging, Rubinstein and van Tulder (401), in a best-evidence review of diagnostic procedures for neck and low back pain, concluded that in patients 50 years of age or older, plain spinal radiography together with standard laboratory tests are highly accurate in identifying the underlying systemic disease; however, plain radiography was not a valuable tool for nonspecific neck pain. They also showed that no systematic reviews were identified which examined the diagnostic accuracy of diagnostic imaging in those with neck pain.

Table 29. Distinguishing features of cervical radicular pain and somatic referred pain.

	SOMATIC PAIN	RADICULAR PAIN
CAUSES	Facet joint pain Myofascial syndrome Discogenic pain	Disc herniation Annular tear Spinal stenosis
SYMPTOMS QUALITY	Deep Aching Poorly localized Neck worse than arm No paresthesia Covers a wide area No radicular or shooting pain	Sharp Shooting Well localized Arm worse than neck Paresthesia are very reliable Well defined area Radicular distribution
MODIFICATION	Worse with extension Better with flexion No radicular pattern	Worse with flexion Better with extension Radicular pattern
RADIATION	Neck to head, shoulder blades, upper back, radiation below elbow – unusual, no radicular pain	Follows nerve root distribution, radiation below elbow common, radicular and shooting pain
SIGNS		
Sensory alterations	Uncommon	Probable
Motor changes	Only subjective weakness Atrophy is rare	Objective weakness Atrophy may be present
Reflex changes	None	Commonly expressed but seen occasionally



Source: Bogduk N. *Medical Management of Acute Cervical Radicular Pain: An Evidence-based Approach*, 1st edition. Cambridge Press, Newcastle, 1999 (367).

Fig. 7. ***Maps of the distribution of pain evoked by mechanical stimulation of the C4, C5, C6, and C7 spinal nerves.***

Table 30. *Signs and symptoms of nerve root compression of the cervical region.*

Root Involvement	Location of Lesion	Referred Pain	Motor Dysfunction	Sensory Dysfunction	Reflex Changes
C5	C4/5	Shoulder and upper arm	Shoulder muscles (deltoid-supraspinatus-infraspinatus) ↓ abduction and external rotation	↓Upper and lateral aspect of the shoulder	↓ Biceps reflex
C6	C5/6	Radial aspect of forearm	Biceps and brachialis muscles ↓ flexion of the elbow and supination	Radial aspect of forearm	↓ Thumb reflex and brachioradialis reflex
C7	C6/7	Dorsal aspect of forearm	Triceps muscle ↓ extension of the elbow	↓ Index and middle digits	↓ Triceps reflex
C8	C7/T1	Ulnar aspect of forearm	Intrinsics of the hand ↓ adduction and abduction	↓ Ring and little digits	No change

Thus, plain radiography is not of any significant use in neck pain or radiculopathy. Myelography is an invasive and stressful investigation. However, this can show the deformations produced by intradural, dural, and some extradural lesions of the cervical vertebral canal. However, it does not demonstrate a lesion directly, and it demonstrates those affecting the lateral reaches of the cervical spine nerves poorly, if at all (1643). Conventional CT scan provides axial images, in which the lateral reaches of the intervertebral foramina can be seen. CT myelography is considered to be an accurate and reliable test and has proven to be superior to myelography in the diagnosis of cervical disc protrusions; however, it is an expensive and invasive test. MRI is the choice of imaging in the modern era—replacing myelography, CT scan, and CT myelography. MRI is considered to be as accurate as CT myelography for detecting cervical nerve root compression, even though it may be slightly inferior for detecting bony impingements of nerve roots (1613,1644). As observed with MRI, the prevalence of numerous abnormalities of the cervical spine in asymptomatic individuals is a concern (541,1644,1645).

Neurophysiologic testing with electromyography and nerve conduction studies offer no advantage in radiculopathy. However, they are of significant value in the identification and differentiation of cervical radiculopathy with a peripheral lesion.

The most common causes of cervical nerve root compression are cervical spondylosis, disc degeneration, disc herniation, and spinal stenosis. However, numerous other causes exist. Radiculopathy is a shooting, radiating pain that extends into the hand, or with paresthesia in forearm and hand, accompanied by objective neurologic signs with sensory loss, objective motor weakness, or hyporeflexia. In difficult cases, without radicular symptoms, diagnostic interventions applied include very rarely selective nerve root blocks, associated with high risk, and more commonly, cervical provocation discography. Thus, for these guidelines cervical nerve root blocks have not been assessed.

In the majority of the cases, cervical disc herniation, spinal stenosis, radiculitis, and symptomatic spondylosis are diagnosed by imaging and neurophysiologic testing. However, when there is no correlation between radiologic pathology and clinical assessment, cervical provocation discography and cervical selective nerve root blocks have been recommended (38). However, cervical nerve root blocks or transforaminal epidural injections are associated with inordinate risk (269,1023-1032,1646-1658).

1.3.1 Cervical Provocation Discography

Cervical provocation discography is intended to both identify a painful cervical intervertebral disc and depict internal derangements (1588,1659-1661).

History, physical examination, neurophysiologic assessment, and imaging studies are incapable of identifying a cervical degenerated disc as painful (14,257,372,401,515,681,696,697,700,721,1643-1645,1659-1692). Thus, it appears that cervical provocation discography can diagnose discogenic pain without disc herniation and radiculitis.

The major obstacle confronting 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 (697,700,1588,1659-1662,1693-1695).

Multiple questions have been raised regarding the utility of cervical discography, including reported high

false-positive rates, the lack of standardization; the discrepancies regarding the need for "control levels," pain concordance and pain intensity threshold; and utilization (697,700,1588,1659-1663,1672).

Validity is exemplified by disc stimulation symptom mapping (541,1663) in patients with pain and asymptomatic volunteers. Ohnmeiss et al (1682) 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 (696) demonstrated that discography provides additional information regarding structural changes not available by any other non-invasive 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 (1696) 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 that discography is necessary to identify a painful disc(s).

Multiple systematic reviews assessed cervical discography and arrived at the conclusion that the evidence is limited (38,697,700).

The recent systematic review of cervical discography (38) utilized 3 evaluations meeting inclusion criteria (382,1697,1698). This systematic review also included various outcome studies comparing surgical outcomes.

Our literature search yielded no additional studies.

1.3.1.1 Evidence Assessment

A total of 41 manuscripts were considered for accuracy and the utility of cervical discography in chronic neck pain (38). There were 23 studies evaluating the accuracy of discography. There were 3 studies (382,1697,1698) meeting inclusion criteria for assessing the accuracy and prevalence of discography, with a prevalence of 16% to 40%, with all studies including the same senior author.

Bogduk and Aprill (1697) determined the prevalence of discogenic pain in 56 patients with post-traumatic neck pain that had undergone provocation discography. Utilizing IASP criteria requiring 2 negative control discs, 20% of the patients had positive discograms.

Yin and Bogduk (382) conducted a retrospective study designed to determine the prevalence of different causes of neck pain in a private practice pain clinic. They showed the prevalence of discogenic pain to be 16%. These investigators showed that in those subjects who completed controlled blocks or more than one invasive test, a pathoanatomic diagnosis was obtained in 83% of subjects. The advantages of this study include a comprehensive evaluation for all causes of neck pain and the large number of subjects. The flaws include the retrospective study design and high percentage of patients who did not complete all investigations.

April and Bogduk (1698) evaluated zygapophysial joint pain in 318 consecutive patients with intractable neck pain who underwent provocation discography and cervical zygapophysial joint blocks. The results showed that provocation discography provided unambiguous information and was the sole investigation performed in 152 patients, in 127 of whom a symptomatic disc was found at one or more levels, whereas in 25 patients provocation discography was negative at the levels investigated.

1.3.1.2 Prevalence

Based on IASP criteria (1659) and the systematic review (38), the data show a prevalence rate ranging between 16% and 40% (382,1697,1698) (Table 31).

1.3.1.3 False-Positive Rates

Overall, false-positive results with cervical provocation discography are a serious concern, with cited prevalence rates exceeding 50%. Schellhas et al (1663) found that the numerical rating pain score produced by

Table 31. *Cervical provocation discography utilizing IASP criteria.*

Study	Methodological Criteria	Number of Subjects	Prevalence Estimates
Bogduk &Aprill, 1993 (1697)	7/9	56	20%
Yin & Bogduk, 2008 (382)	7/9	88	16%
Aprill & Bogduk, 1992 (1698)	7/9	318	40%

Adapted and Modified from: Onyewu O, et al. An update of the appraisal of the accuracy and utility of cervical discography in chronic neck pain. *Pain Physician* 2012; 15:E777-E806 (38).

discography in asymptomatic subjects was significantly lower ($P \leq 0.0001$) than in patients with neck pain. Schellhas et al (1663) 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.

1.3.1.4 Analysis of Evidence

Based on the review of the present evidence, the diagnostic accuracy of cervical discography is limited.

1.3.1.5 Complications

The most recognized complication of any discography procedure is bacterial discitis, with a reported incidence that is typically less than 1% (1699-1704). The most common microbe in discitis is Staphylococcus epidermidis, but streptococcus and Escherichia coli are also frequently implicated. Escherichia coli can be inoculated from the hypopharynx (1705).

Further complications include a vasovagal response, a hematoma that can include neural compromise within the spinal canal, an allergic drug reaction, headache, herniated cervical disc, quadriplegia, pneumothorax with lower cervical disc injections, thecal sac puncture, and arachnoiditis along with complications (868,887,888,932,944,1699,1700,1706-1710).

1.3.1.6 Recommendations

Based on the systematic review (38), IASP criteria (1659), ISIS criteria (1711), and ASIPP criteria (1471), cervical discography is indicated only when a treatment is available 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.

1.4 Therapeutic Interventions

Various treatment methods include conservative management with drug therapy or non-interventional modalities, interventional pain management, and surgical management.

Surgery is considered for patients with intractable symptoms and signs of cervical radiculopathy. However, no current data exist regarding the proper timing for surgery. Surgery indications differ, based on whether a patient exhibits only radiculopathy or whether spinal cord impairment is also present (1712-1722).

Among the conservative modalities of treatment, education, exercise, traction, manipulation, medications, physical therapy modalities, bracing, psychological counseling, and cognitive behavior therapies have been utilized (515,1709,1723-1737).

Interventional pain management techniques include cervical epidural injections (9,765,1738-1763).

1.4.1 Cervical Epidural Injections

Cervical epidural injections have been used to treat radicular pain from herniated discs, spinal stenosis, chemical discs, chronic neck pain with or without radiculitis secondary to post cervical surgery syndrome, and chronic neck pain of discogenic origin. Epidural injections in the cervical spine are performed either by interlaminar or transforaminal approaches. Cervical epidural steroid injections, specifically utilizing the transforaminal approach, have been associated with devasting complications (269,1023-1032,1646-1658,1738). However, significant complications also have been reported with interlaminar epidurals with spinal cord damage and quadriparesis (1023,1738-1740). Complications of fluoroscopically guided interlaminar cervical epidural injections have been reported to be much less frequent and major complications are rare (899,1413,1741-1759).

There have been 3 systematic reviews (9,765,1759), multiple guidelines (8), a Cochrane review of medicinal and injection therapies for mechanical neck disorders (1760), and a document reassessing the evidence of the ACOEM guidelines (217) that included analysis of cervical epidural injections. However, the evidence for cervical interlaminar epidural injections has been a subject of debate and at best has had only moderate success in managing cervical radiculopathy, while there was no evidence available in the management of axial or discogenic neck pain, spinal stenosis, or post surgery syndrome at the time of these evaluations.

Diwan et al (9) in recent systematic review with literature included through December 2011 assessed the evidence with inclusion of 7 randomized trials (251,254,801,802,1761-1763) showing good evidence for cervical disc herniation, and fair evidence for axial or discogenic pain, spinal stenosis, and post cervical surgery syndrome. Our literature search identified 9 new studies (907,1764-1771) published since the systematic review (9).

1.4.1.1 Disc Herniation and Radiculitis

There were a total of 4 studies meeting the inclusion criteria evaluating cervical interlaminar epidural injections in managing disc herniation or radiculitis (252,802,1761-1763) with 2 duplicate publications (252,802). None of the newly identified studies met

inclusion criteria. Table 7 of the systematic review (9) shows characteristics of the included trials. There was only one high quality randomized trial performed with an active control design under fluoroscopic evaluation (252,802). Two of the other 3 studies were performed blindly (1761,1762), with one being described as a placebo control design even though the control group received steroids (1761). The second study utilized morphine as an additive to the solution (1762). Finally, the last study (1763) compared continuous versus single epidural injections providing up to approximately 8 injections in the single group and assessed only 6 month pain relief. The quality of these 3 studies performed without fluoroscopy was moderate.

Among all the randomized trials, only one study utilized 120 participants with 60 patients in each group, either with local anesthetic or local anesthetic with steroids.

Of the 4 randomized trials meeting the inclusion criteria evaluating cervical interlaminar epidural injections, all of them showed positive results for the long-term; however, the results were strong in only one study (252,802).

1.4.1.2 Axial or Discogenic Pain

There was only one randomized controlled trial evaluating axial discogenic pain and the role of cervical interlaminar epidural injections, in patients without disc herniation, radiculitis, or facet joint arthropathy (251,801). This trial showed positive results with pain and function. This was a large study performed in a contemporary IPM practice setting utilizing an active control design with 60 patients in each group and appropriate outcome parameters.

1.4.1.3 Spinal Stenosis

There was only one randomized trial meeting the inclusion criteria in the evaluation of central spinal stenosis in the cervical spine (253). This trial was of an active control design and a preliminary report, but showed positive results.

1.4.1.4 Post Surgery Syndrome

There was only one randomized trial evaluating the effectiveness of cervical interlaminar epidural injections with or without steroids in post surgery syndrome with an active control design, but with preliminary results (254). The results were positive at 3, 6, and 12 months both for pain and functional status with or without steroids.

1.4.2 Analysis of Evidence

Based on the USPSTF criteria, the evidence is considered at 3 levels – good, fair, and limited.

1.4.2.1 Cervical Disc Herniation

For cervical disc herniation with radiculitis, based on one large fluoroscopically directed active control study with local anesthetic with or without steroids (252,802), in conjunction with 3 smaller randomized trials with positive results (1761-1763), the evidence is good.

Cervical epidural with local anesthetic only is supported by one randomized, fluoroscopically directed trial with 120 patients (252,802), showing positive results. However, as there was only one study, the evidence is considered as fair.

1.4.2.2 Axial or Discogenic Pain

There was only one study evaluating the results of cervical discogenic or axial pain (251,801), which showed positive results in 120 patients. The level of evidence, therefore, is fair.

1.4.2.3 Spinal Stenosis

There was only one study evaluating the results of spinal stenosis (253), which showed positive results in 60 patients. The level of evidence, therefore, is fair.

1.4.2.4 Post Surgery Syndrome

There was only one study evaluating the results of post surgery syndrome (254), which showed positive results in 56 patients, thus, the level of evidence is fair.

1.4.3 Summary of Evidence

In summary, the evidence is good for radiculitis secondary to disc herniation with local anesthetics and steroids, fair with local anesthetic only; whereas, it is fair for local anesthetics with or without steroids for axial or discogenic pain, pain of central spinal stenosis, and pain of post surgery syndrome (Table 32).

1.4.4 Complications

While serious complications of cervical interlaminar epidural procedures are rarely seen, they include spinal cord trauma, spinal cord or epidural hematoma formation, nerve injury, subdural or subarachnoid injection, intravascular entry either venous or arterial, vascular injury or vascular embolism, and injection leading to abscess (282,765,885-888,893,899,932-944,947-951,954-956,959,960,962-964,1023,1082,1738-1759,1764-1789). Multiple minor side effects include increase in neck

Table 32. *Results of randomized trials of effectiveness of cervical interlaminar epidural injections.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment(s)
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-term		
								> 6 mos.	≥ 12 mos.	
DISC HERNIATION AND RADICULITIS										
Manchikanti et al, 2012, 2010 (252,802) RA, AC, F 11/12	120 local anesthetic = 60 Local anesthetic with steroids = 60	Local anesthetic or with Celestone Number of injections = 1 to 4	Significant improvement > 50% pain relief and > 50% functional status improvement	83% vs. 70%	82% vs. 73%	72% vs. 68%	P	P	P	Positive results in a randomized large trial performed under fluoroscopy with long-term follow-up
Castagnera et al, 1994 (1762) RA, AC, B 7/12	24	Local anesthetic with steroid or steroid plus morphine Number of injections = 1	Pain relief, VAS, work status	79.2%	79.2%	79.2%	P	P = steroids N = local anesthetics	P	A small randomized trial performed blindly with positive results.
Stav et al, 1993 (1761) RA, AC, B 7/12	42	Local anesthetic with steroid or IM steroid Number of injections = 1 to 3	Pain relief, change in range of motion, reduction of daily dose of analgesics, return to work.	NA	NA	68% vs.11.8%	NA	NA	P	A small randomized trial performed without fluoroscopy with positive results.
Pasqualucci et al, 2007 (1763) RA, AC, B 7/12	40 of 160	Bupivacaine with methylprednisolone acetate	Pain control of greater than 80%, pain-free hours of sleep	NA	Single vs. continuous 58.5%, 73.7% improvement	NA	NA	P	NA	A small randomized controlled trial with an extremely complicated design performed without fluoroscopy with positive results.
DISCOGENIC PAIN										
Manchikanti et al, 2012, 2010 (251,801) RA, AC, F 10/12	120	Local anesthetic or with Celestone	Significant improvement > 50% pain relief and > 50% functional status improvement	68% vs. 77%	67% vs. 73%	72% vs. 68%	P	P	P	A large randomized controlled trial performed under fluoroscopy with positive results.
SPINAL STENOSIS										
Manchikanti et al, 2012 (253) RA, AC, F 10/12	60	Local anesthetic or with Celestone	Significant improvement > 50% pain relief and > 50% functional status improvement	77% vs. 87%	87% vs. 80%	73% vs. 70%	P	P	P	Preliminary results of a large randomized trial performed under fluoroscopy with positive results.

Table 32 (cont.). *Results of randomized trials of effectiveness of cervical interlaminar epidural injections.*

Study Study Characteristics Methodological Quality Scoring	Participants	Interventions	Outcome Measures	Pain Relief and Function			Results			Comment(s)
				3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.	Long-term		
								> 6 mos.	≥ 12 mos.	
POST SURGERY SYNDROME										
Manchikanti et al, 2012 (254) RA, AC, F 10/12	56	Local anesthetic or with Celestone	Significant improvement > 50% pain relief and > 50% functional status improvement	68% vs. 68%	64% vs. 71%	71% vs. 64%	P	P	P	Preliminary results of large randomized controlled trial performed under fluoroscopy with positive results.

RA = Randomized; AC = Active-Control; F = Fluoroscopy; B = Blind; P = Positive; N = Negative; NA = Not Applicable
Adapted and modified from: Diwan SA, et al. Effectiveness of cervical epidural injections in the management of chronic neck and upper extremity pain. *Pain Physician* 2012; 15:E405-E434 (9).

pain, vasovagal reactions, headache, insomnia, increase in temperature, and dural puncture.

Manchikanti et al (899) evaluated the complications and side effects of epidural injections. Of these, 2,376 were performed in the cervical region with an interlaminar approach. The results illustrated intravascular entry in 4.2%, return of blood in 1.2%, profuse bleeding in 0.7%, bruising in 0.3%, vasovagal reaction in 0.04%, transient nerve root irritation in 0.25%, transient spinal cord irritation in 0.21%, dural puncture in 1%, postlumbar puncture headache in 0.08%, and facial flushing in 0.08%.

A cervical spinal cord injection of epidural corticosteroids is a devastating complication. In a comprehensive longitudinal study including multiparametric MRI (1765), the authors identified multiple cases of cervical spinal cord injection after an interlaminar approach to cervical epidural steroid injection. In this case report, the authors presented a case of intramedullary injection during the interlaminar epidural steroid injection procedure. They highlighted the fact that various factors impede the investigation and publication of serious adverse events. They also developed new imaging MRI techniques for spinal cord white matter quantification and used the best available physiological tests to characterize a cervical spinal cord lesion caused by an inadvertent intramedullary injection of Depo-Medrol. In this case report, the patient, after a second interlaminar epidural injection at the C5-6 interspace, developed left hemiparesis and bilateral hyperreflexia. The authors described how defusion tension imaging and magnetization transfer may better distinguish between posttraumatic demyelination and axonal degeneration than conventional MRI.

1.4.5 Recommendations

Based on the present review for guidelines, there is good evidence for disc herniation and fair evidence for axial or discogenic pain, central spinal stenosis, and post cervical surgery syndrome. Cervical interlaminar epidural injections are indicated for these conditions with appropriate indications.

2.0 Cervical Facet Joint Pain

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 (1790-1795). Cervical facet joints are well innervated by the medial branches of the dorsal rami (1286,1628,1690,1790,1796-1800) with free and encapsulated nerve endings with nociceptors and mechanoreceptors (464,1286,1796,1799-1814). Anatomical, biomechanical, and physiological bases have been described for facet joint pain (1286,1815-1822).

Kras et al (1286) noted that evidence is mounting in favor of mechanical injury as being the initiating factor in cervical facet joint pain (299,1812,1823-1829). Both mechanical injury and inflammation of the facet joint have been shown to produce persistent pain in otherwise normal rats (1274-1276). In addition, mechanical injury of the facet joint increases cytokines messenger RNA in the dorsal root ganglion (1275) and intraarticular injection of an NSAID agent alleviates injury-induced pain in the same model (1277), suggesting that inflammation has a role in the pain response after a mechanical joint insult. It has also been shown that painful cervical facet joint distraction induces an immediate and sustained increase of prostaglandin E2 (PGE2) receptor EP2 expression in the dorsal root ganglion, implicating peripheral inflammation in the initiation and maintenance of facet joint pain (1286). Inflammatory mediators such as cytokines, prostaglandins, and neuropeptides have been shown to increase within the joint and dorsal root ganglion in joint inflammation and arthritis (1276,1278-1281). In particular, prostaglandin E2 (PGE2) has been identified as a key mediator of inflammation-induced behavioral sensitivity and increased neuronal excitability (1286,1282-1285).

Dong et al (1274) showed that neuronal stress activation is associated with painful facet injury, and that joint loading may directly mediate the behavior of the dorsal root ganglia (DRG) neurons in this class of injury. In vivo studies demonstrate that certain facet joint distractions initiate persistent firing of nociceptive afferents in the facet capsule (1814), and induce persistent mechanical allodynia and spinal glial activation (1806,1807,1812). Quinn et al (1811) showed that the frequency of neuronal firing increased in rats with neck pain compared to the non-painful and sham groups, as did the incidence and frequency of spontaneous and after discharge firing. They also showed that the proportion of cells in the deep laminae that responded as wide dynamic range neurons also increased in the painful group relative to non-painful or sham groups. They concluded that these findings suggest that excessive facet capsule stretch, while not producing visible tearing, can produce functional plasticity of dorsal horn neuronal activity. The increase in neuronal firing across a range of stimulus magnitude after injury provides the first direct evidence of neuronal modulation in the spinal cord following facet joint loading, and suggests that facet joint chronic pain following whiplash injury is driven, at least in part, by central sensitization.

Chua et al (1810) also showed that there were differences in sensory processing between chronic cervical zygapophysial joint pain patients with and without cervicogenic headache. They showed that the main difference between patients with or without cervicogenic headache was the lateralization of pressure hyperalgesia to the painful side of the head of the headache patients, accompanied by cold as well as warm relative hyperesthesia on the painful side of the head and neck. They concluded that these results suggested that neuraxial spread of central sensitization was probably linked to the trigeminal spinal nucleus.

There is continuing discussion on the role of facet joint degeneration in chronic neck pain as a rationale for treatment. The morphology of lumbar facet joint degeneration showed that the pathological changes attributed to facet joint degeneration were articular cartilage thinning, sclerosis of the subchondral bone, osteophyte formation, and hypertrophy (464). Kettler et al (464), after evaluating the morphological changes of cervical facet joints in the elderly concluded that the prevalence of cervical facet joint degeneration is probably very high in individuals aged 50 years and more, with a tendency to increase in severity with age. All levels of the middle and lower cervical spines were affected to almost the same degree, whereas in the lumbar spine, an increase in degeneration towards the lower levels was reported. In most cases, the cartilage in the cervical spine was evenly degenerated all over the joint surface while in the lumbar spine, certain regions were reported to be affected predominantly. In this study, only specimens of facet joints from 59 to 92 aged persons were evaluated.

Furthermore, following spinal trauma, pathological lesions may be produced in the facet joints and/or accentuate already existing pathology. Hypertrophic changes of facet joints in the cervical spine also have been described. Morishita et al (1830) examined the image and clinical characteristics of patients with cervical facet hypertrophy and the significance of such characteristics and concluded that the hypertrophic change of a facet joint occurred at the mid-level of the cervical spine, usually unilaterally, was more frequent in males, and was associated with neck pain. In another study (1831), it was illustrated that stretching the facet joint capsule beyond physiological range could result in an altered axonal morphology that may be related to secondary or delayed axotomy changes similar to those seen in central nervous system injuries where axons are subjected to stretching and shearing. It was concluded that these changes may contribute to neuropathic pain and are

potentially related to neck pain after whiplash events.

Whiplash may also cause increased laxity of the cervical capsular ligament (1832). One interpretation is that capsular ligament injuries, in the form of increased laxity, may be one component perpetuating chronic pain and clinical instability in whiplash patients. In fact, Bogduk (1833) in describing the biological features of whiplash injury from motor vehicle accidents showed that a spectrum of injuries could occur in the zygapophysial joints based on the results of postmortem studies. He concluded that the fact that multiple lines of evidence, using independent techniques, consistently implicate the cervical zygapophysial joints as a site of injury and source of pain, strongly suggesting that injury to these joints is a common basis for chronic neck pain after whiplash. Curatolo et al (1834) also discussed the role of tissue damage in whiplash-associated disorders. Their results demonstrated that numerous investigations conducted in animals, cadavers, healthy volunteers, and patients have documented lesions of various tissues. Furthermore, most lesions are undetected by imaging techniques. However, for zygapophysial (facet) joints, lesions have been predicted by bioengineering studies and validated through animal studies; for zygapophysial joint pain, a valid diagnostic test and a proven treatment are available. The influence of lower cervical joint pain on a range of motion also has been described (1835). Hall et al (1835) showed that the average range of unilateral rotation to the limited side during a flexion-rotation test (FRT) was significantly reduced in patients with lower cervical facet joint pain.

The differences have been demonstrated in pressure and thermal pain hypersensitivity between patients with acute and chronic neck pain and healthy subjects (1836). Widespread decreased pressure pain thresholds in patients with chronic but not acute, mechanical neck pain as compared with controls were identified. Furthermore, as compared with patients with acute neck pain and controls, patients with chronic neck pain also showed cold pain hypersensitivity (1836). Javanshir et al (1836) concluded that the results supported the existence of different sensitization mechanisms between patients with acute and chronic mechanical insidious neck pain. However, neck muscle strength and its relationship to neck pain have not been widely studied.

2.1 Diagnosis of Cervical Facet Joint Pain

The diagnosis of facet joint pain may not be made based on a radiologic evaluation or clinical assessment with certainty (405-407). There is little information on the validity or utility of a self-reported history in evaluating neck pain disorders (405-409). While routine clinical physical examination is more effective in ruling out cervical radiculopathy than confirming its presence, its usefulness in non-radicular disorders or facet joint pain is debatable. Local tenderness is not diagnostic of zygapophysial joint pain in the cervical spine (410). A manual examination of the cervical spine is not a valid means of diagnosing cervical zygapophysial joint pain (408). There is, however, some evidence that some features of inspection, range of motion, strength, palpation, and provocation tests, can be useful. Range of motion has been described to be moderately reliable, as it does not seem to matter whether it is assessed by the clinician (assessing active or passive range of motion with or without a device) or self-described by the patient (405,408-414,1678,1837-1839). There is also some evidence that chronic whiplash-associated disorder patients and subjects with neck pain and myalgia have less mobility in the cervical spine compared with controls (1840). Patients with chronic neck pain also may have slightly lower neck muscle strength compared with controls (412). Even then, a role for physiotherapists has been suggested in the screening of patients suitable for diagnostic cervical facet joint blocks (1841). Schneider et al (1841) showed that utilizing clinical prediction guides may allow practitioners to use the results of a patient's history, self-report measures, and physical examination toward optimal diagnostic and therapeutic decisions, namely, selecting the patient for cervical diagnostic facet joint blocks.

There is no evidence that common degenerative changes on a cervical MRI are strongly correlated with neck pain symptoms (405). The evidence illustrates that common degenerative changes are highly prevalent in asymptomatic subjects and are also prevalent with increasing age (425,466,538,1579,1582,1608,1645,1842-1850). Moreover, there is no evidence that common degenerative changes on cervical MRI are associated with pain in patients with suspected cervicogenic headache (405,1851). Multiple evaluations have been shown to be non-diagnostic for facet joint pain (466,1846-1850). The utilization of an MRI to evaluate patients with acute unilateral neck pain and restricted motion (1846) showed no synovial effusion or inflammation around the joints of the cervical spine.

Single photon emission computerized tomography scan (SPECT) was shown to have increased uptake into the facet joints in only 43% of patients (1289). While there is ample literature addressing low back pain,

there is no significant literature for the cervical spine for the diagnosis of facet joint pain by SPECT (441,1291, 1307,1312,1316,1852).

Self assessment questionnaires, however, may have utility in routine clinical practice and research by categorizing patients' clinical presentation, subjective functional impact of neck pain, and force over time (405). However, there is no evidence that a self-assessment questionnaire alone can accurately diagnose a structural cause of illness in patients with neck pain. There is evidence that generic questionnaires may be more useful than neck specific questionnaires for comparing individuals with neck pain with other disease groups (413,414,1837,1853-1856). In one study, however, it was shown that in patients with neck pain the use of a self-assessment questionnaire to monitor health care utilization showed poor recollection, rendering it unreliable as a source (408).

Thus, multiple evaluations may be the basis for a suspicion of, but not diagnosis of, cervical facet joint pain. Consequently, diagnostic cervical facet joint nerve blocks have been described as a rational step in the diagnosis of cervical facet joint pain (13).

2.1.1 Diagnostic Cervical Facet Joint Nerve Blocks

Falco et al, in a systematic review (13), showed good evidence for the diagnostic accuracy of cervical facet joint blocks. In addition, Rubinstein and van Tulder (401) in a best-evidence review of diagnostic procedures for neck and low back pain concluded that there was strong evidence for the diagnostic accuracy of facet joint blocks in the diagnosis of neck pain. Although the diagnosis has been well established, significant debate surrounds the various treatments utilized in the management of chronic neck pain arising from cervical facet joints (8,257,321,323,401,1381,1732,1857-1863).

Diagnostic blocks of a cervical facet or zygapophysial joint can be performed by anesthetizing the joint or 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 obtained by performing controlled blocks, either in the form of placebo injections of normal saline or comparative local anesthetic blocks.

The rationale for using cervical facet joint blocks for diagnosis is based on the fact that facet joints are capable of causing pain and that they have a nerve supply (1255,1628,1790,1796,1797,1800,1814). Using diagnostic techniques of known reliability and validity, facet joints have shown to be a source of pain in patients (382,1345-1347,1352,1353). Conventional clinical and radiologic techniques are unreliable in diagnosing cervical facet or zygapophysial joint pain (1471,1857).

The value, validity, and clinical effectiveness of cervical diagnostic facet joint nerve blocks were also confirmed through the application of therapeutic modalities based on the diagnosis of facet joint pain with controlled comparative local anesthetic blocks (765,804, 1325,1364,1366,1857,1858,1864,1865).

Controlled diagnostic blocks of cervical facet joints with 2 local anesthetics (or placebo-controlled) are the primary 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 (1800). The construct validity of cervical facet joint blocks is important in eliminating placebo effect as the source of confounding results and to secure true-positive results (382,1345-1347,1471,1857,1866-1871). Potential and real confounding factors were assessed in several studies. Influence of age, surgery, psychopathology, and prior opioid exposure were evaluated in 3 reports and found not to have significant impact on the prevalence of cervical facet joint related chronic neck pain (1352,1353,1358,1868,1872).

Our literature search yielded no additional studies in relation to diagnostic cervical facet joint injections.

2.1.1.1 Evidence Assessment

A total of 26 manuscripts for diagnostic accuracy evaluation and 9 manuscripts for studies evaluating various factors influencing the diagnostic validity of facet joint diagnostic interventions concluded that diagnostic cervical facet joint nerve blocks are safe, valid, and reliable with good evidence with utilization of controlled diagnostic blocks with at least 75% pain relief as the criterion standard with dual blocks (382,1345-1347,1697,1698,1866,1867,1869,1870,1871,1873,1874).

There were 3 randomized trials (1869,1871,1874) and 2 placebo-controlled studies of diagnostic accuracy (1869,1871). There was one study in the single block group using 50% to 74% relief as the cutoff threshold (1874). Two studies met inclusion that utilized a single block with a cutoff threshold > 75% pain relief (1698,1707). There were no studies with a cutoff between 50% and 74% pain relief that employed controlled diagnostic blocks as the criterion standard.

There were 9 studies (382,1345-1347, 1866,1867,1869-1871) using controlled diagnostic

blocks with a criterion standard ranging between 75% and 100% relief. In this evaluation, 4 studies utilized ≥ 90% pain relief (1867,1869-1871), whereas 5 studies utilized 75% or greater relief as criterion standard (382,1345-1347,1866). Inclusion criteria were different. Thus, there was homogeneity only among the 4 studies (1345-1347,1866). Consequently, there was no meta-analysis performed.

The evidence was synthesized based on the relief criteria when cervical facet joint injections were performed. Table 33 illustrates the results of diagnostic studies.

Table 4 of the systematic review (13) illustrates characteristics of the diagnostic accuracy studies considered for inclusion (382,1345-1347,1697,1698,1866,1867,1869-1872). Of these, one study (206) utilized 50% to 74% relief as the criterion standard or cutoff threshold for a positive block, whereas 2 studies utilized 75% to 100% pain relief as the criterion standard with a single block (1697,1698). There were no studies evaluating with controlled diagnostic blocks with 50% relief as the criterion standard. There were 9 studies utilizing controlled diagnostic blocks with a 75% cutoff threshold (382,1345-1347,1866,1867,1869-1871).

Table 5 of the systematic review (13) illustrates the study characteristics of published reports of cervical facet joint blocks evaluating the influence of various factors on diagnostic accuracy (1352-1354,1358,1868,1873-1875).

There was only one study evaluating the role of cervical facet joint nerve blocks with ≥ 50% relief with a single block as the criterion standard (1874). This was not designed to be a prevalence study; however, it showed a prevalence of 25% in patients with 0.5 mL of bupivacaine administered and 55% in patients administered with 0.25 mL of bupivacaine.

There were 2 studies meeting the inclusion criteria evaluating cervical facet joint pain using a cutoff threshold between 75% and 100% relief following a single block, by the same authors (1697,1698). They evaluated neck pain in combination with discography and diagnostic cervical medial branch blocks in patients sustaining chronic neck pain after a motor vehicle injury. The prevalence in this group was 64% in one study (1697) and definitively 23% and probably 64% in the other study.

There were a total of 9 studies meeting the inclusion criteria with 75% to 100% pain relief with controlled diagnostic blocks (382,1345-1347,1866,1867,1869-1871). One study evaluated only false-positive rates (1871). Among the 8 studies assessing prevalence (382,1345-1347,1866,1867,1869,1870), all of them utilized 80% or more relief as the criterion standard except for one study (1866) that utilized ≥ 75% as the criterion standard. The prevalence of facet joint pain in these studies varied from 39% to 60% in heterogenous population.

2.1.1.2 Prevalence of Cervical Facet Joint Pain

The current evidence shows the prevalence utilizing criteria of 75% to 100% pain relief to range from 36% to 67% (Table 33).

2.1.1.3 Influence of Various Factors on Diagnosis

Eight studies were available to evaluate the multiple factors affecting the diagnosis of cervical facet joint pain (1352-1354,1358,1868,1873-1875). Among these, one study evaluated the age-related prevalence of cervical facet joint pain (1352), 2 studies evaluated the influence of psychological factors (1353,1354), one study evaluated the diagnostic volume (1874), 2 studies evaluated the role of sedation (1358,1873), and one study evaluated the role of opioid usage on the validity of diagnostic facet joint nerve blocks (1875).

2.1.1.4 False-Positive Rates

Based on the systematic review by Falco et al (13), false-positive rates utilizing 75% to 100% relief as the criterion standard with single blocks ranged from 27% to 63% (Table 33).

2.1.1.5 Analysis of Evidence

Based on the USPSTF criteria, the evidence was classified as good, fair, and limited or poor.

The evidence is limited based on one study with a single block with 50% to 74% pain relief as the criterion standard (1874).

The evidence for a single block with 75% to 100% relief as the criterion standard is limited based on the results of 2 studies from the same group of authors (1697,1698).

No studies were available in the category of dual blocks with 50% to 74% relief.

The evidence for controlled diagnostic blocks with 75% to 100% relief as the criterion standard is good based on 9 high-quality studies (382,1345-1347,1866,1867,1869-1871) in a heterogeneous group of neck pain patients.

2.1.2 Summary of Evidence

Overall, when 75% or greater relief is utilized as

Table 33. *Data of prevalence and false-positive rates of pain of cervical facet joint origin based on diagnostic blocks.*

Study	% Relief Used	Methodological Criteria Score	Number of Subjects	Prevalence Estimates with 95% Confidence Intervals	False-Positive Rates with 95% Confidence Intervals
50% - 74% with Single Block					
Cohen et al, 2010 (1874)	> 50%	5/12	24	55% with low volume and 25% with high volume	NA
75% - 100% with Single Block					
Aprill & Bogduk, 1992 (1698)	≥ 90%	6/12	318	25%-63%	NA
Bogduk & Aprill, 1993 (1697)	≥ 90%	6/12	56	41%-64%	NA
75% - 100% with Controlled Blocks					
Yin and Bogduk, 2008 (382)	> 80%	9/12	143	55%* (95% CI; 38%, 62%)	NA
Manchukonda et al, 2007 (1347)	> 80%	9/12	251 of 500	39% (95% CI; 32%, 45%)	45% (95% CI 37%, 52%)
Manchikanti et al, 2004 (1346)	> 80%	9/12	255 of 500	55% (95% CI; 49%, 61%)	63% (95% CI 54%, 72%)
Manchikanti et al, 2002 (1345)	> 80%	9/12	120	67% (95% CI; 58%, 75%)	63% (95% CI 48% , 78%)
Manchikanti et al, 2002 (1866)	> 75%	9/12	106	60% (95% CI; 50%, 70%)	40% (95% CI, 34%, 46%)
Speldewinde et al, 2001 (1867)	> 90%	9/12	97	36% (95% CI; 27%, 45%)	NA
Barnsley et al, 1995 (1870)	> 90%	9/12	50	54% (95% CI; 40%, 68%)	NA
Lord et al, 1996 (1869)	> 90%	9/12	68	60% (95% CI; 46%, 73%)	NA
Barnsley et al, 1993 (1871)	> 90%	9/12	55	NA	27% (95% CI, 15%, 38%)

NA = Not Available or Not Applicable; CI = Confidence Interval; * = Adjusted
Adapted and Modified from: Falco FJE, et al. An updated review of diagnostic utility of cervical facet joint injections. *Pain Physician* 2012; 15:E807-E838 (13).

the criterion standard with controlled blocks, the evidence is good based on multiple high quality studies of diagnostic accuracy incorporating prevalence with or without false-positive rates. The evidence is limited or not available in all other categories.

2.1.3 Recommendations

Diagnostic cervical facet joint nerve blocks are recommended in patients with somatic or non-radicular neck pain or headache and upper extremity pain, with duration of pain of at least 3 months, without preponderance of evidence of discogenic pain, disc herniation, or evidence of radiculitis.

2.2 Therapeutic Cervical Facet Joint Interventions

Cervical facet joint pain may be managed conservatively; however, once the conservative management fails appropriate diagnosis with controlled diagnostic blocks is essential. Following this the treatment may be achieved with therapeutic cervical facet joint interventions. The treatment is provided with intraarticular cervical facet joint injections, therapeutic cervical medial branch blocks, or radiofrequency neurotomy.

Significant controversy surrounds various treatments utilized in the management of chronic neck pain arising from cervical facet joints (8,14,116,118,129,161-175,217,321-323,1364). The evidence illustrated that the long-term therapeutic benefits of intraarticular injection of facet joints was limited (14,1364,1732). Cervical facet joint interventions for managing chronic neck pain are one of the most commonly performed interventions in the United States (162,165,167-169,171,1876). With exploding medical costs and utilization, and repeated

questions about the effectiveness of cervical facet joint interventions, it is essential to update the evidence periodically utilizing appropriate methodology (331). Thus, this systematic review was undertaken to evaluate and update the effectiveness of therapeutic cervical facet joint interventions (14).

Falco et al (14) in a systematic review of therapeutic cervical facet joint interventions with strict criteria and literature search extending through June 2012 identified 4 randomized trials (257,804,1732,1858,1877,1878) and 6 observational studies (1381,1864,1879-1882) which met the inclusion criteria for evidence synthesis. Based on one randomized, sham-controlled, double-blind trial and 5 observational studies, the indicated evidence for cervical radiofrequency neurotomy is fair. Based on one randomized, double-blind trial, active-controlled trial and one prospective evaluation, the indicated evidence for cervical medial branch blocks is also fair. Based on 2 RCTs, the evidence for cervical intraarticular injections is limited. There were no additional studies identified since June 2012 with further literature search.

2.2.1 Radiofrequency Neurotomy

Radiofrequency lesioning is performed utilizing either a heat lesion or pulsed mode radiofrequency. A thermal radiofrequency neurotomy lesion for medial branch denervation is performed at 80° to 85° C. Clinically, a higher temperature allows for a larger lesion to be made. The size of the lesion is influenced by the vascularity of the surrounding tissue, with the greater the vascularity of the tissue, the smaller the lesion being produced. Due to the mechanism of radiofrequency neurotomy, which is described as denaturing of the nerves, the pain returns when the axons regenerate requiring repetition of the radiofrequency lesioning. In contrast, the pulsed mode radiofrequency is an application of a strong electric field to the tissue that surrounds the electrode. The temperature of the tissue surrounding the tip of the electrode does not exceed 42° C and heat is dissipated during the silent period. Our literature search yielded no additional studies.

2.2.1.1 Evidence Assessment

One randomized trial (1858) and 5 observational studies (1381,1879-1882) were included in assessing the effectiveness of radiofrequency neurotomy. The randomized trial pertains to Lord et al's (1858) percutaneous radiofrequency neurotomy study published in 1996. This randomized, double-blind clinical trial included 24 patients comparing percutaneous radiofrequency neurotomy to a sham treatment wherein the procedural technique was the same but radiofrequency was not applied in the control group. Patients with cervical spinal pain from automobile accidents were included in the study after comparative diagnostic blocks identified those with cervical facet joint derived neck pain. At 3 months all patients were formally interviewed by completing the visual analogue scale and the McGill Pain Questionnaire (MPQ). At 27 weeks, one patient in the control group and 7 in the active treatment group remained free of pain. The median time for return of pain to at least 50% of the preoperative level was 263 days in the active group and 8 days in the placebo group. This study found that radiofrequency neurotomy could provide pain relief for a moderate proportion of patients lasting from months to over a year.

This is a meticulously performed study on a small number of patients; however, the technique is not commonly utilized in the United States. Carragee et al (515) criticized the differences in baseline characteristics of patients between both groups and the nature of the blinding. Carragee et al (515) reported that blinding was in doubt, as 42% of the active group developed long-term anesthetic or dysesthetic areas of skin and none of the patients in the control group developed changes. They stated that these changes revealed the treatment assigned in nearly half of the active treatment group. With regards to the baseline characteristics the results showed no significant differences based on these differences and based on litigation. The results showed that 58% of patients in the control group and 25% in the active-treatment group had a return of their accustomed pain in the period immediately after the radiofrequency procedure at the 3-month follow-up. Lord et al (1858) were unable to avoid such an issue and in fact, this is a problem with any of the sham procedures in interventional pain management. In fact, Dreyfuss and Baker (1883) supported Lord et al (1858) for maintaining the blinding of the subjects admirably well and the evidence of the difficulty of performing such a study is demonstrated by an extremely limited number of published sham studies involving an invasive treatment. However, Carragee et al (1884) maintained their criticism. The small number of patients included in this study also has been an issue; however, the study met inclusion criteria.

All other radiofrequency neurotomy studies were of an observational nature with 4 prospective and one retrospective. Sapir and Gorup (1879) in 2001 examined the efficacy of radiofrequency medial branch

neurotomy to treat cervical zygapophysial joint pain from whiplash in a prospective study comparing the results of litigants and non-litigants. All patients were involved in an automobile accident at least 20 weeks prior to inclusion in the study and had failed conservative treatment. Those subjects with a positive response to confirmatory diagnostic blocks were enrolled into the study and divided into groups of litigants and non-litigants. Pain was evaluated prior to treatment based on the VAS as well as other outcome measures such as self-report of improvement and change in medication usage. The administration of all questionnaires to the subjects was blind to their legal status, but the treatment operator was not blind to the legal status of the patient. Fifty patients were included in the study meeting the criterion of at least 75% pain relief from comparative diagnostic blocks and underwent radiofrequency neurotomy. Forty-six patients completed the study consisting of 29 (63%) litigants and 17 (37%) non-litigants. Twenty-one patients (14 litigants and 7 non-litigants) reported a recurrence of pain within one year and 25 patients (15 litigants and 10 non-litigants) remained asymptomatic at one year. Time to pain recurrence defined as 50% return of pain was approximately 8.3 ± 2.3 months in the 21 patients whose pain returned within one year. There was an overall VAS pain reduction of 4.6 ± 1.8 from radiofrequency neurotomy at one year with a small but statistically significant difference with litigants having a slightly greater reduction in pain. There were no clinically discernible treatment outcome differences between the litigant and non-litigant groups. In this study radiofrequency neurotomy of cervical facet joint neck pain was found to be an effective treatment for chronic cervical whiplash independent of litigation.

The results of the observational study by Cohen et al (1881) showed the only clinical variable associated with success was paraspinal tenderness. Factors associated with treatment failure included radiation to the head, opioid use, and pain exacerbated by neck extension and/or rotation. They concluded that selecting patients based on key clinical variables may increase the chance of treatment success for cervical facet radiofrequency denervation.

The results of the study by Macvicar et al (1882) showed that in the 2 practices, 74% and 61% of patients achieved a successful outcome. Relief lasted 17 to 20 months from the first radiofrequency, and 15 months for repeat treatments. Allowing for repeat treatment, patients maintained relief for a median duration of 20 to 26 months, with some 60% still having relief at follow-up. They concluded that cervical radiofrequency can be very effective when performed in a rigorous manner in appropriately selected patients. Chronic neck pain, mediated by the cervical medial branches, can be temporarily, but completely, relieved, and patients fully restored to desired activities of daily living, if treated with radiofrequency neurotomy.

The results of the study by Speldewinde (1381) showed that of 379 procedures, 272 (72%) were regarded as successful by the patients, irrespective of region treated. The results were highly significant by t-test, and the effect size was large as determined by the Cohen's d. Adverse events were infrequent and relatively minor. Repetitions of the procedure were highly successful. They concluded that neurotomy of the cervical, thoracic, lumbar, and sacroiliac joints was uniformly successful with 72% of recipients obtaining an average of 86% reduction in pain for a period of 12 months.

Govind et al (1880) evaluated radiofrequency neurotomy for the treatment of third occipital headache with a revised technique using a large gauge electrode ensuring minimum separation between the 3 electrode placements, and holding the electrode in place by hand. The revised technique was used to treat 51 nerves in 49 patients diagnosed as suffering from third occipital headache on the basis of controlled diagnostic blocks of the third occipital nerve. The criteria for successful outcome was complete relief of pain for at least 90 days associated with restoration of normal activities of daily living, and no use of drug treatment for headache. Of the 49 patients, 43 (88%) achieved a successful outcome. The median duration of relief in these patients was 297 days, with 8 patients continuing to have ongoing relief. Fourteen patients underwent a repeat neurotomy to reinstate relief with 12 (86%) achieving a successful outcome with a median duration of relief in these patients of 217 days, with 6 patients having ongoing relief. This revised technique apparently improved the success rate greatly compared to the previous technique by Lord et al (1885).

Among the excluded studies, the studies by McDonald et al (1886) and Barnsley (1887) are noteworthy as they showed significant progress on a long-term basis, even though they failed to meet the inclusion criteria. Thus, radiofrequency neurotomy showed fair evidence overall even though described as fair on the strict criteria.

The results of the effectiveness of cervical conventional radiofrequency neurotomy are illustrated in Table 34.

Table 34. *Results of randomized trials and observational studies of cervical conventional radiofreqency neurotomy.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain Relief			Results			Comment(s)
			3 mos.	6 mos.	12 mos.	Short-term relief ≤ 6 mos.	Long-term relief		
							> 6 mos	≥ 12 mos.	
Lord et al, 1996 (1858) RA, Sham control, DB 11/12	24	3, 6, and 12 month follow-up; 0 to 5 of 100 on visual analog scale; word count 3 or less on McGill Pain questionnaire.	NA	1 of sham 7 of active	58% in active treatment group	P	P	P	A meticulously performed randomized double-blind sham controlled trial showing the efficacy of radiofrequency neurotomy with positive results for short-term and long-term.
Sapir and Gorup, 2001 (1879) P, C, CC 7/12	Litigants = 29 Non-litigants = 17 Total = 46	Visual analog scale and self-report of improvement.	NA	NA	Mean VAS change 4.6 ± 1.8	P	P	P	A prospective evaluation in a small number of patients
Macvicar et al, 2012 (1882) P 7/12	104	Successful outcome was defined as complete relief of pain, or at least 80% relief, for at least 6 months, with complete restoration of activities of daily living, no need for any further health care, and return to work.	NA	74% & 61%	74% & 61%	P	P	P	A large prospective evaluation with positive short-term and long-term results.
Speldewinde, 2011 (1381) P 7/12	130	Numeric Rating Scale, Functional Rating Index, Activities of Daily Living, General Health Questionnaire, psychiatric morbidity	NA	76%	76%	P	P	P	A large prospective evaluation with positive short-term and long-term results.
Govind et al, 2003 (1880) P 7/12	49	The criteria for successful outcome were complete relief of pain for least 90 days associated with restoration of normal activities of daily living, and no use of drug treatment for the headache.	NA	88%	88%	P	P	P	A relatively small prospective evaluation with positive short-term and long-term results.
Cohen et al, 2007 (1881) RE 7/12	92	Pain reduction measured using a modified visual analog scale or numerical pain scores.	NA	55%	55%	P	P	P	A retrospective evaluation with positive short-term and long-term results.

RA = Randomized; DB = Double-Blind; P = Prospective; RE = Retrospective; C = Controlled; CC = Case Controlled; VAS = Visual Analog Scale; P = Positive
Adapted and Modified from: Falco FJE, et al. Systematic review of therapeutic effectiveness of cervical facet joint interventions: An update. Pain Physician 2012; 15:E838-E868 (14).

2.2.1.2 Analysis of Evidence

Based on one randomized, sham-controlled, double-blind trial (1858), 4 prospective studies (1381,1879,1880,1882) and one retrospective evaluation (1881), the indicated evidence for cervical radiofrequency neurotomy is fair.

2.2.2 Medial Branch (Zygapophysial or Facet Joint) Nerve Blocks

Cervical medial branch blocks have been known for their diagnostic capability and are commonly utilized prior to radiofrequency neurotomy. They have also been shown to be effective for long-term therapy. However, the exact mechanism of the therapeutic effect of cervical medial branch blocks is not known. Similar to radiofrequency neurotomy, cervical medial branch blocks may be repeated to reinstate relief when pain returns. In contrast to radiofrequency neurotomy where pain returns when the axons regenerate requiring repetition of radiofrequency procedures, the mechanism of return of pain in therapeutic cervical medial branch blocks is not known.

Falco et al (14) in their systematic review included one high quality randomized trial (257,804,1877) and a moderate quality observational study (1864), reaching the conclusion that the evidence is fair for therapeutic medial branch blocks. Our literature search yielded no additional studies for inclusion.

2.2.2.1 Evidence Assessment

One randomized trial (257,804,1877) and one observational study (1864) met inclusion criteria. The outcome results of the high quality randomized, double-blind controlled trial of therapeutic cervical medial branch nerve blocks in patients with function-limiting chronic neck pain (257,804,1877) showed significant improvement with decreased pain and improvement in functional status at completion of the 2-year follow-up in 85% of patients treated with local anesthetic only and 93% of the patients with local anesthetics and steroids. Over a period of 2 years, the average pain relief per procedure ranged from 17 to 19 weeks, with an average number of procedures of 5.7 with total relief of 83 ± 27.5 weeks in Group I and 89 ± 21.1 weeks in Group II. Opioid intake and employment status showed clinically important improvement, though it was not statistically significant. The results of this study were similar to lumbar and thoracic facet joint nerve blocks (255,258,803). There were no other studies available, either observational or randomized, evaluating the therapeutic outcomes of cervical medial branch blocks with a long-term follow-up of at least 2 years.

This randomized trial (257,804,1877) was designed to reflect everyday clinical practice. The authors found that the 2 drugs used in combination with a local anesthetic, namely Sarapin, and a steroid did not differ significantly in their response. The small differences between the 2 treatments were unlikely to be of clinical importance even in larger studies. This is one of the largest studies with the longest follow-up of an interventional technique, specifically for facet joint nerve blocks, in managing chronic neck pain. This study resolves the issue of the addition of Sarapin and a steroid to local anesthetic for therapeutic cervical medial branch blocks.

The moderate quality observational study by Manchikanti et al (1864) also showed significant improvement in differences in numeric pain scores and significant pain relief (50% or greater) at 3 months, 6 months, and 12 months, compared to baseline measurements. Functional improvement was demonstrated at 12 months from baseline. There was significant improvement with an increase in employment among the patients eligible for employment (employed and unemployed) from baseline to 12 months, and improved psychological functioning.

The results of the effectiveness of cervical medial branch blocks are illustrated in Table 35.

2.2.2.2 Analysis of Evidence

Based on one randomized, double-blind, active-controlled trial (257,804,1877) and one prospective evaluation (1864), the indicated evidence for cervical medial branch blocks is fair.

2.2.3 Intraarticular Injections

Intraarticular injections have been utilized extensively in managing cervical facet joint pain. Uncontrolled observations have suggested that the intraarticular injections of corticosteroids may be useful in the treatment of pain in the cervical zygapophysial joint (1888-1892). However, RCTs have failed to show significant improvement (1732). Falco et al (14) in the systematic review showed limited evidence for cervical intraarticular corticosteroid injections. Our literature search yielded no additional studies.

2.2.3.1 Evidence Assessment

Two randomized trials were available for inclusion in the evidence assessment of cervical intraarticular injections (Table 36).

Table 35. *Results of randomized trials and observational studies of cervical medial branch blocks.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain Relief			Results			Comment(s)
			3 mos.	6 mos.	12 mos.	Short-term relief ≤ 6 mos	Long-term relief		
							> 6 mos	≥ 12 mos.	
Manchikanti et al, 2010, 2008, 2006 (257,804,1877) RA, DB, AC, F 11/12	Group I-no steroid = 60 Group II-steroid = 60	Measured numeric pain scores, Neck Pain index, opioid intake, and employment status at baseline, 3, 6, and 12 months. The procedures were repeated upon the return of pain and deterioration in functional status to less than 50%.	83% versus 85%	87% versus 95%	85% versus 92%	P	P	P	A large randomized double-blind controlled trial performed under fluoroscopy with or without steroids showed positive long-term results.
Manchikanti et al, 2004 (1864) P, F 7/12	100	Pain relief, Oswestry Disability Index, psychological status, work status	92%	82%	56%	P	P	P	A large prospective assessment performed under fluoroscopy with long-term follow-up showed positive results.

RA = Randomized; DB = Double-Blind; AC = Active-Control; P = Prospective; P = Positive
Adapted and Modified: Falco FJE, et al. Systematic review of therapeutic effectiveness of cervical facet joint interventions: An update. *Pain Physician* 2012; 15:E838-E868 (14).

Table 36. *Results of randomized trials of cervical intraarticular injections.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain Relief			Results			Comment(s)
			3 mos.	6 mos.	12 mos.	Short-term relief ≤ 6 mos.	Long-term relief		
							> 6 mos.	≥ 12 mos.	
Park & Kim, 2012 (1878) RA, AC, F 6/12	200	Cervical range of motion, NRS	SPP	SPP	SPP	P	P	P	A moderate quality large randomized controlled trial which showed improvement in significant proportion of patients..
Barnsley et al, 1994 (1732) RA, DB, AC, F 12/12	41	VAS, McGill Pain Questionnaire	20%	20%	20%	N	N	N	A small randomized double-blind controlled trial showing negative results.

RA = Randomized; DB = Double-Blind; AC = Active-Control; SPP = Significant Proportion of Patients; N = Negative; U = Unclear; VAS = Visual Analog Scale; NRS = Numeric Rating Scale
Adapted and Modified from: Falco FJE, et al. Systematic review of therapeutic effectiveness of cervical facet joint interventions: An update. *Pain Physician* 2012; 15:E838-E868 (14).

Barnsley et al (1732) evaluated 41 patients with cervical zygapophysial joint pain after randomly assigned to receive 1 mL of intraarticular injection of bupivacaine, 0.5%, or betamethasone, 5.7 mg, under double-blind conditions. The results showed that less than half of patients reported relief of pain for more than one week, and less than one in 5 patients reported relief for more than one month, irrespective of the treatment received. The median time to return of 50% of the preinjection level of pain was 3 days in the 21 patients in the corticosteroid group, and 3.5 days in the 20 patients in the local anesthetic group. The authors concluded that intraarticular injection of betamethasone is not effective therapy for pain in the cervical zygapophysial joints after whiplash injury.

Park and Kim (1878) assessed the effect of adding cervical facet joint injections in a multimodal treatment program for long-standing cervical myofascial pain syndrome with referral pain patterns of cervical facet joint syndrome in 200 patients in a randomized trial. These patients received therapeutic cervical facet joint injections at bilateral C5/6 and C6/7 after diagnostic, controlled, double-blind blocks. They provided the same co-interventions such as medication and a home exercise program to patients in Group I and the non-injection group. Overall, follow-up was available in 155 patients in the intervention group and 151 patients in non-injection group. Intervention group patients showed increased cervical range of motion, a marked reduction in NRS, and a decreased incidence of combined tension-type headache compared with non-injection group at the one week, 3 month, 6 month, and one year follow-up. The intervention group also showed a decreased number of visits compared with the non-injection group across all age groups. The young age group in the intervention group showed a markedly decreased number of visits compared with the other age groups over the one year study period. They also showed a markedly longer symptom-free period after treatment compared with other age groups until the end of the study. The authors concluded that the addition of therapeutic cervical facet joint injections to a multimodal treatment program is a useful therapeutic modality for patients, especially young patients, suffering from longstanding neck pain. However, in this study, allocation of the groups and blinding of the investigators was not performed since there was a group without injections. Further, there were also significant (over 20%) of the patients lost to follow-up at one year even though the study was an active-control evaluation.

2.2.3.2 Analysis of Evidence

Based on 2 RCTs (1732,1878), the evidence for cervical intraarticular injections is limited.

2.2.4 Summary of Evidence

The indicated evidence for cervical radiofrequency neurotomy is fair, cervical medial branch blocks is fair, and cervical intraarticular injections is limited.

2.2.5 Complications

Complications from intraarticular injections, medial branch blocks or radiofrequency thermoneurolysis in the cervical spine are exceedingly rare (8,14,257,282,321-323,804,887-889,891,932,944,959,966, 967,1235, 1381,1382,1400,1402,1404,1410,1411,1429,1732, 1800,1858,1864,1877,1879,1880,1886-1913). However, serious complications with cervical facet joint injections may occur. Complications include those related to placement of the needle, the temperature, and those related to the administration of various drugs.

Proximity of the needle to the vertebral artery, spinal cord, and nerve root creates risk for injury and makes precise and accurate needle placement exceedingly important. Complications may include dural puncture, spinal cord trauma, subdural injection, neural trauma, injection into the intervertebral foramen and intravertebral arteries; intravascular injection into veins or vertebral arteries; infectious complications including epidural abscess and bacterial meningitis; and side effects related to the administration of steroids, local anesthetics, and other drugs.

Okada (1899) showed that in a series of cervical facet joint injections, a communicating pathway existed in 80% of subjects between the facet joint and interlaminar space, the opposite facet joint, extradural space, and interspinous space when volumes in excess of 1 mL were used. Others (1909) also have shown that extraarticular leaks have been observed in up to 7% of the cases, even with low volumes.

Manchikanti et al (282) in a prospective, non-randomized study investigated the incidence in characteristics of adverse effects and complications in over 20,500 cervical facet joint nerve blocks with 3,370 encounters. The results showed there were no major complications. Multiple side effects and complications observed included overall intravascu-

lar penetration in the cervical region of 20%, local bleeding in 66.9%, oozing with 28.9% of encounters, local hematoma seen only in 2.3% of the patients with profuse bleeding, bruising, soreness, nerve root irritation, and all other effects such as vasovagal reactions observed in 1% or less of the episodes. They concluded that the study illustrated that major complications are extremely rare and minor side effects are common.

Vertebral artery and ventral ramus damage, along with a risk of embolus resulting in serious neurological sequelae with spinal cord damage and cerebral infarction, are exceedingly rare, but are potential complications with cervical facet joint injections.

Other minor complications include lightheadedness, flushing, sweating, nausea, hypotension, syncope, pain at the injection site, and headaches. Side effects related to the administration of steroids are generally attributed to the chemistry or to the pharmacology of the steroids (8,1898). These include suppression of the pituitary-adrenal axis, hyperadrenocorticism, Cushing's syndrome, osteoporosis, avascular necrosis of the bone, steroid myopathy, epidural lipomatosis, weight gain, fluid retention, and hyperglycemia.

Toxicity of local anesthetics with or without steroids has been discussed (1430-1456).

Reported complications of radiofrequency thermoneurolysis include a worsening of the usual pain, burning or dysesthesias, decreased sensation and allodynia in the skin in the region of the facets denervated, transient pain, persistent weakness, and inadvertent lesioning of the spinal nerve or ventral ramus resulting in motor deficits, sensory loss, and deafferentation pain.

A spinal cord lesion can lead to quadriplegia, motor weakness, loss of proprioception and sensory function, bowel and bladder dysfunction, Brown-Sequard syndrome, and spinal cord infarction.

2.2.6 Recommendations

Based on the available evidence, there is fair evidence for conventional radiofrequency neurotomy and therapeutic facet joint nerve blocks with limited evidence for intraarticular injections. Consequently, the recommendation is that therapeutic facet joint nerve blocks or conventional radiofrequency neurotomy may be provided based on the response from controlled diagnostic blocks.

VII. MANAGEMENT OF THORACIC PAIN

Thoracic pain is less common than either low back pain or neck pain; however, the degree of disability resulting from thoracic pain disorders may be similar to that of low back or neck pain (1719,1914,1915). Furthermore, the thoracic region is often linked to symptoms and disorders that may manifest elsewhere in the body. Conditions that implicate the thoracic spine are many and varied, potentially confusing the clinician (1916).

Thoracic intervertebral discs and thoracic facet joints have been shown to be pain generators; however, thoracic radicular pain is very infrequent. In addition, patients may experience chest wall pain secondary to multitude of causes including intercostal neuritis (1917).

1.0 Disc-Related Pathology, Spinal Stenosis, and Radiculitis

The most common causes of thoracic radicular pain and thoracic radiculopathy, though very rare, are disc protrusion and thoracic spondylosis. In spondylotic patients, symptoms may be a result of ischemic neuritis of the nerve root (373). Post-thoracic laminectomy syndrome may be responsible for persistent thoracic pain. Painful spinal stenosis, though extremely rare, may result from disc bulging, protrusion, and herniation, combined with osteophytes and arthritic changes of facet joints that can cause narrowing of the spinal canal or neural foramina (373).

As with the lumbar spine, imaging studies including MRI, CT, myelography, and radiographs are incapable of identifying a degenerated disc as painful in the thoracic spine (1471,1918-1924).

Thoracic discs are innervated structures and have been shown to elicit pain (1471,1918,1925). Moreover, thoracic discs have been shown to cause chronic upper back and mid back pain (1921-1924). Discogenic pain in the thoracic spine has been described but not well studied (15).

Thoracic spinal nerves are distributed to deep structures such as muscles, joints, and ligaments, as well as to the skin. Thus, radicular pain is felt in deep structures, in areas remote from the expected dermatome. However, the herniated nucleus pulposus (HNP) in the thoracic region is much less common than in the lumbar or cervical region (1471,1881,1925-1956). Carson et al (1934) in 1971 estimated that the clinical incidence of thoracic disc prolapse was most frequently at T11/12. Even though thoracic disc prolapse is rare in the upper

third of the thoracic spine, the T1/T2 disc is the most commonly affected (1935), usually involving individuals in the fourth to sixth decades of life (1931).

1.1 Diagnosis of Thoracic Disc Related Pathology

Assessment is based on history, physical examination, neurological examination, and imaging. Quite often it is difficult to identify differences between somatic and radicular pain which is more complex in the thoracic spine than lumbar or cervical spine in that symptoms are similar in various conditions in the thoracic spine based on the description of neurological myotomes and dermatomes in multiple reviews and textbooks. Neurological assessment includes tone, coordination, proprioception, and abdominal and lower limb reflexes. As it is well known, the plantar reflex is particularly important in assessing spinal cord function. Dura mater signs include neck flexion and slump test.

In reference to imaging, age-related changes are extremely common in the thoracic spine in asymptomatic subjects. The great majority of patients with radiologic osteoarthritis are asymptomatic. A high prevalence of anatomic irregularities has been found in asymptomatic patients (458,1957). Even though plain radiograph is the most common imaging technique, it does not satisfy the objective of identification of the cause of the pain and there is concern that plain radiographs are not sensitive enough to exclude disease. CT myelography is an alternative investigation in patients who have contraindications to MRI (1958). MRI though commonly utilized, raises concerns that it is too sensitive, thus giving rise to false-positive findings. In most instances it can reliably distinguish infection, fracture, and tumor (458).

The utility of electrophysiologic studies has been based on the ability to objectify abnormalities of nerve conduction resulting from radiculopathy and to identify the particular segment.

Although the majority of patients who are diagnosed with noninvasive modalities undergo treatment the includes noninvasive interventions and is based on noninvasive diagnostic interventions, some patients may require diagnostic interventions with provocation discography to identify discogenic pain and controlled diagnostic facet joint nerve blocks to eliminate facet joint pain.

1.1.1 Thoracic Provocation Discography

The Task Force on Taxonomy of Classification of Chronic Pain in 1994 described criteria for the diagnosis of discogenic pain (671,1659,1959). The Task Force (1959) 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 by provocation discography of the putatively symptomatic disc that reproduces the patient's accustomed pain to stem from an intervertebral disc, and with provocation of at least 2 adjacent intervertebral discs that clearly do not reproduce 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 (1959) 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 apprehension on the part of the patient or because of the coexistence of a separate source of pain within the segment under investigation.

Degeneration of the thoracic disc, along with end-plate irregularities and changes due to osteophyte formation, are common findings (1960-1964). Four systematic reviews evaluating the role of provocation discography in the diagnosis of spinal pain have presented limited evidence supporting the role of discography in identifying the subset of patients with thoracic discogenic pain (37,697,700,1920). Singh et al (37,1920), in determining the accuracy of thoracic discography in the evaluation of chronic thoracic pain, concluded that the clinical value of thoracic provocation discography is limited. Our literature search yielded no additional studies.

1.1.1.1 Evidence Assessment

Two studies evaluating provocation discography met inclusion criteria (1886,1887). In 1994, Schellhas et al (1923) published their experience with thoracic discograms performed on 100 outpatients by a retrospective analysis. After MRI, clinically suspect, morphologically abnormal thoracic discs and at least one nearby controlled level disc were injected with either non-ionic contrast or saline, filmed, and individually described by the patient as concordant versus non-concordant relative to clinical pain, and rated in pain intensity on a scale of 0 to 10. The results illustrated that discs with annular tears, intrinsic degeneration, and vertebral body endplate infarctions were painful approximately 75% of the time. Schellhas et al (1923) demonstrated a clinical concordance of 50% with painless control levels. In this series, clinically concordant extraspinal pain such

as chest wall, intrathoracic, and upper abdominal pain were frequently provoked with thoracic disc injections. They described non-protruding disc derangements such as may be seen either in active or old juvenile discogenic disease (Scheuermann's disease). Internal disc derangements may be painful and clinically significant with more than 50% of the painful discs that they studied falling into this category. The authors concluded that thoracic discography can be performed safely by experienced individuals as a reliable tertiary diagnostic procedure to determine if degenerated discs on MRI studies are related to clinical complaints. The shortcomings of this evaluation include it being a retrospective evaluation. They described the technical aspects extensively, even though characteristics of patients' pain patterns were not provided at baseline. Furthermore, a consistent reference standard was not applied. There was no blinded comparison of the test.

Wood et al (1924) performed a prospective evaluation. They sought to determine the responses to thoracic discography by asymptomatic and symptomatic individuals. Using a 4-level discography, they evaluated 10 adult lifelong asymptomatic volunteers, ages 23 to 45 years, who underwent MRI of the thoracic spine. Provocation responses were graded on a scale of 0 (no sensation) to 10 (extreme pain or pressure), and filmed discs were graded using a modified Dallas scheme. Concomitantly, 10 non-litigious adults, ages 31 to 55 years, experiencing chronic thoracic pain were similarly studied. The results showed the mean pain responses in the asymptomatic volunteers to be 2.4/10. Three discs in the asymptomatic group were intensely painful with scores of 7/10, 8/10, and 10/10, with all 3 exhibiting prominent endplate irregularities and annular tears typical of thoracolumbar Scheuermann's disease. On discography, 27 of 40 discs were abnormal, with endplate irregularities, annular tears, and/or herniations. They also reported that the 10 discs that read as normal on MRI showed annular pathology on discography. In the group with chronic thoracic pain, the average pain response was 6.3/10 ($P < 0.05$). Of the 48 discs studied, 50% or 24 were concordantly painful, with a response of 8.5/10 ($P < 0.05$). Seventeen discs had non-concordant pain or pressure, with an average pain score of 4.8/10 ($P < 0.05$) and 5 had no response. On MRI, 21 of the 48 discs appeared normal, whereas on discography, only 10 were judged as normal. They concluded that on discography, thoracic discs with prominent Schmorl's nodes may be intensely painful, even in lifelong asymptomatic individuals, but the pain is unfamiliar or non-concordant. They also concluded that thoracic discography may demonstrate disc pathology not seen on MRI.

Evidence was also provided for the relative lack of reliability of MRI at identifying painful deranged discs (1924). They reported a high incidence of relatively painless disc pathology with discography that was missed on MRI, including annular tears and frank herniations, in both the symptomatic and asymptomatic patients. Furthermore, they noted that a general trend toward more painful responses was being observed with greater degrees of pathology, especially with endplate pathology such as Scheuermann's disease. Variability was reported in perceived pain or pressure, even though typically it was on the same side as the disc pathology, whether it was a tear or herniation.

This original controlled prospective study in asymptomatic and symptomatic individuals had some deficiencies (1924). There were only 10 lifelong asymptomatic volunteers. While they concluded that thoracic discography in the truly asymptomatic individual is not painful, regardless of the degree of pathology observed, they reported 3 of the 40 discs (7.5%) as intensely painful with pain of 7, 8, and 10 on a scale of 0 to 10. However, the 3 of them exhibited prominent endplate changes typical of thoracolumbar Scheuermann's pathology. Two of these painful responses were in one volunteer. Consequently, 20% of the asymptomatic volunteers reported pain when they had severe Scheuermann's pathology. Once the 3 painful discs or 2 painful patients were removed, the average pain response was less than 2/10. Only one volunteer reported aching muscle-like pain for 48 hours, which resolved quickly at that point with no sequelae. The authors have not provided detailed results with regards to negative contiguous discs, one above and one below, thus, the criteria was limited solely to the elicitation of concordant pain. Twenty-seven of 49 or 55% of the discs studied in the symptomatic group were concordant.

1.1.1.2 Accuracy

Wood et al (1924) 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. Furthermore, 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, 5 discs exhibited with no pain response at all.

Schellhas et al (1923) 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.

1.1.1.3 Prevalence

The prevalence of thoracic discogenic pain has not been determined.

1.1.1.4 False-Positive Rates

Utilizing the data by Wood et al (1924), it appears that the false-positive rates with thoracic discograms is 0 if a pain response of 7 or above is considered as positive with concordant pain with negative contiguous discs. When endplate irregularities and annular tears are taken into consideration as shown in the asymptomatic patients, even though the mean response in volunteers was 2.4/10, 3 discs in 2 patients were intensely painful with scores ranging from 7 to 10 of 10. Consequently, pain may be produced in 20% of patients with separate pathology. Considering the clinical realities which dictate that provocation thoracic discography be performed only in symptomatic patients, utilizing the IASP criteria (1959), and that these positive patients may have been dormant and fallen within the range of the prevalence of discogenic pain, it is considered that the false-positive rates with thoracic provocation discography is low.

1.1.1.5 Analysis of Evidence

The evidence based on this analysis is limited due to only 2 moderate quality studies with no recent literature available.

1.1.1.6 Complications

Complications relating to thoracic discography include discitis, nerve root injury, epidural abscess, allergic contrast reaction, subarachnoid puncture, meningitis, direct trauma to the spinal cord, pneumothorax, and trauma to retroperitoneal structures including the kidney and the spleen (1923,1924,1965).

1.1.1.7 Recommendations

Based on IASP criteria (1959), ISIS criteria (1964), and ASIPP criteria (1471), if the indication is appropriate and a treatment is available, thoracic discography can be performed to diagnose thoracic discogenic disease.

1.2 Therapeutic Interventional Techniques for Thoracic Disc-Related Pain

The most common treatment of disc ailments is conservative management followed by interventional techniques with epidural injections. The therapeutic interventional techniques in managing pain in the thoracic spine secondary to disc herniation, radiculitis, spinal stenosis, and discogenic pain is limited to epidural injections other than open surgery. While there have been a few case descriptions of minimally invasive surgery in managing thoracic spinal pain, the literature is extremely scant.

Surgery is most commonly indicated when addressing the catastrophic effects of thoracic intervertebral disc prolapse (1958). The surgical treatment of a prolapsed intervertebral disc has undergone significant evolution over the years (1965-1970).

1.2.1 Epidural Injections

While epidural injections are common in the lumbar and cervical spine, they are not frequently performed in the thoracic spine; however, thoracic epidural injections have been used in the acute setting for the relief of acute post thoracotomy pain. There continues to be a paucity of literature concerning thoracic epidural injections with or without steroids in the treatment of chronic thoracic and chest wall pain of spinal origin.

To date, there has been only one systematic review by Benyamin et al (10) which identified the preliminary results of only one randomized, double-blind controlled trial (250) in the treatment of chronic mid back, upper back, and chest wall pain secondary to disc herniation, radiculitis, or discogenic pain. In fact, there may be more studies evaluating epidural injections in the treatment of post thoracotomy pain (1971-1973). Our literature search yielded no additional studies.

1.2.1.1 Evidence Assessment

Only 2 studies, one randomized trial and one observational study were identified. However, the observational study (1971) evaluated post thoracotomy syndrome. The randomized trial (250) reported preliminary results with spinal pain of discogenic heterogenous ailments, whereas, the observational study (1971) assessed post thoracotomy syndrome. They concluded that the evidence for thoracic epidural injections in treating chronic thoracic pain is considered fair and is limited for post thoracotomy pain.

Of the 17 thoracic epidural studies identified, only 2 studies were included (250,1971), both by Benyamin et al

(10). The 15 excluded studies were mainly assessments of post-thoracotomy pain and reviews (1972-1983).

Table 37 illustrates characteristics of studies considered for inclusion.

1.2.1.2 Analysis of Evidence

The evidence for thoracic epidural injection in treating chronic thoracic pain is fair based on one randomized trial (250) and limited for post thoracotomy pain based on one observational study (1971).

1.2.1.3 Complications

Very few studies have examined the adverse effects of thoracic epidural injections for the treatment of chronic mid and upper back pain (1984,1985). One study (1984) examined the complication rate of thoracic foraminal injections at the same institution and found a complication rate of 4.1% (12 out of 296 injections). All of these were considered minor complications (lightheadedness, local numbness, muscle spasm, vasovagal response, and headache) with one major complication of an avoidable pneumothorax.

Botwin et al (1985) reviewed adverse effects of fluoroscopically guided interlaminar thoracic epidural injections for the treatment of spondylosis and herniated nucleus pulposus. A retrospective review of the charts of 21 patients revealed a 20.5% minor complication rate, all without morbidity. Complications included pain at the injection site (7.7%), facial flushing (5.1%), headache (2.6%), insomnia the night of the injection (2.6%), and fever the night of the procedure (2.6%).

Manchikanti et al evaluated the complications and side effects of epidural injections (899,932,944,959). Among 10,000 epidurals performed, 301 were performed in the thoracic region. The results illustrated intravascular entry in 4%; return of blood in 2.7%; profuse bleeding in 1.3%; local hematoma in 0.7%; bruising in 0.3%; vasovagal reaction, transient nerve root irritation, postlumbar puncture headache, and facial flushing in 0.33%; transient spinal cord irritation in 1%; dural puncture in 1.3%; and profuse bleeding in 1.3% (899).

1.2.1.4 Recommendations

Thoracic epidural injections are recommended for thoracic discogenic, disc-related, post surgery syndrome or spinal stenosis pain with fair albeit rather weak evidence and based on only one randomized preliminary controlled trial.

Table 37. *Assessment of randomized trials and non-randomized studies for inclusion criteria.*

Study Study Characteristics Methodological Quality Scoring	Number of Patients	Control vs. Intervention or Comparator vs. Treatment	Follow-up Period	Outcome Measures	Results			Comment(s)
					Short-term relief	Long-term relief		
					≤ 6 mos.	> 6 mos.	≥ 12 mos.	
Manchikanti et al, 2010 (250) RA, AC, F 11/12	40 Local anesthetic only = 20 Local anesthetic with steroids = 20	6 mL of local anesthetic only or 6 mL of local anesthetic with 6 mg of nonparticulate betamethasone.	One year	NRS, ODI, employment status, opioid intake	P	P	P	Positive first randomized trial
Ayad & El Masryl, 2012 (1971) P, B 7/10	21	8 patients underwent conservative management whereas 13 patients underwent epidural injections with clonidine 150 mg, 80 mg of methylprednisolone acetate diluted in 8 mL of 0.5% lidocaine.	6 months	VAS, sleep patterns, appetite changes, ADL	P	NA	NA	Small study with positive short-term results

RA = Randomized; AC = Active Control; F = Fluoroscopy; P = Prospective, B = Blind; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; VAS = Visual Analog Scale; ADL = Activities of Daily Living; NA = Not Applicable; P = Positive
Adapted and Modified from: Benyamin RM, et al. A systematic evaluation of thoracic interlaminar epidural injections. *Pain Physician* 2012; 15:E497-E514 (10).

2.0 Thoracic Facet Joint Pain

Thoracic facet joint pain is common considering that thoracic pain is not as prevalent as cervical and lumbar pain. Investigations into the assessment of various causes of thoracic pain are less frequent.

Even though the description of the involvement of thoracic facet joints as a cause of chronic mid back and upper back pain dates back to 1987 (1986), thoracic facet joint pain patterns were not described until 1994 and 1997 by Dreyfuss et al (1987) and Fukui et al (1988). Subsequently multiple studies have described thoracic facet joints as the source of chronic pain in 34% to 48% of patients with chronic mid back and upper back pain (1346,1347,1989,1990).

Based on the postulates of Bogduk (1472), thoracic facet joints have been shown to have an abundant nerve supply (15,16,1471,1960,1961,1987,1988,1991-1993); 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 (1987,1988); shown to be affected by osteoarthritis, rheumatoid arthritis, spondylitis, degeneration, inflammation, and injury leading to pain upon joint motion and restriction of motion (1961,1962,1994); and been shown to be a source of pain in patients, using diagnostic techniques of known reliability and validity (1346,1347,1989).

2.1 Diagnosis of Thoracic Facet Joint Pain

Conventional clinical and radiologic techniques are unreliable in diagnosing facet or zygapophysial joint pain (111,112,375,384,401,420,422,1325,1339,1471,1857, 1960,1987,1995). Consequently, controlled local anesthetic blocks of thoracic facet joints or medial branch blocks are employed to diagnose facet joint pain (1996).

2.1.1 Diagnostic Thoracic Facet or Zygapophysial Joint Blocks

The recent systematic review by Atluri et al (15) evaluated the diagnostic accuracy of thoracic facet joint nerve blocks. They identified 3 studies utilizing controlled comparative local anesthetic blocks, with ≥ 80% pain relief as the criterion standard. The evidence is good for the diagnosis of thoracic pain of facet joint origin with controlled diagnostic blocks. Our literature search yielded no additional studies.

2.1.1.1 Evidence Assessment

Three studies met the inclusion criteria evaluating the prevalence and false-positive rates of facet joint nerve blocks in the diagnosis of mid back and upper back pain (1346,1347,1989).

Descriptive characteristics of these studies are included in Table 5 of the systematic review by Atluri et al (15). All 3 studies (1346,1347,1989) were performed by the same group, with utilization of the same methodology, with controlled comparative local anesthetic blocks with 80% pain relief based on the duration of local anesthetics with lidocaine administered first, followed by bupivacaine, with the ability to perform maneuvers which were painful prior to injection therapy, and with the duration of relief such that the second block exceeded the first block irrespective of the duration in hours, days, or months. These studies evaluated not only the prevalence but also false-positive rates with confidence intervals. There was no significant difference among the 3 studies with prevalence or false-positive rates. The selection criteria, inclusion, and exclusion criteria of the patients was the same in all 3 studies.

2.1.1.2 Prevalence

The prevalence was illustrated to be 34% to 48%. Confidence intervals (95% CI) ranged from 22% to 62% (Table 38). The combination of results of all 3 studies yielded a prevalence rate of 40% (with a 95% CI of 33% to 48%) and a false-positive rate of 42% (with a 95% CI of 33% to 51%).

2.1.1.3 Confounding Factors

The influence of psychological factors was evaluated in the diagnosis of thoracic facet joint pain in only one study (1353). Based on this evaluation, the prevalence of facet joint pain in patients suffering with chronic upper or mid back pain involving thoracic facet joints was shown to be present in 40% (95% CI; 18% to 62%) of patients without psychopathology, whereas it was 31% (95% CI; 16% to 47%) in patients with vs 37% (95% CI; 19% to 54%) without major depression, 33% (95% CI; 19% to 48%) versus 35% (95% CI; 15% to 55%) in patients with or without generalized anxiety disorder, and 36% (95% CI; 7% to 65%) versus 33% (95% CI; 21% to 46%) in patients with or without somatization disorder without any significant differences between the patients with psychological disorders and without psychopathology. However, due to small numbers in the study, there was a wide variation in 95% confidence intervals. This report is not considered conclusive with regards to the influence of psychological factors. Sedation as a confounding factor was evaluated in the cervical and lumbar spine

Table 38. *Data of prevalence of thoracic joint pain by controlled diagnostic blocks*

Study	% Relief Used	Methodological Criteria Score	Number of Subjects	Prevalence Estimates	False-Positive Rates
Manchikanti et al, 2002 (1989)	≥ 80%	10/12	46	48% (95% CI; 34% - 62%)	58% (95% CI; 38% - 78%)
Manchikanti et al, 2004 (1346)	> 80%	10/12	72	42% (95% CI; 30% - 53%)	55% (95% CI; 38% - 78%)
Manchukonda et al, 2007 (1347)	> 80%	10/12	65	34% (95% CI; 22% - 47%)	42% (95% CI; 36% - 53%)

CI = Confidence Intervals
Adapted and Modified from: Atluri S, et al. Diagnostic accuracy of thoracic facet joint nerve blocks: An update of the assessment of evidence. *Pain Physician* 2012; 15:E483-E496 (15).

(1095,1358,1359,1873). No such studies were available regarding the thoracic spine.

2.1.1.4 False-Positive Rates

Based on the controlled local anesthetic block with 50% pain relief, false-positive rates of single local anesthetic blocks range from 42% to 58% with CIs ranging from 22% to 78% (Table 38).

2.1.1.5 Analysis of Evidence

The evidence for the diagnostic accuracy of controlled, dual diagnostic blocks with at least 80% concordant relief criterion standard thoracic facet joint nerve blocks is good.

2.1.1.6 Recommendations

Based on the systematic review (15), IASP criteria (1960), ISIS criteria (1997), and ASIPP criteria (1492), diagnostic thoracic facet joint nerve blocks are indicated in patients with somatic or nonradicular upper back or mid back pain, with lack of obvious evidence for discogenic pain, disc herniation or evidence of radiculitis. Based on the present evidence it also appears that criterion standard of controlled diagnostic blocks with 75% pain relief is essential.

2.2 Therapeutic Thoracic Facet Joint Interventions

Facet joint pain originating from the thoracic spine is generally managed with conservative management; however, after failure of conservative management, therapeutic facet joint interventions including medial branch blocks and radiofrequency neurotomy have been described (242,258,487,803,1381,1383,1998-2000). However, the evidence has been highly variable.

Previous systematic reviews have provided fair evidence for therapeutic thoracic medial branch blocks (16,1995), whereas evidence for radiofrequency neurotomy of thoracic facet joint nerves was indeterminate (16,1995).

2.2.1 Therapeutic Medial Branch Blocks

Thoracic medial branch blocks are known for their diagnostic capability. They are commonly utilized prior to radiofrequency neurotomy. But, they also have been shown to be effective for long-term therapy; however, the exact mechanism of therapeutic effect of thoracic medial branch blocks is not known. Similar to radiofrequency neurotomy, thoracic medial branch blocks may be repeated to reinstate pain relief when it returns without any deleterious effects. In contrast to radiofrequency neurotomy where pain returns when the axons regenerate requiring repetition of radiofrequency procedures, the mechanism of return of pain in therapeutic thoracic medial branch blocks is not known.

Four systematic reviews assessed the effectiveness of therapeutic thoracic facet joint nerve blocks (16,1364,1366,1995). The recent systematic review by Manchikanti et al (16) showed fair evidence. Our literature search showed one new publication (258), which is a 2-year result of a previous publication by Manchikanti et al (803).

2.2.1.1 Evidence Assessment

One randomized trial (1990) and one prospective evaluation (2001) assessed therapeutic medial branch blocks. The double-blind randomized trial is published as 3 reports (258,803,1990). The observational report (2001) of medial branch blocks was performed by the same group of investigators. Manchikanti et al (258,803,1990) in the randomized trial evaluated 100 patients with 50 patients in each group receiving local anesthetic with or without steroids. The authors assessed the outcomes with numeric pain scores, Oswestry Disability Index, opioid intake and return to work status. All outcomes were assessed at baseline, 6 months, 12 months, and 24 months. Significant pain relief was defined as greater than 50% relief along with greater than 50% improvement in functional status. The results showed 80% of the patients with significant improvement at the end of one year and 2 years in Group I and 84% in Group II with no

significant difference. The majority of patients experienced significant pain relief for 46 to 47 weeks requiring approximately 3 to 4 treatments with an average relief of 14 to 16 weeks per episode of treatment over a period of one year. Over a period of 2 years they experienced approximately 86 weeks of relief and also required 6 procedures per 2 years on average.

The observational study published in 2006 included 55 consecutive patients with improvement shown in 76% of the patients at the end of one year.

The results of the randomized and observational studies of thoracic facet joint medial branch blocks are illustrated in Table 39.

2.2.1.2 Analysis of Evidence

The evidence for therapeutic medial branch blocks is fair in managing chronic mid back or upper back pain of facet joint origin after the diagnosis is established with controlled, comparative local anesthetic blocks.

2.2.2 Radiofrequency Neurotomy

Radiofrequency lesioning is performed utilizing either a heat lesion or pulsed mode radiofrequency. A thermal radiofrequency neurotomy lesion for medial branch denervation is performed at 80° to 85° C. The mechanism of radiofrequency neurotomy is by denaturing of the nerves. Thus, the pain returns when the axons regenerate requiring repetition of the radiofrequency lesioning. In contrast, the pulsed mode radiofrequency is an application of a strong electric field to the tissue that surrounds the electrode. The temperature of the tissue surrounding the tip of the electrode does not exceed 42° C and heat is dissipated during the silent period.

The 4 systematic reviews have shown limited evidence for radiofrequency neurotomy of thoracic medial branches. Our literature search yielded no additional studies.

2.2.2.1 Evidence Assessment

Two observational studies of radiofrequency neurotomy (1381,2002) met the inclusion criteria (Table 40).

Among these, Stolker et al (2002) published a prospective outcome study in 1993 assessing 40 patients with thoracic pain with radiofrequency neurotomy that showed positive short-term and long-term improvement; however, this was a poorly performed study. Recently, in 2011 Speldewinde (1381) published the results of 28 patients in a prospective outcome evaluation with radiofrequency neurotomy. Outcome parameters included NRS, functional rating index, activities of daily living scale, general health questionnaire, depression

Table 39. *Results of randomized and observational studies of thoracic medial branch blocks.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain Relief			Results			Comment(s)
			3 mos.	6 mos.	12 mos.	Short-term relief ≤ 6 mos.	Long-term relief		
							> 6 mos.	≥ 12 mos.	
Manchikanti et al, 2012, 2010, 2008 (258,803,1990) RA, DB, F 10/12	Group I - no steroid = 50 Group II- steroid = 50	Numeric pain scores, Oswestry Disability Index, opioid intake, and return to work status. All outcomes were assessed at baseline, 6 months, 12 months, and 24 months. Significant pain relief was defined as > 50% relief. Significant functional improvement was > 40% reduction of Oswestry Disability Index.	79% vs 83%	79% vs 81%	80% vs 83%	P	P	P	The randomized controlled trial showed positive results with long-term follow-up
Manchikanti et al, 2006 (2001) P, F 7/13	55 consecutive patients, all meeting diagnostic criteria for thoracic facet joint pain	Measured numeric pain scores, Oswestry Disability Index, employment status, and Pain Patient Profile at 3, 6, 12, 24, and 36 months.	71%	71%	71%	P	P	P	Prospective evaluation showed positive results on a long-term basis for procedures performed under fluoroscopy.

RA = Randomized; DB = Double-Blind; P = Prospective; vs = Versus; P = Positive

Adapted and modified from: Manchikanti KN, et al. An update of evaluation of therapeutic thoracic facet joint interventions. *Pain Physician* 2012; 15:E463-E481 (16).

and anxiety scale, and duration of pain relief. They defined successful outcome as at least 50% reduction of pain, for at least 2 months. The results showed positive response in 68% of patients in the thoracic region with radiofrequency neurotomy. Further, 85% of pain relief was illustrated for 9 months in 18 of 28 patients (64%).

2.2.2.2 Analysis of Evidence

The evidence for thoracic radiofrequency neurotomy is limited, but emerging.

2.2.3 Thoracic Facet (Zygapophysial) Intraarticular Joint Injections

There are no studies available for previous systematic reviews with our search criteria showing the effectiveness of thoracic intraarticular injections.

2.2.4 Summary of Evidence

Based on one high quality, double-blind, randomized trial and one observational report, medial branch blocks provide fair evidence in managing chronic mid back or upper back pain of facet joint origin after the diagnosis is established with controlled, comparative local anesthetic blocks.

Based on 2 observational studies meeting methodological quality assessment criteria, the evidence for thoracic radiofrequency neurotomy is limited, but emerging.

There are no studies available for previous systematic reviews with our search criteria showing the effectiveness of thoracic intraarticular injections.

2.2.5 Complications

Complications of thoracic facet joint interventions are similar to those of the cervical or lumbar region (282,1409,1410,1412,1418,1822,1896,1910,1912,2002-2004). These include bleeding, infection, and neural trauma. In the United States, facet joint interventions are one of the most commonly utilized modalities of treatments in managing chronic thoracic pain, similar to neck and low back pain (8,162,163,165,167,168,170). The facet joint interventions are administered by 3 approaches utilizing either intraarticular injection, medial branch block, or by performing radiofrequency neurotomy. Radiofrequency neurotomy may be performed with conventional heat radiofrequency, pulsed radiofrequency, or cooled radiofrequency.

2.2.6 Recommendations

Based on the present evaluation, there is fair evidence that thoracic facet joint pain confirmed by controlled diagnostic blocks may be treated with therapeutic medial branch blocks.

Table 40. *Results of randomized and observational studies of thoracic radiofrequency neurotomy.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain Relief			Results			Comment(s)
			3 mos.	6 mos.	12 mos.	Short-term relief ≤ 6 mos.	Long-term relief		
							> 6 mos	≥ 12 mos.	
Stolker et al, 1993 (2002) P 8/13	40 patients with thoracic pain were evaluated	Pain relief with numeric rating scale	N/A	N/A	64%	N/A	P	P	Prospective evaluation with positive results.
Speldewinde, 2011 (1381) P 7/13	28 patients with thoracic pain as part of outcomes of percutaneous zygapophysial and sacroiliac joint neurotomy in a community setting with total of 379 patients included	Numeric rating scale, functional rating index, activities of daily living scale, general health questionnaire, depression and anxiety scale, duration of pain relief.	N/A	N/A	64%	P	P	P	A prospective evaluation with positive results.

P = Prospective; P = Positive; NA = Not Applicable
Adapted and modified from: Manchikanti KN, Atluri S, Singh V, Geffert S, Sehgal N, Falco FJE. An update of evaluation of therapeutic thoracic facet joint interventions. *Pain Physician* 2012; 15:E463-E481 (16).

VIII. IMPLANTABLES

Implantables in managing chronic pain include spinal cord stimulation (SCS) and intrathecal drug delivery systems. SCS provides neuromodulation, which is reversible and non-destructive. SCS is generally limited to conditions such as neuropathic pain, whereas intrathecal delivery systems are primarily effective for nociceptive or mixed pain.

1.0 Spinal Cord Stimulation

SCS is primarily implanted for FBSS and complex regional pain syndrome (CRPS) (505,507,508,2005-2025).

Multiple systematic reviews have been performed, with the first review published in 1995 (507). Taylor et al (2005) concluded that the level of evidence for the efficacy of SCS in chronic back and leg pain secondary to FBSS was moderate. In another systematic study, Taylor (508) in evaluating neuropathic back and leg pain secondary to FBSS concluded that the evidence was of Grade B. A Cochrane review for SCS (505) concluded that evidence was limited for SCS for FBSS. Frey et al (35) indicated the evidence to be Level II-1 or II-2 for clinical use on a long-term basis in relieving chronic intractable pain of FBSS.

Multiple manuscripts have been published describing SCS (2005-2062).

1.1 Evidence Assessment

Two randomized trials (2026-2028) and 12 observational studies met inclusion criteria (2025,2029-2037,2054,2055).

Kumar et al (2026,2027) compared SCS with conventional medical management (CMM) in patients with neuropathic pain secondary to FBSS with predominant leg pain of neuropathic radicular origin. By 12 months, the protocol analysis showed 48% of the SCS group and 9% of the medical management group achieved at least 50% pain relief. By 24-month follow-up, 42 out of 52 randomized patients continuing SCS reported significantly improved leg pain relief, QOL, and functional capacity; and 13 patients (31%) required a device-related surgical revision (2026). At 24 months, of 46 out of 52 patients randomized to SCS and 41 of the 48 patients randomized to CMM who were available, the primary outcome was achieved by 34 (47%) out of 72 patients who received SCS as final treatment versus one (7%) of 15 for CMM. The authors concluded that compared with the medical management group, the spinal cord group experienced improved leg and back pain relief, QOL, and functional capacity, as well as greater treatment satisfaction.

Eldabe et al (2060) also analyzed the components of pain, function, and health-related QOL from this study. This analysis examined the sub-dimensions of health outcomes measures to provide insight into patient well-being. The results showed that while at baseline patients reported moderate to severe leg and back pain adversely affecting all dimensions of function and QOL, at 6 months compared with CMM alone patients also receiving SCS reported superior pain relief, function, and health-related QOL on overall and most sub-component scores. The majority of these improvements with SCS were sustained at 24 months. Nonetheless, they also acknowledged that 36% to 40% of patients experienced ongoing marked disability related to standing and lifting and health-related QOL problems with pain and discomfort. They concluded that longer-term pain management and research must focus on these refractory FBBS patients with persisting poor function and health-related QOL outcomes.

North et al (2028) presented results of SCS versus repeated lumbosacral spine surgery for chronic pain in an RCT. Of the 99 patients from a consecutive series invited to participate in the study, 60 candidates consented to randomization and 50 proceeded to a treatment. Among 45 patients (90%) available for follow-up, SCS was more successful than reoperation (9 of 19 patients versus 3 of 26 patients, $P \leq 0.01$). The long-term success rates at 2.9 ± 1.1 years were for SCS, 47% versus reoperation 12% ($P \leq 0.01$).

Multiple observational studies (2025,2029-2037,2054) meeting inclusion criteria showed positive results. Table 41 shows results of published studies of effectiveness of SCS in post lumbar surgery syndrome including randomized as well as observational studies. Among the observational studies 11 of 12 showed positive results ranging from 48% to 74%.

Among the newer studies Kinfe et al (2025) enrolled 81 patients prospectively. Over 90% of the patients had FBBS combined with lower extremity pain and lower back pain. They implanted percutaneous paddle leads under local anesthesia after a successful trial stimulation with pain assessment for 7 days. The median follow-up was of 12 months and the data showed favorable clinical outcomes for paresthesia coverage and pain reduction with a risk profile comparable with known percutaneous techniques (VAS 8.4 versus 2.3). The authors concluded that the use of minimally invasive percutaneous paddle leads is effec-

tive and safe with a low migration rate.

Slavin et al (2054), in 2013, published results of a meta-analysis of 4 prospective, multicenter studies that collected outcome data from patients implanted with spinal cord stimulators to treat chronic pain of the back and lower extremities. Two of these studies were conducted as long-term studies lasting one year and 2 years, with short-term studies lasting 6 months. A total of 300 patients from 28 investigational sites were prospectively evaluated for efficacy at 3 months after implant and safety at 6 months after implant. Outcome measures included patient reported percent of pain relief, patient satisfaction, QOL improvement, pain evaluation on a 0 to 10 rating, pain relief rating, short form McGill Pain Questionnaire, VAS, the short form-36, and the total number of adverse events. The results showed that at 3 months after implantation of the permanent system, 75.4% of patients (190/252) reported a 50% or greater pain relief as determined by the patient reported degree of pain relief. In the 2 long-term studies, 80.9% of patients (140/173) were satisfied or very satisfied with therapy at the one year evaluation point. QOL data indicated that at 3 months after implant, 77.8% of patients reported QOL as improved or greatly improved. Similar to the short-term improvement, QOL was improved or greatly improved for 74% of patients in the long-term study at one year. The authors concluded that this analysis provides further evidence of the safety and effectiveness of SCS in treating chronic intractable pain of the trunk and limbs.

In contrast, Turner et al (2055) and Hollingworth et al (2061) showed a lack of clinical or cost effectiveness of SCS for FBBS in a workers compensation population. In a prospective, population based controlled cohort study,

Table 41. *Results of published studies of effectiveness of spinal cord stimulation in post lumbar surgery syndrome.*

Study	Study Characteristics	Methodological Quality Scoring	Patients	Pain Relief		Results	
				≤ 12 mos.	> 12 mos.	Short-term ≤ 12 mos.	Long-term > 12 mos.
Kumar et al (2026,2027)	RA	8/9	SCS = 52 CMM = 48	48% vs 9%	58% vs 17%	P	P
North et al (2028)	RA	8/9	SCS = 24 Reoperation = 26	SCS 9/19 Reoperation 3/26	SCS 9/19 Reoperation 3/26	P	P
Kinfe et al (2025)	O	8/13	81	--	Median VAS 8.4 vs 2.3	P	P
Slavin et al (2054)	O	9/13	300	81%	74%	P	P
Turner et al (2055)	O	8/13	SCS = 51 Pain clinic = 39 Usual care = 68	10%	10%	N	N
Van Buyten et al (2029)	O	8/13	254	--	68%	P	P
Kumar and Toth (2030)	O	8/13	182	--	48%	P	P
De La Porte and Van de Kelft (2031)	O	8/13	78	--	58%	P	P
Devulder et al (2032)	O	8/13	69	--	77%	P	P
North et al (2033)	O	8/13	50	--	53%	P	P
Dario (2034)	O	8/13	49	--	71%	P	P
De La Porte and Siegfried (2035)	O	8/13	94	--	60%	P	P
Burchiel et al (2036)	O	8/13	219	--	55%	P	P
Ohnmeiss et al (2037)	O	8/13	40	--	70%	P	P

RA = Randomized; O = Observational; SCS = Spinal Cord Stimulation; CMM = Conventional Medical Management; vs = Versus; P = Positive
Source: Frey ME, Manchikanti L, Benyamin RM, Schultz DM, Smith HS, Cohen SP. Spinal cord stimulation for patients with failed back surgery syndrome: A systematic review. *Pain Physician* 2009; 12:379-397 (35).

Turner et al (2055) evaluated outcomes of workers' compensation recipients with FBBS who received at least a trial (N = 51) versus those who were evaluated at a multidisciplinary pain clinic and did not receive SCS (N = 39) or received neither SCS nor pain clinic evaluation with usual care (N = 68). Patients completed measures of pain, function, medication use, and work status at baseline and 6, 12, and 24 months later. Fewer than 10% of patients in any group achieved success at any follow-up on the composite primary outcome encompassing less than daily opioid use and improvement in leg pain and function. At 6 months, the SCS group showed modestly greater improvement in leg pain and function, but with higher rates of daily opioid use. These differences disappeared by 12 months. Patients who received a permanent spinal cord stimulator did not differ from patients who received some patient clinic treatment on the primary outcome at any follow-up. Overall, less than 10% were successful in each group at each follow-up and 19% had spinal cord stimulators removed within 18 months. Both trial and permanent spinal cord stimulators were associated with adverse events. They concluded that they found no evidence for greater effectiveness of SCS versus alternative treatments in the patient population after 6 months. This study in patients receiving workers' compensation showed no significant difference in any of the modalities of treatments, however, various types of treatments provided in pain clinic setting are not identified. Reviewing the treatments for back and leg pain provided shows that surgery excluding SCS, spinal injections, physical therapy, occupational therapy, massage, back brace/corset, psychological therapy, ultrasound, and bedrest were reported. Spinal injections were provided to 27% of patients in the SCS group, 32% in pain clinic group, and 33% in usual care. Consequently, it is not well understood what the differences between pain clinic and usual care were.

Further, the study lacks randomization with significant concerns about the bias with implication that workers' compensation patients could only get the therapy if they were in the study and multiple confounding factors without appropriate matching of cohorts. The primary outcome measure was also created by the authors and was composite score of opioid reduction, a functional measure and leg pain.

In the follow-up evaluation of costs and cost effectiveness of SCS for FBBS (2061) in the workers' compensation population Hollingworth et al analyzed the data. After adjusting for costs, including productivity loss, the mean cost for SCS was $99,438, the cost for a pain clinic was $79,364, and for usual care was $70,080. Overall, incremental costs were higher for SCS. Medical costs alone were $52,091 for SCS, $34,800 for a pain clinic treatment, and $23,964 for usual care. While this assessment concludes that SCS is not cost effective, some of the cost ratios are unusually high in the pain clinic group specifically for office visits. There were no significant differences between medication costs. As described above, ths study has been criticized for design and outcome measures.

The cost effectiveness of SCS has been performed in FBSS (2009,2010,2056). Taylor et al (2009) found that initial health care acquisition costs were offset by a reduction in post implant health care resource demands and costs. Mean 5-year costs were $29,123 in the intervention group compared to $38,029 in the control group for FBSS. Taylor et al (2056) in an updated cost effectiveness evaluation published in 2010 utilized the cost-utility model developed for the NICE Technology Appraisal (2063) to compare the cost effectiveness of SCS versus CMM and SCS versus reoperation. They showed the incremental cost effectiveness of SCS compared with CMM was £5624 (USD 8364) per quality-adjusted life year, with 89% probability that SCS is cost effective at a willingness to pay threshold of £20,000 (USD 29,746). They also showed that compared with reoperation, the incremental cost-effectiveness of SCS was £6392 (USD 9,506) per quality-adjusted life year, with 82% probability of cost-effectiveness at the £20,000 (USD 29,746) threshold. Furthermore, the results showed that when the longevity of a rechargeable implanted pulse generator is 4 years or less, a rechargeable (and initially more expensive) implanted pulse generator is more cost-effective than a nonrechargeable implanted pulse generator. They concluded that in selected patients with FBBS, SCS is cost effective both as an adjuvant to CMM and as an alternative to reoperation.

Other investigators also showed similar findings illustrating the cost effectiveness of SCS even though initial health care acquisition costs are higher than other treatments (2010-2014,2031).

1.2 Analysis of Evidence

The indicated evidence for SCS is fair for long-term relief in managing patients with FBSS.

1.3 Complications

The most common adverse event reported

in the literature is lead migration followed by lead fracture and infection at the incision site of an implantable pulse generator or in the surgical pocket (35,505,507,508,2005-2025,2039-2043,2048,2055,2057,2061,2063-2072). Overall up to 34% of SCS patients may experience an adverse event (2006).

1.4 Recommendations

SCS is indicated in chronic low back pain with lower extremity pain secondary to FBBS, after exhausting multiple conservative and interventional modalities.

2.0 Implantable Intrathecal Drug Administration Systems

Intrathecal infusion systems are most commonly used in the treatment of recalcitrant chronic cancer or non-malignant pain after all other methods have failed including conservative and surgical treatment. The use of intrathecal pumps has come under criticism by some based on the American College of Occupational and Environmental Medicine (ACOEM) and American Pain Society (APS) guidelines that claim there is a lack of effectiveness based on a lack of randomized trials (150,2073-2076). However, these guidelines have come under scrutiny due to their incomplete review of the literature and exclusion of recent high quality published studies, outdated assessment criteria, inconsistent conclusions, and failure to comply with current standards for producing high quality objective guidelines for various interventional techniques (103,112,115,150,2074-2076).

Hayek et al (225) in a systematic review on intrathecal therapy for cancer and non-cancer pain in 2011 concluded that intrathecal therapy is moderately effective and safe in controlling refractory painful conditions that have failed multiple other treatment modalities, both in cancer and non-cancer related conditions. They also noted that the recommendation for intrathecal infusion systems is limited to a moderate recommendation for non-cancer pain based on the current moderate evidence derived from 15 observational studies for chronic non-cancer pain. They subsequently concluded that intrathecal drug delivery remains a valuable therapy for chronic painful conditions, both cancer and non-cancer related, and is often employed as a last resort.

In updated practice guidelines (128) for chronic pain management published in 2010 by the American Society of Anesthesiologists (ASA) Task Force on Chronic Pain Management and the American Society of Regional Anesthesia and Pain Medicine (ASRA), intrathecal injection or infusion for neuropathic pain were shown to provide up to 12 months of pain relief.

Patel et al (2077), in a 2009 systematic review on intrathecal infusion systems for the long-term management of chronic non-cancer pain, concluded that there was limited evidence for intrathecal infusion systems providing long-term pain relief in chronic non-cancer pain. Although the evidence was limited based on 4 observational studies, their recommendation was strong for the use of intrathecal infusion systems for the treatment of chronic non-cancer pain.

Falco et al (27), in an update of the previous systematic by Patel (2077), utilized 7 non-randomized studies all meeting inclusion criteria. They provided limited evidence for the effectiveness of intrathecal infusion systems in managing chronic non-cancer pain.

Oral opioids, which have been used extensively for all types of pain continue to escalate in terms of usage, side effects, complications, and fatalities including deaths which exceed motor vehicle injuries (84-92,2078-2097). Consequently, various types of intrathecal infusion systems have been developed for the management of chronic intractable pain with opioids and other agents (27,225,262,277,898,1506,2077,2098-2112). Even then, there is a paucity of literature in reference to intrathecal infusion systems for long-term management of chronic non-cancer pain with a lack of randomized trials. Systematic reviews must be updated frequently in today's atmosphere of increased understanding and constant availability of new information (331,332,2101).

Multiple systematic reviews utilized variable methodologies and inclusion criteria. However, a common theme among all the systematic reviews is that there is a paucity of good quality publications for intrathecal infusion therapy, especially for chronic, noncancer pain. While the literature has significant heterogeneity of patient types, medications, and devices, all of them conclude that there is effective pain relief. Apart from the systematic reviews described by Patel et al (2077), Hayek et al (225), and Falco et al (27), Noble et al (2103) included 16 studies with 2,801 patients. Their outcomes showed 25% relief in 56.3%, and 50% relief in 40.8% of patients. The findings were inconsistent overall in reference to QOL, functional status, employment status, and use of other medications. They also showed a reoperation rate of 9% to 42%. Their conclusion was that in

many aspects, the effectiveness data of intrathecal pumps for chronic noncancer pain from uncontrolled case series showed inconsistent findings. Turner et al (506) in a systematic review included 6 observational studies meeting the inclusion criteria. They showed that pain improved on average across all studies, but with increased opioid consumption over time, and significant complications. Overall the results lead to an unclear determination in reference to long-term effectiveness.

Waara-Wolleat et al (2104) assessed the effectiveness of intrathecal fentanyl and sufentanil, concluding that sufentanil did not produce lower extremity edema as opposed to morphine. A limited number of studies with a small number of subjects suggest that intrathecal infusion of lipophilic opioids is generally effective and well tolerated, but that more studies are recommended.

Simpson et al (2105) in a systematic review looked at intrathecal opioids with controlled studies and case series. Overall, they found one RCT, 6 case series, and 3 cost studies. The conclusion was that intrathecal infusion for pain and spasticity appears effective for prescreened patients. However, drug and device complications are common.

Table 10 of the systematic review by Falco et al (27), Table 4 of the systematic review by Patel et al (2077), and Table 12 of the systematic review by Hayek et al (225) showed the descriptive characteristics of various studies included.

Our literature search yielded no additional studies.

2.1 Evidence Assessment

Seven observational studies (2102,2106-2111) met the inclusion criteria.

Deer et al (2102) in a 2004 publication obtained data on patient demographics, clinical practices, and long-term outcomes for patients with chronic low back pain treated with implantable drug-delivery systems (IDDS). Thirty-six physicians enrolled 166 patients to be trialed for drug-delivery systems, with 154 of them receiving pump implantation. The IDDS group experienced a statistically significant reduction of numeric pain ratings when ratings were compared between baseline and 6 months and between baseline and 12 months. The numeric pain rating was reduced by more than 48% for back pain and 32% for leg pain at 12 months. At baseline, nearly 30% of the IDDS group had an Oswestry Disability Index in the minimal to moderate disability range and 60% were in the severe disability range. By the 6 month follow-up, there were 65% in the minimal to moderate disability range. At the 12 month follow-up, 73% were in the minimal to moderate disability range. Those in the severe disability range decreased to 30% and 22%, respectively, at the 6 and 12 month follow-up. At 12 months, 42% of the IDDS patients had reduced their use of oral opioids. At the 12 month follow-up, 87% of the IDDS group stated a fair to excellent QOL, 80% were satisfied with the IDDS, 87% would repeat the implant, and 87% would recommend IDDS to a friend or family member. Adverse events were reported in 23 patients receiving an IDDS implant and 21 required surgery to correct the problem. Adverse events included infection, dislodgment/migration, and cerebrospinal fluid (CSF) leak. The most common adverse event was a reaction to the medication. Other reported events that were infrequent included catheter kinking and fractures. This study found that IDDSs are successful in managing chronic low back pain in patients who have not found effective relief with other therapies.

Roberts et al study (2106) assessed 88 patients with chronic non-cancer pain on average for 9.8 years following treatment with intrathecal opioids for an average duration of 3 to 4 years. All patients who had been treated with intrathecal opioids by implanted drug administration systems for at least 6 months were included and evaluated by a self-administered questionnaire. The mean global pain relief was 60% and 74% of patients reported an increase in activity levels post IDDS implant. Opioid consumption as measured by the Medication Quantification Scale (MQS) was 31.2 ± 2.6 prior to IDDS and 12.7 ± 1.4 ($P < 0.0001$). There was no change in work status. The mean intrathecal morphine dose increased from 9.95±1.49 mg/day at 6 months to 15.26 ± 2.52 mg/day at 36 months after initiation of therapy, suggesting that intrathecal opioid therapy is not significantly affected by the development of tolerance.

Multiple side effects and complications included catheter dislodgement, occlusion, nerve root irritation; pump malfunction; leakage; pocket hematoma; wound infection; epidural hematoma; and other complications with seating, weight gain, decreased concentration, cognition, or memory, nausea and vomiting, arthralgia, peripheral edema, pruritus, decreased libido, erectile dysfunction, and menstrual abnormalities.

In 1996, Winkelmüller & Winkelmüller (2108) evaluated the long-term effects of continuous intrathecal opioid treatment for chronic pain of nonmalignant etiology. Patients had neuropathic as well as nociceptive and mixed types of pain (the majority of patients – 73 of 120, had pain arising from lumbar spinal surgeries). The follow-up period was from 6 months to 5.7 years, with only 36 patients followed up for > 4 years. The deafferentation pain and neuropathic pain showed the best results on a long-term basis with 62% to 68% reduction in pain. Thirty-one or 25.8% of the 120 cases were considered treatment failures. Throughout the follow-up period, 74.2% of patients benefited from the intrathecal opioid therapy, with an average pain reduction after 6 months of 67.4% and, as of the last follow-up examination, it was 58.1%. Ninety-two percent of the patients were satisfied with the therapy and 81% reported an improvement in their QOL.

Although the authors describe a lengthy follow-up period ranging from 6 months to 5.7 years, it is not clear how many patients had been followed up for more than 12 months. The last follow-up period is mentioned in several of the parameters but is not clearly defined. Based on the review of the data, it appears that 36 patients received intrathecal opioid medications for a period of more than 4 years. Furthermore, there were multiple complications with undesirable incidents and failures. They removed 25 pumps for various reasons. Twenty-six percent of the cases were considered as treatment failures. The overall success rate in 89 of the 120 patients benefiting from continuous opioid therapy over an observation period of 0.5 to 5.7 years is highly variable.

Thimineur et al (2107) evaluated the long-term outcome of intrathecal opioid therapy in chronic non-cancer pain prospectively and included 2 comparative groups. Data analysis suggests the study group of pump participants had improvements in pain, mood, and function from baseline to 36 months. However, the average reductions in pain in this study were less impressive than several previous investigations. The authors have not described the proportion of patients with significant pain relief of 50% or more. They concluded that intrathecal opioid therapy for non-cancer pain should be considered appropriate only when all other conservative medical management has been exhausted. Further confounding factors in this study included opioid medication administered to the recipients, along with injection treatments.

Rauck et al (2109) evaluated 110 patients in a prospective, non-randomized, open-label, multi-center (7 sites) investigational device exemption study approved by the FDA for the Prometra® IDDS. There were 107 patients with chronic nonmalignant pain with a numeric rating scale (NRS) score ≥ 4, and/or those requiring a pump replacement that had documented pain relief with intrathecal morphine infusion. The primary endpoint was to evaluate the cumulative accuracy of drug delivery as determined by the ratio of the delivered to programmed drug volume (DP ratio) for all refills per patient with a 90% CI within 85% - 115%. The secondary endpoints consisted of efficacy, VAS, NRS, ODI, and serious adverse events (SAEs). The mean accuracy of the Prometra pump was 97.1%, with a 90% CI of 96.2 - 98.0%. Decreases in pain and disability were reported at 68.4% of patient visits. No unanticipated adverse events or device complications were reported. The authors concluded that the Prometra pump provides an accurate, effective, and safe system for intrathecal administration of morphine sulfate for treatment of chronic intractable pain.

There was also a complication rate of 25.5% including infection, hematoma, pain, abscess, nausea and vomiting, drug withdrawal syndrome, temporary paralysis, catheter migration, catheter tear or break, pump migration, catheter occlusion, and pump flip.

Veizi et al (2110) examined the effect of intrathecal co-administration of bupivacaine with opioids during the initial phase of opioid titration and up to one year after implantation of an IDDS. There were 2 cohorts with 72 patients infused with an opioid (O) (morphine or hydromorphone) as a single medication and 54 patients infused with an opioid (O) (morphine or hydromorphone) and a local anesthetic bupivacaine (O+B).

There was a significant reduction in pain intensity in the O and O+B groups at 12 months. The O group average pain improved significantly from baseline with an average of 7.42 ± 2.1 to 5.85 ± 2.8 ($P < 0.001$) at 12 months. The O+B group average pain also improved significantly from baseline with an average of 7.35 ± 2.0 to 5.03 ± 2.4 ($P < 0.001$) at 12 months. There was no significant difference in the degree of pain relief between the 2 groups ($P = 0.09$). The combination of opioids with bupivacaine (O+B) from the start of intrathecal infusion treatment resulted in a reduced progression of opioid dose escalation in comparison to patients started with opioids (O). The rate of increase of intrathecal opioids in the O group at 12 months was 535 ± 180% compared

to the O+B group where the dose increase was significantly lower at 185 ± 85% ($P < 0.004$).

In both groups, there was a statistically significant decrease in oral opioid consumption compared to preimplant doses. The average morphine equivalent daily dose (MEDD) at baseline was 138 ± 112 and 126 ± 87 mg/day in the O and O+B groups respectively. Oral opioid doses in the O cohort decreased to postimplant values of 100 ± 173 mg at 3 months, 81 ± 104 at 6 months, and 64 ± 93 at 12 months ($P < 0.001$). The average MEDD in the O+B cohort at postimplant also declined significantly to 126 ± 87 mg/day at 3 months, 108 ± 124 mg/day at 6 months, and 72 ± 102 mg/day at 12 months ($P = 0.0.01$). There was no difference in the opioid dose decrease between the O and O+B groups over the 12 months ($P = 0.18$).

The authors in this study demonstrated that the addition of bupivacaine to opioids from the onset of intrathecal infusion therapy resulted in the reduction of opioid dose escalation in patients with chronic nonmalignant pain. In addition, there was a significant reduction in the use of oral opioids.

Hamza et al (2111) evaluated 58 consecutive patients in a 3 year prospective study to determine the efficacy of low dose intrathecal opioids with pump implantation for the treatment of chronic noncancer pain. The implanted patients were assessed at baseline and at 6 month intervals post operatively ending at 36 months utilizing the Brief Pain Inventory (BPI) and Patient Global Assessment (PGA).

There was substantial improvement in all of the BPI outcome measures ($P < 0.001$) from baseline to 36 months, which encompassed BPI worst and average pain, BPI physical function scale (BPI-PFS), BPI behavior scale (BPR-BS), and BPI enjoyment scores. The PGA from baseline to 36 months demonstrated a reduction in pain by 65.2% (range 20% - 95%, SD [standard deviation] = 21.8%); and an improvement in function by 42.7% (range 10% - 80%, SD = 19.4%). Although there was a statistically significant increase in the intrathecal dose from 6 to 36 months ($P < 0.001$), the average increase was only 11.4% over 3 years. Oral consumption of opioids was considerably reduced at 3 months post implant compared to baseline ($P < 0.001$) from 126.71 mg/day (95% CI = 100.83 - 152.58 mg/day, standard error [SE] = 12.92) to 3.80 mg/day (CI = 2.01-5.60, SE = 0.90). This was a 97% reduction in the use of oral opioids at 3 months, which remained unchanged over the 3 years of follow-up.

This study showed that long-term low dose intrathecal opioid pump therapy can be very effective in controlling chronic noncancer pain. There was substantial and sustained pain relief and functional improvement. In addition, there was only a small increase in intrathecal opioids over the 3 year period and a large reduction in the use of oral opioids.

Among the studies not meeting inclusion criteria, Deer et al (2113) compared the effectiveness of a combination of bupivacaine with opioids and opioid alone. Their patient population included non-cancer as well as cancer pain patients (with spinal metastases). The majority of patients, however, had non-cancer pain (back and leg pain after unsuccessful back surgery). Patients served as their own comparison arm as they were on opioid alone prior to the inclusion of bupivacaine. All but one patient experienced some reduction in pain as well as need for opioids via other routes. Use of non-opioid medications was also reduced but was statistically insignificant. The authors concluded that in patients treated with intrathecal opioids, the addition of bupivacaine may improve outcomes.

A study by Duse et al (2114) prospectively evaluated the effects of chronic intrathecal morphine delivery on emotional variables affecting pain perception and functioning in patients with severe chronic non-cancer pain involving the low back and/or lower extremities. Of 42 patients evaluated, 30 were implanted with an IDDS after a successful epidural morphine infusion trial. Significant progressive improvements were noted in the affective, evaluative, sensory, and mixed components of the MPQ. Good to excellent satisfaction was reported in 29 of the 30 implanted patients, activities of daily living were improved in 26 patients and 12 patients were able to return to full-time employment. No significant complications were noted.

A study by Atli et al (2115) retrospectively examined charts of 57 patients, 55 with non-cancer pain. There was a statistically significant decrease in VAS pain scores at one, 2, and 3 years post-implant. A clear trend of temporal decrease in percentage of patients with > 50% pain relief and those with > 30% pain relief emerged, such that by the end of 3 years post-implant 18% of patients experienced > 50% pain relief and 37% had > 30% pain relief. Oral opioid consumption was decreased significantly throughout the 3-year follow-up and 24% of patients had ceased all oral opioid consumption. Of note, higher initial oral

opioid consumption was correlated with lower likelihood of long-term pain relief with intrathecal opioids.

Shaladi et al (2116) studied a group of older patients with severe osteoporosis and recent vertebral fracture with intrathecal morphine using a specific evaluation questionnaire for such populations with the Questionnaire of the European Foundation of Osteoporosis (QUALEFFO) on which a maximum score of 150 indicates poor health. The mean functional score QUALEFFO before trial was 114.7. After pump implant the mean QUALEFFO score had fallen to 92.1, and, after one year, the mean QUALEFFO score fell to 79.1. Considering that the pain from a recent vertebral fracture may normally improve after 6 months to a year, the contribution of the pump implant to the reduction in pain scores in this study is unclear. In addition, vertebroplasty and kyphoplasty are less expensive options compared to an intrathecal infusion pump. Thus, intrathecal morphine for vertebral fractures may have limited applications to patients who are not candidates for vertebral augmentation procedures.

A Canadian study also demonstrated the cost effectiveness of intrathecal infusion devices. Kumar et al (2012) looked at the cost of implanting a programmable drug delivery pump versus conservative treatment of chronic pain. Their population consisted of failed back syndrome patients. Successful outcomes were measured using the pain scale, ODI, and QOL. The cumulative costs for intrathecal drug delivery during a 5-year period were $29,410, as opposed to $38,000 for conservative treatments. High initial costs of equipment required for intrathecal drug delivery were recovered by 28 months. After this time, managing patients with conservative treatments became more expensive for the remainder of the follow-up period. The ODI showed a 27% improvement for patients in the intrathecal drug delivery group, compared with a 12% improvement in the control group. This is an important finding and may help justify the initial cost of the implantable pump system. However, considering the life of the programmable pump, there is obviously a high added cost for maintaining this treatment option beyond the initial life of the pump for the patient's life span.

Cost effectiveness also was assessed (2112). In post lumbar surgery syndrome, it was shown that intrathecal morphine delivery resulted in lower cumulative 60-month costs of $16,579 per year and $1,382 per month versus medical management at $17,037 per year or $1,420 per month (2112), a relatively small difference.

Overall, all the observational studies have shown a long-term benefit from intrathecal infusion devices used for chronic non-cancer pain, as illustrated in Table 42.

2.2 Analysis of Evidence

The evidence for intrathecal infusion systems is limited for long-term relief of chronic non-cancer pain.

2.3 Complications

Complications related to intrathecal therapy can be technical, biological, or medication related. While the vast majority of complications are minor, some serious complications can occur (27,225,506,2077,2099-2100,2102-2154). An increased mortality rate in patients with non-cancer pain receiving intrathecal opioid therapy (mortality rate of 0.088% at 3 days after implantation, 0.39% at one month, and 3.89% at one year) was identified as likely related to the opioids as well as other factors that may be mitigated especially at the start of therapy (2146,2147). Other serious complications include granuloma formation that may be related to the amount and concentration of opiates, mostly morphine and hydromorphone (2138,2148-2152). Surgical interventions in these cases are rare (2153) as most cases improve with weaning off of the intrathecal opiate, replacing it with preservative-free saline, which has been shown to reverse the course leading to resolution of the granuloma (2148,2149). Granulomas may occur in as many as 3% of implanted patients and most are asymptomatic (2154). Routine MRI to rule out intrathecal granulomas was not recommended by the authors of this prospective study given the relatively low incidence (2154). The earliest sign of granuloma may be increased pain despite increasing opiate infusion; hence, clinical vigilance is of prime importance. Other complications of IDDS include catheter kinking, catheter fracture/leakage, catheter migration, CSF leak, seroma, hygroma, infection, pump erosion through the skin, and medication side effects including, but not limited to, pruritus, nausea, vomiting, respiratory depression, and cognitive side effects.

2.4 Recommendations

Intrathecal infusion systems are indicated in recalcitrant non-cancer pain with post surgery syndrome.

Table 42. *Results of published studies of effectiveness of intrathecal infusion systems.*

Study Study Characteristics Methodological Quality Scoring	Participants	Outcome Measures	Pain Relief and Function		Results	
			< 12 mos.	≥ 12 mos.	Short Term Relief < 12 mos.	Long Term Relief ≥ 12 mos.
Deer et al, 2004 (2102) O 8/12	166 patients	Numeric pain ratings and ODI scores.	↓ Pain ↑ Function	↓ Pain ↑ Function	N/A	P
Roberts et al, 2001 (2106) O 8/12	88 patients	Global pain relief and physical activity, medication consumption, work status.	↓ Pain ↑ Function	↓ Pain ↑ Function	N/A	P
Thimineur et al, 2004 (2107) O 8/12	38 intrathecal pump recipients and 31 intrathecal candidates who had an unsuccessful trial or declined the IT therapy, and another group of 41 patients that were newly referred.	SCL-90-R, SF-36, BDI, MPQ, ODI, pain drawing, and pain rating.	N/A	↓ Pain ↑ Function	N/A	P
Winkelmüller and Winkelmüller, 1996 (2108) O 8/12	120 patients	VAS, level of activity, patients' mood, and quality of life were also evaluated.	↓ Pain ↑ Function	↓ Pain ↑ Function	N/A	P
Rauck et al, 2010 (2109) O 8/12	110 patients	VAS, NRS ODI, adverse events	↓ Pain ↑ Function	N/A	P	N/A
Veizi et al, 2011 (2110) O 8/12	126 patients	Pain scores/VAS, oral opioids intake, IT opioid dose, IT medications type and rate, pain intensity scores.	↓ Pain	↓ Pain	P	N/A
Hamza et al, 2012 (2111) O 8/12	58 patients	Pain scores, oral opioids intake, IT opioid dose, BPI (physical functioning, behavior, enjoyment), and (behavior), PGA (pain and functional improvement)	↓ Pain ↑ Function	↓ Pain ↑ Function	P	P

O = Observational; IT = Intrathecal; P = Positive; N = Negative; N/A = Not Applicable; ODI = Oswestry Disability Index; SCL-90-R = Symptom checklist 90-R; VAS = Visual Analog Scale; SF-36 = Short-form 36; BDI = Beck Depression Inventory; MPQ = McGill Pain Questionnaire; VAS = Visual Analog Scale; NRS = Numerical rating scale; BPI = Brief Pain Inventory; PBA = Patient Global Assessment
Adapted and modified from: Falco FJE et al. Intrathecal infusion systems for long-term management of chronic non-cancer pain: An update of assessment of evidence. *Pain Physician* 2013; 16:SE185-SE216 (27).

IX. AN ALGORITHMIC APPROACH

The algorithmic approach described here is based on the best available evidence on the epidemiology of various identifiable sources of chronic spinal pain (8,2155). This algorithmic approach is designed to promote the efficient use of IPM techniques based on the best available evidence. However, this may not be applicable in each and every patient. The purpose of the described algorithmic approach is to provide a disciplined approach to the use of spinal interventional techniques in managing spinal pain. This approach includes evaluation, diagnostic, and therapeutic approaches, which in turn avoid unnecessary care as well as poorly documented practices.

This algorithmic approach does not dictate standard of care — these are guidelines. Furthermore, with space constraints, comprehensive initial evaluations and all the findings are not provided. Thus, this should not be construed as the entire evaluation. Only relevant descriptions are provided.

1.0 Comprehensive Algorithm

Figure 8 illustrates an algorithmic approach for evaluation and management of a chronic pain patient (8,128). Appropriate history, physical examination, and medical decision-making are essential to the provision of appropriate documentation and patient care. Not covered in this algorithm are socioeconomic issues and psychosocial factors that may be important in the clinical decision-making process. A comprehensive and complete evaluation will assist in complying with regulations, providing appropriate care, and fulfilling an algorithmic approach.

2.0 Low Back Pain

2.1 Diagnosis

Figure 9 illustrates a diagnostic algorithmic approach for chronic low back pain without disc herniation (8,2155). For confirmed disc herniation, radiculitis, or spinal stenosis, diagnostic approaches depend on symptoms, signs, and radiologic evaluation. Thus, this algorithmic approach for chronic low back pain without disc herniation is based on the best available evidence on the epidemiology of various identifiable sources of chronic 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 (8,11,13,15,17,33,36-38,644,1250,1325,1469,1471,2155).

If there is evidence of radiculitis, spinal stenosis, or other demonstrable causes resulting in radiculitis, one may proceed with diagnostic transforaminal or therapeutic epidural injections (8,644,2155). Otherwise, an algorithmic approach should include diagnostic interventions with facet joint blocks and sacroiliac joint injections, followed by discography. At the present time, lumbar discography time suffers from significant controversy with fair evidence (36). In contrast, there is good evidence to support facet joint nerve blocks in the diagnosis of lumbar facet joint pain and sacroiliac joint injections (11,17).

An algorithm for investigating chronic low back pain without disc herniation commences with clinical questions, physical findings, and findings of radiological investigations (8,374,2155). Controlled studies have illustrated the prevalence of lumbar facet joint pain in 15% to 45% of patients and false-positive rates of 27% to 45% of patients with chronic low back pain (11). An average prevalence of 31% (95% CI; 28% - 33%) and false-positive rate of 30% (95% CI; 27% - 33%) was shown in a systematic review (1250). Thus, facet joints are entertained first in the algorithm because of their commonality as a source of chronic low back pain, available treatment, and ease of performance of the blocks. Furthermore, among all the diagnostic approaches in the lumbosacral spine, medial branch blocks have the best evidence of accuracy with their ability to rule out false-positives and demonstrated validity with multiple compounding factors, including psychological factors, exposure to opioids, and sedation (11,1250). In this approach, the investigation of facet joint pain is considered as a prime investigation, ahead of disc provocation and sacroiliac joint blocks. Multiple studies have indicated that facet joint pain may be bilateral in 60% to 79% of cases and involving 3 joints in 21% to 37% of patients (11,12,255,1250,1345-1347,1387).

Diagnostic blocks must be performed under controlled conditions. In the United States, commonly performed diagnostic blocks are often accomplished with 2 separate local anesthetics – in what is referred to as controlled comparative local anesthetic blocks with a small volume of local anesthetic. If a patient experiences at least 75% relief with the ability to perform previously painful movements within a timeframe that is appropriate for the duration of the local anesthetic used and the duration of relief with the second block relative to the first block is commensurate with the respective local anesthetic employed in each block, then, a positive diagnosis is made. However, based on patient condition and regulations, the criterion standard of

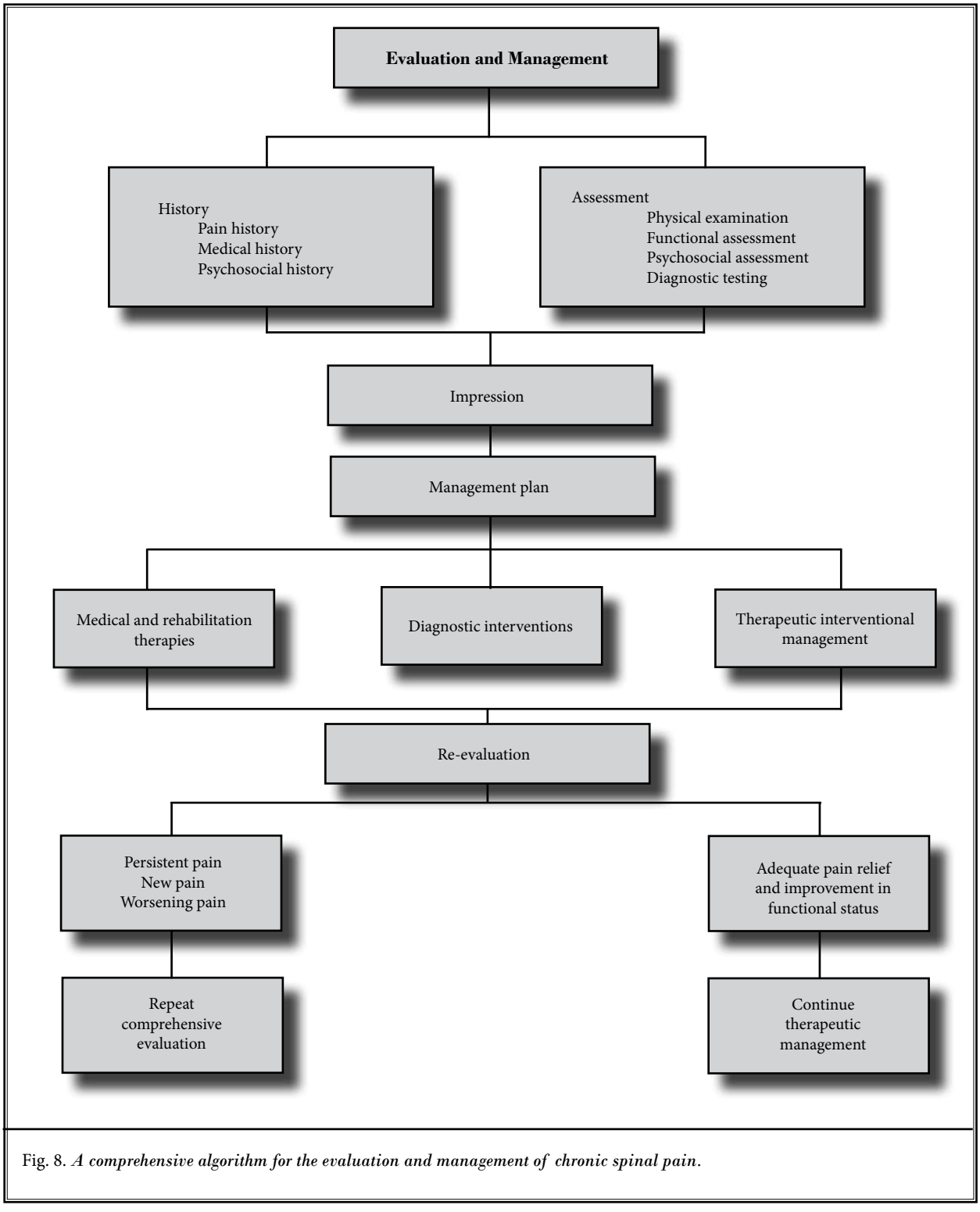


Fig. 8. *A comprehensive algorithm for the evaluation and management of chronic spinal pain.*

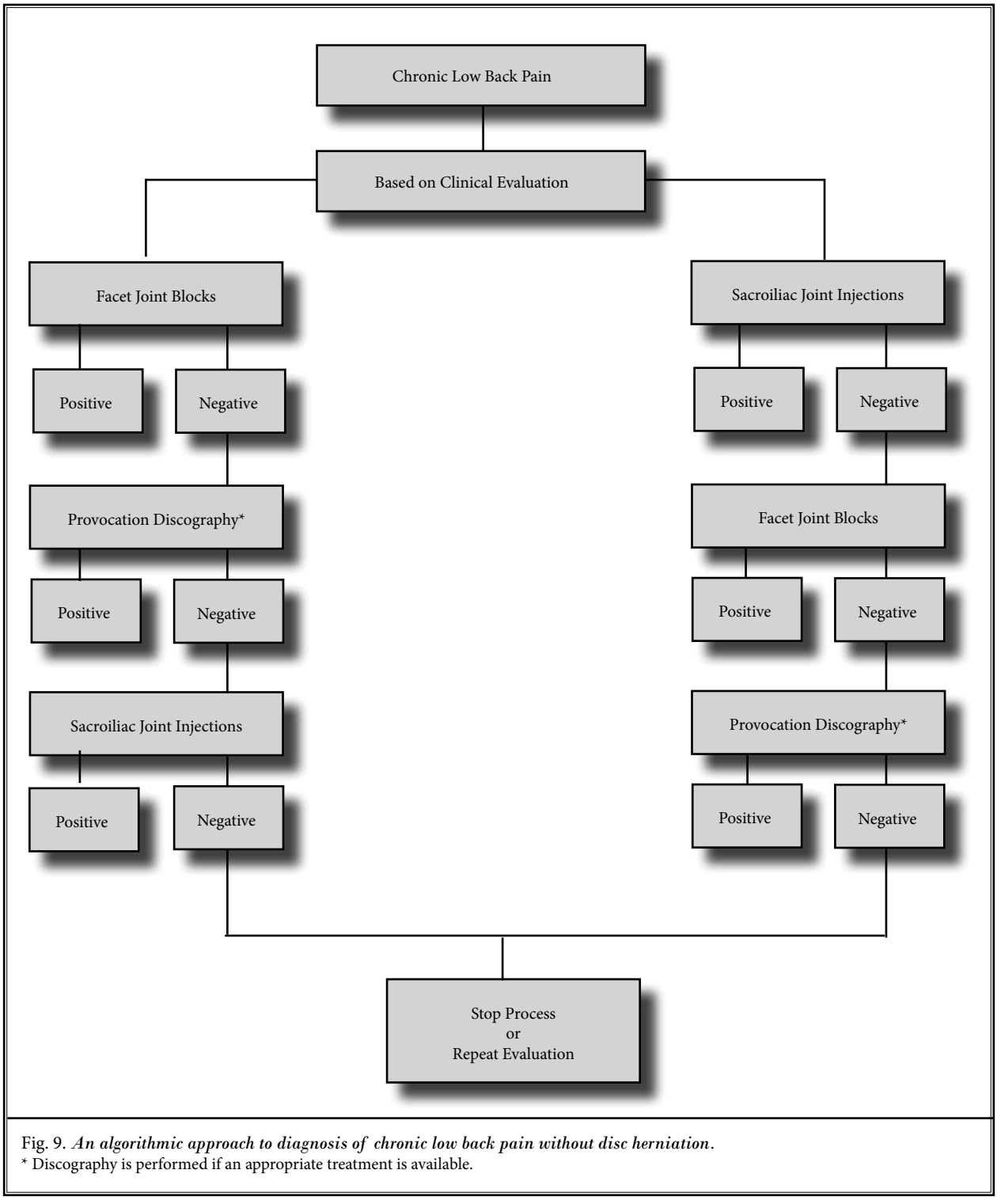


Fig. 9. *An algorithmic approach to diagnosis of chronic low back pain without disc herniation.*
* Discography is performed if an appropriate treatment is available.

pain relief and either a single block or double block paradigm is changed.

In this algorithm, to pursue the sacroiliac joint as the pain generator, pain must be caudal to L5 and must be positive for at least some provocative tests, along with tenderness over the sacroiliac joint (8,17,1461). Sacroiliac joint blocks have a good evidence of accuracy in the diagnosis of sacroiliac joint pain utilizing comparative controlled local anesthetic blocks. The prevalence of sacroiliac joint pain is estimated around 25% using a double block paradigm with false-positive rates of single, uncontrolled, sacroiliac joint injections of approximately 20%.

One or both sacroiliac joints may be blocked utilizing controlled comparative local anesthetic block paradigms. The relief obtained should be 75% with the ability to perform previously painful movements and also should be concordant based on the local anesthetic injection with a bupivacaine injection outlasting a lidocaine injection (11,17). However, based on patient condition and regulations, the criterion standard of pain relief and either a single block or double block paradigm is changed.

If pain is not suggestive of facet joint or sacroiliac joint origin, then the epidural injection algorithm is followed (8,10,11,17,28,30,33). Caudal and lumbar interlaminar epidurals are non-specific as far as identifying the source of pain. If a patient fails to respond to epidural injections, the discogenic approach may be undertaken.

Lumbar provocation discography is seldom performed as an initial test in the present algorithm. Provocative lumbar discography is performed as the first test in only specific settings of suspected discogenic pain and availability of a definitive treatment is offered or solely for diagnostic purposes prior to fusion. Otherwise, once facet joint pain, and if applicable sacroiliac joint pain, is ruled out and the patient fails to respond to at least 2 fluoroscopically directed epidural injections, discography may be pursued if determination of the disc as the source of pain is crucial. MRI will assist in ruling out any red flags and disc herniation, but will not determine if the disc is the cause of the pain. Hancock et al (375) in a systematic review of tests designed to identify the disc as a pain generator concluded that centralization was the only clinical feature associated with a discogenic pain etiology (390). Provocation discography continues to be controversial with respect to diagnostic accuracy and its impact on surgical volume (39). Lumbar discography has been refined substantially since its inception and its diagnostic accuracy is fair (39). However, to be valid, the provocation discography must be performed utilizing strict criteria of having concordant pain in one disc with at least 2 negative discs, one above and one below except when the L5/S1 is involved. In that case, only one negative disc is needed along with the suspect disc (L5/S1 in this case) displaying evoked intensity of a pain score of 7 on a scale of 0 to 10 or 70% of worst spontaneous pain (i.e., worst pain of 7 = 7 x 70% = 5) (8,39,379,567,1471,2155).

2.1.1 Diagnostic Efficiency

Under the present algorithmic approach, once facet joint pain is excluded, the patient may be treated with epidural injections or sacroiliac joint blocks may be pursued provided the patient meets the criteria for sacroiliac joint blocks. Lumbar provocation discography is the last step in the diagnostic algorithm and is utilized only when appropriate treatment can be performed if disc abnormality is noted (8,2155). The only other indication is to satisfy patients' impressions if the patient does not improve with any other modalities of treatments.

Based on the available evidence, it appears that lumbar facet joints account for 30% of cases, sacroiliac joint pain accounts for less than 10% of cases, and discogenic pain accounts for 25% of the patients with chronic low back pain without disc herniation or spinal stenosis.

2.2 Management Algorithm

2.2.1 Radicular Pain Algorithm

Even though, disc protrusion, herniation, and prolapse resulting in sciatica are seen in less than 5% of the patients with low back pain (374,554,1559), many patients with post surgery syndrome, spinal stenosis, and radiculitis without disc protrusion may respond to epidural injections (8-10,28,30,31,722,765,766,906,968,1037,1038,1759). Patients non-responsive to epidural injections will require either mechanical disc decompression (21-24), percutaneous adhesiolysis (19), or implantation of a spinal cord stimulator (8,35) or intrathecal infusion systems (8,27) depending on the clinical presentation, pathology, and other biopsychosocial factors.

Based on the comprehensive literature and available evidence, there is good evidence for caudal epidural injections, lumbar interlaminar epidural injections, and lumbar transforaminal epidural injections in managing radicular pain or disc herniation (28,30,31). In addition, the evidence is fair for caudal, lumbar interlaminar, and transforaminal epidural injections in managing spinal stenosis. The evidence for post surgery syndrome is fair for

caudal epidural injections and limited for transforaminal epidural injections. The evidence for lumbar interlaminar epidural injections in post surgery syndrome is not available. The evidence assessment is based on contemporary practice in interventional pain management settings for all the procedures performed under fluoroscopy.

Consequently, a patient without previous surgical intervention with unilateral, single, or 2 level involvement may be treated with transforaminal, caudal, or interlaminar approaches. However, bilateral or involvement of multiple segments will lead to either interlaminar or caudal epidural injections based on the upper or lower levels being involved. In case of extensive stenosis or lack of response to caudal or interlaminar approaches, transforaminal epidural approach may be appropriate.

2.2.2 Somatic Pain Algorithm

Figure 10 illustrates therapeutic algorithmic management. The patients testing positive for facet joint pain may undergo either therapeutic facet joint nerve blocks or radiofrequency neurotomy based on the patients' preferences, values, and physician expertise. However, there is only limited evidence for lumbar intraarticular facet joint injections (12). In contrast, based on the review of included therapeutic studies the evidence is fair to good for lumbar facet joint nerve blocks and good for lumbar radiofrequency neurotomy (12).

The next modality of treatment is epidural injections. Epidural injections show variable evidence in managing axial or discogenic pain (28,30,31). The assessment of the evidence from these guidelines and systematic reviews (28,30,31) is fair with caudal and interlaminar epidural injections and limited with transforaminal epidural injections in managing axial or discogenic pain without disc herniation, radiculitis, facet joint pain, or sacroiliac joint pain.

The evidence for therapeutic sacroiliac joint interventions is fair for cooled radiofrequency neurotomy, and limited for intraarticular injections, periarticular injections, conventional radiofrequency neurotomy, and pulsed radiofrequency neurotomy.

The assessment of evidence for intradiscal procedures shows limited to fair evidence for IDET and biaculoplasty, whereas it is limited for discTRODE.

2.3 Algorithm for Chronic Non-Responsive Pain

Patients non-responsive to epidural injections may be considered for mechanical disc decompression,

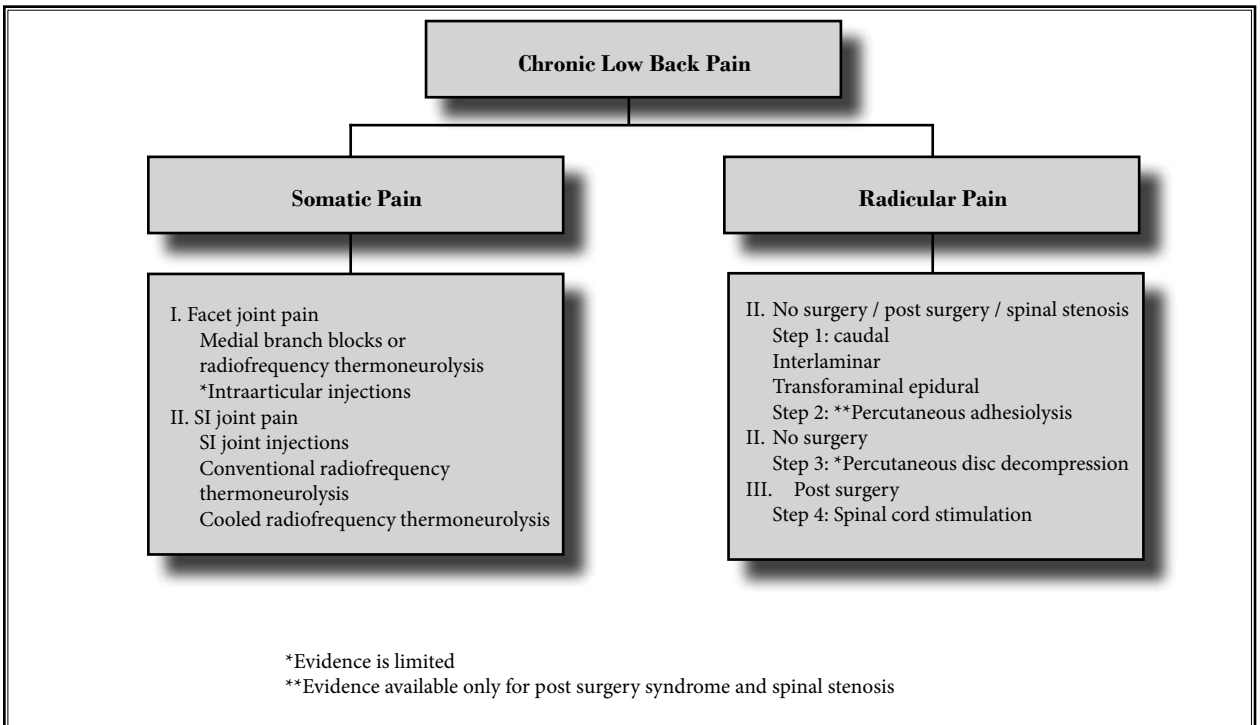


Fig. 10. *A suggested algorithm for therapeutic interventional techniques in management of chronic low back pain.*

percutaneous adhesiolysis, spinal cord stimulation, or implantation of intrathecal infusion systems.

Percutaneous mechanical disc decompression includes APLD, percutaneous lumbar laser disc decompression, a mechanical high rotation per minute (RPM) device utilizing an Archimedes' screw (DeKompressor), and coblation nucleoplasty or plasma decompression (21-24).

Based on the current evidence synthesis, the evidence is fair for nucleoplasty and limited for APLD, mechanical disc decompression, and decompression utilizing Dekompressor. The evidence has been sparse for all types of mechanical disc decompression even though APLD and PLLD have been in existence for decades with numerous publications (21-24). Only recently, one randomized trial was conducted for nucleoplasty providing fair evidence. An RCT is underway for lumbar laser disc decompression or discectomy. Based on the current evidence, the evidence for IDET and biaculoplasty is fair and limited for discTRODE.

In patients with post-lumbar surgery syndrome after failure to respond to fluoroscopically directed epidural injections, percutaneous adhesiolysis is considered (8,19). Based on the current literature, the evidence is fair to good for percutaneous adhesiolysis in managing post lumbar surgery syndrome and spinal stenosis with chronic low back or lower extremity pain non-responsive to conservative modalities including fluoroscopically directed epidural injections.

The next step in the radicular pain algorithm is implantable therapy with SCS and implantable infusion systems. SCS is recommended to the patient population for whom all other appropriate medical options have been tried without sufficient improvement in pain control. Based on the present evidence synthesis there is fair evidence for SCS in managing chronic low back and lower extremity pain secondary to post lumbar surgery syndrome (35,2026,2028-2038).

Finally, long-term management of chronic non-cancer pain may be achieved with intrathecal infusion systems (27). However, there is only limited evidence. The literature continues to be scant with no randomized trials meeting inclusion criteria with long-term follow-ups.

3.0 Neck Pain

3.1 Diagnosis

Figure 11 illustrates an algorithmic approach to the diagnosis of chronic neck pain without disc herniation, radiculitis, spondylitic myelopathy, or spinal stenosis. This represents an algorithmic approach for the investigation of neck pain based on the best available evidence on the epidemiology of various identifiable sources of chronic neck pain. The current evidence of diagnostic utility of controlled diagnostic blocks shows the prevalence of 36% to 67% with an average prevalence of 49% with a false-positive rate of 27% to 63% (average 49%) with single diagnostic blocks with good evidence (11). The current evidence of cervical discography as a diagnostic test for chronic spinal pain (38) is limited.

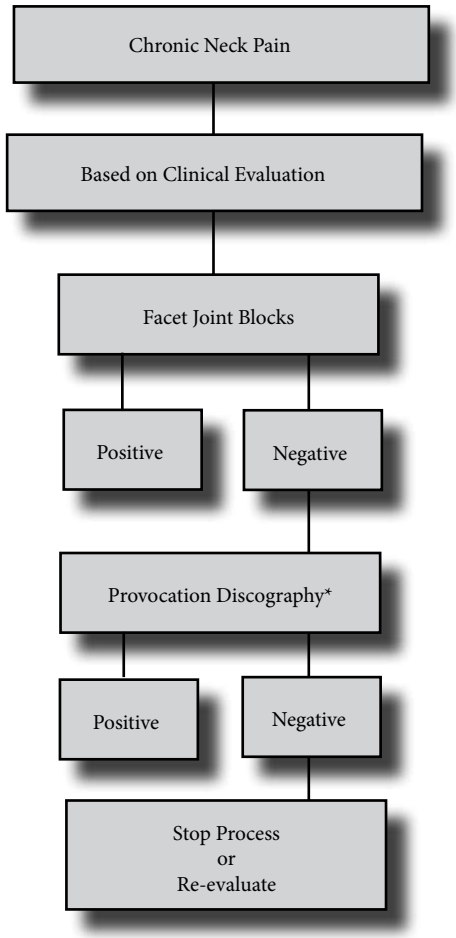
If there is evidence of radiculitis, spinal stenosis, spondylotic myelopathy, post surgery syndrome, or other demonstrable causes resulting in radiculitis, an interventionist may proceed with therapeutic epidural injections. The current evidence for interlaminar epidural injections is good for radiculitis secondary to disc herniation and fair for axial or discogenic pain, pain of central spinal stenosis, and pain of post surgery syndrome (251-254,801,802,1761-1763).

In contrast, cervical transforaminal epidural injections have been associated with high risk and without evidence either for diagnostic or therapeutic purposes (934,1010,1023-1031,1646,1758). Thus, an algorithmic approach should include the diagnostic interventions with facet joint blocks, therapeutic epidural injections, followed by discography.

An algorithm of investigation of chronic neck pain without disc herniation or radiculitis commences with clinical questions and physical and imaging findings. The controlled studies have illustrated the presence of facet joint pain on average in 40% to 50% of cases, ranging from 36% to 67% of the patients and 39% in a large study (8,11,1347,1857). Thus, the facet joints are entertained first in the algorithm in patients without radicular symptoms because of their commonality as a causative factor for chronic neck pain and headache and ease of performance. Consequently, the investigation of facet joint pain is considered as a prime investigation ahead of disc stimulation. Multiple studies have indicated the facet joint pain to be bilateral in 69% to 72% of cases and involving at least 3 joints in 50% to 85% of patients (14,1345-1347,1857).

The diagnostic blocks must be performed under controlled conditions. Diagnostic blocks are often performed using 2 separate local anesthetics – controlled comparative local anesthetic blocks with a small volume of injectate.

If the facet joints are shown to be causative of chronic neck pain with 75% relief and the ability to perform previously painful movements with concordant response with 2 different local anesthetics, a positive diagnosis is made. However, based on patient condition and regulations, the criterion standard of pain relief and either a



*Limited evidence and indicated only when appropriate treatment is available.

Fig. 11. *An algorithmic approach to diagnosis of chronic neck pain without disc herniation.*

single block or double block paradigm is changed.

Cervical interlaminar injections are indicated if the facet joints are not suspected as a source for neck pain. However, if the patient fails to respond to epidural injections, further diagnostic interventions evaluating the disc may be undertaken provided a treatment can be offered.

Cervical provocation discography is seldom performed as an initial test in the present algorithmic approach. Once facet joint pain is ruled out and the patient fails to respond to at least 2 fluoroscopically directed epidural injections, discography may be pursued if the determination of the disc as the source of pain is crucial. However, to be valid, the provocation discography must be performed utilizing criteria with concordant pain in one disc with at least 2 negative discs, with evoked intensity of pain of 7 of 10 or 70% of worst spontaneous pain (e.g., worst pain of 7≥ 7 x 70% = 5, being the pain score that would be significant upon disc provocation) (8,38,1471,2156).

3.1.1 Diagnostic Efficiency

Under the present algorithmic approach, which is simple, efficient, and cost-effective, once facet joint pain is excluded, the patient may be treated with epidural injections. Essentially, cervical provocation discography is the last step in the diagnostic algorithm and is utilized only when appropriate treatment can be offered if the disc abnormality is demonstrated. However, a rare but justifiable indication is to satisfy the patients' impressions if the patient does not improve with any other modalities of treatment. Thus far, studies have demonstrated the effectiveness of epidural injections in the cervical region in discogenic pain (9,13,38,251,746,772, 777,801,834, 835,840,1023,1759,1761,1762,2157-2161).

3.2 Management Algorithm

3.2.1 Radicular Pain Algorithm

Disc protrusions, herniations, or prolapses and spinal stenosis are less common in the cervical spine than in the lumbar spine (372). However, spondylosis and radiculopathy may be more common (372). Radiculitis may also result from cervical spinal stenosis, post surgery syndrome, and discogenic pain without disc herniation. The current evidence indicates lack of evidence for transforaminal epidural injections and high risk with good evidence for cervical interlaminar epidural injections in disc herniation ,and fair evidence in discogenic pain without radiculitis or disc herniation, spinal stenosis, and post surgery syndrome.

3.2.2 Somatic Pain Algorithm

As illustrated in Fig. 12 showing the therapeutic algorithmic management of chronic neck pain, patients testing positive for facet joint pain may undergo either therapeutic facet joint nerve blocks or radiofrequency neurotomy based on patients' preferences, values, and physician expertise. Current evidence synthesis of the literature shows limited evidence for therapeutic intraarticular facet joint injections, and fair evidence for conventional radiofrequency neurotomy and therapeutic facet joint nerve blocks. Thus, intraarticular facet joint injections are not indicated in cervical facet joint pain.

3.2.3 Chronic Non-Responsive Pain Algorithm

Given a failure to respond to less invasive modalities of treatments, the consideration is then for SCS and intrathecal infusion systems. These modalities in managing chronic intractable neck pain have not been evaluated.

4.0 Thoracic Pain

4.1 Diagnosis

Figure 13 illustrates the diagnostic algorithmic approach for chronic thoracic pain without disc herniation or radiculitis.

This algorithm for investigation of thoracic pain is based on the best available evidence on the epidemiology of various identifiable sources of chronic mid back and upper back pain. Facet joint pain has been proven to be one of the common causes of pain with proven diagnostic techniques (15,16). The current literature review shows that based on the controlled, comparative local anesthetic blocks, thoracic facet joint pain has been shown to be present in approximately 40% of patients with mid-upper back pain with false-positive rates of 42% with good evidence of accuracy (15,16). In contrast, the evidence of diagnostic accuracy of thoracic discogenic pain is limited.

Consequently, if a patient has any signs of radiculitis or disc herniation or other demonstrable causes resulting in radiculitis, one may proceed with therapeu-

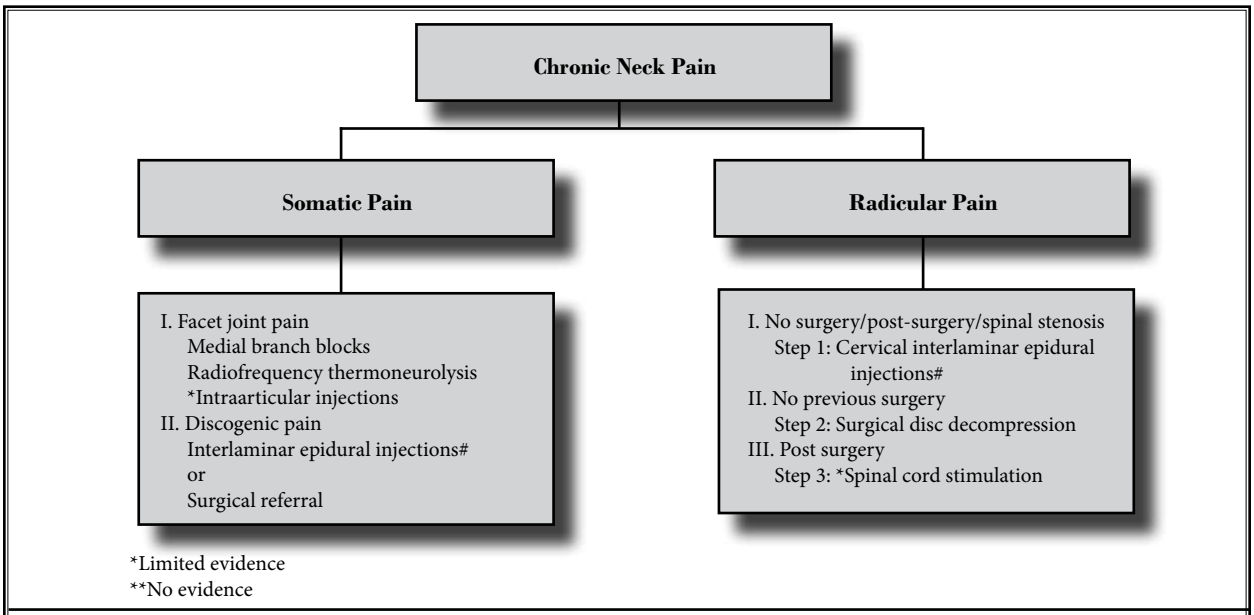


Fig. 12. *A suggested algorithm for therapeutic interventional techniques in the management of chronic neck pain.*

tic epidural injections. The current literature shows fair evidence for the effectiveness of thoracic interlaminar epidural injections. Otherwise, an algorithmic approach should include diagnostic interventions with facet joint blocks, epidural injections, and in rare circumstances, provocation thoracic discography.

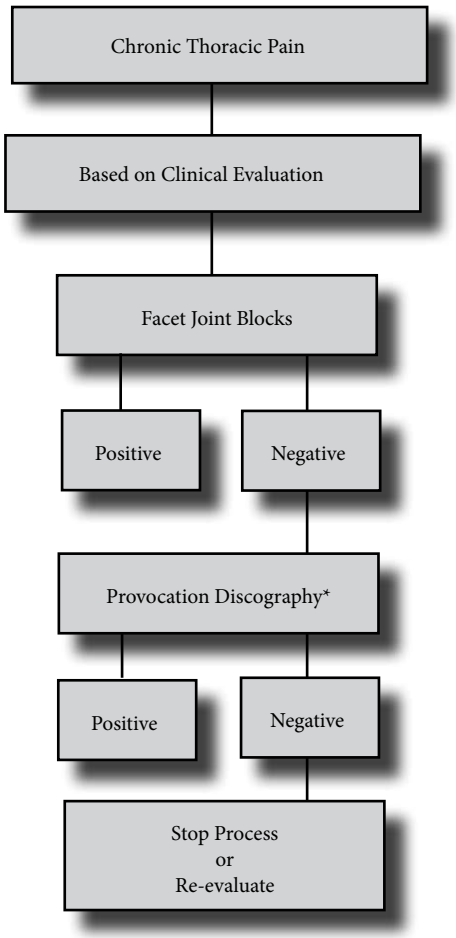
An algorithm for investigating chronic mid back or upper back pain without disc herniation commences with clinical questions, clinical findings, and findings of imaging. In this approach, investigation of facet joint pain is considered as the prime investigation, ahead of disc stimulation. Facet joint pain is bilateral in 64% to 84% of cases and involving 3 joints or more in 81% to 94% of patients (15,16,1346,1347,1989).

The diagnostic blocks must be performed under controlled conditions. If a patient experiences at least 75% relief with the ability to perform previously painful movements with a concordant response in relation to duration of local anesthetics, a positive diagnosis is made. However, based on patient condition and regulations, the amount of achieved relief and either a single block or double block paradigm is changed.

Thoracic provocation discography is seldom performed, not only as an initial test, but in the settings of IPM. Once facet joint pain is ruled out and the patient fails to respond to at least 2 fluoroscopically directed epidural injections, investigations may cease or, under rare circumstances, discography may be pursued.

4.1.1 Diagnostic Efficiency

Under the present algorithmic approach, once facet joint pain is excluded, the patient may be treated with epidural injections. Thoracic provocation discography is an extremely rare and last step in the diag-



*Limited evidence and indicated only when appropriate treatment is availaable.

Fig. 13. *An algorithmic approach to diagnosis of chronic thoracic pain without disc herniation or radiculitis.*

nostic algorithm and is utilized only when appropriate treatment can be performed if the disc abnormality is noted. The only very rare exception may be to perform discography to satisfy the patient's impressions if the patient does not improve with any other modalities of treatment.

Given the relatively lower frequency of involvement of the thoracic spine and lack of significant pertinent literature, it appears that thoracic facet joints account for 40% of the cases of chronic mid back and upper back pain, whereas the remaining cases are considered to be discogenic pain or without specific diagnosis.

4.2 Management Algorithm

Figure 14 illustrates therapeutic algorithmic management. The patients testing positive for facet joint pain may undergo either therapeutic facet joint nerve blocks or radiofrequency neurotomy based on the patient's preferences, values, and physician expertise. The current evidence shows fair evidence for therapeutic thoracic facet joint nerve blocks, with limited evidence for radiofrequency neurotomy, and no evidence for therapeutic intraarticular injections.

4.2.1 Radicular Pain Algorithm

Disc protrusions and herniations are much less common in the thoracic spine than the lumbar or cervical spine. Nonetheless, very few patients who present with thoracic radiculitis, post surgery syndrome, spinal stenosis, and radiculitis without disc protrusion, and patients failing to show evidence of facet joint pain are candidates for epidural injections. Epidural injections are most commonly provided through an interlaminar route rather than transforaminal which is associated with high risk. Thoracic interlaminar epidural injections show fair (weak) evidence.

4.2.2 Somatic Pain Algorithm

As illustrated in Fig. 14 displaying the therapeutic algorithmic management of chronic thoracic pain, patients testing positive for facet joint pain may undergo therapeutic facet joint nerve blocks, however radiofrequency neurotomy may be offered based on the patients' preferences, values, and physician expertise.

The next modality of treatment is epidural injections. The evidence for interlaminar epidural injections is fair (10).

4.2.3 Algorithm for Chronic Non-Responsive Pain

Patients non-responsive to facet joint interventions and epidural interventions in the thoracic spine, in rare circumstances, may be considered for disc decompression or intrathecal implantables either with SCS or intrathecal infusion systems. However, there is no evidence available for any of the management modalities. Consequently, management is based on physician experience and patients' values and beliefs.

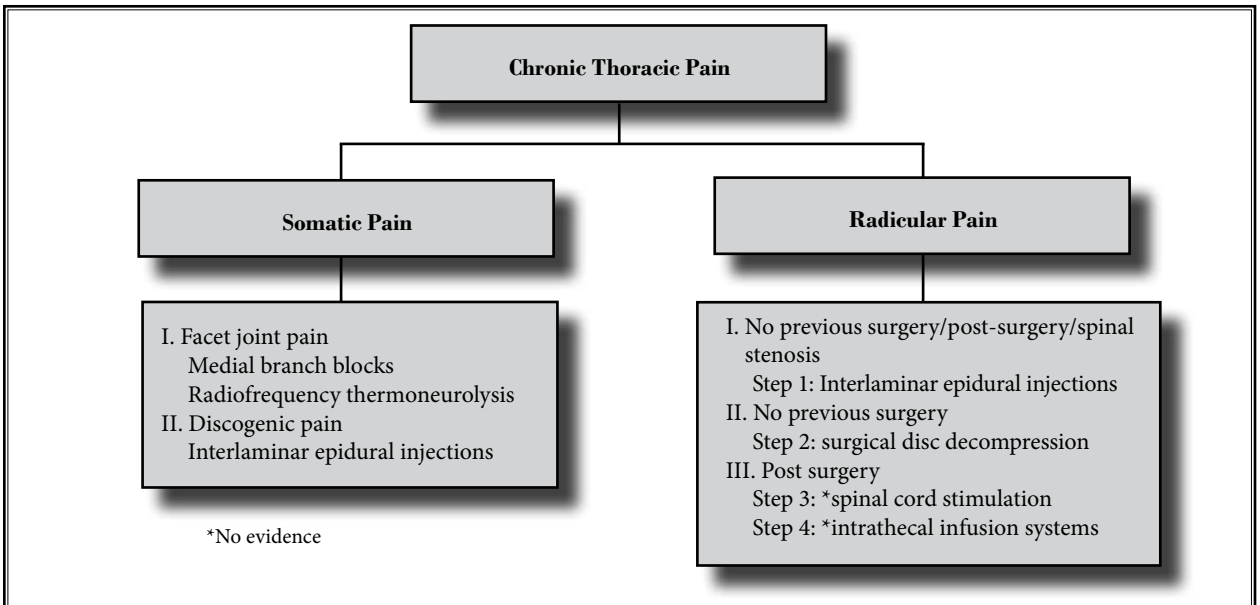


Fig. 14. *A suggested algorithm for therapeutic interventional techniques in the management of chronic thoracic pain.*

X. DELIVERY OF INTERVENTIONAL TECHNOLOGY

Delivery of interventional technology involves the type of procedures, frequency of procedures, drugs injected, with minimization or avoidance of complications.

1.0 Neuraxial Steroids

The literature, though enormous, provides only some guidance which is not conclusive. Based on the principles of EBM, the average relief per procedure if feasible is considered as the recommended duration if it is safely performed without complications.

The utilization of steroids in neural blockade has been empirical beginning in the 1950s and 1960s (768,2162-2166). They were first used for the treatment of lumbar radiculopathy at a time when the use of steroids by injection was becoming fashionable (768). When it became apparent that the injection of steroids into joints could relieve certain types of joint pain, investigators and practitioners turned their use to problems of back pain, as well as lumbar radiculopathy (768,2162-2164). Subsequently, when epidural steroid administration seemingly was effective for management of sciatica, others followed the concept and adapted the treatment for other types of neural blockade including facet joint injections (2165-2167).

The search into the rationale for the use of epidural steroids began retrospectively with the focus on the strong anti-inflammatory effects of corticosteroids (768). During this search, attractive propositions were made employing an inflammatory component in lumbosacral radiculopathy. Various authors referred to the available literature that indicated that sciatica might be associated with inflammation (768,831,984,2166-2174). Ryan and Taylor (2175), by examining samples of CSF during administration of intrathecal and epidural injections, observed that inflammation was a critical component of radicular pain, and that intraspinal steroids were likely to be most effective when this inflammation was still acute, before the pathology had progressed to nerve root fibrosis or axonal death. Lindahl and Rexed (2176) described inflammation, edema, and proliferative or degenerative changes in biopsy samples from the posterior nerve roots of patients undergoing laminectomy.

Consequently, in lumbar disc herniation and radiculopathic pattern of symptoms, consideration for a primary biochemical inducement of pain over a mechanical mechanism is a contemporary topic of spinal research. Even then, the exact pathomechanism by which a degenerative intervertebral disc leads to neural inflammation and pain has not been determined. Using modern techniques of chemical analysis, biochemical markers can be identified which participate in the degenerative cascade and possibly with onset of pain (2177). While, Scuderi et al (2177) were unable to identify the presence of inflammatory peptides in the epidural lavage of patients with symptomatic radicular pain due to herniated disc disease, de Souza Grava et al (2178) indicated that specific cytokines released during the inflammatory process induced by the herniated intervertebral disc play a fundamental role in the development of mechanical and thermal hyperalgesia and that the maintenance of this inflammation may be the most important point for the chronification of the pain. In addition, Shamji et al (2179) concluded that there was evidence of altered gait in a model of noncompressive disc herniation with radiculopathy in a rat model. However, systematic inflammation was absent, but mechanical allodynia, local inflammation, and autoreactive immune activation were observed. Cuéllar et al (2180) also developed an animal model for the study of biochemical changes that occur in the epidural space after intervertebral disc herniation. The performed epidural lavage in 48 rats after L5 dorsal root ganglion exposure to autologous nucleus pulposus illustrating nucleus pulposus causing the elevation of IL-6, TNF-α, and IFN-γ - all attenuated by IFN-γ blockade. However, Brisby et al (2181) showed inconclusive results after assessment of proinflammatory cytokines in cerebrospinal fluid and serum in 39 patients with disc herniation and sciatica. They (2181) showed concentrations of IL-8 in cerebrospinal fluid were increased in 12 out of 39 patients, and these increased levels of IL-8 correlated to a short duration of pain and to more pronounced herniation with normal concentrations of IL-1β, IL-6, IFN-gamma, and TNF-alpha in cerebrospinal fluid and serum in almost all patients with lumbar disc herniation. However, they were unable to demonstrate any relationship between IL-8 concentrations in cerebrospinal fluid and pain intensity, positive neurological findings, or a positive straight leg raising test.

Thus, the role of various chemicals and inflammation has been extensively investigated with discogenic pathology and radicular pain (28,30,31,36,309,571-574,576-580,583,681-685). The complex mechanism of discogenic pain includes chemical nociception leading to low back pain with or without disc herniation (8,378,380,577,642,1471,1594,2182-2186). The research

in animals has shown upregulation of various pain regulated molecules, such as calcitonin gene related peptide and Substance P, in the dorsal root ganglions neurons innervating degenerated intervertebral discs (2185-2187). In fact, in recent years epidural TNF- α inhibitory injections have been utilized to treat lumbar radiculitis rather than epidural steroid injections (931,2187-2194).

Epidural steroid injections have been widely used in managing not only lumbar radiculitis, but also discogenic pain without disc herniation, spinal stenosis, and post surgery syndrome (8,28,30,31). In earlier studies, Berg (2195) and Green (2196) observed a consistent reduction in the swelling of involved nerve roots coincidental with improvement in the patient's sciatic symptoms with steroid administration. Thus, it is postulated that corticosteroids reduce inflammation either by inhibiting the synthesis or release of a number of pro-inflammatory substances or by causing a reversible local anesthetic effect (2197-2209). The various modes of action of corticosteroids include membrane stabilization, inhibition of neural peptide synthesis or action, blockade of phospholipase A2 activity, prolonged suppression of ongoing neuronal discharge, and suppression of sensitization of dorsal horn neurons.

The role of epidural steroids has been evaluated in experimental models. Epidural injections of betamethasone in a model of lumbar radiculopathy showed a significant effect on thermal hyperalgesia, while administration of intravenous (IV) methylprednisolone dramatically reduced the nerve root injury produced by epidural application of autologous nucleus pulposus in a pig experimental model (2202,2203). Minamide et al (2207) studied the effects of steroid and lipopolysaccharide on spontaneous resorption of herniated intervertebral discs in an experimental study in the rabbit, showing that lipopolysaccharide accelerated the process of herniated intervertebral disc resorption, whereas high dose steroids suppressed the process. Kingery et a (2208) examined the effects of systemic methylprednisolone on acute nociception and on pain behavior in hyperalgesia in normal and neuropathic rats and reported that chronic steroid treatment prevented the development of neuropathic edema and completely blocked neurogenic extravasation. However, the findings also showed that corticosteroids did not affect nociceptive thresholds in normal or neuropathic hyperalgesic rats. Lee et al (2204) demonstrated that the behavioral pattern changes observed in the irritated nerve root model are caused in part by a high level of phospholipase A2 activity initiated by inflammation, and that the mechanism of action of epidural steroid injection in this model is inhibition of phospholipase A2 activity. Lundin et al (2205) demonstrated the protection of damage to C-fibers in lumbar disc herniation when combined with surgery. Byrod et al (2206) demonstrated that the nucleus pulposus can induce a rapid increase in endoneural vascular permeability in spinal nerve roots after epidural application. This increase can be partially prevented by pretreatment with high-dose methylprednisolone. Finally, Johansson and Bennett (2209) studied the effect of local methylprednisolone on pain in a nerve injury model by inducing peripheral mononeuropathy and showed that the heat hyperalgesia and mechano-allodynia, but not the mechano-hyperalgesia, were depressed in the animals receiving the corticosteroids, but not in those treated with saline, with the effect remaining during the 11-day test period.

The recent literature shows no significant difference in the outcomes with or without steroids with medial branch blocks (11-26,1250,1389,1857,1995) and epidural injections (9,10,28,30,31,772,777,834,835, 840,906,968,1759,1990,2001). Further many of the techniques including radiofrequency neurolysis and disc decompressions do not require any steroids. It has also been shown that local anesthetics provide short-term and long-term symptomatic relief, even though the mechanism of action providing such relief is not known. They are also effective in neuropathic pain where steroids have very little effect (2210). In addition, it has been postulated that local anesthetics provide relief by multiple mechanisms which include suppression of nociceptive discharge (2211), the blockade of sympathetic reflex arc (761,2203), the blockade of axonal transport (2212,2213), the blockade of sensitization (2214,2215), and anti-inflammatory effects (2216). In addition, local anesthetics have been shown to block the axonal transport of the nerve fibers with lower concentrations of local anesthetics compared with those which are necessary for a block of nerve conduction (2212,2213). In fact, as early as 1941, Wertheim and Rovenstine (2217) reported that the analgesic effect of a 2% procaine injection may continue for 4 to 6 weeks. In 1990, Arner et al (2211) reported the long-lasting effectiveness of local anesthetic conduction blocks beyond the expected duration of local anesthetic with complete pain relief lasting 12 to 48 hours and further relief lasting 4 to 6 days. This phenomenon of pain relief beyond the local anesthetic effect has been reported after a single block, as well as a series of blocks over the years (2218-2224). Consequently, it is postulated that the effectiveness of

local anesthetics is based on the direct effects of local anesthetic on various mechanisms in chronic pain including noxious peripheral stimulation, sensitization (2214,2215), neurotransmitter release resulting in secondary hyperalgesia (1763), and phenotype changes, which form the basis for neuronal plasticity (2225,2226).

The most commonly used formulations of long-acting steroids include methylprednisolone (Depo-Medrol), triamcinolone acetonide (Aristocort or Kenalog), and betamethasone acetate and phosphate mixture (Celestone Soluspan) (876,879-883,965,1028-1030,1408,2137,2227-2247).

The chemistry of neuraxial steroids has taken center stage in recent years due to the devastating complications following epidural injections, specifically transforaminals. Steroid particle embolization of small radicular arteries is believed to be an important causative factor (246,1028-1030,1758,2246-2248).

Tiso et al (1028) presented a case of adverse central nervous system sequelae after selective transforaminal block and the role of corticosteroids. Their results showed that in the patient, quadriparesis ensued shortly after injection of corticosteroid solution. The patient was admitted to the neurosurgical intensive care unit and ultimately underwent brainstem decompressive surgery when focal neurologic deficits became evident. The working diagnosis was massive cerebellar infarct. Light microscopic data were presented to illustrate particulate size in corticosteroid solutions and potential for embolic microvascular occlusion. Corticosteroid suspensions (and to a lesser extent solutions) contained large particles capable of occluding metarterioles and arterioles. They proposed a potential role for corticosteroid particulate embolus during unintended intra-arterial injection as a potential mechanism.

Benzon et al (1029), in a comparison of the particle sizes of different steroids and the effect of dilution, reviewed the relative neurotoxicities of the steroids. Their results showed Dexamethasone and betamethasone sodium phosphate were pure liquid. The proportion of larger particles was significantly greater in the methylprednisolone and the compounded betamethasone preparations compared with the commercial betamethasone. There was no statistical difference between the commercial betamethasone and triamcinolone, although betamethasone had a smaller percentage of the larger particles. Increased dilution of the compounded betamethasone with lidocaine decreased the percentage of the larger particles, whereas increased dilution of methylprednisolone 80 mg/mL with saline increased the proportion of larger particles. They concluded that commercial betamethasone is the recommended preparation if a nonsoluble steroid is preferred. Dexamethasone is a nonparticulate steroid, but its routine use awaits further studies on its safety and efficacy.

Derby et al (1030), in assessing the size and aggregation of corticosteroids used for epidural injections, assessed 4 types of corticosteroid preparations in various solutions and evaluated under a light microscope. These included dexamethasone, sodium phosphate injection, triamcinolone acetonide injectable suspension, betamethasone sodium phosphate and betamethasone acetate injectable suspension, and methylprednisolone acetate injectable suspension. The results showed dexamethasone sodium phosphate particle size was approximately 10 times smaller than red blood cells and the particles did not appear to aggregate; even mixed with 1% lidocaine hydrochloride solution and with the contrast, the size of the particles were unchanged. In contrast, triamcinolone acetonide and betamethasone sodium phosphate showed variable sizes with some particles larger than red blood cells, along with aggregation of particles which was evident. Further, methylprednisolone acetate showed uniformity in size and the majority was smaller than red blood cells which were not aggregated, but the particles were densely packed.

Gazelka et al (246) examined whether mixing clonidine and various corticosteroids results in increased particle size or aggregation. They evaluated under a light microscopy for particle size made of samples of clonidine alone and clonidine mixed with equal parts of 3 corticosteroids solutions: dexamethasone sodium phosphate injection, triamcinolone acetonide injectable suspension, and betamethasone sodium phosphate and betamethasone acetate injectable suspension. Clonidine was determined to be nonparticulate when examined by light microscopy, clonidine mixed with equal parts of each of the 3 corticosteroids did not result in increased clumping or increased particle size over each of the corticosteroids measured alone. Further, dexamethasone 4 mg/mL solution had no measurable particles, and there was no apparent aggregation in the solution. The triamcinolone 40 mg/mL solution contained particles measuring 2.3 μm to 200 μm. The particles were densely packed with extensive aggregation observed. These measurements were similar to those reported by Derby et al (1030). The betamethasone 6 mg/mL solution contained long, rod-shaped particles of varying sizes. The particles formed extensive aggregates. These measured from 1.5 to 7.5 μm, but

most were much smaller than maximum measurement, similar to those reported by Derby et al.

Though all formulations of steroids may be considered safe, formulations of betamethasone appear to be safer with no significant difference in the effectiveness (2137). Formulations of commonly used epidural steroids are shown in Table 43 and the pharmacologic profile of commonly used epidural steroids is shown in Table 44 (890,1029,1990,2001,2218,2219,2220,2232-2277).

Differences in the effectiveness of various types of steroids were evaluated in multiple observational studies (921,983,2244,2249-2252) and in 2 randomized trials (232,233). The randomized trials showed no significant difference between methylprednisolone 40 mg compared to 6 mg of either commercial betamethasone or non-particulate compounded betamethasone. Further, there was no significant difference when compared to the effect of local anesthetics with any of the steroids. The observational studies showed variable results with slight superiority for particulate steroids in short-term observations of less than 3 months. The long-term data are available only from randomized trials. In one study, nonparticulate dexamethasone phosphate was shown to be close to the safety and effectiveness of particular methylprednisolone acetate in the treatment of lumbar radiculopathy (921). In another study of selective nerve root blocks with betamethasone and triamcinolone (2249), there was no significant difference in effectiveness between the 2. However, in another study comparing dexamethasone and triamcinolone treatments (983), they were shown to have different effects, with triamcinolone being more effective than dexamethasone in lumbar radiculopathy. One study comparing Celestone Soluspan and Kenalog (2244) showed Kenalog to be superior to Celestone at one and 2 weeks after injection (2244). In a study evaluating the cervical transforaminal epidural injections (2250), the effectiveness of dexamethasone was slightly less than that of triamcinolone, even though the difference was neither statistically nor clinically significant. In a study assessing the comparison of 2 doses of corticosteroids in epidural steroid injections (2252), there was no significant difference in the outcomes either with 40 mg of methylprednisolone or 80 mg, both showing comparable results, with a less adverse profile with the 40 mg dosage. This philosophy was also reaffirmed in another study (2251) evaluating the dosages of corticosteroids in transforaminal epidural steroid injections for lumbar radicular pain due to a herniated disc. There were no significant differences among the groups at one week after the second transforaminal epidural injection. Among the doses of 5 mg, 10 mg, 20 mg, or 40 mg, all of them were equal except the 5 mg dosage. The authors (2251) recommended a minimal effective dose of corticosteroid of 10 mg equivalent of triamcinolone in transforaminal epidural steroid injections for patients with lumbar radiculopathy.

In reference to the adrenal suppression and duration of action of various steroids, multiple animal and human

Table 43. *Formulations of commonly used epidural steroids.*

	Depo-Medrol		**Kenalog**	**Celestone Soluspan**	**Decadron**
	Methylprednisolone Single-dose vials		**Triamcinolone acetonide Single-dose vials**	**Betamethasone, Sodium Phosphate, and Betamethasone Acetate Injectable Suspension**	**Dexamethasone sodium phosphate Single-dose vials**
Amount of steroid	40 mg/mL	80 mg/mL	40 mg/mL	6 mg/mL	4 mg/mL
Polyethylene glycol 3350	29.1	28.2	—	—	—
Polysorbate 80	1.94	1.88	0.04%	—	—
Monobasic sodium phosphate	6.8	6.59	—	3.4	—
Diabasic sodium phosphate	1.42	1.37	—	7.1	—
Myristyl-gamma-picolinium chloride (MGPC)	0.195	0.189	—	—	—
Benzyl alcohol	—	—	0.99%	—	—
Edetate disodium	—	—	—	0.1	—
Benzalkonium chloride	—	—	—	0.2	—
Sodium sulfite	—	—	—	—	1 mg
PH Carboxymethylcellulose sodium			0.75% 5.0 – 7.5	6.8 – 7.2	

Table 44. *Profile of commonly used epidural steroids.*

Drug	Equivalent Dose	Epidural Dose	Anti-inflammatory Potency	Sodium Retention Capacity	Duration of Adrenal Suppression		
					IM	Single Epidural	Three Epidurals
Hydrocortisone	20 mg	N/A	1	1	NA	NA	NA
Depo-Methylprednisolone (Depo-Medrol)	4 mg	40-80 mg	5	0.5	1-6 weeks	1-3 weeks	NA
Triamcinolone acetonide (Kenalog)	4 mg	40-80 mg	5	0	2-6 weeks	NA	2-3 months
Betamethasone (Celestone Soluspan)	0.75 mg	6-12 mg	33	0	1-2 weeks	NA	NA
Dexamethasone (Decadron)	0.75 mg	8-16 mg	27	1	NA	1-3 weeks	NA

Data adapted and modified from: McEvoy et al (2236), Bonica (2220), Jacobs et al (2253), Maillefert et al (2237) Kay et al (2273), Hsu et al (2277), Mikhail et al (2227), Schimmer and Parker (2235) and Benzon et al (1029).

studies have been published (890,2237,2254-2273). Commonly observed effects of corticosteroids include suppression of pituitary adrenal axis, hypocorticism, Cushing's syndrome, osteoporosis, avascular necrosis of the bone, steroid myopathy, epidural lipomatosis, weight gain, fluid retention, and hyperglycemia (874-878,2278-2282). Equivalent doses, antiinflammatory potency, sodium retention capacity, and duration of adrenal suppression are illustrated in Table 44. Duration of adrenal suppression with epidural injections is an important consideration in interventional pain management. This has been variously described as one to 3 weeks for depomethylprednisolone and epidural dexamethasone, 2 to 3 months with multiple epidurals of triamcinolone, and one to 2 weeks with intramuscular betamethasone. In an evaluation of pituitary adrenal axis function following a single intraarticular injection of methylprednisolone, it was shown that separation lasted for one to 6 weeks and full recovery was expected in most patients after one to 2 weeks (2254). Only a few patients exhibited separation for up to 2 weeks. In an experimental assessment (2255), adrenocortical suppression in dogs was observed after a single dose of methylprednisolone acetate for 3 weeks; however, adrenal response to adrenocorticotropic hormone was suppressed for 5 weeks. Thus, they concluded that a single dose of methylprednisolone is capable of altering adrenocortical function in dogs for at least 5 weeks. A single epidural injection of 15 mg of dexamethasone acetate was shown to be associated with transient adrenal suppression, for 7 days which returned to normal in 21 days. In an assessment of epidural triamcinolone on the suppressive effect of pituitary-adrenal axis in human subjects (2273), it was shown that the median suppression was less than one month and all patients had recovered by 3 months. This study also showed that sedation with midazolam accentuated the suppression of the hypothalamic-pituitary adrenal axis. Based on the evidence obtained from high dose steroids in ovarian cancer patients, the results showed that there was transient decrease in hypothalamic-pituitary adrenal axis function, but there was no long-term inhibition. Hypothalamic-pituitary adrenal function may be suppressed for approximately 8 days from the commencement of chemotherapy cycles with administration of dexamethasone for first 8 days of chemotherapy (2266). However, even topical steroid application on a long-term basis may cause Cushing's syndrome and adrenocortical insufficiency (2267). An evaluation of patients receiving long-term intraarticular corticosteroids tests of the hypothalamic-pituitary adrenal axis 5 to 7 weeks after the last injection revealed suppression in some patients.

Consistent with the present literature of the pharmacology of steroids, it appears that non-particulate steroids may be the agents of choice for transforaminal epidural injections, though no trials have compared particulate to non-particulate steroids. However, particulate steroids may be safely utilized for interlaminar or caudal epidural injections. Caution must be exercised in the use of particulate steroids in transforaminal epidural injections and specifically for cervical transforaminal epidural injections, particularly if sharp needles are used.

2.0 Antithrombotic and Antiplatelet Therapy

Among multiple issues crucial in performing interventional techniques, bleeding risk and perioperative management of patients on anticoagulants and antithrombotic therapy is one of the major ones without appropriate guidance or literature to support

the existing opinions. The majority of the guidelines developed thus far are not based on appropriate evidence, due to the paucity of evidence in this area. Cardiovascular and cerebrovascular diseases are among the leading causes of morbidity and mortality (2283-2287); and chronic persistent pain is the leading cause of disability and functional impairment across the globe (46-49,2288-2290). Antithrombotic therapy has been established with a favorable risk benefit ratio for the prevention of cardiovascular disease and in limiting the present and future burden of cardiovascular and cerebrovascular disorders (2291-2313). It has been estimated that a significant proportion of patients with cardiovascular, cerebrovascular, or peripheral vascular disease, receiving antithrombotic therapy undergo surgical interventions including interventional techniques.

Based on a recent survey, it appears that the majority of interventional pain physicians discontinue antiplatelet therapy and anticoagulant therapy (2314), even though continuation of antithrombotic therapy is considered as "safe" (944,2315,2316). Based on the multiple guidelines published with evidence derived from case reports, it has been the generally accepted to stop antiplatelet therapy and is considered as standard of care by some (2317-2327). However, there is also significant disagreement among the guidelines. Epidural hematomas have been reported in one in 150,000 of all epidurals, the incidence has been higher in the cervical and thoracic spine. There is also a trend of increasing epidural hematoma cases following neuraxial blocks (2314,2320,2321,2328,2329); however, one report indicates decreasing tendencies (2330). Epidural hematoma is a serious complication that may result in spinal cord injury but only occurs with procedures that involve placing a needle into the spinal canal (i.e. posterior interlaminar epidural steroid injection). Epidural hematoma is not a risk of injections of the exterior spine such as medial branch blocks.

The risks of withdrawing antiplatelet therapy include cardiovascular, cerebrovascular, and peripheral vascular thrombosis which may result in ominous consequences including stroke and death. In a systematic review and meta-analysis of the hazards of discontinuing or not adhering to aspirin regimens among patients at risk for coronary artery disease (2291) noncompliance or withdrawal of aspirin treatment was associated with significant complications in those with or at moderate to high risk for coronary artery disease. This study showed aspirin non-adherence or withdrawal being associated with a 3-fold higher risk of major adverse cardiac events which was magnified in patients with intracoronary stents with the conclusion that aspirin discontinuation in such patients should be advocated only when bleeding risk clearly overwhelms that of atherothrombotic events. In a study of the evaluation of incidence of death and acute myocardial infarction (MI) associated with the discontinuation of clopidogrel (Plavix) after acute coronary artery syndrome (2296), the authors observed a clustering of adverse events in the initial 90 days after discontinuation among both medically treated and percutaneous coronary intervention treated patients with acute coronary syndrome, supporting the possibility of clopidogrel rebound effect. It has been described that more than two-thirds of the sudden cardiac events (acute coronary syndrome or sudden cardiac death) (2331-2333) and half of the postoperative myocardial infarctions (2331,2334-2337) are due to the disruption and thrombosis of an unstable plaque. The data on cerebrovascular events are not known; however, acute coronary syndrome is linked with pro-inflammatory and pro-thrombotic conditions that involve an increase in fibrinogen, C-reactive protein, and plasminogen activator inhibitor (2338). Thus, in the post operative setting, the risk of acute coronary syndrome is further aggravated by augmented release of endogenous catecholamines, increased platelet adhesiveness, and decreased fibrinolysis, which are characteristic of the acute phase reaction (2336,2339,2340).

It has also been described that stoppage of antiplatelet therapy may result in either hypercoagulability with thrombosis or bleeding complications (2291,2294,2295,2341-2380). Studies assessing the risk of maintaining antiplatelet therapy have shown increased surgical blood loss of 2.5% to 20% with aspirin and 30% to 50% with aspirin and clopidogrel (2358,2381). However, no increase in surgical mortality has been linked to the increased bleeding, except during intracranial surgery (2347,2358).

Based on the available information, the risks of coronary events from withdrawing patients from antiplatelet agents in the perioperative period are generally higher than those of maintaining them through the perioperative period. Thus, Chassot et al (2331) recommended that it is necessary to modify the approach of withdrawing patients from all antiplatelet agents 7 to 10 days before surgery, except when bleeding might occur in a closed cavity. After a comprehensive literature review, they (2135) also proposed that

even if large prospective studies with a high degree of evidence are still lacking on different antiplatelet regimens during noncardiac surgery, apart from low coronary risk situations, patients on antiplatelet drugs should continue their treatment throughout surgery, except when bleeding might occur in a closed space. They also recommended consideration of a therapeutic bridge with shorter-acting antiplatelet drugs. In fact, multiple guidelines have provided variable guidance (944,2314-2318,2382-2395). In a systematic review, Dunn and Turpie (2385) after evaluating 31 reports concluded that most patients can undergo dental procedures, arthrocentesis, cataract surgery, and diagnostic endoscopy without alteration of their anticoagulant regimen, however, for other invasive and surgical procedures, oral anticoagulation needs to be withheld and the decision whether to pursue an aggressive strategy of perioperative administration of intravenous heparin or subcutaneous low molecular weight heparin (LMWH) should be individualized.

With the increasing performance of interventional procedures over the years, the number of patients undergoing interventional techniques, with not only coronary artery stenting, but a multitude of other cardiovascular, peripheral vascular, and cerebrovascular risk factors may be increasing. Thus, interventional pain physicians managing these patients are confronted with the complex issue of weighing the risks of hemorrhagic complications when continuing the antiplatelet agents in the perioperative period against the risk of cerebral and cardiovascular events if the drugs are discontinued abruptly. Even though data suggest that the traditional attitude of discontinuing the medication 7 days before interventions poses considerable risk, multiple guidelines recommend these polices and it has been a general practice to discontinue these drugs (944,2314-2331). An evaluation by Manchikanti et al (944) of over 18,000 procedures with over 12,000 encounters and over 3,000 patients, showed no significant prevalence of adverse events observed in those who continued with or ceased antithrombotic therapy. In addition, another issue related to interventional pain management is that most reports are related to regional anesthesia for surgical procedures, with few reports of epidural hematoma in patients undergoing interventional techniques for chronic pain with or without antithrombotic therapy – continued or discontinued.

Based on the comprehensive review of the literature and assessment of all the factors, Manchikanti et al (2282) determined the evidence as follows:

There is good evidence for the risk of thromboembolic phenomenon in patients who discontinue antithrombotic therapy, spontaneous epidural hematomas with or without traumatic injury in patients with or without anticoagulant therapy associated with stressors such chiropractic manipulation, diving, and anatomic abnormalities such as ankylosing spondylitis, and the lack of necessity of discontinuation of nonsteroidal anti-inflammatory drugs (NSAIDs), including low dose aspirin prior to performing interventional techniques.

There is fair evidence that excessive bleeding, including epidural hematoma formation may occur with interventional techniques when antithrombotic therapy is continued, the risk of thromboembolic phenomenon is higher than the risk of epidural hematomas with discontinuation of antiplatelet therapy prior to interventional techniques, to continue phosphodiesterase inhibitors (dipyridamole [Persantine], cilostazol [Pletal], and Aggrenox [aspirin and dipyridamole]), and that anatomic conditions such as spondylosis, ankylosing spondylitis and spinal stenosis, and procedures involving the cervical spine; multiple attempts; and large bore needles increase the risk of epidural hematoma; and rapid assessment and surgical or nonsurgical intervention to manage patients with epidural hematoma can avoid permanent neurological complications.

There is limited evidence to discontinue antiplatelet therapy with platelet aggregation inhibitors to avoid bleeding and epidural hematomas and/or to continue antiplatelet therapy clopidogrel (Plavix), ticlopidine (Ticlid), or prasugrel (Effient) during interventional techniques to avoid cerebrovascular and cardiovascular thromboembolic fatalities.

Based on the comprehensive review of the evidence, it has been shown that most commonly, epidural hematomas appear spontaneously. In addition, there has been a large number of epidural hematoma reports in patients after regional anesthesia. Epidural hematoma or bleeding instances have been reported with interventional techniques in patients without antiplatelet therapy, discontinued antiplatelet therapy, and continued platelet therapy. However, Manchikanti et al (2314), in a survey, showed epidural hematoma in 29 patients with discontinuation of antiplatelet and warfarin therapy compared to 26 patients with continued antiplatelet therapy. In contrast thrombolic complications were much higher when antithrombotics

were discontinued with only 9 compared to 153 with discontinuation of antiplatelet and warfarin therapy (2314,2320,2321,2328,2329).

Manchikanti et al (2282), based on the comprehensive review with extensive literature search and analysis of various guidelines and the literature has provided recommendations specific for interventional techniques, adapted for these guidelines. Table 45 shows ASIPP recommendations and other guidelines (2317,2396-2399). The recommendations for various agents are dependent on multiple factors including the individual patient, risk factors, and cardiologist's opinion. This must be a shared decision. The risks of thromboembolic phenomenon and bleeding with hematoma formation must be considered equally.

- NSAIDS, including low dose aspirin, do not increase the risk of spinal epidural hematoma and are not a contraindication for interventional techniques (evidence – good).
- However, high dose aspirin and combination of multiple drugs should be taken into consideration and may or may not be discontinued based on clinical judgment of individual risk and benefits assessment. In this regard, the simultaneous use of multiple agents that possess anticoagulant properties (e.g. NSAIDs or aspirin along with SSRIs, fish oil, etc.) will increase the risk of morbidity and/or mortality.
- Phosphodiesterase inhibitors including dipyridamole (Persantine), dipyridamole plus aspirin (Aggrenox), and cilostazol (Pletal) do not appear to increase the risk of spinal epidural hematoma and are not a contraindication for interventional techniques (evidence – fair).
- They may or may not be discontinued prior to interventional techniques.
- Platelet aggregation inhibitors including ticlopidine (Ticlid), clopidogrel (Plavix), and prasugrel (Effient) may be continued or discontinued prior to interventional techniques (evidence – fair).
- Based on patient factors and managing cardiologist's opinion, if a decision is made to discontinue, the current recommendations are that they may be discontinued for 7 days with clopidogrel and prasugrel and/or 10 to 15 days with ticlopidine (evidence – fair).
- There is also emerging evidence that discontinuation of 3 days may be effective (evidence – limited).
- Warfarin may be continued or discontinued based on INR achieved during therapy (evidence – good).
- For high risk interventional techniques including interlaminar epidural injections, percutaneous adhesiolysis, disc decompression, sympathetic blocks, and placement of implantables, warfarin should be discontinued for an appropriate period of time and an INR of 1.4 or less must be achieved (evidence – good).
- For intermediate risk procedures such as caudal epidural injection, paravertebral interventional techniques, and peripheral joint injections, and warfarin should be continued for an appropriate period of time and an INR of 2 or less may be considered (evidence – limited).
- Unfractionated heparin or LMWH may be discontinued approximately 12 hours prior to providing interventional techniques (evidence - limited).
- Dabigatran (Pradaxa) may be stopped 2 to 4 days for major interventional techniques with high risk of bleeding in patients with creatinine clearance greater than 50 mL per minute. For low risk or paravertebral interventional techniques and caudal, it may be stopped for one day in patients with normal renal function. May be stopped at least 4 to 5 days for those with creatinine less than 50 mL per minute. (evidence – limited)
- Rivaroxaban (Xarelto) may be stopped for one day or longer (evidence – limited).

3.0 Indications

The indications, frequency, and total number of interventions have been considered important issues, even though debated and poorly addressed. These are based on flawed assumptions from non-existing evidence. Over the years, some authors have recommended one injection for diagnostic as well as therapeutic purposes. Some have preached 3 injections in a series irrespective of a patient's progress or lack thereof; whereas, others suggest 3 injections followed by a repeat course of 3 injections after 3-, 6-, or 12-month intervals. There are also proponents who propose that an unlimited number of injections with no established goals or parameters should be available. A limitation of 3 mg per kilogram of body weight of steroid or 210 mg per year in an average person and a lifetime dose of 420 mg of steroid also have been advocated; however, with no scientific basis. The comprehensive review of the literature in preparation of these guidelines and review of all the systematic reviews has not shown any basis for the above reported assumptions and limitations. The

Table 45. *Antithrombotic/antiplatelet therapy and interventional techniques guidelines.*

Medication	ASIPP Guidance		ASRA Guidelines (2317,2396)	Nordic Guidelines (2397)	European Guidelines (2398)	Belgium Guidelines (2399)
	Time to Wait After Last Dose of Medication Before High Risk Interventional Techniques Are Performed	Time to Wait After Last Dose of Medication Before Caudal or Paravertebral Interventional Techniques are Performed				
NSAIDS	Do not stop	Do not stop	Do not stop	12 hours to 2 weeks	Do not stop	Do not stop
Aspirin						
Low dose aspirin	Do not stop	Do not stop	Do not stop	None to 12 hours	Do not stop	Do not stop
High dose aspirin	May stop for 7 days	May stop for 7 days	7 days	3 days	Do not stop	NA
Antiplatelet Agents						
Phosphodiesterase Inhibitors						
Dipyridamole (Persantine)	Do not stop	Do not stop	Do not stop	Do not stop	NA	NA
Cilostazol (Pletal)	Do not stop	Do not stop	NA	NA	42 hrs	NA
Aggrenox (dipyridamole plus aspirin)	Do not stop	Do not stop	NA	NA	NA	NA
Platelet Aggregation Inhibitors						
Clopidogrel (Plavix)	May stop for 7 days	May stop for 7 days	5-10 days	5 days	7 days	7 days
Prasugrel (Effient)	May stop for 7 days	May stop for 7 days	7-10 days	5 days	7-10 days	7 days
Ticlopidine (Ticlid)	May stop for 14 days	May stop for 14 days	5-10 days	5 days	10 days	10 days
Vitamin K Antagonists						
Warfarin	When INR is 1.4 or less, both warfarin may be stopped for 1-5 days.	When INR is 2.0 or less, both warfarin may be stopped for 1-5 days.	When INR is 1.4 or less, stop for at least 5 days.	When INR is below 1.4-2.2 stop for 1-4 days	When INR is 1.4 or below	When INR is less than 1.4. Stop for 4-10 days
Thrombin Inhibitors						
Dabigatran (Pradaxa)*	Normal renal function 2-4 days Impaired renal function (creatinine clearance < 50 mL/min) at least 5 days	Normal renal function 24 hrs. Impaired renal function (creatinine clearance < 50 mL/min) at least 5 days	NA	NA	NA	NA
Anti-Xa Agents						
Rivaroxaban (Xarelto)	24 hrs	24 hrs	NA	NA	NA	NA
Heparins						
Heparin (treatment) -IV	6 hrs and a PTT within normal limits	6 hrs and a PTT within normal limits	10-12 hrs and a PTT within normal limits	4 hrs and a PTT within normal limits	4-6 hrs and a PTT within normal limits	6 hrs and a PTT within normal limits
Heparin (treatment) - SC	12 hrs and aPTT within norm al limits	12 hrs and aPTT within normal limits	10-12 hrs and a PTT within normal limits	4 hrs and a PTT within normal limits	4-6 hrs and a PTT within normal limits	12 hrs and a PTT within normal limits
LMWH	12 hrs	12 hrs	10 hrs	10-24 hrs	12 hrs	12-24 hrs

*These recommendations are dependant on multiple factors including the individual patient, risk factors, and cardiologist's opinion.
LMWH = Low Molecular Weight Heparin; PTT = Partial Thromboplastin Time; NSAID = Nonsteroidal Anti-inflammatory Drugs; INR = International Normalized Ratio; hrs = Hours
Source: Manchikanti L, et al. Assessment of bleeding risk of interventional techniques: A best evidence synthesis of practice patterns and perioperative management of anticoagulant and antithrombotic therapy. *Pain Physician* 2013; 16: SE261-SE318.

administration must be based solely on patients' response, safety profile of the drug, experience of the patient, and pharmacological and chemical properties such as duration of action and suppression of adrenals. Further, multiple well controlled trials have illustrated no significant difference with local anesthetic alone, or in combination with local anesthetic and steroids (9,10,12,14,16,28,30,31,232-237,242-244,250-255,257,258,618,712,746,773,777,798-804,833-835,840).

3.1 Epidural Injections

3.1.1 Diagnostic Lumbar Transforaminal Epidural Injections

Lumbar and sacral transforaminal epidurals or selective nerve root blocks are utilized for diagnostic purposes (evidence – limited). Common indications are as follows:

- To identify an inflamed nerve root in a patient with a history of radicular pain when results of visual anatomic studies and neurophysiologic studies are not collaborative.
- To identify the pain generator when patients have multiple abnormalities on anatomic studies.
- To determine the symptomatic level in multilevel disc herniation.
- To determine a previously undocumented nerve root irritation as a result of spondylolisthesis.
- To determine the symptomatic level in multilevel stenosis.
- To determine the symptomatic root in patients with documented post operative fibrosis.

3.1.2 Therapeutic Epidural Injections

Lumbar epidural injections include caudal, interlaminar, and transforaminal. Common indications are as follows:

- Chronic low back and/or lower extremity pain of at least 3 months duration which has failed to respond or poorly responded to noninterventional and nonsurgical conservative management resulting from:
    - Disc herniation/lumbar radiculitis (evidence – good for caudal, interlaminar, and transforaminal)
    - Lumbar spinal stenosis (evidence – fair for caudal and interlaminar, limited for lumbar transforaminal)
    - Post lumbar surgery syndrome (evidence – fair for caudal and limited for transforaminal)
    - Axial or discogenic low back pain without facet joint or sacroiliac joint pain or disc herniation (evidence – fair for caudal and lumbar interlaminar and limited for transforaminal)
- Moderate to severe pain causing functional disability.
- Lumbar interlaminar may be performed in post surgery syndrome only if the access to the epidural space is obtained outside the scar.
- Caudal epidural is the modality of choice for post surgery syndrome based on the level of pathology.

3.1.3 Cervical Epidural

While cervical epidural injections may be administered either by interlaminar or transforaminal approach, only the interlaminar approach has been studied with appropriate indications and effectiveness. Further, cervical transforaminal epidural injections are associated with high risk. Common indications for cervical interlaminar epidurals are as follows:|

- Chronic neck and/or upper extremity pain of at least 3 months duration which has failed to respond or poorly responded to non-interventional and nonsurgical conservative management resulting from:
    - Disc herniation/cervical radiculitis (evidence – good)
    - Cervical spinal stenosis (evidence – fair)
    - Post cervical surgery syndrome (evidence – fair)
    - Axial or discogenic pain without facet joint pathology or disc herniation (evidence – fair)
- Intermittent or continuous pain causing functional disability.

3.1.4 Thoracic Epidural

Thoracic epidural injections may be performed either with an interlaminar approach or a transforaminal approach. The literature is scant in reference to thoracic epidural injections. Consequently, only interlaminar epidural injections are described herewith. Common indications are as follows:

- Chronic mid back or upper back pain of at least 3 months duration which has failed to respond or poorly responded to non-interventional and nonsurgical conservative management resulting from:
    - Thoracic disc herniation/radiculitis
    - Thoracic spinal stenosis
    - Thoracic post surgery syndrome
    - Axial or discogenic pain without facet joint

pathology or disc herniation
- Moderate to severe pain causing functional disability.

3.1.5 Frequency of Epidural Procedures
- Guidelines of frequency of interventions apply to epidural injections caudal, interlaminar, and transforaminal.
- In the diagnostic phase, a patient may receive 2 procedures at intervals of no sooner than 2 weeks or preferably 4 weeks (14,19,35,84,85, 321,340,567,644,697,765,772,968,676,1036-1038, 1085,1127-1129,1191,364,1365,1468,1469,1857, 1920, 1995,2077,2156).
- In the therapeutic phase (after the diagnostic phase is completed), the suggested frequency of interventional techniques should be 2 months or longer between each injection, provided that > 50% relief is obtained for 2 months (14,19,35,84,85, 321,340,567,644,697,765,772,968,676,1036-1038, 1085,1127-1129,1191,364,1365,1468,1469,1857, 1920, 1995,2077,2156)
- If neural blockade is applied for different regions, they may be performed at intervals of no sooner than one week and preferably 2 weeks for most types of procedures. The therapeutic frequency may remain at intervals of at least 2 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures can be performed safely.
- In the treatment or therapeutic phase, the epidural injections should be repeated only as necessary according to medical necessity criteria, and it is suggested that these be limited to a maximum of 4 times per year.
- Cervical and thoracic regions are considered as one region and lumbar and sacral are considered as one region.

3.2 Percutaneous Adhesiolysis

At the present time, the evidence is available for percutaneous adhesiolysis in the lumbar region only utilizing a caudal approach. Evidence for the cervical and thoracic regions and transforaminal approach in the lumbar region is only emerging. Common indications for percutaneous adhesiolysis with a caudal approach in lumbar region are as follows:
- Chronic low back and/or lower extremity pain of at least 6 months duration which failed to respond to or poorly responded to non-interventional and non-surgical conservative management and fluoroscopically directed epidural injections secondary to:
  - Failed back surgery syndrome (evidence – fair to good)
  - Central spinal stenosis (evidence – fair)
  - Disc herniation/radiculitis/severe degenerative disc disease (evidence – NA)
- Intermittent or continuous pain causing functional disability.

3.2.1 Frequency of Interventions
- The number of procedures are preferably limited to:
  - 2 interventions per year, with a 3-day protocol
  - 4 interventions per year, with a one-day protocol.

3.3 Intradiscal Procedures

For intradiscal electrothermal therapy, IDET, and bi-aculoplasty is limited to fair and is limited for disctrode.

Common indications are as follows:
- Chronic axial low back pain of discogenic origin of at least 6 months duration after failure to respond to conservative treatment.
- Abnormal nucleus signal on T2-weighed MRI images with > 60% residual disc height.
- Positive concordant discogram at low pressure.
- Normal neurologic exam (or at least no new deficits attributable to the level to be treated).
- Negative straight-leg raise.
- MRI with no evidence of root compression, tumor, or infection (if root compression is present, consider PMDD).

3.3.1 Mechanical Disc Decompression

For percutaneous disc decompression, the evidence is limited for automated percutaneous lumbar discectomy (APLD), percutaneous lumbar laser disc decompression, and decompressor; and it is limited to fair to nucleoplasty for which the Centers for Medicare and Medicaid Services (CMS) has issued a noncoverage decision.
- Common indications are as follows:
- Radicular symptoms in a specific dermatomal distribution that correlates with MRI findings of at least 6 months duration after failure of conservative management.
- Positive straight leg raising test or positive bowstring sign, or both.
- Neurologic findings or radicular symptoms.
- Imaging studies (CT, MRI, discography) indicating a subligamentous contained disc herniation.
- Well maintained disc height of 60%.

3.4 Facet Joint Interventions

Facet joint interventions are applied in the cervical, tho-

racic, and lumbar regions. These include diagnostic, as well as therapeutic. Further, approaches include intraarticular injections, facet joint nerve blocks, conventional radiofrequency neurotomy, and pulsed radiofrequency neurotomy. The evidence is variable for each modality and for each region. The indications described here apply for cervical, thoracic, and lumbar facet joint interventions.

3.4.1 Diagnostic Facet Joint Nerve Blocks

Diagnostic facet joint injections may be performed either with an intraarticular approach or by blocking the facet joint nerves. However, the evidence is limited to poor for intraarticular injections, thus the evidence here described is based on diagnostic facet joint nerve blocks. The evidence for diagnostic accuracy of facet joint nerve blocks is good in the lumbar, thoracic, and cervical regions.

Common indications for diagnostic facet joint nerve blocks are as follows:

- Somatic or nonradicular neck, mid back, upper back or low back and headache, upper extremity pain, chest wall pain or lower extremity pain of at least 3 months duration.
- Moderate to severe 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 evidence, either for discogenic or sacroiliac joint pain.
- Lack of disc herniation or evidence of radiculitis.

3.4.2 Therapeutic Facet Joint Interventions

Therapeutic facet joint interventions are available for the cervical, thoracic, and lumbosacral regions. Therapeutic facet joint interventions include intraarticular injections, therapeutic facet joint nerve blocks, and radiofrequency neurotomy, either conventional or pulsed. The evidence is limited for these interventions. The evidence for intraarticular injections is limited for the cervical and thoracic regions and not available for the lumbar region. The evidence is fair to good for therapeutic facet joint nerve blocks, and fair for cervical and thoracic medial branch blocks. The evidence is good for radiofrequency neurotomy in the lumbosacral region, fair in the cervical region, and poor in the lumbar thoracic region (16,258,803). The evidence for pulsed radiofrequency is limited or not available.

- Indications for therapeutic facet joint interventions are based on the diagnosis established with a positive response to controlled diagnostic blocks, either placebo or comparative local anesthetic blocks, with a criterion standard of 75% pain relief with ability to perform prior painful movements without significant pain.

3.4.3 Frequency of Interventions

- In the diagnostic phase, a patient may receive 2 procedures at intervals of no sooner than 2 weeks or preferably 4 weeks, with careful judgment of response (14,19,35,84,85,321,340,567,644,697,765, 772,968,676,1036-1038,1085,1127-1129, 1191,364,1365,1468,1469,1857,1920, 1995, 2077, 2156).
- In the therapeutic phase (after the diagnostic phase is completed), the suggested frequency would be 2 - 3 months or longer between injections, provided that ≥ 50% relief is obtained for 2 months (14,19,35,84,85,321,340,567,644,697,765,772,968,676,803,1036-1038,1085,1127-1129,1191,364,1365,1468, 1469,1857,1920, 1995,2077,2156).
- If the interventional procedures are applied for different regions, they may be performed at intervals of no sooner than one week or preferably 2 weeks for most types of procedures.
- It is suggested that therapeutic frequency remain at least a minimum of 2 months for each region; it is further suggested that all the regions be treated at the same time provided that all procedures can be performed safely.
- In the treatment or therapeutic phase, the interventional procedures should be repeated only as necessary according to the medical necessity criteria, and it is suggested that these be limited to a maximum of 4 times for local anesthetic and steroid blocks over a period of one year, per region.
- Under unusual circumstances with a recurrent injury or cervicogenic headache, procedures may be repeated 6 times a year after stabilization in the treatment phase.
- For facet joint neurolysis, the suggested frequency would be 6 months or longer (maximum of 2 times per year) between each procedure, provided that 50% or greater relief is obtained for 4 months.
- The therapeutic frequency for medial branch neurotomy should remain at intervals of at least 6 months per each region with multiple regions involved. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.
- Cervical and thoracic are considered as one region and lumbar and sacral are considered as one region for billing purposes.

3.5 Sacroiliac Joint Interventions

Sacroiliac joint interventions include intraarticular

injections, periarticular injections, and radiofrequency neurotomy of the nerve supply, either with cooled radiofrequency, conventional radiofrequency, or pulsed radiofrequency (the evidence for diagnostic accuracy of sacroiliac joint injections – good, evidence for therapeutic interventions intraarticular – limited, periarticular injections – limited, cooled radiofrequency neurotomy – fair, conventional radiofrequency neurotomy – limited, pulsed radiofrequency neurotomy – limited).

Common indications are as follows:

- Somatic or nonradicular low back and lower extremity pain of at least 3 months duration below the level of L5 vertebra, which failed to respond to more conservative management, including physical therapy modalities with exercises, chiropractic management, and non-steroidal anti-inflammatory agents.
- Lack of obvious evidence for disc-related or facet joint pain.
- For therapeutic sacroiliac joint interventions with intraarticular injections or radiofrequency neurotomy, the joint should have been positive utilizing controlled diagnostic blocks.
- Intermittent or continuous pain causing functional disability.

3.5.1 Frequency of Interventions

- In the diagnostic phase, a patient may receive 2 procedures at intervals of no sooner than 2 weeks or preferably 4 weeks.
- In the therapeutic phase (after the diagnostic phase is completed), the suggested frequency would be 2 months or longer between injections, provided that > 50% relief is obtained for 6 weeks.
- If the procedures are done for different joints, they should be performed at intervals of no sooner than one week or preferably 2 weeks. It is suggested that therapeutic frequency remain at 2 months for each joint. It is further suggested that both joints be treated at the same time, provided the injections can be performed safely.
- In the treatment or therapeutic phase, the interventional procedures should be repeated only as necessary according to the medical necessity criteria, and it is suggested that they be limited to a maximum of 4 times for local anesthetic and steroid blocks over a period of one year, per region.
- For sacroiliac joint radiofrequency neurotomy, the suggested frequency is 6 months or longer between each procedure (maximum of 2 times per year), provided that > 50% relief is obtained for 4 months.

4.0 Documentation

Documentation is to provide evidence or information. Documentation includes evaluation and management services, procedural services, and billing and coding. While the purpose of documentation is to provide information, it reflects the competency and character of the physician (8,2400-2402).

4.1 Medical Necessity

Medical necessity requires appropriate diagnosis and coding by the *International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)* to justify services rendered and indicates the severity of a patient's condition (2403). The Balanced Budget Act (HR 2015, Section 4317) requires all physicians to provide diagnostic information for all Medicare/Medicaid patients starting from January 1, 1998 (2403,2404). Medical necessity is defined in numerous ways (2405-2409):

- The CMS (2407) defines medical necessity as, "no payment may be made under Part A or Part B for any expense incurred for items or services which . . . are not reasonable and necessary for the diagnosis or treatment of illness or injury or to improve the functioning of a participant."
- The American Medical Association (AMA) (2409) defines medical necessity as, "health care services or procedures that a prudent physician would provide to a patient for the purpose of preventing, diagnosing or treating an illness, injury, disease or its symptoms in a manner that is:
  - In accordance with generally accepted standards of medical practice.
  - Clinically appropriate in terms of type, frequency, extent, site, and duration.
  - Not primarily for the convenience of the patient, physician or other healthcare provider."

4.2 Elements of Documentation

Federal, state, third party payer, and managed care plans rely heavily on provider documentation when assessing the claims for various parameters (8,2400-2402,2410-2423). These include:

- Was the billed service actually rendered or provided to the patient?
- Was the level of service or extent of the service accurately reported?
- Was the service or procedure medically necessary?

- Was the claim sent to the correct primary insurer for the service or procedure performed?

4.3 Types of Documentation

Documentation includes evaluation and management services and interventional techniques (2400,2401,2419,2420). Documentation for spinal interventional techniques may vary based on whether the procedure was performed in a facility setting such as hospital outpatient department or ambulatory surgery center versus in a physician's office.

4.4 Documentation of Interventional Procedures

All spinal interventional techniques are considered surgical procedures (8,2401,2419,2420,2424). Documentation requirements are as follows:

- History and physical.
- Indications and medical necessity.
- Intra-operative procedural description.
- Post-operative monitoring and ambulation.
- Discharge/disposition.

4.5 History and Physical

The physician's history should include the following elements:

- Documentation of the signs and symptoms warranting the interventional procedure.
- A listing of the patient's current medications including dosages, route, and frequency of admission.
- Any existing co-morbid conditions and previous surgeries.
- Documentation of any social history or conditions which would have an impact on the patient's care upon discharge from the facility following the procedure.

The physician's physical examination should not only reflect the relevance of the interventional procedure, but also the type of anesthesia planned. Generally, for interventional techniques, if no anesthesia is to be administered, the physical examination is limited to the assessment of the patient's mental status and an examination specific to the proposed procedure, including any co-morbid conditions (8,2401,2402,2419,2420).

However, if intravenous sedation or any other type of anesthesia is planned, the physical examination should also include documentation of the results of an auscultatory examination of the heart and lungs, and an assessment and written statement about the patient's general health, in addition to the assessment of mental status and an examination specific to the proposed procedure and any co-morbid conditions (2401).

4.6 Indications and Medical Necessity

Medical necessity must be established for each and every procedure and encounter (8,2400-2402,2404-2409,2419-2422). General documentation requirements for spinal interventional techniques for indications and medical necessity are as follows:

1. Complete initial evaluation including history and physical examination.
2. Physiological and functional assessment, as necessary and feasible.
3. Definition of indications and medical necessity, as follows:

- Suspected organic problem.
- Non-responsiveness to conservative modalities of treatment.
- Pain and disability of moderate-to-severe degree.
- No evidence of contraindications such as severe spinal stenosis resulting in intraspinal obstruction, infection, or predominantly psychogenic pain.
- Responsiveness to prior interventions with improvement in physical and functional status for repeat blocks or other interventions.
- Repeating interventions only upon return of pain and deterioration in functional status.

4.7 Procedural Documentation

This includes a description of the procedure, post operative monitoring, and discharge/disposition (8,2401,2402,2410,2411,2419,2420) (Table 46).

Table 46. *Procedural documentation guidelines for interventional techniques.*

1.	**History and physical**
2.	**Indications and medical necessity**
3.	**Description of the procedure**
	Consent
	Monitoring
	Sedation
	Positioning
	Site preparation
	Fluoroscopy
	Drugs utilized
	Needle placement
	Complications
4.	**Post-operative monitoring**
5.	**Discharge and instructions**

XI. SUMMARY

The results of the summary of evidence and recommendations are provided in managing low back pain, cervical pain, and thoracic pain based on the comprehensive review of the literature. Unless otherwise stated, the evidence for therapeutic interventions is based on long-term improvement.

I. Management of Low Back Pain

1. Diagnostic Selective Nerve Root Blocks

- The evidence for accuracy of diagnostic selective nerve root blocks is limited in the lumbar spine in patients with an equivocal diagnosis and involvement of multiple levels.
- Diagnostic selective nerve root blocks are recommended in the lumbar spine in select patients with an equivocal diagnosis and involvement of multiple levels.

2. Lumbar Discography

- The evidence for diagnostic accuracy for lumbar provocation discography is fair and the evidence for lumbar functional anesthetic discography is limited.
- Lumbar provocation discography is recommended with appropriate indications in patients with low back pain to prove a diagnostic hypothesis of discogenic pain specifically after exclusion of other sources of lumbar pain.

3. Diagnostic Lumbar Facet Joint Nerve Blocks

- The evidence for diagnostic lumbar facet joint nerve blocks is good with 75% to 100% pain relief as the criterion standard with controlled local anesthetic or placebo blocks.
- Diagnostic lumbar facet joint nerve blocks are recommended in patients with suspected facet joint pain.

4. Diagnostic Sacroiliac Joint Blocks

- The evidence for diagnostic intraarticular sacroiliac joint injections is good with 75% to 100% pain relief as the criterion standard with controlled local anesthetic or placebo blocks, and fair due to the limitation of the number of studies with 50% to 74% relief with a dual block.
- Controlled sacroiliac joint blocks with placebo or controlled comparative local anesthetic blocks are recommended when indications are satisfied with suspicion of sacroiliac joint pain

5. Therapeutic Epidural Injections

- The evidence for caudal epidural, interlaminar epidural, and transforaminal epidural injections is good in managing disc herniation or radiculitis; fair for axial or discogenic pain without disc herniation, radiculitis or facet joint pain with caudal and lumbar interlaminar epidural injections, and limited with transforaminal epidural injections; fair for spinal stenosis with caudal, interlaminar, and transforaminal epidural injections; and fair for post surgery syndrome with caudal epidural injections and limited with transforaminal epidural injections.
- The recommendation for epidural injections for disc herniation is that one of the 3 approaches may be used; for spinal stenosis any of the 3 approaches are recommended; whereas for axial or discogenic pain, either lumbar interlaminar or caudal epidural injections are recommended. However for transforaminal the evidence is limited for axial or discogenic pain and post surgery syndrome.

6. Therapeutic Lumbar Facet Joint Interventions

- The evidence for lumbar conventional radiofrequency neurotomy is good, limited for pulsed radiofrequency neurotomy, fair to good for lumbar facet joint nerve blocks, and limited for intraarticular injections.
- Among the therapeutic facet joint interventions either conventional radiofrequency neurotomy or therapeutic facet joint nerve blocks are recommended after the appropriate diagnosis with controlled diagnostic lumbar facet joint blocks.

7. Therapeutic Sacroiliac Joint Interventions

- The evidence for sacroiliac cooled radiofrequency neurotomy is fair; limited for intraarticular steroid injections; limited for periarticular injections with steroids or botulinum toxin; and limited for both pulsed radiofrequency and conventional radiofrequency neurotomy.
- Due to emerging evidence for intraarticular injections, they are recommended in select cases with or without periarticular injections. Cooled radiofrequency neurotomy is recommended after appropriate diagnosis confirmed by diagnostic sacroiliac joint injections.

8. Percutaneous Adhesiolysis

The evidence for lumbar epidural adhesiolysis in managing chronic low back and leg pain secondary to post lumbar surgery syndrome is fair to good and spinal stenosis is fair.

- Percutaneous adhesiolysis is recommended after failure of conservative management and fluoroscopically directed epidural injections.

9. Thermal Annular Procedures

The evidence for IDET and biaculoplasty is limited to fair and is limited for discTRODE.

- IDET and biaculoplasty may be performed in a select group of patients with discogenic pain nonresponsive to conservative modalities including epidural injections.

10. Percutaneous Disc Decompression

- The evidence for various modes of percutaneous disc decompression is limited to fair for nucleoplasty, and limited for APLD, percutaneous lumbar disc decompression, and decompressor.

The CMS has issued a noncoverage decision for nucleoplasty.

- APLD and percutaneous lumbar disc decompression and nucleoplasty are recommended in select cases.

II. Management Of Neck Pain

1. Cervical Provocation Discography

- The evidence for the diagnostic accuracy of cervical discography is limited.
- 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. Diagnostic Cervical Facet Joint Nerve Blocks

- The evidence for diagnostic cervical facet joint nerve blocks is good with a criterion standard of 75% or greater relief with placebo or local anesthetic controlled diagnostic blocks.
- Diagnostic cervical facet joint nerve blocks are recommended for the diagnosis of cervical facet joint pain.

3. Therapeutic Cervical Interlaminar Epidural Injections

- The evidence is good for cervical disc herniation or radiculitis; whereas, it is fair for axial or discogenic pain, pain of spinal stenosis, and pain of post cervical surgery syndrome.
- Cervical interlaminar epidural injections are recommended for patients with chronic neck and upper extremity pain secondary to disc herniation, spinal stenosis, and post cervical surgery syndrome.

4. Therapeutic Cervical Facet Joint Interventions

- The evidence is fair for cervical radiofrequency neurotomy and cervical medial branch blocks, and limited for cervical intraarticular injections.
- Conventional radiofrequency neurotomy or therapeutic facet joint nerve blocks are recommended in managing chronic neck pain after the appropriate diagnosis from controlled diagnostic blocks.

III. Management Of Thoracic Pain

1. Thoracic Provocation Discography

- The evidence for thoracic discography is limited.

Thoracic discography is recommended to decide if an intervertebral disc is painful or not in rare circumstances.

2. Diagnostic Thoracic Facet or Zygapophysial Joint Nerve Blocks

- The evidence for diagnostic accuracy of thoracic facet joint nerve blocks is good with a criterion standard of at least 75% pain relief with placebo or local anesthetic controlled diagnostic blocks.
- The diagnostic thoracic facet or zygapophysial joint nerve blocks are recommended in the diagnosis of chronic thoracic pain.

3. Thoracic Epidural Injections

The evidence for thoracic epidural injection in treating chronic thoracic pain is fair.

- Thoracic epidural injections are recommended for thoracic discogenic, disc-related, post surgery syndrome, or spinal stenosis pain.

4. Therapeutic Thoracic Facet or Zygapophysial Joint Nerve Blocks

The evidence is fair for therapeutic thoracic facet or zygapophysial joint nerve blocks, limited for radiofrequency neurotomy, and none for thoracic intraarticular injections.

- Therapeutic thoracic facet or zygapophysial joint nerve blocks are recommended.

- However, radiofrequency neurotomy and conventional radiofrequency neurotomy may be performed based on emerging evidence.

IV. Implantables

1. Spinal Cord Stimulation

The evidence for SCS is fair in managing patients with FBBS.

- Spinal cord stimulation is indicated in chronic low back pain with lower extremity pain secondary to FBBS, after exhausting multiple conservative and interventional modalities.

2. Implantable Intrathecal Drug Administration Systems

The evidence for intrathecal infusion systems is limited in managing chronic noncancer pain.

- The recommendations for intrathecal infusion pumps include recalcitrant chronic noncancer pain

V. Antithrombotic and Antiplatelet Therapy

- Nonsteroidal anti-inflammatory agents including low dose aspirin do not increase the risk of spinal epidural hematoma and are not a contraindication for interventional techniques.
- However, high dose aspirin and combination of multiple drugs should be taken into consideration and may or may not be discontinued based on clinical judgment of individual risk and benefits assessment. In this regard, the simultaneous use of multiple agents that possess anticoagulant properties (e.g. NSAIDs or aspirin along with SSRIs, fish oil, etc.) will increase the risk of morbidity and/or mortality.
- Phosphodiesterase inhibitors including dipyridamole (Persantine), Aggrenox (dipyridamole plus aspirin), and cilostazol (Pletal) do not appear to increase the risk of spinal epidural hematoma and are not a contraindication for interventional techniques (evidence – fair). They may or may not be discontinued prior to interventional techniques (evidence – good).
- Platelet aggregation inhibitors including ticlopidine (Ticlid), clopidogrel (Plavix), and prasugrel (Effient) may be continued or discontinued prior to interventional techniques (evidence – fair).
- Based on patient factors and managing cardiologist's opinion, if a decision is made to discontinue, the current recommendations are that they may be discontinued for 7 days with clopidogrel and prasugrel and/or 10 to 15 days with ticlopidine (evidence – fair).
- There is also emerging evidence that discontinuation of 3 days may be effective (evidence – limited).
- If a clinician chooses to discontinue, they may be discontinued for 7 days (evidence – limited).
- Warfarin may be continued or discontinued based on INR achieved during therapy (evidence – good).
- For high risk interventional techniques including interlaminar epidural injections, percutaneous adhesiolysis, disc decompression, sympathetic blocks, and placement of implantables, warfarin must be discontinued for an appropriate period of time and INR of 1.4 or less must be achieved (evidence – good).
- For intermediate risk procedures such as caudal epidural injection, paravertebral interventional techniques, and peripheral joint injections, warfarin must be continued for an appropriate period of time and an INR of 2 or less may be considered (evidence – limited).
- Unfractionated heparin or LMWH may be discontinued approximately 12 hours prior to providing interventional techniques (evidence - limited).
- Dabigatran (Pradaxa) may be stopped 2 to 4 days for major interventional techniques with high risk of bleeding in patients with creatinine clearance greater than 50 mL per minute. For low risk or paravertebral interventional techniques and caudal, it may be stopped for one day in patients with normal renal function. May be stopped at least 4 to 5 days for those with creatinine less than 50 mL per minute. (evidence – limited)
- Rivaroxaban (Xarelto) may be stopped for one day or longer (evidence – limited).

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Author Affiliations

Laxmaiah Manchikanti, MD, is Medical Director of the Pain Management Center of Paducah, Paducah, KY and Clinical Professor, Anesthesiology and Perioperative Medicine, University of Louisville, Louisville, KY. drm@asipp.org

Salahadin Abdi, MD, PhD, is Professor and Chair, Department of Pain Medicine, University of Texas, MD Anderson Cancer Center, Houston, TX. sabdi@mdanderson.org

Sairam Atluri, MD, is Medical Director, Tri-State Spine Care Institute, Cincinnati, OH. saiatluri@gmail.com

Ramsin M. Benyamin, MD, is Medical Director, Millennium Pain Center, Bloomington, IL, and Clinical Assistant Professor of Surgery, College of Medicine, University of Illinois, Urbana-Champaign, IL. ramsinbenyamin@yahoo.com

Mark V. Boswell, MD, PhD, is Chairman, Department of Anesthesiology and Perioperative Medicine, University of Louisville, Louisville, KY. mark.boswell@louisville.edu

Ricardo M. Buenaventura, MD, is Medical Director, Pain Relief of Dayton, Centerville, OH, and Clinical Associate Professor, Department of Surgery, Wright State University School of Medicine, Dayton, OH. rbuena@yahoo.com

David A. Bryce, MD, is from Advanced Pain Management, Madison, WI. tonys09@gmail.com

Patricia A. Burks, LPT, is Clinical Director and Director of Physical Therapy Services at the Pain Management Center of Paducah, Paducah, KY. clinicaldirector@thepainmd.com

Aaron K. Calodney, MD, is Medical Director, Texas Pain, The Texas Spine and Joint Hospital, Tyler, TX. aaroncalodney@me.com

David L. Caraway, MD, is with St. Mary's Pain Relief Center, Huntington, WV. carawaymd@aol.com

Kimberly A Cash, RT, is a Research Coordinator at the Pain Management Center of Paducah, Paducah, KY.

Paul J. Christo, MD, is Associate Professor, Johns Hopkins University School of Medicine, Director, Multidisciplinary Pain Fellowship (2003-2011), Director, Blaustein Pain Treatment Center (2003-2008), Division of Pain Medicine, Department of Anesthesiology and Critical Care Medicine, Baltimore, MD. pchristo@jhmi.edu

Steven P. Cohen, MD, is Professor, Department of Anesthesiology and Critical Care Medicine, Pain Management Division, Johns Hopkins School of Medicine, Baltimore, MD and Professor, Department of Anesthesiology, Uniformed Services University of the Health Sciences, Bethesda, MD. Scohen40@jhmi.edu

James Colson MS, MD, is Associate Professor of Anesthesiology, Department of Anesthesiology, Pain Medicine Service, West Virginia University Hospitals, Morgantown, WV. jdcol@charter.com

Ann Conn, MD, is Staff Physician, Premier Pain Relief, Covington, LA. annconn@gmail.com

Harold J. Cordner, MD, is with Florida Pain Management Associates, Sebastian, FL. gassdoc@aol.com

Sareta Coubarous, DO, is Attending Physician, Mid Atlantic Spine & Pain Physicians, Newark, DE. osteorehabdoc@yahoo.com

Sukdeb Datta, MD, is Medical Director, Laser Spine & Pain Institute, New York, NY, and Professorial Lecturer, Mount Sinai School of Medicine, Department of Anesthesiology, New York, NY. sdattamd@gmail.com

Timothy R. Deer, MD, is Medical Director, The Center for Pain Relief, and Clinical Professor, Anesthesiology, West Virginia University School of Medicine, Charleston, WV. doctdeer@aol.com

Sudhir Diwan, MD, is Executive Director of Manhattan Spine and Pain Medicine, New York, NY. sudhir.diwan63@gmail.com

Frank J.E. Falco, MD, is Medical Director of the Mid Atlantic Spine & Pain Physicians of Newark, DE, Director, Pain Medicine Fellowship, Temple University Hospital, Philadelphia, PA, and Associate Professor, Department of PM&R, Temple University Medical School, Philadelphia, PA. cssm01@aol.com

Bert Fellows, MA, is Director Emeritus of Psychological Services at the Pain Management Center of Paducah, Paducah, KY. bert@thepainmd.com

Stephanie C. Geffert, MLIS, is Director of Research and Education and Administrative Assistant at Mid Atlantic Spine & Pain Physicians, Newark, DE, and Fellowship Coordinator at Temple University Hospital, Philadelphia, PA. sgeffert@midatlanticspine.com

Scott E. Glaser, MD, is Medical Director of Pain Specialists of Greater Chicago, Burr Ridge, IL. sglaser@painchicago.com

Jay S. Grider, DO, PhD, is Medical Director, UK Healthcare Pain Services, Division Chief, Pain and Regional Anesthesia and Associate Professor, Department of Anesthesiology, University of Kentucky, Lexington, KY. jsgrid2@email.uky.edu

Sanjeeva Gupta, MD, is a Consultant in Pain Medicine and Anaesthesia, Bradford Teaching Hospital NHS Foundation Trust, Bradford Royal Infirmary, Bradford,

United Kingdom. sgupta6502@aol.com

Haroon Hameed, MD, is with Mid Atlantic Spine & Pain Physicians, Newark, DE. drharoonhameed@yahoo.com

Mariam Hameed, MD, is with Brigham and Women's Hospital, Chestnut Hill, MD. mairahameedmd@yahoo.com

Hans Hansen, M,D is Medical Director of The Pain Relief Centers, Conover, NC. hans@hippocrates.org

Standiford Helm II, MD, is Medical Director, The Helm Center for Pain Management, Laguna Hills, CA. drhelm@thehelmcenter.com

Jeffrey W. Janata, PhD, is Associate Professor of Psychiatry, Director, Behavioral Medicine Program University Hospitals of Cleveland Case Western Reserve University, Cleveland, OH. jeffrey.janata@case.edu

Rafael Justiz, MD, is Medical Director, Oklahoma Pain Physicians, Oklahoma City, OK. rjustiz@yahoo.com

Marion Lee, MD, is Director of Centers for Pain Management, Tifton, GA. painanswers@aol.com

Kavita N. Manchikanti, MD, is a second year resident in Physical Medicine and Rehabilitation at the University of Kentucky, Lexington, KY. kavita.manchikanti@gmail.com

Carla D. McManus, RN, BSN, is a Nursing Administrator at the Pain Management Center of Paducah, Paducah, KY. carla@thepainmd.com

Obi Onyewu, MD, is Attending Physician, Mid Atlantic Spine & Pain Physicians, Newark, DE, and Elkton, MD; Faculty, Pain Medicine Fellowship Program, Temple University Hospital, Philadelphia, PA; and Adjunct Assistant Professor, Temple University Medical School, Philadelphia, PA. obionyewu@aol.com

Allan T. Parr, MD, is Medical Director, Premier Pain Center, Covington, LA. alparr@alparr.com

Vikram Patel, MD, is Medical Director of ACMI Pain Care, Algonquin, IL. vikpatel1@yahoo.com

Gabor B. Racz, MD, is Professor and Chairman Emeritus, Texas Tech University Health Sciences Center, Lubbock, TX. gbracz@yahoo.com

Nalini Sehgal, MD is Medical Director, Interventional Pain Program, and Associate Professor and Director Interventional Pain Management, Department of Orthopedics and Rehabilitation Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI. Sehgal@rehab.wisc.edu

Manohar Sharma, MD, FRCA, FFPMRCA, is a Consultant in Pain Medicine, Department of Pain Medicine, The Walton Centre for Neurology and Neurosurgery NHS Foundation Trust, Liverpool, and a Fellow of the Faculty of Pain Medicine of the Royal College of Anaesthetists and Treasurer of British Pain Society Interventional Pain Medicine Special Interest Group, United Kingdom. manoharpain@yahoo.co.uk

Thomas T. Simopoulos, MD, is Assistant Professor, Department of Anesthesia, Critical Care, and Pain Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA. tsimopou@bidmc.harvard.edu

Vijay Singh, MD, is Medical Director, Spine Pain Diagnostics Associates, Niagara, WI. vj@wmpnet.net

Howard S. Smith, MD, is Professor and Director of Pain Management for Albany Medical College, Department of Anesthesiology, Albany, NY. smithh@mail.amc.edu

Lee T. Snook, MD, is Medical Director of Metropolitan Pain Management Consultants, Inc., Sacramento, CA. lsnook@pain-mpmc.com

John Swicegood, MD, is Medical Director, Advanced Interventional Pain and Diagnostics of Western Arkansas, Fort Smith, AR. swice99@gmail.com

Ricardo Vallejo, MD, PhD, is Director of Research, Millennium Pain Center, Bloomington, IL; and Adjunct Professor of Biology, Illinois State University, Normal, IL. vallejo1019@yahoo.com

Stephen P. Ward, MD, FRCA, FFPMRCA, a Consultant in Pain Medicine, Brighton and Sussex University Hospitals NHS Trust, Council Member of the British Pain Society, a Fellow of the Faculty of Pain Medicine of the Royal College of Anaesthetists and Secretary of the British Pain Society Interventional Pain Medicine Special Interest Group, United Kingdom. stephen.ward@bsuh.nhs.uk

Bradley W. Wargo, DO, is an Interventional Pain Physician at the McFarland Clinic, Mary Greeley Medical Center, Ames, IA. drbwargo@gmail.com

Jie Zhu, MD, is Adjunct Assistant Professor, Temple University Medical School, Philadelphia, PA; Faculty, Pain Medicine Fellowship Program, Temple University Hospital, Philadelphia, PA; and Attending Physician, Mid Atlantic Spine & Pain Physicians, Newark, DE and Elkton, MD. zzzzjim@gmail.com

Joshua A. Hirsch, MD, is Vice Chief of Interventional Care, Chief of Minimally Invasive Spine Surgery, Service Line Chief of Interventional Radiology, Director of Endovascular Neurosurgery and Neuroendovascular Program, Massachusetts General Hospital; and Associate Professor, Harvard Medical School, Boston, MA. hirsch@snisonline.org

Conflicts of Interest

Dr. Benyamin is a consultant with Bioness and Nevro; serves on the advisory boards of Vertos Medical and Nuvo Pharma; teaches/lectures for Vertos Medical, Boston Scientific, Neurotherm, and Bioness; and receives research/grants from Alfred Mann Foundation, Teknon Foundation, Spinal Restoration, Inc., Bioness, Boston Scientific, Vertos Medical, Medtronic, Kimberly Clarke, Epimed, BioDelivery Sciences International, Inc., Theravance, Mundipharma Research, Cephalon/Teva, AstraZeneca, and Purdue Pharma, LP.

Dr. Caraway is a consultant for Medtronic, Inc., Bioness, Spinal Modulation, Inc., and Vertos, Inc.

Dr. Calodney is a consultant for Stryker, Inc., Medtronic, Inc., and Nimbus Concepts

Dr. Cohen served as a funded co-investigator on a Department of Defense Study. He is also a consultant for Halozyme and Kimberly Clark.

Dr. Datta receives research support from Sucampo Pharmaceuticals and an honorarium from Smith and Nephew

Dr. Deer is a consultant and research advisor for Bioness, Flowonix, Jazz, Medtronic, Nevro, St. Jude, Spinal Modulation, and Vertos.

Dr. Falco is a consultant for St. Jude Medical Inc. and Joimax Inc.

Dr. Grider is an educational trainer for Vertos Medical.

Dr. Helm is a clinical investigator with Epimed and receives research support from Cephalon/Teva, AstraZeneca, and Purdue Pharma, LP. He has attended an advisory group meeting for Activas.

Dr. Justiz is a Consultant for St. Jude, Epimed, Annulex technologies, and currently in a study with Bioness.

Dr. Alan Kaye is a speaker for Depomed, Inc.

Dr. Racz is a Consultant for and has family ownership of Epimed International, is a consultant to Cosman RF company, and has Medtronic patent issues.

Dr. Schultz is a paid consultant for Medtronic.

Dr. Vallejo receives research support from Cephalon/Teva, BioDelivery Sciences International, Inc., Mundipharma Research GmbH & Co., AstraZeneca, Purdue Pharma, LP, and Theravance, and is a consultant for nevro and Kymberly-Clark.

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