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PRACTICE GUIDELINES

Evidence-Based Practice Guidelines for Interventional Techniques in the Management of Chronic Spinal Pain

Laxmaiah Manchikanti, MD, Peter S. Staats, MD, Vijay Singh, MD, David M. Schultz, MD, Bradley D. Vilims, MD, Joseph F. Jasper, MD, David S. Kloth, MD, Andrea M. Trescot, MD, Hans C. Hansen, MD, Thomas D. Falasca, DO, Gabor B. Racz, MD, Timothy R. Deer, MD, Allen W. Burton, MD, Standiford Helm, MD, Leland Lou, MD, MPH, Cyrus E. Bakhit, MD, Elmer E. Dunbar, MD, Sairam L. Atluri, MD, Aaron K. Calodney, MD, Samuel J. Hassenbusch, MD, and Claudio A. Feler, MD

Evidence-based practice guidelines for interventional techniques in the management of chronic spinal pain are systematically developed and professionally derived statements and recommendations that assist both physicians and patients in making decisions about appropriate health care in the diagnosis and treatment of chronic or persistent pain.

The guidelines were developed utilizing an evidence-based approach to increase patient access to treatment, to improve outcomes and appropriateness of care, and to optimize cost-effectiveness. All types of relevant and published evidence and consensus were utilized. The guidelines include a discussion of their purpose, rationale, and importance, including descriptions of the patient population served, the methodology, and the pathophysiologic basis for intervention.

Multiple diagnostic and therapeutic interventional techniques are included in this document. Strong evidence was shown for diagnostic facet joint blocks for the diagnosis of facet joint pain, and lumbar provocative discography for discogenic pain. Moderate evidence was shown for sacroiliac joint blocks in the diagnosis of sacroiliac joint pain, and for transforaminal epidural injections in the preoperative evaluation of patients with negative or inconclusive imaging studies, but with clinical findings of nerve root irritation.

Moderate to strong evidence was shown for multiple therapeutic interventional techniques including medial branch blocks and medial branch neurotomy; caudal epidural steroid injections and transforaminal epidural steroid injections; lumbar percutaneous adhesiolysis; and implantable therapies.

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. **These guidelines do not represent "standard of care."**

Keywords: Interventional techniques, neural blockade, chronic pain, epidural injections, percutaneous epidural adhesiolysis, discography, facet joint pain, radiofrequency

Contents

From American Society of Interventional Pain Physicians, Paducah, KY. Address correspondence: Laxmaiah Manchikanti, MD, 2831 Lone Oak Road, Paducah, Kentucky 42003. E-mail: drm@apex.net
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Author affiliations are listed in Appendix-A.

1. Introduction

1.1 Purpose

Evidence-based clinical practice guidelines for interventional techniques in the management of chronic spinal pain are statements developed to improve quality of care, improve patient access, improve patient outcomes, improve appropriateness of care, improve efficiency and effectiveness, and achieve cost containment by improving the cost-benefit ratio.

1.2 Rationale

A myriad of treatment options exist for patients in pain. We are obligated to provide our patients only the services that have documented clinical efficacy with minimal risk and cost efficacy. Available evidence documents a wide degree of variance in the definition and the practice of interventional pain management (1-49). Application of interventional techniques by multiple specialties is also highly variable for even the most commonly performed procedures and treated condition(s).

Interventional pain management is defined 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. The terms multidisciplinary or comprehensive elicit significant confusion. The terms relate to a pain physician's primary specialty. Thus, an interventionalist perceives a multidisciplinary or comprehensive program as the one with interventional techniques as the primary modality with physical and psychological modalities as secondary components. In contrast a psychiatrist, rehabilitation specialist or a surgeon might tend to emphasize psychology/psychiatry, physical therapy/functional rehabilitation and surgery, with multidisciplinary management achieved by secondary application of other modalities such as interventional techniques.

Many of the conditions of spinal pain and other chronic pain conditions are considered as either acute recurrent problems that are characterized by periods of quiescence punctuated by flare-ups, or chronic diseases, like diabetes or hypertension requiring long-term treatment with ongoing care (46). On the basis of advances in imaging, neural anatomic findings, new discoveries in chemical mediation, the development of precision diagnostic and therapeutic injection techniques, and reported non-operative treatment successes, the importance of interventional techniques in managing chronic spinal pain has been rationalized. Many guidelines, systematic reviews, and even Cochrane Reviews published pertaining to interventional pain management have been seriously questioned (12-14, 40-49). It has been highlighted that such reviews have some major shortcomings, with potentially harmful health care implications for patients in the United States (41).

These guidelines address the issues of systematic evaluation and ongoing care of chronic or persistent pain. Primarily, these guidelines provide information about the scientific basis of recommended procedures. The guidelines, properly applied, should increase compliance, dispel misconceptions, contribute to appropriate patient expectations, and facilitate the relationship between patients, physicians, and the payers.

Information included or excluded in this document is to be considered as a scholarly and scientific attempt to accurately reflect the best available knowledge. This document, therefore, stands as a work in progress. At no time should this document be construed as a defined pathway for treating chronic spinal pain, but a best attempt to provide rational interpretation of available data and add science to the art of interventional pain management. The scientific investigations inevitably will continue and contributions from authors and anecdotal sources are welcomed, encouraged, and assessed in an objective and scholarly environment. The authors encourage others to participate with further development of these guidelines. It is the intent of the authors of this document to be forthright, and to eliminate procedural, specialty, or practice bias.

Thus, these guidelines are expected to be proactive, non-nihilistic and scientifically valid to the greatest extent possible.

1.3 Implementation and Review

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 dates for implementation and review were established:

- Effective date - February 1, 2003
- Expiration date - January 31, 2005
- Scheduled review - July 1, 2004

1.4 Methodology

The most common method for the development of guidelines is based on evidence and consensus. In addition, reviews, clinical decision analyses, and economic analyses are also very commonly utilized in the medical literature. Implicit in the definition of clinical practice guidelines is that they not only be systematically and scientifically developed but also should be able to assist the practitioner and patient in making real-life clinical decisions. Evidence-based guideline development provides a link between the strength of recommendations and the quality of evidence.

In developing these guidelines, all types of evidence are utilized. If an evidence-based approach failed to provide adequate levels of evidence, consensus and expert opinions have been utilized. These approaches are described for each technique.

While an evidence-based approach may seem to enhance the scientific rigor of guideline development, recommendations may not always meet the highest scientific standards (40). The current evidence-based medicine is defined as the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients (50). The practice of evidence-based medicine requires the integration of individual clinical expertise with the best available external clinical evidence from systematic research. It should be emphasized that, in addition to randomized controlled trials, many other factors are significant in both clinical and policy decisions. These factors, such as patient preferences and resources contribute to decisions about the care of patients (1). Thus, all evidence should be considered and no one sort of evidence should necessarily be the determining factor in a decision. The "gold standard" of randomized, placebo controlled, double blinded and independently observed prospective trials was meant to be applied to drug trials.

Table 1. *Designation of levels of evidence*

Level I	**Conclusive:** Research-based evidence with multiple relevant and high-quality scientific studies or consistent reviews of meta-analyses
Level II	**Strong:** Research-based evidence from at least one properly designed randomized, controlled trial of appropriate size (with at least 60 patients in the smallest group); or research-based evidence from multiple properly designed studies of smaller size; or at least one randomized trial, supplemented by predominantly positive prospective and/or retrospective evidence.
Level III	**Moderate:** Evidence from a well-designed small randomized trial or evidence from well-designed trials without randomization, or quasi-randomized studies, single group, pre-post cohort, time series, or matched case-controlled studies or positive evidence from at least one meta-analysis.
Level IV	**Limited:** Evidence from well-designed nonexperimental studies from more than one center or research group.
Level V	**Indeterminate:** Opinions of respected authorities, based on clinical evidence, descriptive studies, or reports of expert committees.

Adapted from Manchikanti et al (19)

Certain difficulties arise in trying to apply this model to surgical or minimally invasive procedures such as the ethical limitations of blinded surgical techniques or placebo use that prolong suffering and yet expose to surgical risk, cost prohibition, expected side effect of non-sham procedures that prevent placebo blinding, ability to recruit adequate numbers for procedures of limited applicability, etc. Thus, we must look to alternative ways to evaluate interventional techniques. Hence, in the development of these clinical guidelines of interventional techniques in managing chronic spinal pain, all applicable standards to rate the strength of evidence were utilized (40, 44, 50-55).

In evaluating the strength of evidence, multiple types of studies used for assessing clinical and public health interventions, including systematic reviews, experimental studies, non-randomized and observational studies, and diagnostic test studies were evaluated utilizing criteria described by the Agency for Healthcare Research and Quality (AHRQ) (52). Manchikanti et al (47) described the AHRQ criteria (52) in detail showing the important domains and elements for systems to rate the quality of individual articles. Table 1, shows the designation of levels of evidence from level I through V considered in the interventional pain management guideline preparation.

The search strategy utilized for evidence synthesis was comprehensive and included an extensive search of Index Medicus and EMBASE; all relevant and published peer-reviewed indexed and non-indexed journals; scientific meeting proceedings, scientific newsletters; and cross-references from articles, systematic and narrative reviews. In the analysis of evidence, systematic reviews, randomized clinical trials, observational reports and diagnostic test studies were utilized. A separate search strategy was designed for each subject under investigation. The inclusion and exclusion criteria as shown in Table 2 were utilized. Table 3 illustrates important domains and elements for systems to rate the quality of systematic reviews, randomized clinical trials, observational studies and diagnostic test studies. Four types of quality evaluation forms obtained and modified from AHRQ (52) and Manchikanti et al (44) have been utilized for each quality evaluation of systematic review(s), randomized controlled trial(s), observational evaluation(s) and diagnostic test(s). All systematic reviews randomized trials, prospective trials; retrospective evaluations with at least 50 patients, and abstracts presented in the past 2 years were utilized, if criteria were met.

In the development of these clinical practice guidelines, multiple resources were utilized to create principles for developing guidelines. Of particular importance are The National Health and Medical Research Council criteria (51) with nine basic principles as illustrated in Table 4.

As recommended by the National Health and Medical Research Council (51) and Shaneyfelt et al (40), the present guidelines include the following:

1. Documentation of the purpose of the guidelines;
2. Description of the natural history of chronic spinal pain and treatments and various interventional techniques that are available;
3. Identification of various conditions where recommendations might not apply;
4. Detailed description of the probable outcomes;
5. Maintenance of flexibility and compre-

Table 2. *Study evaluation (inclusion/exclusion) algorithm*

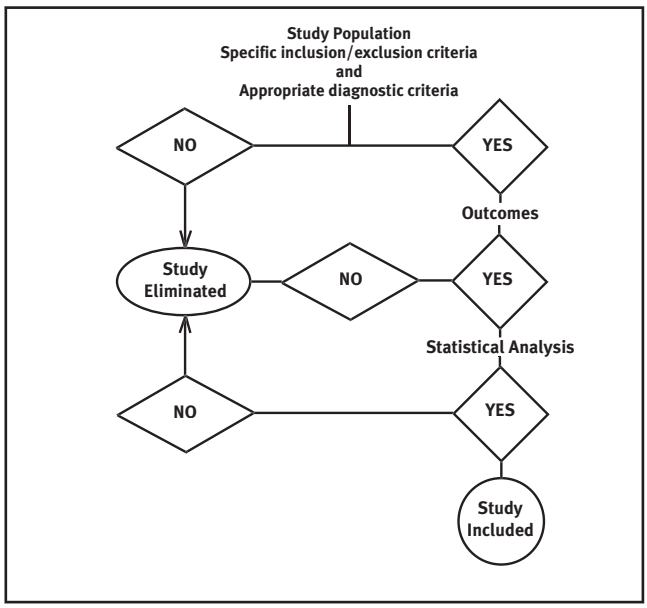


Table 3. *Important domains and elements for systems to rate quality of individual articles*

Systematic Reviews	Randomized Clinical Trials	Observational Studies	Diagnostic Test Studies
Study question	Study question	Study question	*Study population*
Search strategy	*Study population*	*Study population*	*Adequate description of test*
Inclusion and exclusion criteria	*Randomization*	*Comparability of subjects*	*Appropriate reference standard*
Interventions	*Blinding*	*Exposure or intervention*	*Blinded comparison of test and reference*
Outcomes	*Interventions*	*Outcome measurement*	*Avoidance of verification bias*
Data extraction	*Outcomes*	*Statistical analysis*	
Study quality and validity	*Statistical analysis*	Results	
Data synthesis and analysis	Results	Discussion	
Results	Discussion	*Funding or sponsorship*	
Discussion	*Funding or sponsorship*		
Funding or sponsorship			

* *Key domains in italics* Adapted from AHRQ (52)

hensive nature of the guidelines;
6. Description of the support services required for each potential treatment;
7. Inclusion of the information for consumers and clinicians, on all special clinical training or equipment that is needed;
8. Cost-effectiveness and cost comparisons of various options;
9. Reference to the type and strength of evidence on which recommendations are based;
10. Documentation of certainty or uncertainty of any conclusions;
11. Documentation of the economic appraisals used in formulating the guidelines; and
12. Acknowledgment of consensus-based recommendations whenever applied.

2. Chronic pain

In this new millennium, chronic pain continues to be an epidemic, and is coupled with claims of inadequate treatment (56-71). Understanding of pain, including diagnosis and treatment is in its infancy, in spite of modern developments in medicine. The devastating nature of chronic pain which can destroy the quality of life by eroding the will to live, disturbing sleep and appetite, creating fatigue, and impairing recovery from illness or injury is not well appreciated (56-66). Consequences may be especially grave for the elderly in chronic pain resulting in vocational, social, and family discord, which may make the difference between life and death (67-69), particularly for elderly women with low back pain (68).

On the basis of advances in genetic and cellular understanding, which may allow precise treatment of disorders; with specific drugs that have been selected by patient genetics; on the basis of imaging advances, neuroanatomic findings, and the discoveries of chemical mediation; reported successes with the understanding of disc pathology, disc alterations, and minimally invasive treatments; and the development and understanding of precision diagnostic and therapeutic interventional techniques, appropriate treatment may be provided.

2.1 Definition

Chronic pain is beset with controversy, starting with its definition. For some chronic pain conditions, it is defined as, "pain that exists beyond an expected time frame for healing." For other conditions, it is recognized that, "healing may never occur." Bonica (72) defined chronic pain as, "Pain which persists a month beyond the usual course of an acute disease or a reasonable time for any injury to heal that is associated with chronic pathologic processes that causes a continuous pain or pain at intervals for months or years". In many cases, chronic pain is understood as persistent pain that is not amenable to routine pain control methods. Pain is a highly disagreeable sensation that results from an extraordinarily complex and interactive series of mechanisms integrated at all levels of neuraxis, from the periphery to higher cerebral structures (73). Pain is usually elicited by the activation of specific nociceptors, either by two types of peripheral nociceptors connected with C- and A-delta fibers in the case of nociceptive pain, (74) or from injury to sensory fibers or from damage to the CNS in the case of neuropathic pain (75). Thus, chronic pain is a chronic disease and should be treated as such (46, 76). The National Academy of

Table 4. *Basic principles of guideline development*

- Outcomes (survival rates to quality-of-life attributes)
- Best available evidence (according to its quality, relevance and strength)
- Appropriate systems to synthesize the available evidence (judgment, experience and good sense)
- Multidisciplinary process of development
- Flexibility and adaptability
- Cost-effectiveness of treatments
- Appropriate dissemination
- Evaluation of implementation and impact of guidelines
- Appropriate revision of the guidelines on a regular basis

Adapted from NHRMC (51)

Sciences (77), following the synthesis of a diverse body of literature, conceptualized the injury process as a physiological pathway that begins with some form of structural low-tolerance relationship, progresses to symptom occurrence or adaptation, and ultimately results in either impairment or disability.

2.2 Prevalence

In a Gallup Survey of "Pain in America" more than 4 out of 10 adults (42%) said they experienced pain on a daily basis. Moulin et al (78), in a 2002 publication, reported chronic non-cancer pain in 29% of Canadians, with average duration of pain of 10.7 years and 80% of them reporting moderate to severe pain. They also reported an increased frequency in women and older age groups. Elliott et al (79), in a 4-year follow-up study, concluded that chronic pain is a common, persistent problem in the community with relatively high incidence and low recovery rates. Based on this survey in 2000, it was concluded that the average annual incidence of chronic pain (pain or discomfort present either all the time, or on and off for 3 months or longer), was 8.3% with average annual recovery rate of 5.4%. Patients aged 45 to 74 were less likely to recover from their chronic pain compared with those aged 25 to 34. Yeung et al (80), in a cross sectional study of prevalence of musculoskeletal symptoms in single and multiple body regions, showed that musculoskeletal symptoms for multiple body parts (2 or more) were more prevalent (64% of all workers) than those for single body regions (19%). They showed that approximately 85% of lower back symptoms were associated with disorders in other body regions. Verhaak et al (62), following the review of 15 epidemiological studies, concluded that in the adult population, chronic pain ranges from 2% to 40%, with a median point prevalence of 15%. Elliott et al (63) reported self-reported chronic pain in 50% of patients, equivalent to 46% of the general population. Blythe et al (64) reported chronic pain in 17% of males and 20% of females. For males, prevalence peaked at 27% in the 65 to 69 year age group and for females, prevalence peaked at 31% in the oldest age group of 80-84 years. Andersson et al (81) reported incidence of persistent pain for 6 months in 49% of the adult population, with functional disability in 13%. Croft (82) and MacFarlane et al (83) described that pain is increasing in the modern era due to greater awareness of pain, cultural shift, and the inherent difficulty of tracking the prevalence of pain over time. The International Association for the Study of Pain (IASP) appointed task forces to study the epidemiology of pain in 1996 (84), and specifically, pain in the elderly in 1999 (85). It was consistently described that the elderly suffered not only with pain of longer duration, but with higher frequency (66-69, 72, 81, 84-88).

Complaints of multiple pain problems in children and adolescents are no exception (65, 89-94). Barajas et al (89) showed a pain prevalence of 27.1% without any gender difference, however with a higher prevalence (32.7%) in the younger group. In fact, back pain in adolescents has been described as a raging public health crisis with increasing prevalence in some countries, while it is falling in others (97-100).

Among the chronic pain problems, pain emanating from various structures of the spine constitutes the majority of the problems, despite all the efforts expended into information, research, prevention, treatment and rehabilitation (101). Lifetime prevalence of spinal pain has been reported as 65% to 80% in the neck and low back (87, 88, 101-136). In contrast, the epidemiological data in relation to thoracic pain support the view that the thoracic spine is less commonly involved (131, 132, 137-141). Linton et al (131) estimated the prevalence of spinal pain in the general population as 66%, with only 15% of those reporting thoracic pain, in comparison to 56% to 44% for the lumbar and cervical regions respectively. Occhipiniti et al (138), in a survey of factory workers, described a prevalence of thoracic pain of 5%, in contrast to the prevalence of cervical and lumbar pain of 24% and 33% respectively. Ylinen and Ruuska (136), in contrast to the above reports, reported that neck pain is more commonly encountered in clinical practice than is low back pain. Hellsing and Bryngelsson (101) also stated that the prevalence of low back pain increased from 38% to 74% during the 20-year period. In addition, they reported that neck or shoulder problems were nearly as common as back problems.

Cassidy et al (112) and Côté et al (116) assessed prevalence of low back pain and neck pain and its impact on general health in the Canadian population. The results showed 47% of the patients reporting grade I low back pain (low pain intensity and low disability) vs 39% with neck pain; 12% grade II low back pain (high pain intensity and low disability) vs 9% with neck pain; and 13% grade III (high pain intensity/moderate disability), and grade IV low back pain (high pain intensity/severe disability) vs 5% with neck pain. Thus, a total of 13% of the population with low back pain and 5% of the population with neck pain suffer with high pain intensity coupled with moderate or severe disability. An additional 12% with low back involvement and 9% with neck involvement suffer with high pain intensity but with low disability. The studies evaluating chronic low back pain estimated the average of age related prevalence of persistent low back pain as 12% in children and adolescents, 15% in adults, and 27% in the elderly (67, 69, 87, 88).

2.3 Chronicity

Duration of pain and its chronicity have been topics of controversy. In a 2000 publication of a 4-year follow-up study (79), the overall prevalence of chronic pain was reported to increase 8.3% at annual follow-up. Seventy-nine percent of those with chronic pain at baseline still had it at follow-up. These authors concluded that chronic pain is not only a common and persistent problem in the community with a relatively high incidence, but also had prolonged course with low recovery rates. Of those patients with chronic pain at baseline, only 21.5% recovered with no pain at follow-up. It is also conventionally believed and repeatedly quoted that most episodes of low back pain will be short-lived, with 80% to 90% of attacks resolving in about 6 weeks irrespective of the administration or type of treatment, and 5% to 10% of patients developing persistent back pain (142-146). However, this concept has been questioned, as the condition tends to relapse, so most patients will experience multiple episodes. Modern evidence has shown that the prevalence of low back pain ranges from 32% to 79% at 3 months and 35% to 75% at 12 months (111, 147-155). Chronicity also has been demonstrated with neck pain with chronic persistent pain resulting in 26% to 44% of the patients after an initial episode of neck pain or whiplash (133-136, 156-158).

2.4 Economic Impact

More than 40 million people in the United States are affected with musculoskeletal pain, resulting in more than 300 million physician visits, costing hundreds of millions of dollars each year. Overall, approximately 50% to 60% of the US population is either partially or totally, temporarily or permanently disabled. Over 400 million workdays are lost each year. In the United States, the number of persons reporting disabling conditions increased from 49 million during 1991 to 1992 to 54 million during 1994 to 1995 (159-161). During 1996, direct medical costs for persons with disabilities were $260 billion (162, 163). A 1999 United States report of prevalence of disabilities and associated health conditions among adults reported 44 million or 22% of the adults as having a disability (164). Of the total percentage of disabilities, 63% occurred among working adults; of these, 27.8 million (16.5%) had a disability and 17.7 million (10.5%) had a limitation in their ability to work at a job or business. Of those adults aged $\geq$ 65 years, 16.3 million (50%) had a disability. The age specific prevalence rate of disability was the highest among respondents aged 65 or > for all functional activities, activities of daily living, and instrumental activities of daily living (164). Of all the adults with disabilities, 17.5% had arthritis and rheumatism, 16.5% had back or spine problems, and only 7.8% had cardiac or vascular problems. The cost of medical care for a disabled older person averages 3 times that for a non-disabled senior (165).

Cousins (166) suggested that the cost of health care for patients with chronic pain might exceed the combined cost of treating patients with coronary artery disease, cancer, and AIDS. de Lissovoy et al (167) estimated that in the United States, the cost of treatment in the first year after failed back surgery for pain was approximately $18,883 in 1997. However, health care expenditures comprise only a relatively small portion of the costs associated with chronic pain. The majority of the costs are associated with disability compensation, lost productivity, and lost tax revenue. The annual health care cost incurred by a chronic pain patient, excluding costs for surgical procedures, may range from $500 to as high as $35,400, with the average ranging from $12,900 to $18,833 annually (167-170). Contrary to popular belief, the vast majority of chronic pain patients are managed with medication. In 1999, more than 3 million prescriptions were written for OxyContin® (170). Thus, the costs for OxyContin alone would exceed $4,500 per year, not including related physician visits or laboratory work (42). Further, there has been growing support for the use of anti-convulsants, anti-depressants, and topical preparations for neuropathic pain syndromes (39, 170). This could add $1,500 to $3,000 per year. Further, 500,000 – 1,000,000 spine surgeries and 2 – 5 million interventional procedures are estimated to be performed in the United States each year.

3. Structural Basis

Chronic spinal pain is a multifactorial disorder with many possible etiologies. Chronic spinal pain is recognized as a multidimensional problem with both sensory and affective components. The biopsychosocial model, which emerged in the 1980s, views chronic spinal pain as a biopsychosocial phenomenon, in which biological, psychological and social factors dynamically interact with each other. In the 1990s, the biopsycho-social approach dominated chronic spinal pain management, at least among academicians, with efforts to introduce "psychosocial" approaches. The multi-dimensional mechanism of pain in multidisciplinary management has taken different meanings for different specialties, ignoring fundamental facts that pain is not explained by pure theories of either physical or psychological origins. Thus, pain management in some circles, has reached a stage of psychosocial reductionism, which has essentially eliminated the *bio* part from the biopsychosocial approach, leaving "psychosocial," "psychological," or "functional" approaches.

The concept of psychogenic pain has stimulated controversy in the field of pain medicine, not only regarding its prevalence, but indeed, its very existence (171). Essentially, psychogenic pain is considered within the context that "since there is nothing wrong with your body, there must be something wrong with you." Some state that the term psychogenic pain is fundamentally meaningless (172). The diagnosis of psychogenic pain not only fails to provide a valid organic diagnosis, but it also fails to provide validation of patient symptomatology and complaints. Thus, psychogenic pain also implies it is unreal or illusional. The concept of psychogenic pain is weakened by the fact that its diagnostic signs have been challenged. Gagliese and Katz (172) believe that medically unexplained pain is not a symptom of a psychological disorder and that it is time to abandon thinking that separates mind and body. Thus, the challenge remains for proponents to provide empirical evidence to prove that psychopathology causes pain and, in doing so, to specify the mechanisms by which it is generated (172). Modern technology, including magnetic resonance imaging (MRI), computed tomographic axial scanning (CT), neurophysiologic testing, and comprehensive physical examination with psychological evaluation, can identify the cause of low back pain in only 15% of patients in the absence of disc herniation and neurological deficit (2, 173). In addition, overall inaccurate or incomplete diagnosis in patients referred to pain treatment centers has been described as ranging from 40% to 67%, and the incidence of psychogenic pain has been shown to be present only in 1 of 3,000 patients, with the presence of pain of organic origin mistakenly branded as psychosomatic in 98% of the cases (174, 175). Psychogenic pain should not be confused with factitious illness and malingering, which are distinct psychiatric disorders.

Staats et al (176) outlined the psychological behaviorism theory of pain with a number of features. They described that one of the features is that human behavior is complex, as are pain phenomena. That complexity makes it impossible to deal with pain in a simple way, referring only to some things but not others. That is why there are different approaches to pain, because each deals with certain aspects of the phenomena, but not others. The complexity of pain phenomena makes it necessary for the general theory to include various levels of study of human behavior. If, for example, the focus is on the biological aspects of pain, then much will be missed, for learning principles and personality principles play such an important role. The same thing is true when the focus is on a simple use of behavior principles, as occurs in the behavioral approach. Thus, central to the understanding of the structural basis of chronic spinal pain is the provision of a physical diagnosis and validation of patient symptomatology whenever it is feasible rather than discouning emotional involvement.

This concept will remove many of the terms utilized in the past, "psychogenic," "somatizing," "hysterical," and more recently, "medically unexplained" to explain many of the pain problems not amenable to diagnosis by present methodology utilizing physical examination, radiological and electrodiagnostic testing. Providing a structural basis of pain also will invalidate the theory that maladaptive psychological processes are primarily responsible for causing regional pain syndromes, and therefore, the assumption that psychological or behavioral interventions are the most logical treatment modalities.

The majority of painful conditions include various types of pain originating from the spine with pain in the neck, upper back, mid back, low back and upper or lower extremities. Bogduk (177) postulated that, for any structure to be deemed a cause of back pain:

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

The same philosophy may be applied for cervical and thoracic pain. Kuslich et al (178) identified facet joints, ligaments, fascia, muscles, intervertebral discs and nerve root dura as tissues capable of transmitting pain in the low back. Thus, the structures responsible for pain originating in the spine and afflicting the neck, mid back, upper back and low back, upper extremities and lower extremities may originate from the vertebrae, intervertebral discs, spinal cord, nerve roots, facet joints, ligaments, muscles, and sacroiliac or atlanto-axial and atlanto-occipital joints. However, vertebrae, muscles and ligaments have not been proven to be common sources of spinal pain. In contrast, facet joint pain, discogenic pain, and sacroiliac joint pain have been proven to be common causes of pain with proven diagnostic techniques (177, 179).

Cavanaugh et al (180) described how idiopathic low back pain has confounded healthcare practitioners for decades and how the cellular and neural mechanisms that lead to facet pain, discogenic pain, and sciatica are not well understood. In a series of neurophysiologic and neuroanatomic studies, they showed the evidence in support of facet pain, including an extensive distribution of small nerve fibers and endings in the lumbar facet joint, nerves containing substance P, high threshold mechanoreceptors in the facet joint capsule, and sensitization and excitation of nerves in facet joint and surrounding muscle when the nerves were exposed to inflammatory or algesic chemicals. Evidence for pain of disc origin included an extensive distribution of small nerve fibers and free nerve endings in the superficial anulus of the disc, as well as small fibers and free nerve endings in the adjacent longitudinal ligaments. They also described possible mechanisms of sciatica including vigorous and long-lasting excited discharges when dorsal root ganglia were subjected to moderate pressure, excitation of dorsal root fibers when the ganglia were exposed to autologous nucleus pulposus, and excitation and loss of nerve functions in nerve roots exposed to phospholipase A_2. These findings render support for a structural and chemical basis for low back pain.

Pang et al (181) by applying spinal pain mapping, which is a sequence of well-organized nerve block procedures, analyzed 104 cases in a pain clinic. They prospectively evaluated consecutive adult patients with intractable low back pain (who had failed conservative therapy) of undetermined etiology after medical history, physical examination, x-ray, CT, MRI, EMG/NCV evaluation of the lumbar spine. By using pain mapping, the source of pain was facet joint(s) in 24%, combined lumbar nerve root and facet disease in 24%, combined facet(s) and sacroiliac joint(s) in 4%, lumbar nerve root irritation in 20%, internal disc disorder in 7%, sacroiliac joint in 6%, and sympathetic dystrophy in 2% of the patients. Pain mapping failed to demonstrate causes of pain in the remaining 13% of the patients. However, Pang et al (181) used a single block technique with the potential for false-positive results (2, 173, 177, 179). Manchikanti et al (182) evaluated the relative contributions of various structures in patients with chronic low back pain who have failed to respond to conservative modalities of treatments including physical therapy, chiropractic and drug therapy. These patients had lack of radiological evidence to indicate disc protrusion or radiculopathy. Utilizing precision diagnostic injections (controlled comparative double diagnostic blocks), they showed that 40% of the patients suffered from facet joint pain, 26% from discogenic pain, 2% from sacroiliac joint pain, and possibly 13% from segmental dural/nerve root pain with no cause identified in 19% of the patients.

3.1 Facet Joint Pain

The facet or zygapophysial joints are paired diarthrodial articulations between posterior elements of the adjacent vertebrae (183-185). These joints are formed by the articulation of the inferior articular process of one vertebra with the superior articular process of the next vertebra. Cervical facet joints have been shown to be capable of being a source of pain in the neck and referred pain in the head and upper extremities (186-189); thoracic facet joints have been shown to be capable of causing local and referred pain patterns in upper back, mid back and chest wall (190); and lumbar facet joints have been shown to be capable of being a source of pain in the low back and referred pain in the lower extremity (191-196) in normal volunteers.

Facet joints are well innervated by the medial branches of the dorsal rami (197-203). In the cervical spine below C2/3, the cervical facet joints are supplied by medial branches of the cervical dorsal rami above and below the joint, which also innervate the deep paramedian muscles. The C2/3 joint is supplied by the third occipital nerve (197, 204). However, innervation of the atlanto-occipital and atlanto-axial joints is derived from the C1 and C2 root, respectively (203, 205). In the thoracic and lumbar spine, the facet joints are innervated by medial branches of the dorsal rami of the spinal nerves except at L5 level. The L5 dorsal ramus divides into medial and lateral branches, with the medial branch continuing medially, innervating the lumbosacral joint (198, 206-208). Each segmental medial branch of the dorsal ramus supplies at least two (in humans, monkeys and cats) or three (in rats) facet joints (199).

As with any synovial joint, degeneration, inflammation and injury of facet joints can lead to pain upon joint motion. Pain leads to restriction of motion, which eventually leads to overall physical decon-

ditioning. Irritation of the facet joint innervation in itself also leads to secondary muscle spasm. It has been assumed that degeneration of the disc would lead to associated facet joint degeneration and subsequent spinal pain. These assumptions were based on the pathogenesis of degenerative cascade in the context of a three joint complex that involves the articulation between two vertebrae consisting of the intervertebral disc and adjacent facet joints, as changes within each member of this joint complex will result in changes in others (209-221). Ingelmark et al (218) noted that changes in the structure of the disc were accompanied by significant osteoarthritis in the facet joints of the same level, which was suggestive of a causal association between the two. It was also the view of Vernon-Roberts and Pirie (219) that disc degeneration causes osteophyte formation and facet joint changes, because facet joints at relatively normal disc levels are either normal or only slightly degenerate. Many of the studies during the past 30 to 40 years have proposed that disc degeneration initiates degenerative changes in the facet joints by altering the mechanical function of the entire motion segment (222). This concept has been confirmed by findings in radiologic and histologic studies in which disc narrowing is seen as an early feature (223-225). Numerous other causes, including rheumatoid arthritis, ankylosing spondylitis and capsular tears, etc., also have been described as sources of facet joint pain (177). However, radiographic changes of osteoarthritis have been shown to be equally common in patients with and without low back pain, and degenerative joints seen on CT are not always painful, even though some studies report severely degenerated joints as being more likely to be symptomatic (177, 179, 226-229). Most recent studies have shown that facet joint pain can be seen in patients with no evidence of osteoarthritis and shortly following a traumatic incident (229-232, 233, 234).

Facet joints have been implicated as responsible for spinal pain in 15% to 45% of patients with low back pain (182, 233-238), 54% to 67% of patients with neck pain (239-242) and 48% of patients with thoracic pain (243) in controlled studies. These figures were based on responses to controlled diagnostic blocks of these joints, in accordance with the criteria established by the International Association for the Study of Pain (21). Pang et al (181), by using spinal pain mapping with nerve blocks with a single block, estimated facet joint pain was present in 24% of patients, with an additional combined lumbar nerve root and facet disease in 24% and combined facet and sacroiliac joint disease in 4%, yielding a total involvement of facet joints in 52% of patients with chronic low back pain.

3.2 Disc Related Pain

The motion segment is the basic functional unit of the spine, acting as a mobile tri-joint complex composed of the intervertebral disc between adjacent vertebral bodies and the posteriorly situated facets (244). The cervical spine forms the cephalic portion of the flexible axial spine while the lumbar spine forms the caudal portion of the flexible axial spine. The human intervertebral disc is a very complex joint structure that can be separated macroscopically into three distinct components: the nucleus pulposus (NP) representing a centrally located gelatinous homogenous mass; the anulus fibrosus (AF) consisting of concentrically organized layers of collagen fibrils, which contain the nucleus pulposus; and the cartilaginous endplates (EP), which separate the nucleus pulposus and anulus fibrosus from the adjacent vertebral bone. Any disturbance of the integrity and interplay of one of the three structures can result in a compromised function of the intervertebral disc. The innervation of intervertebral discs has been extensively described in fetal and adult animals, as well as in humans. The cervical sinuvertebral nerves were found to have an upward course in the vertebral canal, supplying the disc at their level of entry and the disc above (246). Branches of the ventral nerve were noted to supply the lateral aspects of the cervical discs. Histologic studies of discs obtained at operation showed the presence of nerve fibers as deeply as the outer third of the anulus (247). Later studies demonstrated nerve distribution throughout the anulus, however, with the highest concentration in the middle third of the cervical disc (248). The lumbar disc innervation has been described extensively since 1947, when it was recognized that the discs receive a nerve supply and can be intrinsically painful (246). The intervertebral disc and posterior longitudinal ligament have been shown to contain free nerve endings (249-253). The outer third of the anulus is richly innervated (251-253), and nerve fibers may extend as deeply as the middle third of the anulus. However, in patients with chronic low back pain and abnormal discs, the nerve supply may be more extensive into the anulus and nucleus (254-256). Multiple animal experiments also have shown that the posterior portion of the lumbar intervertebral disc is innervated by the sympathetic nerves multisegmentally and bilaterally (257). Animal experiments have shown that sensory information from the lumbar intervertebral discs is conducted through the rami communicants, (259) the anterior portion of the L5/6 lumbar intervertebral disc is innervated from the L1 or L2 in rats (259), and the dorsal portion of the L5/6 disc of rats was shown to be multisegmentally innervated by the T13 to L6 dorsal root ganglia, with the sensory fibers from T13, L1, and L2 dorsal root ganglia innervating the dorsal portion of the L5/6 disc through the paravertebral sympathetic trunks (260). Thus, intervertebral discs, along with vertebrae, facet joints, posterior longitudinal ligament and dura mater, are innervated segmentally by the dorsal ramus and the sinuvertebral nerves branching from the spinal nerve(s) of the corresponding levels (198, 261-265).

Discs can produce pain in the neck and upper extremities; thoracic spine, chest wall and abdominal wall; and low back and lower extremities. Disc related pain is caused by disc degeneration, disc herniation, or by biochemical effects including inflammation. The first to create widespread interest in the disc as a source of pain in American literature were Mixter and Barr (266) with their 1934 hallmark description of the herniated nucleus pulposus. Their primacy has been disputed by others (267-269) who claim that the first disc prolapse operation had been conducted by Oppenheim and Krause in Berlin. Indeed, the literature also has attributed descriptions of ruptured intervertebral disc to multiple others including Kocher in 1896 (270), Middleton and Treacher (271), Goldwait (272), Dandy (273) and Schmorl (274). Semmes and Murphey (275) described cervical intervertebral disc herniation. For many years, intervertebral disc herniation led many practitioners to assume that it is the most common cause of back problems. However, modern evidence implicates intervertebral disc herniation in only a small percentage of back complaints (276-284).

Pain from disc herniation can arise from nerve root compression and stimulation of nociceptors in the anulus or posterior longitudinal ligament. However, a simple compression or mass effect cannot be the mechanism of pain due to disc disease. In fact, several studies evaluating progressive disc herniation have shown that, even though the resolution of symptoms tends to be associated with dimunition of the size of the disc herniations, it is not always the case, as compression may continue in spite of resolution of the symptomatology (280-284). Mixter and Ayers in 1935 (285), soon after the hallmark description of Mixter and Barr in 1934 (266), demonstrated that radicular pain can occur without disc herniation. Thus, the pathophysiology of spinal radicular pain is a subject of ongoing research and controversy. Proposed etiologies include neural compression with dysfunction, vascular compromise, inflammation, and biochemical influences (244).

Spinal nerve roots have unique properties that may explain their proclivity to produce symptoms (286). Spinal nerve roots, unlike peripheral nerves, lack a well-developed intraneural blood-nerve barrier, which probably makes them more susceptible to symptomatic compression injury than peripheral nerves, making them more vulnerable to endoneural edema formation (286-288). Endoneural edema can be induced by increased vascular permeability, which is caused by mechanical nerve root compression (287, 288). In addition, elevated endoneural fluid pressure, caused by intraneural edema, can impede capillary blood flow and may cause intraneural fibrosis (287). This is crucial as spinal nerve roots receive approximately 58% of their nutrition from surrounding cerebral spinal fluid (286-288). Thus, nerve roots may be rendered hyperesthetic and hypersensitive to compressive forces by perineural fibrosis, which interferes with cerebrospinal fluid-mediated nutrition (286-288). In addition, venous and capillary stasis with congestion may contribute to symptomatic nerve root syndromes (287, 288). Consequently, nerve root ischemia, and/or venous stasis, may generate pathologic biochemical changes, which cause radicular pain (287). It was also shown that even though the occlusion pressure for radicular arterioles is significantly higher in experimentally induced ischemia through nerve root compression, compensatory nutrition from cerebrospinal fluid diffusion during low pressure radicular compression was probably inadequate in the presence of either epidural inflammation or fibrosis (286, 288). It was shown in a series of experiments that it is less likely that gradual mechanical deformity produces symptomatic radiculopathy than does the rapid onset of neural and vascular compromise (288-292).

Inflammation is another mechanism of pain. In 1987, McCarron et al (293) in an animal study showed that when autologous nucleus pulposus is placed in the epidural space of dogs, a marked epidural inflammatory reaction is produced that does not occur with saline injections. Since then, many investigators have shown the inflammatogenic properties of the nucleus pulposus and its role in producing spinal pain (293-306). Studies also have shown myelin and axonal injury to the nerve roots and reduced nerve conduction velocities following exposure to autologous nucleus pulposus (288, 295). However, recently it was suggested that normal frozen and hyaluronidase digested nucleus pulposus and experimentally degenerated nucleus pulposus failed to produce similar changes in nerve root function (308, 309). In fact, an autoimmune or chemical basis for lumbar radicular pain was postulated in 1977 (310, 311). Extensive publications have appeared in the literature focusing attention on multiple agents such as Phospholipase A_2 (PLA_2), metalloproteinases, interleukin-6, prostaglandin E_2, and tumor necrosis factor (TNF) (293-320). Phospholipase A_2 is released from an intact disc following injury. Phospholipase A_2 has neurotoxic properties with propagation of an inflammatory cascade via liberation of arachidonic acid resulting in chemotactic and non-cellular mediated responses through leukotrienes and prostaglandins (296, 303, 312). Inflammatory substances in the epidural space may also directly or indirectly induce increased vascular permeability of endoneural blood vessels. Inflammatory substances also have been shown to affect blood flow and endoneural fluid pressure in the dorsal root ganglia (305, 306). Evidence supporting a neurogenic inflammatory basis for pain generation has been emerging (15, 321-323). Neuropeptides such as substance P and calcitonin gene-related peptide are activated and released from the dorsal root ganglion following noxious mechanical stimulation (324-326). Receptors for substance P are present in the outer anulus of the intervertebral disc and in the posterior longitudinal ligament (327). Thus, neuropeptides may sensitize nociceptors in the lumbar disc to the effects of prostaglandins and leukotrienes, and they may stimulate leukotriene activity directly (15). A multitude of other inflammatory agents have also been reported to play an active role in inflammatory process (313-315, 328-339). Even though herniated cervical intervertebral discs also have been shown to produce metalloproteinase, nitric oxide, interleukin-6 and prostaglandin E_2, all of which are potential irritants of the spinal nerves or marks of inflammation (313), most of the data is derived from the lumbar spine. However, arguments by analogy are used and appear to be quite attractive. The role of inflammation in the cervical spine and thoracic spine has not been demonstrated with the same tenacity as in the lumbar spine. Other proposed mechanisms for radicular pain include partial axonal damage, neuroma formation, and focal demyelination (340); intraneural edema (289, 290, 320); and impaired microcirculation (290). Even then, the pathogenic mechanisms linking herniated nucleus pulposus, nerve root injury, and radiculitis or radiculopathy are not completely known (341, 342). Further, within the past decade, a definite trend has emerged in the understanding of disc herniations with radicular symptoms due to the research supporting multiple concepts including resorption of lumbar herniated disc fragments (282, 283, 343, 344) and the occurrence of asymptomatic lumbar disc pathology, including herniations (285, 343-352).

Low back pain and lower extremity pain without disc herniation but related to the disc is considered as discogenic pain. This does not refer to nerve root pain caused by the disc herniation. Rather, it expressly refers to pain arising from the disc itself. Multiple reports have suggested that certain pathologic conditions within the disc, such as internal anular disruption and disc resorption, can cause acute or chronic low back pain (173, 177, 179, 281, 293, 343, 353-358). Even so, the mechanism of pain that arises within the disc continues to be poorly understood. Even though it is accepted that damage to the disc can produce pain, no consensus exists on the responsible mechanisms (173). O'Neill et al (359) demonstrated

that noxious stimulation of the intervertebral disc resulted in low back and referred extremity pain, with the distal extent of pain produced depending on the intensity of stimulation. They showed the results during disc heating with the intradiscal electrothermal annuloplasty with 68% of patients reporting exact reproduction of their presenting pain, in quality and location. They postulated that referred pain in the lower extremity was from noxious stimulation of disc nociceptors. Their results were in contradiction to the study by Kuslich et al (178) in which they found little extremity pain provocation with disc probing. However, O'Neill et al's (359) study also circumvented the criticism that the potential leakage of the contrast or nuclear material onto a nerve root or dorsal root ganglion, or in bulging of the disc causing mechanical neural irritation and causing radicular pain, rather than the nociceptor in the disc causing the lower extremity pain.

Even then, etiology of discogenic pain continues to be an enigma (177, 358). Internal disc disruption is a condition in which the internal architecture of the disc is disrupted, but its external surface remains essentially normal. Disrupted discs do not exhibit either bulging or herniation. Vanharanta et al (360), in a prospective multicenter discographic study evaluated disc deterioration in low back syndromes. He demonstrated positive discographic pain provocation and moderate or severe disc deterioration using CT discography in 82% of the patients with disc herniation, 80% of the patients with degenerative disc disease, 56% of the patients with lumbar syndrome, and 59% of the patients with lumbar radicular syndromes. These features with a normal or near normal contour of discs producing back pain but with no evidence of herniation or prolapse prompted Crock (276) to describe internal disc disruption. Discs with internal disc disruption are rendered painful by either chemical nociception or mechanical stimulation. The characteristic pathologic features of internal disc disruption are radial fissures through the anulus. These are not readily apparent on conventional discograms but are rendered clearly evident by CT discography. The disc stimulation establishes whether or not the disc is painful, and the discography outlines the nucleus and the radial fissure. The correlation between reproduction of pain and the presence of a grade III fissure is very strong (361, 362). Chemical nociception might occur when nerve endings in the anulus become exposed to enzymes and breakdown products involved in the degradative process of the disc. In addition, penetration of the inflammatory cells into the anulus of disrupted discs is also evident. Schwarzer et al (363), in a controlled study, reported the prevalence of pain due to internal disc disruption as 39% in patients suffering with chronic low back pain. Primary discogenic pain was reported by Manchikanti et al (182) to be 26% in a sample of 120 patients but 43% in patients undergoing discography. The prevalence of cervical discogenic pain in patients with chronic neck pain of traumatic origin in informal studies was estimated to be 61% (353). Pang et al (181) in a study of patients with intractable low back pain, utilizing spinal pain mapping with nerve blocks, estimated lumbar nerve root involvement in 20% and internal disc disorder in 7% of the patients.

Irritation of the dura is also expected to elicit somatic pain, perhaps with referred pain, in addition to, and quite apart from, any pain stemming from the inflamed nerve roots (177). Even though there are no studies separating dural pain from radicular pain, it is possible that traditional nerve root pain associated with disc herniation may not be purely radicular pain but rather a mixture of dural and radicular pain. Further, dural tethering can also be a cause of pain, which is consistent with the sensitivity of the dura to mechanical stimulation. In addition, adhesions could develop as a result of chronic epidural inflammation following disc herniation. It also has been proposed that the normally occurring epidural ligaments can tether nerve roots and be a source of somatic pain superimposed on radicular pain (364). Manchikanti et al (182) explored this issue of segmental dural/nerve root pain. They considered all patients who were negative for diagnosis of facet joint pain, discogenic pain or sacroiliac joint pain as potential sufferers of dural/nerve root pain. Of 120 patients, 35 underwent transforaminal epidural injections, and 16 of them responded positively with pain relief, with a potential overall prevalence of segmental dural/nerve root pain of 13%. Pang et al (181) estimated lumbar nerve root involvement in 20% of the patients.

The dorsal root ganglion plays an important role in the mechanism of spinal pain. Experiments have suggested that edema in the dorsal root ganglion underlies the production of nerve root pain in patients with disc herniation (365-367). The effects of inflammation on dorsal root ganglion have been described (305, 306, 368-370).

3.3 Sacroiliac Joint Pain

The sacroiliac joint is an accepted source of low back and/or buttock pain with or without lower extremity pain. Until recently, the evidence for the sacroiliac joint as a pain generator had been only empirical and was derived from successful treatment of patients with sacroiliac joint pain with certain clinical symptoms and physical findings (371). Anatomically and biomechanically, the sacroiliac joint shares all its muscles with the hip joint. Thus, the sacroiliac joint is unable to function in isolation. The sacroiliac joint is subject to unidirectional pelvic shear, repetitive and torsional forces which can contribute to sacroiliac joint pain.

The sacroiliac joint is a diarthrodial joint with a joint capsule and synovial fluid. The sacral side of the joint is lined with the hyaline cartilage and the iliac side with fibrocartilage. The sacroiliac joint receives innervation from the lumbosacral nerve roots (372-377). Fortin et al (372), based on a recent anatomic study on adult cadavers, concluded that the sacroiliac joint is predominantly, if not entirely, innervated by sacral dorsal rami. Grob et al (373) found that the human sacroiliac joint receives myelinated and unmyelinated axons derived from the dorsal rami of the first four sacral nerves. Ikeda (374), in histologic studies of the innervation of the sacroiliac joint, showed that the upper ventral portion of the joint is mainly innervated by the ventral ramus of the fifth lumbar nerve, the lower ventral portion of the joint was mainly supplied by the ramus of the second sacral nerve or branches of the sacral plexus, the upper dorsal portion of the joint was innervated by the lateral branches of the dorsal ramus of the fifth lumbar nerve, and the lower dorsal portion was innervated by nerves arising from a plexus composed of lateral branches of the dorsal rami of the sacral nerves. Murata et al (377) showed that in rats the sacroiliac joint is innervated differently on the ventral and dorsal side. They illustrated that the sensory nerve fibers to the dorsal side of the sacroiliac joint were derived from the DRGs of the lower lumbar and

sacral levels (from L4 to S2), and those to the ventral side from the DRGs of the upper lumbar, lower lumbar, and sacral levels (from L1 to S2). Vilensky et al (375) also showed the presence of nerve fibers and mechanoreceptors in the sacroiliac ligament.

Referral patterns of sacroiliac joint provocation or irritation have been published. Fortin et al (378) successfully generated a pain referral map using provocative injections into the right sacroiliac joint in asymptomatic volunteers. These pain referral patterns extended approximately 10 cm caudally and 3 cm laterally from the posterior superior iliac spine. Fortin et al (379) also evaluated the applicability of a pain referral map as a screening tool for sacroiliac joint dysfunction. They successfully screened for sacroiliac joint dysfunction based on comparison with a pain referral map consistent with the pain radiating through a 3 x 10 cm vertical area just inferior to the posterior superior iliac spine. Slipman et al (380) also demonstrated sacroiliac joint pain referral zones with 94% of the patients describing buttock pain, 72% describing lower lumbar pain, 50% describing lower extremity pain, and 14% describing groin pain.

Utilizing single diagnostic blocks, Schwarzer et al (381) concluded that the prevalence of sacroiliac pain would appear to be at least 13% and perhaps as high as 30%. Maigne et al (382), after selecting patients with low back pain in whom there was a high index of suspicion for pathology, performed a double block, and established the actual frequency of sacroiliac joint dysfunction in this population as 18.5%. Manchikanti et al (182), after studying 120 chronic low back pain patients with precision diagnostic blocks, including medial branch blocks, sacroiliac joint injections and provocative discography, showed that the prevalence of sacroiliac joint pain was 10% of suspected patients, with an overall prevalence of 2% in all the patients evaluated for chronic back pain utilizing a double block paradigm. Pang et al (181), by spinal mapping, utilizing single diagnostic blocks, diagnosed sacroiliac joint pain in 6% of the patients, with an additional 4% with combined facet and sacroiliac joint pain.

3.4 Postlaminectomy Syndrome

Postlaminectomy syndrome or pain following operative procedures of the spine appears quite common (383-409). Post laminectomy syndrome or failed back surgery syndrome is a term coined by Wilkinson (383) to describe continued pain and disability following surgical intervention with multiple possible explanatory etiologies (407-409). Etiologies of failed back surgery syndrome are surgical and non-surgical. Surgical diagnoses included stenosis, internal disc disruption, recurrent disc herniation, or retained disc fragment, spondylolisthesis etc., whereas non-surgical diagnoses included epidural or intraneural fibrosis, degenerative disc disease, radiculopathy, radicular pain, deconditioning, facet joint pain, sacroiliac joint pain, discitis and arachnoiditis etc. It is estimated that 5% to 40% of spinal surgeries (occasionally as high as 68%) may not be successful. It has also been shown that 20% to 30% of patients over 65 who underwent lumbar spine operations had one or more subsequent operations within four years (405). Slipman et al (407), based on their workup in a retrospective review, reported spinal stenosis in 21.5% of the patients, internal disc disruption in 21.5% of the patients, and recurrent disc herniation or retained disc fragment in 12.4% of the patients, compared to epidural/intraneural fibrosis in 22.6% of the patients. Overall, non-surgical etiologies in the prior epidemiologic studies have been reported between 0% and 83% of the underlying causes of failed back surgery syndrome (407). Most of the studies of failed back surgery syndrome were performed by surgical specialists leading to a myriad of surgical diagnoses, whereas Slipman et al (407) provided a non-surgical accounting of their impressions of failed back surgery syndrome. However, they all utilized imaging, EMG and nerve conduction as the major diagnostic instruments. Further, functional rehabilitation specialists and behavioralists use continued pain following surgical intervention as a sign of inaccurate, incorrect, or incomplete surgical intervention; deconditioning syndrome, myofascial syndrome, fibromyalgia, battered root syndrome, degenerative disc disease, and unknown etiology; and somatoform disorder, conversion reaction, and other psychological disorders. However, interventionalists have described major causes of continued pain after surgical interventions as epidural fibrosis, facet joint arthritis, and spinal stenosis, among other causes (409-417).

Epidural fibrosis is a progressive disease (409). There are many possible etiologies of epidural fibrosis, including an anular tear, hematoma, infection, surgical trauma, or intrathecal contrast media. LaRocca and McNab (418) have demonstrated the invasion of fibrous connective tissue into postoperative hematoma as a cause of epidural fibrosis. McCarron et al (293) investigated the irritative effect of material from the nucleus pulposus upon the dural sac, adjacent nerve roots, and nerve root sleeves independent of the influence of direct compression upon these structures. McCarron (410) further explored epidural fibrosis in an experimental model in adult mongrel dogs. He reported an inflammatory reaction in the spinal cord sections taken from dogs sacrificed after the initial injection of homogenized nucleus pulposus, whereas the spinal cord was grossly normal after the initial injection of normal saline.

Cooper et al (419) reported periradicular fibrosis and vascular abnormalities occurring with herniated intervertebral disc. Hoyland et al (420), in a cadaveric study, found significant pathological changes within and around the nerve root complex, including peri-and intraneural fibrosis, edema of nerve roots, and focal demyelination proposing that venous obstruction may be an important pathogenic mechanism in the development of perineural and intraneural fibrosis. It was also shown that perineural fibrosis, which interferes with cerebrospinal fluid-mediated nutrition, can render nerve roots hyperesthetic and hypersensitive to compression forces (286-288). This is important as spinal nerve roots receive approximately 58% of their nutrition from the cerebrospinal fluid (286-288). Songer et al (421) showed that postoperative scar tissue renders the nerve susceptible to injury. Parke and Watanable (392) showed significant evidence of adhesions in cadavers with lumbar disc herniation. They showed lumbar epidural adhesions to be present in 40% at L4/5 level, in 36% at L5/S1 level, and in 16% at L3/4 level.

Epidural fibrosis is commonly seen in patients with recurring symptoms in conjunction with instability in postlumbar surgery syndrome (409, 410, 422-428). However, the role of epidural fibrosis as a causative factor of chronic spinal pain or as a pain generator has been questioned (409, 422, 425, 426). In a study of the relationship between peridural scar evaluat-

ed by magnetic resonance imaging (MRI) and radicular pain after lumbar discectomy, Ross et al (390) showed that subjects with extensive peridural scarring were 3.2 times more likely to experience recurrent radicular pain. Berger and Davis (427) showed that, in the group of 600 patients with a single operation, periradicular fibrosis was diagnosed preoperatively in 0.67% and postoperatively in 11%. They also showed that, in the 400 patients with multiple operations, at the time of the second operation, the incidence of periradicular fibrosis had risen to 47%. However, epidural adhesions have also been demonstrated without surgery.

Epidural fibrosis is described in the epidural space in three compartments. Dorsal epidural scar tissue is formed by resorption of the surgical hematoma (429). Dense scar tissue is formed in the ventral epidural space by ventral defects in the disc (409). This dense scar tissue, however, may persist despite surgical treatment and continue to produce either chronic low back or lower extremity pain even after the surgical healing phase (409). In contrast to the dorsal and ventral epidural spaces, the lateral epidural space includes epiradicular structures out of the root canals (sleeves), containing the exiting nerve root and dorsal root ganglia, which are susceptible to lateral disc defects, facet overgrowth and neuroforaminal stenosis, etc. (430). It is well known that inflammation may render nociceptors more sensitive to mechanical stimuli.

3.5 Spinal Stenosis

Spinal stenosis can be defined as a narrowing of the spinal canal, resulting in symptoms and signs caused by entrapment and compression of the intraspinal vascular and nervous structures (431). Disc bulging, protrusion and herniation in the cervical, as well as lumbar area, combined with osteophytes and arthritic changes of the facet joints can cause narrowing of the spinal canal, encroachment on the content of the dural sac, or localized nerve root canal stenosis (432-437). In addition, some patients have congenitally small canals. Spondylotic processes of the spine may affect the spine, either segmentally or more diffusely (437). There are many reports on spinal stenosis limited to one segment of the spine (431, 438-442). However, it has been reported that 5% of patients with spinal stenosis have symptoms at cervical and lumbar levels (432). Degenerative lumbar spinal stenosis has become the most frequent indication for spine surgery in patients older than 65 years (438-444). Rates of surgery in the United States for spinal stenosis increased eight fold between 1979 and 1992, from 7.8 to 61 procedures per hundred thousand persons age 65 or older (440).

Nachemson and Vingård (445) showed moderate predictor strength for age over 65 years, bilateral non-radicular leg pain, treadmill test with total time of less than 5 minutes, and relief from sitting down or squatting. They found good to moderate evidence for MRI/CT diameter less than 7 mm, and for area less than 70 mm^2. Finally, they found only weak evidence for walking distance of less than 300 meters and no correlation with neurophysiologic tests in the diagnosis of spinal stenosis. Drew et al (446), in evaluating the reliability in grading the severity of lumbar spinal stenosis, suggested that CT scans are not a reliable method by which to examine the severity of lumbar spinal stenosis.

The Agency for Healthcare Research and Quality (AHRQ) developed an Evidence Report/Technology Assessment; No. 32 (447) on the treatment of degenerative lumbar spinal stenosis. The general term spinal stenosis was defined to apply to various mechanisms alone, or in combination, of disc protrusion or herniation, osteotic or bone growth into the spinal canal or the foramina through which the roots pass laterally, and vertebral slippage or spondylolisthesis. In extreme cases, lumbar stenosis can cause cauda equina syndrome, a syndrome characterized by neuromuscular dys-function that may result in permanent nerve damage. The annual incidence of spinal stenosis observed among patients referred to orthopedic departments was approximately 5 per 100,000 inhabitants. Based on the data from the national low back study with chronic low back pain, spinal stenosis was calculated in 35% of the patients (447). The data from the National Ambulatory Medical Care Survey and the National Spine Network indicated that among patients with low back pain seeing a specialist, 13% to 14% might have spinal stenosis (447). In contrast, among patients with low back pain who see a general physician, 3% to 4% may have spinal stenosis. The longitudinal Framingham Heart study found that 1% of men and 1.5% of women had baseline degenerative spondylolisthesis which over the following 25 years increased to 11% of men and 25% of women (447). The AHRQ document (447) described that patients with symptomatic spinal stenosis typically have chronic low back pain and pain and weakness in their legs that limits standing and walking to brief durations and short distances. They may also have limitations of self-supporting daily activities, as well as work, social, and recreational activities leading to weight gain, general physical deterioration, cardiovascular, and other serious health problems and psychological problems.

4. Interventional Techniques

The overall benefit of various types of injection techniques includes pain relief that outlasts by days, weeks, or months the relatively short duration of pharmacologic action of the local anesthetics and other agents used. Clear-cut explanations for these prolonged improvements are not currently available. It is believed that neural blockade alters or interrupts nociceptive input, reflex mechanisms of the afferent limb, self-sustaining activity of the neuron pools and neuraxis, and the pattern of central neuronal activities (448). Explanations for improvements are based in part on the pharmacological and physical actions of local anesthetics, corticosteroids, and other agents. It is believed that local anesthetics interrupt the pain-spasm cycle and reverberating nociceptor transmission, whereas corticosteroids reduce inflammation either by inhibiting the synthesis or release of a number of pro-inflammatory substances and by causing a reversible local anesthetic effect (368, 449-466).

Various modes of action of corticosteroids include membrane stabilization; inhibition of neural peptide synthesis or action; blockade of phospholipase A_2 activity; prolonged suppression of ongoing neuronal discharge; and suppression of sensitization of dorsal horn neurons. Local anesthetics have been shown to produce prolonged dampening of C-fiber activity (467-469). Physical effects include clearing adhesions or inflammatory exudates from the vicinity of the nerve root sleeve. The scientific basis of some of these concepts, at least in part, is proven for spinal pain management with epidural injections of betamethasone and intravenous methylprednisolone (368, 452,

455-458).

Merskey and Thompson (461) described the various mechanisms of benefits for longer periods of time than the duration of the anesthetics used. This phenomenon has been documented in the literature, and is regularly observed by clinicians. The mechanisms by which local anesthetics abolish chronic pain for several days when they are effective for a maximum of four hours if used for acute or "physiological" pain, are not known (461). Several theories have been suggested. In an essay on the future of local anesthetics, Wall (462) listed several theories including the sympathetic nervous system (463). McCormack (464, 465) speculated that such blocks cause temporary abolition of spontaneous ectopic discharges, resulting in abolition of dynamically maintained central hyperexcitability, as well as reinforcing endogenous G-protein-couple receptor inhibition of N-type voltage-sensitive calcium channels. In addition, the data on glial activation in pathological pain (466) also may cast doubt on the utility of cognitive behavioral therapy and other psychological interventions, while lending new legitimacy to local anesthetic block procedures. Watkins et al (466) showed that spinal cord glia can be activated in response to a variety of stimuli, both tissue injury and infections. The activated glia produces a number of proinflammatory cytokines associated with central sensitization. This activation spreads from cell to cell across "gap junctions," following no particular neuronal pathways or anatomical boundaries. In a recent editorial on nerve blocks and cognitive therapy, Merskey and Thompson (461) commented that "it now seems highly likely that 'unexplained' regional pain is the result of organic or neurochemical changes; therefore, they are medically explained. Hence, therapeutic modalities that can, even temporarily, reduce neuronal excitability and sympathetic nervous system malfunction may result in just the sort of benefits from local anesthetic blocks documented . . . The time is right for renewed interest in nerve block models for the relief of pain. Those models are the ultimate foundation of the truly multidisciplinary pain clinic, and their results encouraged pioneers such as Bonica and Travell to take chronic pain seriously. A look at their work may help to renew some well-established approaches that are currently neglected or out of favour."

5. Diagnostic Interventional Techniques

Bogduk (177) postulated that for any structure to be deemed a cause of back pain, the structure should have been shown to be a source of pain in patients, using diagnostic techniques of known reliability and validity. Bogduk (11) also postulated that diagnostic blockade of a structure with a nerve supply with the ability to generate pain can be performed to test the hypothesis that the target structure is a source of the patient's pain. Commonly used interventional diagnostic techniques include facet joint blocks, discography, transforaminal epidural injections, and sacroiliac joint injections.

The popularity of neural blockade as a diagnostic tool in painful conditions is due to several features. Hogan and Abram(470) described multiple challenging clinical situations, including the characteristics of chronic spinal pain, which are purely subjective and the conditions which are, in most cases, inexactly defined with uncertain pathophysiology. Precision diagnostic blocks are used to clarify these challenging clinical situations, in order to determine the pathophysiology of clinical pain, the site of nociception and the pathway of afferent neural signals. Deyo and Weinstein (471) described that precise anatomical diagnosis is elusive in low back pain and that diagnostic evaluation is often frustrating for both physicians and patients. They showed that history, physical examination and imaging provide limited information (472).

Clinical studies of precision diagnostic techniques are variable, not only in quality, but also in quantity. Important considerations include entrance criteria, study size, and the use of controlled subjects (470). Hogan and Abram (470) also expressed their disappointment with the prevalence of placebo responses in patients with pain, as it greatly weakens the relevance of studies in which no controlled subjects or blinding was used. Further, the importance of the false-positive rate (how often patients without a condition will nonetheless have a positive test) and false-negative rate (how often a patient with disease will have a negative test). It is also extremely crucial because they vary inversely with specificity and sensitivity (470). Specificity is a relative measure of the prevalence of false-positives, whereas sensitivity is the relative prevalence of false-negative results. The general parameters of accuracy are described as the specificity and sensitivity of the diagnostic test. The most sensitive test will be positive for all cases in which the disease is present. The specificity is greatest when there is a positive test result only when the disease is present. Thus, the ideal diagnostic test would have a sensitivity of 100% and a specificity of 100%. Since none of the tests available in clinical medicine have these ideal features, there is a degree of uncertainty regarding the accuracy of each and every diagnostic test as applied to an individual clinical case.

It also has been criticized that for many painful conditions, however, a credible standard to document the disease for comparison with test results is unavailable. The Agency for Healthcare Research and Quality (AHRQ) published five key domains for making judgments about the quality of diagnostic test reports as shown in Table 3 which include: study population, adequate description of the test, appropriate reference standard, blinded comparison of test, and reference and avoidance of verification bias.

Hildebrandt (473) published an extensive review on the relevance of nerve blocks in treating and diagnosing low back pain. He described zygapophysial joint blocks, sacroiliac joint blocks, disc stimulation and nerve root blocks. Hildebrandt (473) concluded that the diagnostic use of neural blockade rests on three premises. First, the pathology causing pain is located in an exact peripheral location, and impulses from this site travel via unique and consistent neural route. Second, injection of local anesthetic totally abolishes the sensory function of intended nerves and does not affect other nerves. Third, relief of pain after local anesthetic block is attributable solely to the block of the target afferent neural pathway. However, Hildebrandt (473) cautioned that the validity of these assumptions is limited by complexities of anatomy, physiology and psychology of pain perception and by the effect of local anesthetics on impulse conduction.

Nachemson and Vingård (445), in assessment of patients with neck and back pain, concluded that various studies outside imaging have rarely demonstrated clinical utility. Ramsey et al (474) found that diagnostic and treatment devices lacking in scientific rigor included facet blocks, discography and diagnostic nerve

root infiltration, along with other tests including EMG, stress radiographs and flexion and extension x-rays, bone scintigraphy, thermography, diagnostic ultrasound, and temporary external fixation. Jaeschke et al (475) described that the accuracy of a diagnostic test is best determined by comparing it to an appropriate reference standard such as biopsy, surgery, autopsy, or long-term follow-up (476). A gold standard allows accurate comparison of a given diagnostic test's capacity to yield positive results when the clinical condition is present and negative results when the clinical condition is not present. Thus, a gold standard or reference facilitates accurate determination of the specificity and sensitivity of a test. Tissue confirmation of the presence or absence of a disease at surgery, with a biopsy, or autopsy, which has served as the accepted gold standard across multiple medical disciplines, is not applicable to interventional pain management. Thus, most pain provocative or relieving tests used to diagnose painful conditions of the spine are more closely related to the physical examination than to a laboratory test (34). Stability of the diagnosis over a long period of time with long-term follow-up may be also used as a gold standard. These facts are especially true in the diagnosis of facet joint pain, discogenic pain, and sacroiliac joint pain. Thus, there is no completely reliable gold standard with which to compare the diagnostic test of precision diagnostic injection in conditions where the evaluation is dependent on pain relief or functional improvement as the endpoint. Consequently, a true calculation of clinical accuracy of these tests may not be possible.

The clinical setting in which the test is performed and the prevalence of the disease in that setting also affect the meaningfulness of the test results. The prevalence refers to the frequency of the disease in the general population and to the population seen in a specific setting where the test is used. When the prevalence is high, there is a higher probability that a positive test result indicates the presence of the disease. Consequently, evaluation of a diagnostic test in a population for which the prevalence is low or absent has either limited meaning or no meaning. Thus, the predictive value of a diagnostic test is a function of the prevalence, sensitivity, and specificity.

While diagnostic blockade of a structure with a nerve supply which can generate pain can be performed to test the hypothesis that the target structure is the source of the patient's pain (11, 477), testing the hypothesis by provoking pain in any structure is an unreliable criterion except in provocative discography (478). Thus, relief of pain is the essential criterion in almost all structures. If the pain is not relieved, the source may be in another structural component of the spine similar to the one tested, such as a different facet joint, different nerve root, or some other structure (11). Ideally, all controlled blocks should include placebo injections of normal saline, but it may be neither logistical nor ethical to use placebo injections of normal saline in conventional practice in each and every patient. In addition, one may be required to perform three blocks of the same structure if a placebo is used. As an alternative, the use of comparative local anesthetic blocks, on two separate occasions, during which the same joint is anesthetized using two local anesthetics with different duration of actions, has been proposed (479-481). The use of comparative local anesthetic blocks with facet joint injections has been validated and found to be robust against challenge with placebo (482, 483).

The requirements for diagnostic interventional techniques include a sterile operating room or a procedure room, monitoring equipment, radiological equipment, sterile preparation with all the resuscitative equipment, needles, gowns, injectate agents, intravenous fluids, sedative agents, and trained personnel for preparation and monitoring of the patients. Minimum requirements include history and physical examination, informed consent, and appropriate documentation of the procedure.

Contraindications include bacterial infection, possible pregnancy, bleeding diathesis, and anticoagulant therapy. Precautions are warranted in patients with antiplatelet or antiicoagulant therapy, diabetes mellitus and artificial heart valves.

5.1 Facet or Zygapophysial Joint Blocks

Blocks of a facet or zygapophysial joint can be performed in order to test the hypothesis that the target joint is the source of the patient's pain (11, 477). Facet joints can be anesthetized either with intraarticular injections of local anesthetic or by anesthetizing the medial branches of the dorsal rami that innervate the target joint. If pain is not relieved, the joint cannot be considered the source of pain, whereupon a new hypothesis about the source of pain is required (11). The source may be either in another joint or some other structure. If pain is relieved, the joint may be considered prima fascie to be the source of pain, but steps need to be taken to ensure that the observed response is not false-positive (11). True-positive responses are secured by performing controlled blocks, either in the form of placebo injections of normal saline or comparative local anesthetic blocks, in which on two separate occasions, the same joint is anesthetized but using local anesthetics with different durations of action. Comparative local anesthetic blocks are readily implemented if medial branch blocks are used to anesthetize zygapophysial joints. They may not be implementable for intraarticular blocks, for it is not known whether placement of local anesthetic in a relatively avascular environment, such as a joint space, affects its expected duration of action. Further, an injected capsule may leak into the adjacent neural foramen and result in blockade of the DRG and segmental nerves.

The rationale for using facet joint blocks for diagnosis is based upon the fact that cervical facet joints have been shown to be capable of being a source of neck pain and referred pain in the head or upper limb girdle; thoracic facet joints have been shown to be capable of being a source of thoracic pain and referred pain over the chest wall; and lumbar facet joints have been shown to be capable of being a source of low back pain and referred pain in the lower limb in normal volunteers. Consequently, facet joints are possible sources of pain in patients presenting with neck pain and referred pain; thoracic or chest wall pain; and low back pain and referred pain. There are no historical or clinical features that are either indicative or diagnostic of facet joint pain. Bogduk and Lord (477) described that because zygapophysial joint pain is neither an articular disorder nor a neurological disorder, not only should neurologic signs be absent, but they should also not be expected. In addition, facet joint pain does not meet requirements for other joint pain criteria as joint pain is typically diagnosed on the grounds of swelling, tenderness, and restricted motion. In the context of zygapophysial joint pain, these signs are not available except for restricted motion.

Thus, there is no reliable clinical means of implicating zygapophysial or facet joints as the source of spinal pain in a given patient. Referral patterns described for various joints are not only variable, but also restricted (186-196). Other structures, such as the disc, in the same segment may produce the same pattern of pain. Most maneuvers used in physical examinations are likely to stress several structures simultaneously, especially the discs, muscles, and facet joints, thus failing to provide any reasonable diagnostic criteria. Multiple investigators have attempted to correlate demographic features, pain characteristics, physical findings, and other signs and symptoms with the diagnosis of facet joint pain; but, these were all proven unreliable (11, 226, 227, 233, 236, 238, 477, 478, 484-496). Further, there are no valid and reliable means of identifying symptomatic lesions of the facet joint using currently available imaging technologies (497-503). Even on retrospective review of radiographs of specimens known to have lesions, radiologists could identify lesions in only a small minority of instances (497), if at all (498). The results of most studies fail to show a correlation between radiologic imaging findings and facet joint pain (226-228, 488, 499). Thus far, the majority of the reports indicate no correlation between the clinical picture, MRI, CT scanning, dynamic bending films, single photon emission computed tomography (SPECT), and radionuclide bone scanning (227, 499-508). Thus, controlled diagnostic blocks with two separate local anesthetics (or placebo-controlled) are the only means of confirming diagnosis of facet joint pain.

Cost Effectiveness: Diagnostic facet joint nerve blocks were not evaluated for cost effectiveness systematically. However, multiple authors (33,509) described the feasibility and cost-effectiveness of appropriately performed controlled comparative local anesthetic blocks.

Summary of Evidence: Over 40 publications were examined to evaluate the diagnostic validity of facet joint blocks. Of these, only prospective evaluations performed under fluoroscopic guidance, with low volume injectate (less than 1 mL) were examined, and only studies using placebo controlled or comparative local anesthetic blocks were included (182, 203, 207, 208, 233-243, 416, 478, 482, 483, 510-517). A total of 27 studies met the criteria; however, 2 were duplicates reporting the results on the same patients with a separate analysis (234, 511). Hence, a total of 25 of 27 studies were evaluated based on AHRQ criteria, for validity, specifically prevalence, false-positive rate, false-negative rate, provocation response, and role of psychological factors in diagnostic facet joint blocks (182, 203, 207, 208, 233, 235-243, 416, 478, 482, 483, 510, 512-517).

The face validity of medial branch blocks has been established by injecting small volumes of local anesthetic onto the target points for these blocks and by determining the spread of contrast medium in posteroanterior and lateral radiographs (203, 207, 208). Construct validity of facet joint blocks is also extremely important as placebo effect is the single greatest confounder of diagnostic blocks. Patients are liable to report relief of pain after a diagnostic block for reasons other than the pharmacologic action of the drug administered (483). Thus it is essential to know in every individual case whether the response is a true positive. The theory that testing a patient first with lidocaine and subsequently with bupivacaine provided a means of identifying placebo response has been tested and proven (479-483).

All the studies met the criteria for study population, adequate description of test, appropriate reference standard, namely pain relief, and avoidance of verification bias. However, only 2 studies (482, 483) included blinded comparison of test and reference. Manchikanti et al (237) also tested the validity of lumbar medial branch blocks comparing various types of solutions. The validity of comparative local anesthetic blocks was found to be robust against challenge with placebo for facet joint injections (482, 483). Further, short-term relief was reported in almost all the evaluations described in the literature. Long-term relief of appropriately diagnosed facet joint pain has been reported in many studies, with application of another appropriate reference standard (long-term follow-up) as described in the literature (16, 19, 486, 494, 495).

The specificity of the effect of cervical and lumbar facet joint blocks was demonstrated in controlled trials (203, 207, 208). Provocation response was shown to be unreliable in one controlled study (478). The false-negative rate of diagnostic facet joint blocks was evaluated by Dreyfuss et al (207) and shown to be 8% due to unrecognized intravascular injection of local anesthetic. Confounding psychological factors were evaluated by Manchikanti et al (513) showing a lack of influence of psychological factors on the validity of comparative controlled diagnostic local anesthetic blocks of facet joints in the lumbar spine. False-positive rates were evaluated in multiple investigations (182, 236-243, 416, 510, 511, 513-515, 517). Reported false-positive rates varied from 27% to 63% in cervical spine, 58% in thoracic spine, and 22% to 47% in lumbar spine.

Based on multiple evaluations, facet or zygapophysial joints have been implicated as the source of chronic spinal pain in 15% to 45% of the heterogenous groups of patients with chronic low back pain (182, 233-238), 48% of the patients with thoracic pain (243), and 54% to 67% of the patients with chronic neck pain (239-242).

Based on these evaluations, the validity, specificity and sensitivity of facet joint nerve blocks are considered strong in the diagnosis of facet joint pain. Kwan and Friel (518) expressed pessimism on the validity of facet joint injections for chronic whiplash. Mentioning the studies by April and Bogduk (516), Barnsley et al (239), and Lord et al (240), Kwan and Friel (519) concluded that the subjects in facet joint studies are few in number and that they are at tertiary referral centers and their initial injuries are unknown, especially when studied years after the supposed injury event. They further stated that subjects with facet joint pain are equally as likely to fail to respond to radiofrequency neurotomy as they are to respond, meaning we are still left with a substantial group of subjects with unexplained pain.

Numerous reports in the past based on responses to single block have shown low back pain to be facet related in 7.7% to 75% of patients (16, 226, 487, 490, 493-496, 518). The wide variation in reported prevalence rates may reflect selection bias, variable population subsets referred to individual clinicians or false-positive or placebo responses (16). In studies including larger samples with fewer inclusion criteria, lower prevalence rates were reported (16). However, even in the studies reporting a low prevalence, the authors acknowledged the existence of facet joint pain (227, 233-235, 490, 493, 496, 518).

Safety and Complications: Safety of facet joint interventions with

intraarticular injections and medial branch blocks has been demonstrated. The most common and worrisome complications of facet joint injections or nerve blocks are related to needle placement and drug administration. These complications include dural puncture, spinal cord trauma, infection, intravascular injection, spinal anesthesia, chemical meningitis, neural trauma, pneumothorax, and hematoma formation. Steroid side effects were attributed to the chemistry or to the pharmacology of the steroids (520-526). Radiation exposure was an additional complication (527). Facet capsule rupture also may occur, if large volumes of injectate are used for intraarticular injections (189).

Vertebral artery damage or entry is a potential risk with cervical facet blockade. Such complications occur more frequently with a lateral intraarticular technique than with blockade of the medial branches because the former technique requires deeper penetration of the needle toward the spinal structures. Local anesthetic leakage out of the joint into spinal canal may cause motor and sensory blockade with its risks and complications. In the cervical spine, third occipital nerve blocks can cause transient ataxia and unsteadiness due to partial blockade of the upper cervical proprioceptive afferents and the righting response (204, 521). Furthermore, when C3/4, C4/5 or C5/6 facet joint blocks are performed, the phrenic nerve may be compromised, especially if a large volume of local anesthetic is employed.

5.2 Discography

Discography is a diagnostic pro-cedure designed to determine whether a disc is intrinsically painful. Discography literally means the opacification of the nucleus pulposus of an intervertebral disc to render it visible under radiographs (528). Discography includes disc puncture, disc stimulation, assessment of disc morphology, and assessment of patient's pain response. Discography has been used extensively in the study of lumbar discs, somewhat less so in the cervical spine and infrequently in the thoracic spine. Even though originally introduced as a technique for the study of disc herniation, discography is no longer used in this way. The cardinal component of what is loosely known as discography is disc stimulation; a putatively painful disc is provoked to determine if that disc is the source of a patient's pain (528). Opacification of the disc is only a nominal, and the least critical, component of the procedure. Discography does not compete with CT or MRI in the diagnosis of disc herniation; it is used to pursue a totally different condition (529).

Formal studies have shown that the discs are innervated and can be a source of pain that has pathomorphologic correlates (198, 246-265). Biologic basis for lumbar discography has been well established. However, embryologically and morphologically, the cervical discs differ from lumbar discs and do not suffer the same pathology (528). In addition, there is no evidence that cervical discs suffer the internal disc disruption widely described in lumbar discs. However, Schellhas et al (530) found thoracic discs with anular tears, intrinsic degeneration, and/or associated vertebral body endplate infractions, which were painful approximately 75% of the time. Cervical discs also have been shown to have pre-lesions in the anterior anulus, which may be the basis for cervical discogenic pain but they have not been shown to be painful (498, 531, 532).

The rationale is well established for lumbar discography (17, 528, 529, 533-536). Discography is helpful in patients with lumbar or leg 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. The injected substance in the disc pushes anular fibers aside to form pools of contrast (537). These pools indicate the location of fissures. Contrast exiting from the disc indicates tears in the outer wall of the anulus. Extruded contrast may outline fragments of anulus and nucleus outside the disc and adjacent tissues, such as peridural membranes.

Discography was performed in asymptomatic volunteers without spinal pain in cervical spine (538), thoracic spine (539) and lumbar spine (540). Schellhas et al (538) evaluating 10 lifelong asymptomatic subjects and 10 nonlitigious chronic neck/head pain patients with discography at C3/4-C6/7 after MRI, concluded that of the 20 normal discs from the asymptomatic volunteers, 17 proved to have painless anular tears discographically. They also showed that discographically normal discs were never painful in either symptomatic or asymptomatic groups. Wood et al (539) determined responses to thoracic discography of 10 asymptomatic individuals with 4-level discography following magnetic resonance imaging of the thoracic spine. They showed that 27 of 40 discs were abnormal, with endplate irregularities, anular tears, and/or herniations. Three discs were intensely painful, with all three exhibiting prominent endplate irregularities and anular tears typical of thoracolumbar Scheuermann's disease, in lifelong asymptomatic individuals, but the pain was unfamiliar or non-concordant. In the group with chronic thoracic pain, of the 48 discs, 24 were concordantly painful, 17 had non-concordant pain/pressure, and 5 had no response. On magnetic resonance imaging, 21 of the 48 discs appeared normal, in contrast to discography with only 10 discs being judged as normal. Walsh et al (540) performed discography in 10 discs volunteers without back pain and 7 with low back pain. None of the volunteers reported significant pain upon injection. In 17% of the discs and 50% of the patients, abnormal discs were demonstrated by CT/discography. Among the 7 patients with low back pain in the study, 65% of the discs and 100% of the patients had a positive image.

Over time and with micro- or macrotrauma, there is a natural progression of degeneration of the motion segment with corresponding anatomic, biochemical, and clinical findings. The disc and two facet joints at the same level function as a three joint complex. There are three stages of the degenerative process with dysfunction, instability, and fixed deformity (209-221). Changes in the discs and osteophyte formation have been well described. For many years, disc degeneration was considered as the sole and dominant factor predisposing to spinal pain. Spinal pain without disc herniation or secondary to involvement of other structures is well known (174, 177). Even though the mechanism of pain that arises within the disc continues to be poorly understood, it is accepted that damage to the disc can produce pain without consensus on the responsible mechanisms (177).

Examination of cadaver discs provides an excellent baseline against which images can be compared. Adams et al (537) analyzed 139 cadaveric discs and identified five patterns of contrast distribution on the discograms that corresponded to stages of disc degeneration

determined by inspection of the cadaveric disc sections. Yasuma et al (541), in histological analysis of 181 thoracic and lumbar discs, demonstrated that discography had a 73% sensitivity, 89% specificity, and an overall accuracy of 85% based on the histologic findings. Yu et al (542) compared discography and MRI in postmortem specimens and found discography to be more sensitive than MRI in detecting anular fissures. Saternus and Bornscheuer (543) carried out a postmortem investigation on 70 trauma fatalities and 38 traumatic fatalities of comparable age distribution. They showed that depending on the functional status of the intervertebral disc, the contrast medium flowed from the central depot into the "degenerative" cleft systems.

Several studies have investigated the accuracy of discographic and CT/discographic findings based on the ability to demonstrate pathology confirmed at the time of surgery. Jackson et al (544) compared the sensitivity, specificity, and accuracy of several diagnostic tests based on 231 discs explored at surgery, which included 106 normal discs and 125 abnormal discs. They demonstrated an overall accuracy of 87% for CT discography compared to other tests investigated with 77% for CT/myelography, 74% for CT alone, 70% for myelography, 64% for pain provocation, and 58% for plain discography. Gresham and Miller (545) reported that discography findings correlated with surgical findings better than myelography, 91% with discography and 42% with myelography. Brodsky and Binder (546) reported a sensitivity of 89% based on surgical findings among successfully performed discograms. Yasuma et al (541) reported a false-negative discographic image rate of 32% in patients with a disc protrusion and 56% of patients with a disc prolapse concluding that discography was not sensitive to lesions in the middle or outer anulus not contiguous with the nucleus. Simmons et al (547) also expressed the concern about the 27% false-negative rate reported by Yasuma et al (541). Lehmer et al (548) described a delayed pain response to discographic pain injections and speculated that in such patients the pain might be from incomplete radial fissures as identified in these cadaveric studies. Birney et al (549) reported that discography was more specific than MRI but concluded that MRI and discography were equally as good at identifying disc degeneration but that MRI was significantly better in demonstrating disc herniation. Bernard (550) found that discography most frequently provided a conclusive diagnosis compared to myelography, CT, and MRI. Southern et al (551), in a human cadaveric study, evaluated disc degeneration of the lumbar spine using magnetic resonance imaging and quantitative discomanometry. They concluded that magnetic resonance imaging scores and quantitative manometry parameters correlated well in the assessment of disc degeneration of the lumbar spine. Further, they also concluded that quantitative discomanometry may be an important technique for evaluating early disc degeneration, especially tears of the anular fibers, which may be missed on magnetic resonance imaging.

Discography was also compared independently without surgical findings with myelography, CT, MRI, and results of surgical and conservative management. CT discography has been reported to be more accurate than myelography (356, 545, 546, 552-558). Sachs et al (557) reported that CT discography provided essential diagnostic information not provided by myelography in 33% of the patients. Brodsky and Binder (546) reported that 53% had negative myelograms but positive discograms, with the discographic findings confirmed in patients who later underwent surgery.

Discography was also shown to be superior to plain computed tomography (554, 557, 559). Sachs et al (557) reported that CT discography provided essential information in 30% of the patients. Milette et al (559) showed that among 101 discs that were abnormal by discographic image and in which injection produced symptoms, 50 (49.5%) were normal on the CT scan.

While some authors have found MRI to be as good as discography and preferable because MRI is noninvasive, allows assessment of more levels with one test, has minimal risk of complications, and minimal discomfort (560, 561), others have identified normal discography in patients with normal or equivocal MRIs and point out the value of pain provocation, which MRI cannot provide (357, 538, 539, 562-566). Gibson et al (560) studied 50 discs in 22 patients by both MRI and CT discography and reported that the images agreed in 88%. However, they also stated that the pain provocation was difficult to interpret and of questionable value. Simmons et al (547) reported that MRI and discography agreed in 80% of the 465 lumbar discs but only in 55% of the 164 patients studied. They concluded that based on their findings, relying solely on MRI could result in overtreatment of asymptomatic discs and undertreatment of clinically significant abnormality. Ito et al (567) also reported that the rate of agreement between MRI and discographic pain provocation was only 57.4%. They reported sensitivity of MRI as only 34.8% in detecting symptomatic disruption of the outermost anulus as identified by CT discography. In contrast, Osti and Fraser (568) concluded that discography was more sensitive than MRI in identifying anular tears. They found discography to be more accurate and thus useful for patients with normal MRI and continuing symptoms. Greenspan et al (569) also made similar suggestions. Buirski and Silberstein (570) found no significant differences in the distribution of disc abnormalities between MRI and discography groups and concluded that discography is still needed as a pain provocation tool to determine which disc is related to the patient's symptoms as this cannot be determined based on image alone. Thus, the role of discography in patients with normal MRIs has been debated. Some have advised that if MRI is normal, discography should not be performed (561, 571). In contrast, others have reported cases of discs appearing as normal on MRI as being identified as abnormal with discography or reproducing clinical symptoms upon injection (563-565). Milette et al (572) found that 26% of discs with a normal contour without bulging or protrusions had moderate or severe disc disruption on discographic images. In addition, they found that 15% of discs with a normal central disc intensity and 37% with normal peripheral signal intensity had moderate or severe disc disruption. Some authors who thought that MRI was as accurate as discography, still believed that there was a role for discography in difficult cases or to further investigate discs that appear as abnormal on MRI when considering surgery (561, 573).

The relationship between changes in the endplates as assessed by MRI to discographic findings was also evaluated (570, 574, 575). While one study (570) reported that among 23 discs with changes in the endplates pain was provoked in 91%, an-

other study (576) found that even though specificity was 84%, the sensitivity of endplate changes was only 20.5% in detecting clinically painful discs as identified by discography.

The correlation and relationship between MRI, discography, and HIZ have been extensively studied (577-589). Aprill and Bogduk (577) defined the high intensity zone as a high intensity signal located in the posterior anulus fibrosus which is dissociated from the signal from the nucleus and appears brighter than the nucleus. They found that the presence of an HIZ was predictive of symptomatic disc disruption identified by CT discography with a sensitivity of 71% and specificity of 89%. Schellhas et al (578) supported this concept showing that 87% of HIZs were positive on CT discography. However, these studies were based on patients with an HIZ at least at one level. Lam et al (586), in a prospective blinded study of 73 patients, concluded that in morphologically abnormal discs (grades III, IV, and V) there was a significant correlation between the HIZ and exact or similar pain production. The sensitivity, specificity and positive predictive value for pain production were high, at 81%, 79%, and 87% respectively. Saifuddin et al (579), investigating the relationship of HIZ to CT discographic findings in a broader population, found that the sensitivity of HIZ was only 26.7%, while the specificity was 95.2%. Similar conclusions were reached by Smith et al (580) who reported sensitivity of 31% and specificity of 90%. Thus, these studies support the presence of HIZ as indicative of symptomatic disc disruption; however, the absence of HIZ does not rule out such pathology, since there was such a high false-negative rate. Ito et al (567) also reported a sensitivity of 52.2% and specificity of 89.7%. Lappalainen et al (581) evaluated the diagnostic value of contrast-enhanced magnetic resonance imaging in the detection of experimentally induced anular tears in sheep. They concluded that even though macroscopically visible and histologically evident, it was not always possible to demonstrate experimental anulus injuries by contrast-enhanced magnetic resonance imaging. This experimental study shows that further research work is needed to develop more sensitive methods to detect peripheral, relatively small, but probably clinically important disc injuries. Ricketson et al (582), in contrast to the above human reports, showed no significant relationship between HIZ and discographic images or pain provocation. However, significant criticism has been forwarded against this evaluation (17) questioning its validity, based on literature on discography studies and scoring of HIZ (361, 583, 590, 591). Carragee et al (584) reported that among symptomatic patients, presence of HIZ was seen in 59% of the patients and among asymptomatic subjects, it was 24%. They also reported that in the symptomatic group, the sensitivity was 45.3% and the specificity was 83.9%. Rankine et al (587) evaluated the clinical significance of the high-intensity zone on lumbar spine magnetic resonance imaging and concluded that a high-intensity zone occurred in patients at a prevalence of 45.5% and usually occurred posteriorly 77% of the time and posterolaterally 22% of the time within the anulus. There were no features within the history, functional disability questionnaire, or physical examination that aided in a clinical diagnosis of those patients with a high intensity zone. Saifuddin et al (588) sought to identify the morphological abnormalities of the intervertebral disc, as demonstrated by lumbar discography, that were associated with pain radiation to the hip, groin, buttock, or lower limb. Posterior anular tears were demonstrated in 84 of 260 discs injected with anterior anular tears in 15 discs and with 45 discs, both anterior and posterior tears. A significant association was identified between isolated posterior tears and the production of concordant radiating pain. However, there was no difference between partial thickness posterior tears and full thickness posterior tears associated with leak of contrast medium, with regard to radiating pain. In contrast, Slipman et al (585) evaluated the correlation between the side of concordantly painful, post-discography CT visualized anular tear and the side of patient's low back pain and reported that there was a random correlation between the side of the patient's concordantly painful anular tear and the side of the patient's pain. Smith et al (580) concluded that the interobserver reliability of detecting a high-intensity zone and the positive predictive value of the presence of a high-intensity zone for detecting a severely disrupted and exactly painful disc were much lower than previous studies have shown. Moneta et al (361), studying over 833 discs in 306 patients, found that neither normal discs nor fissured discs hurt.

The relationship of discography to outcomes has been evaluated extensively. These included conservative management, minimally invasive surgery, and open procedures. Rhyne et al (592) retrospectively identified and assessed the outcomes of 25 patients with positive discograms but who did not undergo surgery. They reported that these patients did as well as the results reported for patients treated surgically and therefore concluded that non-operative care may be as good as surgical treatment for discogenic pain. Manchikanti et al (593) evaluated the effectiveness of caudal epidural injection in discography positive and negative patients showing no significant differences in outcomes. Since most minimally invasive procedures are restricted to patients with contained disc herniations, discography plays an important role in minimally invasive surgery by defining the containment. Disc containment was accurately reported by discography in 93% of 132 operative cases, by predicting whether a herniated disc was protruded, extruded or sequestered (594). The role of discography in determining suitability and positive outcomes with chemonucleolysis has been supported (589, 595). However, others (596) found that the role of discography was not so much to determine the condition of the disc, but rather to confirm proper needle placement for a nuclear injection. The role of discography in treating patients with electrothermal therapy (IDET) and percutaneous disc decompression (PDD) with nucleotomy are primarily dependent on results of discography. Further, the value of discography in patient selection for laser disc decompression has been investigated and was shown to be superior to MRI, CT and myelography (597, 598). For treatment of lumbar disc herniation with percutaneous nucleotomy, positive discography results have been shown to improve the results significantly (599-601). Outcomes of open surgery, generally fusion, have been studied extensively following discography (357, 572, 602-618). Favorable results of discography were shown by multiple authors (357, 602, 607-611, 614-616, 618) while negative results were shown with others (572, 603, 612, 617).

While the accuracy of discography as an imaging test is high with high specificity and sensitivity for diagnosis of disc degeneration, the question that revolves

around discography is whether this test is accurate for the diagnosis of discogenic pain. An integral part of the problem is the lack of an adequate gold standard. Surgical exposure can confirm the presence of disc degeneration or disruption, but it cannot definitely confirm the presence or absence of discogenic pain. However, the results from both surgical and minimally invasive treatment of discogenic pain in patients whose diagnosis was confirmed by discography should provide a gold standard for discogenic pain. Positive results have been provided in multiple publications. The face validity of discography has been established by injecting small volumes of contrast into the disc and by determining the concordant pain with spread of the contrast medium in posteroanterior and lateral radiographs and/or computed tomography. Construct validity of the discograms is also extremely important, as a false-positive result is the single greatest confounder of diagnostic discography. Patients are liable to report pain after insertion of the needle for reasons other than stimulation of the nociceptors. Thus, it is essential in each and every case for a response to be considered positive, that concordant pain be produced; and for the test to be valid, there must be at least one disc (preferably two) that do not illicit pain upon injection, thereby serving as a control disc (21). Validity of discography has been established in asymptomatic patients. It was also shown that the site of needle insertion is unlikely to result in a false-positive discography from performing the procedure on the same side as patients reported pain (619). Even then, there is no modern normative data that establishes that cervical discography is a specific test for cervical discogenic pain (528). There is also evidence indicating that up to 40% of the positive cervical discograms may be false-positive (353); the disc stimulation produces the patient's pain but the source of pain lies elsewhere in the same segment. Further, it was shown that cervical discography induced neck pain in 50% of the patients with neurological symptoms due to cervical spondylosis but no neck pain (620). With thoracic discography, pain was produced in lifelong asymptomatic individuals, even though pain was not familiar or concordant (539). Thus, any evidence of value for cervical and thoracic discography is inconclusive at the present time.

In the 1960's, Holt et al (621, 622) reported a significant number of false-positive discograms in 37% of an asymptomatic prison population in lumbar spine (621), with similar findings in cervical spine (622). Simmons et al (623) reassessed Holt's data (621) and pointed out that discography as performed by Holt, although appropriate for its time, was quite different from discography as performed in 1988. The necessity for accurate needle tip positioning was proven by Urasaki et al (601). Walsh et al (540), in a carefully controlled series of disc injections in asymptomatic volunteers, showed a 0% false-positive rate refuting the findings of Holt (621). However, recent studies by Carragee et al (624-627) have shown a higher rate of false-positives than the study of Walsh et al (540). There are a multitude of methodological flaws with each of these similarly structured studies (34, 624-632). Multiple drawbacks described include the technique of disc puncture, interpretation, presence of negative discs, small number of patients, inability to compare pain provocation to clinical or typical pain, post-test and pretest probability, and accuracy of psychological evaluation. Discography is most accurate and useful when the diagnosis of discogenic pain is highly probable, as determined by the history, physical examination, imaging data analyzed, and inability to isolate another source of pain. Manchikanti et al (631) evaluated 50 patients with discography, of which 25 patients were without somatization disorder and 25 patients were with documented somatization disorder. They concluded that provocative discography provided similar results in patients with or without somatization, with or without depression, with somatization but with or without depression or with other combinations of the psychological triad of somatization disorder, depression and generalized anxiety disorder. Saal described (34) that some of the issues raised by Carragee et al (624-627) may be resolved with multiple reports in the literature (633-636) showing disc stimulation is related to reflex reaction in the groin and lower abdomen (633, 634); L5/6 disc was innervated by the L1 or L2 spinal nerves (635); and the sacroiliac joints are dually innervated, including those arising from L1 to L3 (636). Others also have reported psychological influences, perhaps causing false-positive results (590, 596, 637, 638).

Much of the controversy about discography has arisen because the results of discography have been used to help decide whether a certain patient should or should not have surgery, even though patients have usually undergone other diagnostic tests, the results of which were either equivocal or non-diagnostic. Thus, discography should be performed only if the patient has failed to respond to adequate attempts of non-operative care, and if diagnostic tests such as MRI have not provided sufficient diagnostic information. Generally, discography should be viewed as an invasive test to be used to seek abnormalities when results from other tests are equivocal or inconsistent, in a patient with symptoms severe enough to require further evaluation (17). Thus, specific uses for discography include, but are not limited to: further evaluation of demonstrably abnormal discs to help assess the extent of abnormality or correlation of the abnormality with clinical symptoms (in case of recurrent pain from a previously operated disc and a lateral disc herniation); patients with persistent, severe symptoms in whom other diagnostic tests have failed to reveal clear confirmation of a suspected disc as the source of pain; assessment of patients who have failed to respond to surgical procedures to determine if there is painful pseudoarthrosis or asymptomatic disc in a posteriorly fused segment, or to evaluate possible recurrent disc herniation; assessment of discs before fusion to determine if the discs within the proposed fusion segment are symptomatic and to determine if discs adjacent to this segment are normal; and assessment of minimally invasive surgical candidates to confirm a contained disc herniation or to investigate contrast distribution pattern before chemonucleolysis or other intradiscal procedures.

Cost Effectiveness: There are no cost effectiveness studies available in the literature. However, Manchikanti and Singh (509), and Endres and Bogduk (31) described an algorithmic approach in managing chronic low back pain.

Summary of Evidence: Review of the available evidence included 3 studies on normal volunteers (538-540), comparison of discography findings on postmortem specimens (541, 542), comparison with computed tomography and magnetic resonance imaging (541, 544-559, 562-566), high-intensity zone identification (577-580, 582, 584, 586, 587), evi-

dence of discogenic pain or internal disc disruption (181, 182, 363) and false-positives in patients without low back pain or with psychological abnormalities (624-627, 631). **The evidence for cervical and thoracic discography is limited. The evidence for lumbar discography is strong for discogenic pain provided that lumbar discography is performed based on the history, physical examination, imaging data, and analysis of other precision diagnostic techniques.** There is no evidence to support discography without other non-invasive or less invasive modalities of treatments or other precision diagnostic injections.

Safety and Complications: Complications related to discography include infection, neural trauma, intravascular penetration and spinal cord trauma. Lack of permanent effects secondary to discography has been reported (639-642). Zidman et al (643), in an analysis of 4,400 diagnostic disc injections, enumerated the potential morbidity and mortality associated with cervical discography, including discitis, subdural empyema, spinal cord injury, vascular injury, and prevertebral abscess. They demonstrated that significant complications from diagnostic cervical discography procedures occurred in less than 0.6% of the patients and 0.16% of the cervical disc injections. Grubb and Kelly (644) reported their experience in a series of 173 cervical discograms performed over a period of 12 years. They reported complications in 4 patients. Guyer et al (645) described four complications (2.48%) based on number of procedures and 1.49% based on the number of disc injections, which included two cases of discitis, one post injection hematoma, and headache in one patient.

Conner and Darden (617) reported an overall complication rate of 13% (4/31), including the development of an acute epidural abscess that led to myelopathy and eventual quadriplegia. Many of the complications reported with lumbar discography were reported prior to 1970, many in the 1950s (17, 646, 647). Fraser et al (648) reported a 2% to 3% incidence of discitis using an open needle technique and a 0.7% rate using a stiletted double needle technique. Improved adherence to sterile environment, radiographic equipment, improved technique, antibiotic administration and double needle technique have made the procedure increasingly safer. Silber et al (649) described that it is a rare complication after any invasive procedure on the spine with an incidence of 0.2%. However, post procedure discitis represents 30.1% of all cases of pyogenic discitis and has been reported after almost every open and minimally invasive surgical procedure, including laminectomies, discectomies, fusions with or without instrumentation and less invasive procedures, such as discography, chemonucleolysis, myelography, paravertebral injections, and lumbar puncture (649-656). Similar to postoperative vertebral osteomyelitis, post procedural discitis frequently affects the elderly and immunocompromised and is an important cause of postoperative back pain in the spine patient. Other reported complications include subdural empyema (657), nucleus pulposus pulmonary embolism (658), herniated cervical disc (659), quadriplegia (660), and epidural abscess (661, 662).

5.3 Transforaminal Epidural Injections

Like facet joints and intervertebral discs, spinal nerves can be injected with contrast, local anesthetic, or other substances (663). This procedure is transforaminal epidural injection, also referred to as selective nerve root block. Both the provocative response and analgesic response provide clinically useful information (664-671). Steindler and Luck (669) recognized the validity of provocative and analgesic spinal injections as early as 1938. In 1971, MacNab (670) revealed the value of diagnostic, selective nerve root blocks in the preoperative evaluation of patients with negative or inconclusive imaging studies and clinical findings of root irritation. The nerve blocks were utilized to diagnose the source of radicular pain when imaging studies suggested possible compression of several nerve roots (668, 672-682). The relief of usual symptoms following the injection of local anesthetic, 1 mL of 2% Xylocaine, was the main determinant for diagnostic information. Fukusaki et al (683) showed that the perineural injection of 1% lidocaine or dexamethasone does not affect radicular blood flow. Schutz et al (668), Krempen and Smith (672), Tajima et al (673), Haueisen et al (674), Dooley et al (675), Stanley et al (676), Pang et al (181), and Manchikanti et al (182) all described positive results of diagnostic transforaminal epidural injections or selective nerve root blocks. In 1992, Nachemson (684) analyzed the literature on low back pain and indicated that diagnostic, selective nerve root blocks provided important prognostic information about surgical outcome.

Kikuchi et al (679) estimated that approximately 20% of the patients presenting with apparent radicular pain required diagnostic nerve root blocks or epidural blocks. Van Akkerveeken (685) recreated data from his 1989 thesis regarding sensitivity, specificity, and predicative values for diagnostic, selective nerve root blocks. A positive block required concurrent symptom reproduction during root stimulation and full relief following anesthetic infusion (680). Derby et al (677) correlated surgical outcome with pain relief following transforaminal epidural injections with local anesthetic and steroids and reported that patients who failed to obtain sustained relief of radicular pain following the block were less likely to benefit from subsequent surgical intervention. Manchikanti et al (182) explored the role of transforaminal epidural injections in the diagnosis of segmental dural-nerve root pain. They considered all the patients who were negative for diagnosis of facet joint pain, discogenic pain or sacroiliac joint pain as potential sufferers of dural-nerve pain. Of 120 patients, 35 underwent transforaminal epidural injections, and 16 of them responded with pain relief, providing a potential overall prevalence of segmental dural-nerve root pain of 13%.

Controversial aspects of transforaminal epidural injections include terminology and technique. The terminology describing nerve root injections has included transforaminal epidural, selective nerve root block, selective nerve root sleeve injection, selective epidural, selective spinal nerve block, or selective ventral ramus block. However, nerve root block was the first term developed to describe the technique for diagnosing the source of radicular pain when imaging studies suggested a possible compression of several roots. Early studies of selective nerve root injections described an extra-foraminal approach, in which the needle is advanced at a right angle to the spinal nerve outside the neural foramina. Subsequently, a variation of this procedure has emerged which has been termed selective epidural and is also referred to as transforaminal epidural. Diagnostic injections are performed to confirm or exclude a clinically suspected pain generator (664, 671, 686). According to Steindler and Luck (669),

if a structure is the etiology of the pain, stimulating it will provoke the pain while anesthetizing it will alleviate the pain. For this approach to have sufficient specificity, one must be able to selectively anesthetize a given structure, while not affecting nearby structures. With a diagnostic selective nerve root block, there are numerous structures in close proximity that could result in a high false-positive block rate if improper technique is used.

Diagnostic selective nerve root injection is typically performed in a patient with persistent pain when history, examination, imaging, and other precision diagnostic injections and electrophysiology testing do not clarify the pain generator. The sensitivity of diagnostic selective nerve root block ranges from 87% to 100% (668, 672). In 1973, Schutz et al (668) reported finding a corroborative lesion at the time of surgery in 87% of patients with a positive diagnostic block. Krempen and Smith (672) reported 100% surgical confirmation following a positive block. The specificity of diagnostic selective nerve root block ranges from 94% to 100% (675, 676, 680). Dooley et al (675) reported 3 out of 51 blocks to be false-positive, providing a specificity of 94%. Stanley et al (676) also noted 95% specificity. Further, van Akkerveeken (680) reported the specificity of selective nerve root block to be 95% in a prospective study. Diagnostic selective nerve root block can be an effective technique in evaluating patients with multilevel pathology to ascertain which is the pain generator. Similarly, it is useful when the location of symptoms seems to conflict with abnormalities identified with imaging findings. White (687) in 1983 supported the use of diagnostic selective nerve root blocks as a pre-surgical test in patients with equivocal anatomic findings. Herron (681) in 1989, found the procedure useful in identifying previously undocumented disc herniations, the symptomatic level in multi disc herniation, the primary pain generator in the spine-hip syndrome, previously undocumented root irritation in spondylolisthesis, the symptomatic level in multilevel stenosis, and the symptomatic root in patients with documented postoperative fibrosis.

Cost Effectiveness: Cost effectiveness of transforaminal epidural steroid injections has been evaluated in the management of back pain but not in its diagnosis (182, 671). Based on the available evidence, transforaminal epidural injections may be cost effective in select cases in algorithmic management (182, 509).

Summary of Evidence: Review of the available evidence included 13 studies of transforaminal epidural injections or selective nerve root blocks evaluating their role as a diagnostic entity in conjunction with other diagnostic tests (181, 182, 668, 672-677, 679, 680, 681, 687). **The current evidence provides moderate evidence of transforaminal epidural injections in the preoperative evaluation of patients with negative or inconclusive imaging studies, but with clinical findings of nerve root irritation. The present review of the available literature (181, 182) provides limited evidence as to the role of transforaminal epidural injections in the diagnosis of segmental dural-nerve root pain in the absence of disc herniation and negative provocative discography.**

Safety and Complications: The most common and worrisome complications of transforaminal epidural injections in the spine are related to dural puncture, infection, vascular gas embolism, vascular particulate embolism, cerebral thrombosis, epidural hematoma, neural or spinal cord damage, and complications related to administration of steroids (688-697). The risk of dural puncture, vascular penetration, and spinal cord trauma seen with transforaminal epidurals may be similar to lumbar, thoracic, or cervical interlaminar epidural injections. However, recent reports of paraplegia and neurological disorders are specific to transforaminal epidural injections (688, 694, 695). There have been three cases of paraplegia after lumbosacral nerve root block in post laminectomy patients (688) and other reported complications from transforaminal epidural injections. Intravascular uptake was reported in the lumbar region in 10% to 12% of the cases and at S1 level in 21.3% of the cases (689, 690). Botwin et al (691) reported only minor complications.

5.4 Sacroiliac Joint Blocks

The rationale for sacroiliac joint blocks for diagnosis is based upon the fact that sacroiliac joints have been shown to be capable of being a source of low back pain and referred pain in the lower extremity. There are no definite historical, physical, or radiological features to provide definite diagnosis of sacroiliac joint pain (380, 382, 698-702). Nevertheless, Slipman et al (703) has advocated a positive predictive value of 60% in diagnosing sacroiliac joint pain in patients with three positive provocative maneuvers. Broadhurst and Bond (704) reported 77% to 87% sensitivity with three positive provocative sacroiliac joint maneuvers. Thus, a corroborative history and physical examination can enter into the differential diagnosis of sacroiliac joint pain but cannot make a definitive diagnosis of sacroiliac joint syndrome (705, 706). In addition, there are no corroborative radiologic findings identified thus far in patients with sacroiliac joint syndrome (371, 706). Many studies have been done reporting on the efficacy of plain films (382, 700, 707), computed tomography (701), single photon emission computed tomography (708), bone scans (709, 710), nuclear imaging (711-714), and magnetic resonance imaging (715). However, these radiologic studies can only help in assessing anatomic integrity of other possible nociceptive sources that may mimic sacroiliac joint pain, such as the lumbar intervertebral disc. Imaging studies, however, may be helpful in other disorders, which may affect the sacroiliac joint, such as hyperparathyroidism, fracture, Reiter's syndrome, psoriatic arthritis, ankylosing spondylitis, rheumatoid arthritis, and septic sacroiliitis (371, 700).

The sacroiliac joint is subjected to trauma associated with sudden heavy lifting, prolonged lifting and bending, torsional strain, arising from a stooped position, fall onto a buttock, or rear-end motor vehicle accident with the ipsilateral foot on the brake (700). Sacroiliac joint pain may also result from repetitive shear or torsional forces to the sacroiliac joint as occurs in sports such as figure skating, golf and bowling. Sacroiliac joint pain may also result from degenerative process.

The sacroiliac joint is accepted as a potential source of low back and/or buttock pain with or without lower extremity pain. Diagnostic blocks of a sacroiliac joint can be performed in order to test the hypothesis that the sacroiliac joint is the source of the patient's pain. The sacroiliac joint can be anesthetized with intraarticular injection of local anesthetic. If pain is not relieved, the joint cannot be considered the source of pain whereupon, a new hypothesis about the source of pain

is required. True-positive responses are secured by performing controlled blocks, either in the form of placebo injections of normal saline or comparative local anesthetic blocks.

The face validity of sacroiliac joint block has been established by injecting small volumes of local anesthetic with contrast into the target joint and determining the contrast spread in posterior, anterior and lateral radiographs. Construct validity of sacroiliac joint blocks is also extremely important to avoid the placebo effect. Maigne et al (382) established that the false-positive rate of single, uncontrolled, sacroiliac joint injections was 20%. False-positive injection may occur with extravasation of anesthetic agent out of the joint secondary to defects in the joint capsule. False-negative results may occur from faulty needle placement, intravascular injection or inability of the local anesthetic agent to reach the painful portion of the joint due to loculations. Prevalence of sacroiliac joint pain was demonstrated to be 10% to 30% by a single block (181, 381) and 10% to 19% by a double block paradigm (182, 382).

Cost Effectiveness: There are no studies evaluating the cost effectiveness of sacroiliac joint blocks. However, in an algorithmic approach, these appear to be cost effective.

Summary of Evidence: Review of sacroiliac joint diagnostic blocks led to the inclusion of four studies: Pang et al (181), Schwarzer et al (381), Maigne et al (382), and Manchikanti et al (182). Schwarzer et al (381) utilized a single local anesthetic block in select population. Thus, the value of this evaluation is unknown. Pang et al (181) also utilized single block with a prevalence report of 10% of chronic low back pain patients. Maigne et al (382), even though utilizing a double block paradigm that validated the diagnostic ability of the test with false-positive rates, failed to provide the prevalence rate in chronic spinal pain populations, as it was performed in a select group of patients with suspicion of sacroiliac joint pain. Finally, Manchikanti et al (182) showed a low prevalence of sacroiliac joint pain with a double block paradigm. The study was performed in patients suffering with low back pain and negative for other sources of pain. Even though sacroiliac joint block is considered as a gold standard based on the short-term relief, there was no blinded comparison of the test and reference standard in evaluation of these investigations. **Thus, the evidence for specificity and validity of sacroiliac joint diagnostic injections is moderate.**

Safety and Complications: Complications of sacroiliac joint injection include infection, trauma to the sciatic nerve, and other complications related to drug administration. Without fluoroscopy, successful joint injection as documented with CT is successful in only 22% (716). Notable in the study was epidural spread in 24% or foraminal filling in 44%.

6. Therapeutic Interventional Techniques

The rationale for therapeutic interventional techniques in the spine is based upon several considerations. First, cardinal source(s) of chronic spinal pain, namely discs and joints, are accessible to neural blockade. Second, removal or correction of structural abnormalities of the spine may fail to cure and may even worsen painful conditions. Third, degenerative processes of the spine and the origin of spinal pain are complex. Fourth, the effectiveness of a large variety of therapeutic interventions in managing chronic spinal pain has not been demonstrated conclusively. Interventional techniques in the management of chronic spinal pain include neural blockade and minimally invasive surgical procedures ranging from epidural injections, facet joint injections, and neuroablation techniques, to intradiscal thermal therapy, disc decompression, morphine pump implantation, and spinal cord stimulation.

The requirements for therapeutic interventions include a sterile operating room or a procedure room, monitoring equipment, radiological equipment, special equipment based on technique, sterile preparation with all the resuscitative equipment, needles, gowns, injectate agents, intravenous fluids, sedative agents, and trained personnel for preparation and monitoring of the patients. Minimum requirements include history and physical examination, informed consent, appropriate documentation of the procedure.

Contraindications include bacterial infection, possible pregnancy, bleeding diathesis and anticoagulant therapy. Precautions are warranted in patients with anticoagulant or antiplatelet therapy, diabetes mellitus and artificial heart valves.

6.1 Facet Joint Pain

A preponderance of evidence supports the existence of facet joint pain (179-203, 206-208, 226-243, 416, 482-496, 510-517, 717-768); however, there are also a few detractors (493, 496, 769, 770). Facet joint pain may be managed by either intraarticular injections, medical branch blocks, or neurolysis of medial branches. Relief with intraarticular injections or medial branch blocks was considered as short term if it was documented for less than 3 months and long-term if it was documented for longer than 3 months. Relief with medial branch neurotomy was considered short-term if it was less than 6 months and long-term it if was longer than 6 months.

6.1.1 Intraarticular Blocks

Therapeutic benefit has been reported with the injection of corticosteroids, local anesthetics, or normal saline into the facet joints. The literature describing the effectiveness of these interventions is abundant. However, no systematic reviews have been performed. Five randomized clinical trials offer data on the use of intraarticular injections in the spine (718, 723, 757, 758, 765). Open, controlled and uncontrolled clinical studies that evaluated the long term relief of back and leg pain from intraarticular facet joint injections are abundant.

Four studies of intraarticular corticosteroid lumbar facet joint injections (718, 757, 758, 765) and one study in cervical spine (723) were performed comparing the results to those of a similar group not receiving intraarticular steroids. Two randomized trials, one by Carette et al (718) involving lumbar facet joint injections and the second one by Barnsley et al (723) involving cervical facet joint injections, are considered high quality and have been repeatedly quoted in the literature. Carette et al (718) designed an excellent study with regards to randomization and outcomes assessment. However, they failed to exclude placebo responders, which may account for the relatively high incidence of patients in their study with presumed facet joint pain. Thus, failure to exclude the placebo responders invariably dilutes the findings of true responses, making detection of differences between the study and control groups more difficult. Barnsley et al (723) included a small number of patients, a total of 41 patients, whose origin of neck pain

was posttraumatic following whiplash. Thus, as authors have cautioned, these results should not be extrapolated to the treatment of patients with cervical facet joint pain from other causes, because response to intraarticular steroid injections is not known in cervical facet joint pain of spontaneous origin. Other randomized trials by Marks et al (757) and Nash (758) compared the effects of intraarticular injections with medial branch blocks. Even though the number of patients included were of clinical significance with 86 and 67, the patient selection failed to include controlled diagnostic blocks, there was no blinded evaluation by an independent observer, and the authors utilized poor assessment tools. Both studies were excluded from the evidence synthesis. Lilius et al (765), although performing the study with randomization into three groups, used overly broad criteria for inclusion including the patients with neurological deficits. Further, the presence of lumbar facet joint pain was not confirmed by diagnostic blocks. Excessive volumes ranging from 3 mL to 8 mL of active agents, were injected. Finally, placebo responders were not eliminated. Thus, this study was excluded from the evidence synthesis and analysis.

Both well-controlled trials of Carette et al (718) and Barnsley et al (723) were described as negative by the authors. Carette et al (718) studied 101 patients who received more than 50% relief with a single intraarticular lidocaine block with randomization into intraarticular saline or intraarticular methylprednisolone. These authors showed that 42% of the methylprednisolone group (20 patients), whereas 33% of the saline group (16 patients) achieved significant relief at one month follow up. However, at 6-month follow-up, 46% of the patients in the methylprednisolone group compared to 15% of the patients in the saline group continued to experience marked pain relief, with a statistically significant difference. Even though the authors have concluded that the results were negative, the 6-month results of intraarticular injections of lumbar spine are considered positive. Barnsley et al (723) studied 41 patients with neck pain caused by whiplash injury. Results from this study indicate that the time to return to 50% of baseline pain was 3 days in the steroid group and 3.5 days in the local anesthetic group. Less than half of the patients reported relief of pain for more than 1 week, and fewer than 1 in 5 patients reported relief for more than 1 month, regardless of whether the injection was with steroids or local anesthetic. The results of this study are considered as negative.

Among the non-randomized trials, multiple observational studies were evaluated for inclusion. Among these, four prospective evaluations (504, 719, 722, 766) and two retrospective evaluations (720, 721) met the inclusion criteria. Among the prospective trials included in the evidence synthesis, Lynch and Taylor (766) reported total pain relief in 9 of 27 patients receiving intraarticular steroids and partial relief in an additional 16 patients, whereas, none of the 15 patients receiving extraarticular corticosteroids reported total pain relief and only 8 patients reported partial relief. Destouet et al (719) reported significant pain relief for 1 to 3 months in 62% of the patients for 3 to 6 months, in 38% of the patients. Murtagh (504) reported long-term relief of up to 6 months in 54% of the patients. Mironer and Somerville (722) reported long-term relief in 28% of the patients. Among the retrospective evaluations, Lippitt (720) reported greater than 50% relief initially, which declined to 14% at 6 months and 8% at 12 months. In contrast, Lau et al (721) reported initial relief in 56% of the patients, which declined to 44% at 3 months, and 35% at 6 to 12 months.

Cost Effectiveness: No studies were performed evaluating cost effectiveness of intraarticular facet joint injections.

Summary of Evidence: Based on the present review, only one randomized trial by Carette et al (718) is considered as positive in contrast to the second randomized trial by Barnsley et al (723) which is considered negative. Among the non-randomized trials, positive results were noted for short-term relief in all the studies; however, long-term relief was noted only in 3 of the 5 studies.

The evidence of intraarticular injections of local anesthetics and steroids from randomized trials, complimented with that of non-randomized trials (prospective and retrospective evaluations), provided moderate evidence of short-term relief and limited evidence of long-term relief of chronic neck and low back pain.

6.1.2 Medial Branch Blocks

Medial branch blocks have been extensively utilized for diagnostic and prognostic purposes with limited use for therapeutic purposes. The therapeutic role of medial branch blocks was evaluated in three randomized clinical trials (728, 757, 758) and three non-randomized clinical trials (203, 237, 492).

Among the randomized trials, Manchikanti et al (728) studied patients with two types of interventions after the confirmation of diagnosis of facet joint pain with controlled comparative local anesthetic blocks with monitoring of outcomes at various levels. Marks et al (757) and Nash (758) compared the effectiveness of intraarticular injections. However, these authors (757, 758) failed to appropriately diagnose facet joint pain by controlled diagnostic blocks, lacked long-term follow-up, and also lacked outcomes. Thus, among the three, only one study by Manchikanti et al (728) met the inclusion criteria. In this study, Manchikanti et al (728) randomly allocated a total of 73 patients into two groups, either receiving therapeutic medial branch blocks with a local anesthetic and Sarapin or receiving therapeutic medial branch block with a mixture of local anesthetic, Sarapin and methylprednisolone. Included in the study were patients positive for facet joint pain following controlled comparative local anesthetic blocks on two occasions with chronic low back pain failing to respond to conservative management. This evaluation showed significant improvement with therapeutic medial branch blocks in both groups in all aspects including functional status, drug intake, return to work, and improvement in the psychological status. Significant relief was seen with 1 to 3 injections in 100% of the patients up to 1 to 3 months, 82% of the patients for 4 to 6 months, and 21% for 7 to 12 months. The mean relief was 6.5 $\pm$ 0.76 months. Authors noted improvement not only in pain relief, but also with physical, functional, and psychological status, as well as with return to work status. Thus, this study provides evidence of both short-term and long-term response to therapeutic medial branch blocks.

Among the non-randomized evaluations, Manchikanti et al (237) evaluated the therapeutic value of lumbar facet joint nerve blocks with adjuvant agents as part of a study of diagnosis of facet joint pain. The study population con-

sisted of 180 consecutive patients divided into three groups, with 60 patients in each group. The facet joints in all patients were investigated with controlled comparative local anesthetic diagnostic blocks with lidocaine and bupivacaine. The results of this study showed that the diagnostic blocks could have therapeutic value with mean cumulative relief with comparative local anesthetic blocks in patients with facet joint pain of 20.6 $\pm$ 3.97 days, with a range of 3 to 98 days, in patients receiving local anesthetic only; of 29.6 $\pm$ 4.86 days, with a range of 12 to 98 days, in patients receiving local anesthetic and sarapin; and cumulative relief of 49.8 $\pm$ 9.04 days, with a range of 5 to 160 days, in patients receiving local anesthetic, sarapin, and methylprednisolone. The results of this study showed that diagnostic blocks, specifically with adjuvants, are effective in providing short-term relief. Among the other two evaluations (203, 492), only one evaluation by North et al (492) was included. North et al (492) used diagnostic facet blocks and incorporated assessment by disinterested third party. Following the diagnostic medial branch blocks, 42% of the patients reported at least 50% relief of pain. Among 40 patients who underwent temporary blocks but did not undergo radiofrequency denervation, 13% reported relief of at least 50% at long term follow-up with mean interval of 3.2 years. Similar to the other non-randomized trial (237), a study by North et al (492) showed short-term relief following diagnostic blocks.

Cost Effectiveness: The cost effectiveness of lumbar facet joint nerve blocks, with or without steroids, was evaluated by Manchikanti et al (728) with 1-year improvement of quality of life at $3,461. The cost of one-year improvement was similar to various investigations with neural blockade, but also was significantly better than the cost-effectiveness, with intrathecal morphine delivery or lumbar laminectomy, with or without instrumented fusion. Further, the cost effectiveness of facet joint nerve blocks was less than medical treatment of depression management and hypertension. It was also less than total hip arthroplasty for osteoarthritis of the hip and coronary artery bypass grafting for patients with triple-vessel coronary disease. Resolution of psychological distress was also demonstrated by Manchikanti et al (728) following lumbar facet joint nerve blocks.

Summary of Evidence: Based on the present review, one randomized trial by Manchikanti et al (728) showed positive short-term and long-term results. Among the non-randomized evaluations, both of them showed positive effect for short-term relief (237, 492). **Combined evidence of medial branch blocks from one randomized trial, complimented with two non-randomized trials (one prospective and one retrospective evaluation) provided strong evidence of short-term relief and moderate evidence of long-term relief of pain of facet joint origin.**

6.1.3 Medial Branch Neurotomy

Percutaneous radiofrequency neuro-tomy of medial branches is a procedure that offers temporary relief of pain by denaturing the nerves that innervate the painful joint. However, the pain returns when the axons regenerate. This return of pain can be managed by repeating the procedure and reinstating the relief (729). Radiofrequency neurotomy is a neurolytic technique. Other neurolytic techniques include injection of neurolytic agents (748) and cryoneurolysis (749).

There have been two systematic reviews of medial branch neurotomy (18, 19). The systematic review by Geurts et al (18) was marred with inappropriate methodology, inaccurate conclusions, and was followed by criticism (45, 48). Geurts et al (18) included a total of 6 studies (729, 731, 733, 747, 759, 771), two of which (733, 771) were dorsal root ganglion radiofrequency studies, and a third study was intraarticular facet denervation (759). Thus, only three studies were facet radiofrequency, one of which was cervical (729) and the remaining two were lumbar (731, 733). Geurts et al (18) in their results showed that all 6 trials met the inclusion criteria and stated that "this small number, along with clinical and technical heterogeneity precluded statistical analysis." They further stated that "all studies, whether high or low quality, reported positive outcomes." However, in contrast to the description in the results section, they concluded that there is only moderate evidence that radiofrequency lumbar facet denervation is more effective for chronic low back pain than placebo and there was only limited evidence existent for efficacy of radiofrequency neurotomy in chronic cervical zygapophysial joint pain after flexion/extension injury. The inclusion and exclusion criteria were also not optimal in this systematic review, no non-randomized trials were included, and the protocol for literature search was inadequate. Hence, this did not constitute a true synthesis of evidence or a systematic review. Consequently, it was not included in this evidence synthesis. Manchikanti et al (19) also evaluated the medial branch neurotomy in the management of chronic spinal pain. This review utilized inclusion/exclusion criteria, search strategy and followed key domains in rating quality of systematic reviews as described by AHRQ. Based on the stringent criteria, after identifying 7 randomized trials of radiofrequency neurotomy for spinal pain (729, 731, 733, 747, 759, 760, 771), identified only 4 related to medial branch neurotomy (729, 731, 733, 760). Based on the stringent criteria, they included trials by Lord et al (729) and Van Kleef et al (731) for evidence synthesis and excluded studies by LeClaire et al (760) and Gallagher et al (747) due to various deficiencies. A study by LeClaire et al (760) failed to meet one of the key criteria, namely study population with descriptions of specific inclusion and exclusion criteria, as well as appropriate diagnostic evaluation and criteria for inclusion in the study. The study by Gallagher et al (747) was also not included, because it used the invalidated Shealy technique and such important aspects as the effects on physical impairment and disability were not investigated. Manchikanti et al (19) also considered multiple observational studies and included four prospective evaluations (730, 732, 761, 762) and three retrospective evaluations (492, 745, 763). They excluded multiple studies as they failed to meet the criteria established for inclusion.

Our literature search failed to yield any additional investigations for inclusion. Thus, we have adapted the systematic evaluation by Manchikanti et al (19). Among the randomized evaluations, Lord et al (729) evaluated percutaneous radiofrequency neurotomy for management of chronic cervical facet joint pain in a double-blind, placebo-controlled trial. Facet joint pain was diagnosed with the use of double-blinded, placebo-controlled local anesthetic blocks. The results showed that the median time that elapsed before the pain returned to at least 50% of the preoperative level was 263 days in the active treatment group and 80 days in the control group. The authors concluded

that in patients with chronic cervical facet joint pain confirmed by double-blinded, placebo-controlled local anesthesia, percutaneous radiofrequency neurotomy with multiple lesions of target nerves could provide long lasting relief. In the second study, Van Kleef et al (731) showed that after 3, 6, and 12 months, the number of successes in the lesion and sham groups was 9 and 4, 7 and 3, and 7 and 2, respectively. These results demonstrated that radiofrequency denervation of the lumbar facet joints can be effective for pain reduction in patients with lumbar facet joint pain. Table 5 illustrates the description of these two trials included in the effectiveness analysis.

Among the non-randomized or observational studies, Dreyfuss et al (732) described lumbar facet joint radiofrequency neurotomy in 15 patients utilizing strict criteria and procedural considerations. This study showed 60% improvement in 80% of the patients at 1 year. Stolker et al (762) studied thoracic facet joint neurolysis in 45 patients and reported positive results with 47.5% of the patients being pain-free and with an additional 35% having relief greater than 50% at 2-month follow-up. After a fol-

Table 5. *Description of randomized clinical trials included in the effectiveness analysis of medial branch neurotomy*

Study & Authors	Lord et al 1996 (729)	Van Kleef et al 1999 (731)
Number of patients	Treatment = 12 Control = 12	Treatment = 15 Control = 16
Description of Patients	Patients with neck pain of >3 months' duration, who had pain in one or more cervical (C3-C7) zygapophysial joints after a motor vehicle injury. Zygapophysial joint involvement was confirmed by placebo-controlled diagnostic blocks. Mean age 44 years in treatment group, and 43 years in control group.	Patients with cLBP of >12 months' duration. Conservative therapy attempted without success. Absence of any neurologic deficit, and ≥50% pain relief from a diagnostic dorsal ramus nerve blockade with a local anesthetic solution. Mean age was 46.6 years in treatment group and 41.4 years in control group.
Objectives	To evaluate the efficacy of RF denervation by comparing it with a control procedure	To assess the clinical efficacy of RF denervation of the lumbar zygapophysial joints in reducing pain, functional disability, and physical impairment in patients with back pain.
Intervention	i. Radiofrequency lesion group was treated with a 90-second RF lesion of 80°C of the medial branch of the cervical dorsal ramus. ii. In control or sham group, electrodes were introduced as in treatment group, but no radiofrequency lesion was made.	i. Radiofrequency lesion group was treated with a 60-second RF lesion of 80°C of the medial branch of the posterior primary ramus of the segmental nerves L3-L5. ii. In control or sham group, electrodes were introduced as in treatment group, but no radiofrequency lesion was made.
Duration of pain in months median (range)	Treatment = 44 (23-94) Control =34 (25-92)	Treatment = 26 (12-120) Control =48 (12-192)
Follow-up	3 months 6 months 12 months	2 months 3 months 6 months 12 months
Outcomes	Success rate (a score of 0-5 out of 100 on VAS scale a word count of ≤3 on the McGill Pain Questionnaire and the restoration of all four activities of daily living.	Number of successes (%) (≥ 2.point reduction on VAS scale and ≥50% reduction on global perceived effect) Change in VAS mean, high, low Change in Oswestry Disability Scale Global perceived effect
Results	i. Seven patients in treatment and one in control group remained free of pain. The median time to return of at least 50% of the preoperative level of pain was 263 days in treatment group and 8 days in control group. ii. Five patients in each study group underwent second procedures. Three patients in the active-treatment group, who had less than 3 months of relief after the first procedure, did not have relief of their pain after the second procedure. One patient in the control group had no relief after either the initial procedure or the "escape" procedure with active treatment. iii. Success rate of 75% with one or two treatments.	i. After 8 weeks of treatment, 10 of the 15 patients undergoing radiofrequency were successful compared to 6 of the 16 in the control group. The differences in effect on the visual analog scale scores, global perceived effect, and the Oswestry Disability Scale were statistically significant. ii. After 3 months, the number of successes in the lesion and sham groups were 9and 4 (60% vs. 25%) with statistically significant difference (p = 0.02). iii. After 6 months, the number of successes in the lesion and sham groups were 7 and 3 (47% vs. 19%) with statistically significant difference (p = 0.02). iv. After 12 months, the number of successes in the lesion and sham groups were 7 and 2 respectively (47% vs. 13%) with statistically significant difference (p = 0.02).
Conclusion	Positive short and long-term effect	Positive short and long-term effect

Adapted and modified from Manchikanti et al (19)

low up of 18 to 54 months, they reported 83% of the patients with greater than 50% pain relief. Sapir and Gorup (761) studied 46 patients reporting overall reduction in cervical whiplash symptoms and visual analog pain scores in a significant proportion of patients at 1 year in both litigant and non-litigant patients. McDonald et al (730) determined the long-term efficacy of percutaneous radiofrequency medial branch neurotomy in the treatment of chronic neck pain in 28 patients diagnosed as having cervical zygapophysial joint pain on the basis of controlled diagnostic blocks. They reported complete relief of pain in 71% of the patients after an initial procedure. They reported that the median duration of relief after a first procedure was 219 days when failures were included, but 422 days when only the successes were considered. The median duration of the relief after repeat procedures was at least 219 days. Their results showed that radiofrequency neurotomy of the cer-

Table 6. *Description and results of non-randomized prospective trials included in the analysis of medial branch neurotomy*

Study & Author(s)	Dreyfuss et al 2000 (732)	Stoker et al 1993 (762)	Sapir & Gorup (761)	McDonald et al (730)
Objective(s)	i. To establish the efficacy of lumbar medial branch neurotomy under optimum conditions. ii. To avoid shortcomings of the previous reports of the efficacy of lumbar medial branch neurotomy which have been confounded by poor patient selection, inaccurate surgical technique and inadequate assessment of outcome	i. To evaluate effectiveness of percutaneous facet denervation and chronic thoracic spinal pain.	i. To assess the effect of monetary gain on treatment of zygapophysial joint pain in cervical whiplash. ii. To determine whether radiofrequency medial branch neurotomy is effective treatment of whiplash.	i. To determine the long-term efficacy of percutaneous radiofrequency medial branch neurotomy in the treatment of chronic neck pain.
Description of Patients	i. Fifteen patients with chronic low back pain whose pain was relieved by controlled, diagnostic medial branch blocks of the lumbar zygapophysial joints, underwent lumbar medial branch neurotomy. ii. Before surgery, all were evaluated by visual analog scale and a variety of validated measures of pain, disability and treatment satisfaction. iii. A total of 460 people responded to invitations to participate in the study. After the interview, 138 patients remained potentially eligible. After physical examination, 41 patients remained potentially eligible and proceeded to lumbar medial branch blocks. Twenty-two patients who reported at least 80% relief of pain for longer than one hour after the lidocaine blocks underwent confirmatory blocks using 0.5% bupivacaine. Fifteen of the twenty-two patients undergoing bupivacaine blocks obtained at least 80% relief of pain for longer than 2 hours and were offered radiofrequency neurotomy.	i. Forty patients with chronic thoracic spinal pain of >12 months duration which failed to respond to conservative treatment and with a previous evaluation by a specialist, mainly neurologists and orthopedic surgeons, were included. ii. The diagnosis of facet syndrome also was made by clinical criteria and a transient positive response to a prognostic blockade of the medial branch of the dorsal ramus of the thoracic spinal nerve.	i. Fifty-nine patients underwent diagnostic blocks of the cervical medial branch nerves of the posterior primary ramus under fluoroscopic imaging guidance using the controlled 2-phase diagnostic method. ii. The presence of zygapophysial joint pain was confirmed if the blocks were successful. A block was considered successful when the patient obtained a greater than 80% reduction in self-reported symptoms. Patients failed 20 weeks of conservative management after cervical whiplash. iii. The patients were classified as litigant or non-litigant based on whether the potential for monetary gain via litigation existed. Each group underwent identical evaluation and treatment. There were 32 patients in litigation group and 18 patients in non-litigation group.	i. Twenty-eight patients diagnosed as having cervical zygapophysial joint pain on the basis of controlled diagnostic blocks were included.
Intervention	i. Radiofrequency medial branch neurotomy was performed at 85° C for 90 seconds coagulating the target nerve 8-10 mm along its length with 2 lesions. ii. Lesioning was performed at 2 levels for each joint. iii. Electromyography of the multifidus muscle.	i. Percutaneous radiofrequency denervation of the facet joints was carried out.	i. All patients underwent the same diagnostic procedural method for the 2-phase diagnostic cervical medial branch blocks. ii. Radiofrequency neurotomy was performed using a disposable 22-gauge, 100-mm, 4-mm active tip RF lesioning needles with two separate lesions at 80° for 90 seconds at each level denervated.	i. Cervical radiofrequency of zygapophysial joint nerves were performed as described by Lord et al. ii. The procedure was repeated in patients whose pain recurred.
Outcomes	i. Outcomes were conducted at: 6 weeks, 3 months, 6 months, and 12 months. ii. Outcome measurements included electromyography, lifting tasks, North American Spine Society outcome instrument.	i. Pain relief	i. The visual analog scale (VAS) ii. Self-report of improvement (SRI) iii. Medication usage	Outcome measures were the proportion of patients who responded to the initial procedure and the duration of relief subsequently obtained.
Results	i. Sixty percent of the patients obtained at least 90% relief of pain at 12 months. ii. Eighty seven percent obtained at least 60% relief. iii. Relief was associated with denervation of the multifidus in those segments in which the medial branches had been coagulated. iv. Prelesion electrical stimulation of the medial branch nerve with measurement of impedence was not associated with outcome	i. After 2 months, 19 patients (47.5%) were pain free and 14 patients (35%) had more than 50% pain relief, with a total of 82.5% of the patients reporting greater than 50% relief. ii. With long-term follow-up of average 31 months in 36 [patients, 44% were pain-free and 39% had more than 50% pain relief, with a total of 83% of the patients presenting greater than 50% relief.	i. At one year, the overall reduction in cervical whiplash symptoms and visual analog pain scores were significant (non-litigants vs litigants: 2.9 vs 4.0, p=0.05). ii. The difference between litigants and non-litigants in the degree of symptomatology or response to treatment did not reach significance.	i. Complete relief of pain was obtained in 71% of the patients after an initial procedure. ii. No patient who failed to respond to a first procedure responded to a repeat procedure, but if pain returned after a successful initial procedure, relief could be reinstated by a repeat procedure. iii. The median duration of relief after a first procedure was 219 days when failures were included, but 422 days when only successful cases were considered.
Conclusion	Positive short and long-term effect	Positive short and long-term effect	Positive short and long-term effect	Positive short and long-term effect

Adapted and modified from Manchikanti et al (19)

vical zygapophysial joints significantly reduced headache severity in 80% of the patients, both at short-term and long-term follow-up. Description and results are summarized in Table 6.

Among the retrospective evaluations, Tzaan and Tasker (763) evaluated 118 consecutive percutaneous radiofrequency facet rhizotomies performed on 90 patients. They reported that with the first procedure, greater than 50% subjective reduction of pain was present in 41% of the overall patients with 37% of the cases done under local anesthesia, and 46% in cases done under general anesthesia with no significant difference noted. They also included cervical, thoracic and lumbosacral facets and noted no significant difference between unilateral or bilateral involvement. North et al (492) evaluated radiofrequency lumbar facet denervation with the long-term outcome assessment by disinterested third party interview. Forty-five percent of patients undergoing denervation reported at least 50% relief of pain at long-term follow-up. Schaerer (745) evaluated the value of radiofrequency facet rhizotomy in the treatment of patients with chronic neck and low back pain problems in 117 consecutive patients. They reported that overall results were fair to excellent in 68% of the patients with an average follow-up time of 13.7 months.

Cost Effectiveness: No cost effectiveness evaluations were performed with medial branch neurotomy. However, this is expected to be the case based on other interventional techniques, with appropriate management. In addition, Wallis et al (764) showed resolution of psychological distress of whiplash patients following treatment by radiofrequency neurotomy.

Summary of Evidence: Evidence synthesis for medial branch neurotomy included one systematic evaluation by Manchikanti et al (19) providing strong evidence that radiofrequency denervation offered short-term relief and moderate evidence of long-term relief of chronic neck, thoracic and low back pain of facet joint origin. Two randomized trials included were of Lord et al (729) and van Kleef et al (731) also providing positive short and long-term effect. In addition, 4 prospective studies (730, 732, 761, 762) and 3 retrospective evaluations (492, 745, 763) showed positive short-term and long-term results. **Considering the one systematic review, two randomized trials, four prospective evaluations, and three retrospective evaluations, combined evidence of radiofrequency neurotomy of medial branches provided strong evidence of short-term relief and moderate evidence of long-term relief of chronic spinal pain of facet joint origin.**

Complications: Potential side effects with radiofrequency denervation include painful cutaneous dysesthesias, increased pain due to neuritis or neurogenic inflammation, anesthesia dolorosa, cutaneous hyperesthesia, pneumothorax and deafferentation pain (772).

6.2 Epidural Injections

Epidural injection of corticosteroids is one of the commonly used interventions in managing chronic spinal pain (2). Several approaches are available to access the lumbar epidural space: caudal, interlaminar and transforaminal (2). Epidural administration of corticosteroids is one of the subjects most studied in interventional pain management with the most systematic reviews available.

The first systematic review of effectiveness of epidural steroid injections was performed by Kepes and Duncalf in 1985 (24). They concluded that the rationale for epidural and systemic steroids was not proven. However, in 1986 Benzon (25), utilizing the same studies, concluded that mechanical causes of low back pain, especially those accompanied by signs of nerve root irritation, may respond to epidural steroid injections. The difference in the conclusion of Kepes and Duncalf (24) and Benzon (25) may have been due to the fact that Kepes and Duncalf (24) included studies on systemic steroids whereas Benzon (25) limited his analysis to studies on epidural steroid injections only.

The debate concerning epidural steroid injections is also illustrated by the recommendations of the Australian National Health and Medical Research Council Advisory Committee on epidural steroid injections (5). In this report, Bogduk et al (5) extensively studied caudal, interlaminar, and transforaminal epidural injections, including all the literature available at the time, and concluded that the balance of the published evidence supports the therapeutic use of caudal epidurals. They also concluded that the results of lumbar interlaminar epidural steroids strongly refute the utility of epidural steroids in acute sciatica. Bogduk (27) updated his recommendations in 1999, recommending against epidural steroids by the lumbar route because effective treatment required too high a number for successful treatment, but supporting the potential usefulness of transforaminal steroids for disc prolapse. In 1995, Koes et al (3) reviewed 12 trials of lumbar and caudal epidural steroid injections and reported positive results from only six studies. However, review of their analysis showed that there were five studies for caudal epidural steroid injections and seven studies for lumbar epidural steroid injections. Four of the five studies involving caudal epidural steroid injections were positive, whereas five of seven studies were negative for lumbar epidural steroid injections. Koes et al (4) updated their review of epidural steroid injections for low back pain and sciatica, including three more studies with a total of 15 trials which met the inclusion criteria. In this study, they concluded that of the 15 trials, eight reported positive results of epidural steroid injections. Watts and Silagy (29) in 1995 performed a meta-analysis of the available data and defined efficacy in terms of pain relief (at least a 75% improvement) in the short term (60 days) and in the long term (1 year). They concluded that epidural steroid injections increased the odds ratio of pain relief to 2.61 in the short term and to 1.87 in the long term (odds ratio greater than one suggests efficacy; equal to or greater than two suggests significant efficacy). van Tulder et al (20), in analyzing numerous conservative treatments of chronic low back pain, included seven studies of epidural steroid injections. They concluded that there was conflicting evidence with inconsistent findings with regards to the effectiveness of epidural steroid injections. McQuay and Moore (773) in 1998 reviewed the literature and concluded that epidural corticosteroid injections are effective for back pain and sciatica. They also concluded that, even though epidural steroid injections can optimize conservative therapy and provide substantial pain relief for up to 12 weeks in patients with acute or subacute sciatica, few patients with chronic spinal pain report complete relief; the majority must return for repeated epidural injections.

Nelemans et al (14) Cochrane review of injection therapy for subacute and chronic benign low back pain included 21 randomized trials. Of these, 9 were of epidural steroids. They failed to sep-

arate caudal from interlaminar epidural injections, but still concluded that convincing evidence is lacking regarding the effects of injection therapy on low back pain. van Tulder et al (20), in a systematic review of randomized controlled trials of the most common conservative treatments for acute and chronic nonspecific low back pain reviewed various studies involving multiple modalities of treatments. In this evaluation, which was similar to other evaluations by these authors, they included six epidural steroid injection studies and concluded that the effect of these treatments was not proven. Once again, they used the same philosophy as before and failed to separate caudal and interlaminar epidural injections. Bernstein (774) reviewed injections and surgical therapy in chronic spinal pain and concluded that there was limited evidence for the effectiveness of interlaminar or caudal epidural steroid injections for sciatica with low back pain. Curatolo and Bogduk (775) used a pragmatic review of data provided by available systematic reviews and seminal controlled studies pertaining to the treatment of regional musculoskeletal problems, concluding that epidural steroids may offer limited, short-term benefit for sciatica. They also concluded that selective epidural injection of steroids at a target nerve root approached through the intervertebral foramen has the potential to replace the traditional epidural approach.

Vroomen et al (776) reviewed conservative treatment of sciatica with 19 randomized controlled trials, which also included epidural steroid injections. They concluded that epidural steroids may be beneficial for subgroups of nerve root compression. They also described that the literature suggests possible effectiveness of epidural steroids for sciatica. Rozenberg et al (22), in a systematic review, identified 13 trials of epidural steroid therapy. They concluded that 5 trials demonstrated greater pain relief within the first month in the steroid group as compared to the control group. Eight trials found no measurable benefits. They noticed many obstacles for meaningful comparison of cross studies, which included differences in the patient populations, steroid used, volume injected, and number of injections. These authors were unable to determine whether epidural steroids are effective in common low back pain and sciatica based on their review. Rozenburg et al (22) concluded that 3 of the top 5 rated studies did not demonstrate significant benefit of the steroid over the non-steroid group. Hopayiank and Mugford (777) expressed frustration over the conflicting conclusions from two systematic reviews of epidural steroid injections for sciatica and which evidence should general practitioners heed? Rozenburg's systematic review (22) met with all the same deficiencies as other systematic reviews. BenDebba et al (778), in a multicenter study from the Departments of Neurosurgery of John Hopkins School of Medicine, CaseWestern Reserve University, Univer-sity of Tennessee-Memphis, University of Florida, and University of Missouri-Columbia; ambulatory care center of Massachusetts General Hospital and Division of Orthopedic Surgery of UCLA School of Medicine evaluated treatment outcomes in persistent low back pain and sciatica in the United States. However, none of the interventional pain physicians or their departments were involved in the study. Their data revealed that at the 2-year follow-up, the typical patient of the no-treatment group had improved slightly in terms of pain severity and healthcare use, but had experienced little or no improvement in functional disability, physical symptoms and psychological distress. The average patient in the conservative care group reported small improvements in pain severity, functional disability, physical symptoms, and healthcare use, with no change in psychological distress. Patients in the delayed surgical group had outcomes that were less dramatic than those observed in the immediate surgery care group, but greater than those observed in the conservative care group. Patients who were treated surgically by physicians outside the study (an outside surgical care group) did not improve over time. Patients with persistent low back pain who received no treatment showed no spontaneous recovery. Conservative care treatments, prescribed by surgeons who specialize in spinal disorders, did not appear to be any more effective than no treatment.

Epidural injections may be performed by three approaches. There are substantial differences between the three approaches (2, 417, 689-691, 779-819). The interlaminar entry is directed more closely to the assumed site of pathology requiring less volume than the caudal route. The caudal entry is relatively easily achieved, with minimal risk of inadvertent dural puncture. The transforaminal approach is target specific with smallest volume in fulfilling the aim of reaching the primary site of pathology; namely ventrolateral epidural space.

Disadvantages of the caudal approach include: requirement of substantial volume of fluid, dilution of the injectate, extraepidural placement of the needle, and increased risk for intravascular placement of the needle. Disadvantages of interlaminar approach include: dilution of the injectate, extraepidural placement of the needle, intravascular placement of the needle, preferential cranial flow of the solution, preferential posterior flow of the solution, difficult placement (with increased risk) in postsurgical patients, difficult placement below L4/5 interspace, deviation of needle to nondependent side, dural puncture and trauma to spinal cord. Potential disadvantages of the transforaminal approach include: intraneural injection, neural trauma, technical difficulty in presence of fusion and/or hardware, intravascular injection and spinal cord trauma. The use of fluoroscopy to direct needle placement and observe contrast flow should reduce many potential disadvantages

Due to the inherent variations, differences, advantages, and disadvantages applicable to each technique (including the effectiveness and outcomes), caudal epidural injections; interlaminar epidural injections (cervical, thoracic, and lumbar epidural injections); and transforaminal epidural injections (cervical, thoracic, and lumbosacral) are considered as an entity within epidural injections and are discussed as such below.

In this evaluation, a multitude of systematic reviews were considered along with randomized, as well as non-randomized trials for each category, namely interlaminar, caudal and transforaminal epidural injections. Short-term effect was defined as significant relief of less than 3 months and long-term effect was defined as 3 months or longer.

6.2.1. Caudal Epidural Injections

There were no systematic reviews evaluating caudal epidural injections. Among the multitude of trials, there were 9 studies either randomized or double blind (820-828), 3 prospective trials (593, 829, 830) and many retrospective evaluations (831-845). The results of published

Table 7. *Characteristics of published randomized trials of caudal epidural injections*

Study/Methods	Participants	Interventions	Outcomes	Results	Outcomes/ Conclusion
Breivik et al (820) Randomized double blind trial. Randomization according to a list of random numbers.	35 patients with incapacitating chronic low back pain and sciatica. Diagnoses based on radiculography: arachnoiditis (n=8), no abnormality (n=11), inconclusive findings (n=5). Duration: several months to several years.	Caudal epidural injections: Experimental: 20 mL bupivacaine 0.25% with 80 mg depomethylprednisone (n=16) Placebo: 20 mL bupivacaine 0.25% followed by 100 mL saline (n=19). Frequency: up to three injections at weekly intervals.	Timing: not mentioned. Outcome measures: 1. Pain relief: significant diminution of pain and/or paresis to a degree that enabled return to work. 2. Objective improvement: sensation, Lasègue's test, paresis, spinal reflexes, and sphincter disorders.	56% of the patients reported considerable pain relief in experimental group compared to 26% of the patients in the placebo group.	Positive short-term and long-term relief
Bush and Hillier (821) Randomized double blind trial. 28 patients were randomized; only 23 patients were entered into the study.	23 patients with lumbar nerve root compromise. Mean duration (range) in experimental group: 5.8 months (1-13 months) and in control group 4.7 months (1-12).	Caudal epidural injections: Experimental: 25 mL: 80 mg triamcinolone acetonide + 0.5% procaine hydrochloride (n=12) Control: 25 mL normal saline (n=11) Frequency: two caudal injections, the first after admission to the trial and a second after 2 weeks	Timing: at four weeks and one year. Outcome measures: 1. Effect on lifestyle 2. Back and leg pain 3. Angle of positive SLR	Significantly better results with pain and straight leg raising in experimental group in short-term. Pain not significantly different but straight leg raise significantly better in long-term.	Positive short-term relief and negative long-term relief
Matthews et al (822) Double blind. Stratification by age and gender. Survival curve analyses based on cumulative totals recovered.	57 patients with sciatica with a single root compression Experimental group: male/female: 19/4, median duration of pain: 4 weeks (range: 8 days-3 months). Control group: male/female: 24/10, median duration of pain: 4 weeks (range: 3 days-9 weeks).	Caudal epidural injections: Experimental: 20 mL bupivacaine 0.125% + 2 mL (80 mg) methylprednisolone acetate (n=23). Control: 2 mL lignocaine (over the sacral hiatus or into a tender spot) (n=34) Frequency: fortnightly intervals, up to three times as needed	Timing: 2 weeks, 1, 3, 6, and 12 months. Outcome measures: 1. Pain (recovered vs not recovered). 2. Range of movement 3. Straight leg raising 4. Neurologic examination	There was no significant difference between experimental and control group with short-term relief (67% vs 56%). After 3 months, patients in experimental group reported significantly more pain relief than in control group.	Negative short-term relief and positive long-term relief
Beliveau (823) Patients were allocated alternately to the treatment groups.	48 patients with unilateral sciatica. Male/female: 36/12.	Caudal epidural injections: Experimental: 2 mL (80 mg) methylprednisolone + 40 mL of procaine 0.5% (n=24). Control: 42 mL of procaine 0.5% (n=24)	Timing: 1 week after injection. Outcome measures; change in pain	The number of patients improved or completely relieved during 3 months follow-up were similar in both groups 18 vs 16.	Negative short-term and long-term relief
Manchikanti et al (825) A randomized trial with convenient control group.	70 patients after failed conservative management with physical therapy, chiropractic and medication therapy. All patients were shown to be negative for facet joint pain.	Caudal epidural injections: Group I : no treatment Group II: local anesthetic and sarapin total of 20 mL with 10 mL each. Group III: 10 mL of local anesthetic and 6 mg of betamethasone	Timing: 2 weeks, 1 month, 3 months, 6 months and 1 year. Outcome measures: Average pain, physical health, mental health, and functional status	Average pain, physical health, mental health, functional status, narcotic intake and employment improved significantly in Group II and Group III at 2 weeks, 1 month, 3 months, 6 months and 1 year.	Positive short-term and long-term relief.
Helsa and Breivik (826) Double blind trial with crossover design	69 patients with incapacitating chronic low back pain and sciatica. 36 of 69 previously been operated on for herniated disc.	Three caudal epidural injections of either bupivacaine with depomethylprednisolone 80 mg or with bupivacaine followed by normal saline. If no improvement had occurred after 3 injections, a series of the alternative type of injection was given.	Timing: not mentioned. Outcome measures: significant improvement to return to work or to be retrained for another occupation	i. 34 of the 58 patients (59%) receiving caudal epidural injections of bupivacaine and depomethylprednisolone showed significant improvement. ii. 12 of 49 patients (25%) who received bupivacaine followed by saline were improved.	Positive short-term and long-term relief
Revel et al (827) Randomized trial.	60 post lumbar laminectomy patients with chronic low back pain	Forceful caudal injections: Experimental: 125 mg of prednisolone acetate with 40 mL of normal saline in the treatment group. Control: 125 mg of prednisolone in the control group.	Timing: 6 months. Outcome measures: pain relief.	The proportion of patients relieved of sciatica was 49% in the forceful injection group compared to 19% in the control group with significant difference.	Positive short-term and long-term relief
Meadeb et al (828) Randomized trial. Parallel-group study.	47 post lumbar laminectomy syndrome patients in a multicenter study.	Experimental group: forceful injection of 20 mL of normal saline with or without 125 mg of epidural prednisolone acetate. Control group: 125 mg of epidural prednisolone. Frequency: each of the 3 treatments were provided once a month for 3 consecutive months.	Timing: day 1, day 30 and day 120. Outcome measures: visual analog scores.	The VAS scores improved steadily in the forceful injection group, producing a nonsignificant difference on day 120 as compared to the baseline (day 30=120 days).	Negative short-term and long-term relief

reports of the randomized trials are described in Table 7, while Table 8 shows description of non-randomized trials (prospective and retrospective).

Of the 9 randomized or double blind trials, one study was excluded (824) from evidence synthesis. Of the remaining 8 trials, 5 were positive for short-term pain relief (820, 821, 825-827) and 5 were positive for long-term relief with multiple injections (820, 822, 825-827). Among the 3 prospective trials (593, 829, 830) and 4 retrospective trials (831, 832, 834, 836) selected for inclusion, all of them were positive for short-term and long-term relief with multiple injections. Criticism on multiple fronts has been offered on almost all of the evaluations discussed. Among these evaluations, Meadeb et al (828) studied 47 post lumbar laminectomy syndrome patients. Helsa and Breivik (826), in their double blind trial, included 36 of 69 patients with post laminectomy syndrome. Ciocon et al (836) studied the effect of caudal epidural steroid injections in spinal stenosis.

Cost Effectiveness: The cost effectiveness of caudal epidural steroids was evaluated in 2 studies. Manchikanti et al (832), initially in a retrospective evaluation evaluated the cost-effectiveness of blind interlaminar, fluoroscopically directed caudal and transforaminal epidural injections for the management of chronic low back pain. They showed that the cost-effectiveness of caudal epidural steroids was $3,635 and that of transforaminal steroids was $2,927 per year. Interlaminar epidural steroids were shown to be cost effective at $6,024 per year. Manchikanti et al (825), also in a prospective evaluation showed the cost for 1-year improvement for quality-of-life, as $2,550, in patients treated with caudal epidural with local anesthetic and sarapin or steroids under flu-

Table 8. *Characteristics and results of non-randomized studies of caudal epidural injections*

Study/Methods	Participants	Interventions	Outcomes	Results	Outcomes/ Conclusion
Yates (829) Prospective evaluation	20 patients with low back pain and sciatica.	Group I: 60 mg of triamcinolone (3 mL + 47 mL normal saline) Group II: 60 mg of triamcinolone (3 mL + 47 mL lignocaine 0.5%) Group III: 50 mL saline Group IV: 50 mL lignocaine Injections were given at weekly intervals in a random order	Timing: not mentioned. Outcome measures: Subjective and objective criteria of p rogress. Study did not address pain-relief. Study focused on straight leg raising.	Greatest improvement was noted after the injection containing steroid.	Positive short-term and long-term relief.
Waldman (830) Prospective evaluation with independent observer review.	53 patients meeting stringent inclusion criteria with radicular pain distribution anatomically correlating with documented disc herniation and nerve root impingement.	Treatment: 7.5 mL of 1% lidocaine and 80 mg of methylprednisolone with the first block and 40 mg of methylprednisolone with subsequent blocks. Subsequent blocks were repeated in 48 to 72 hour intervals up to 4 caudal epidural blocks.	Timing: 6 weeks, 3 months, 6 months. Outcome measures: Visual analog scale and verbal analog scores.	Combined visual analog scale and verbal analog scores for all patients were reduced 63% at 6 weeks, 67% at 3 months, and 71% at 6 months.	Positive short-term and long-term relief.
Manchikanti et al (593) Prospective evaluation in discogram-positive and discogram-negative chronic low back pain patients.	62 patients were evaluated. Negative provocative discography: 45 patients Positive provocative discography: 17 patients	Caudal epidural injections (1-3) with or without steroids.	Timing: 1 month, 3 months, and 6 months. Outcome measures: Average pain, physical health, mental health, functional status, psychological status, symptom magnification, narcotic intake and employment status.	Improvement 69% of the patients in the negative discography group and 65% of the patients in the positive discography group. Overall health status, psychological status, narcotic intake and return to work showed improvement in successful category.	Positive short-term and long-term relief.
Hauswirth and Michot (831) Retrospective evaluation	75 patients with chronic low back pain and sciatica	Caudal epidural injections of local anesthetic and steroids	Timing: not mentioned Outcome measures: Pain relief	Results were excellent in 60% and good in 24%. 16% of the patients showed no improvement.	Positive short-term and long-term relief.
Manchikanti et al (832) Retrospective evaluation of 225 patients with chronic low back pain.	Chronic pain patients who have failed to respond to conservative management with physical therapy, chiropractic and medical therapy.	Group I: Blind lumbar epidural steroid injections, Group II: Caudal epidural steroid injections under fluoroscopy. Group III: Transforaminal epidural corticosteroid injections under fluoroscopic visualization.	Duration of pain relief with each injection. Outcome measures: pain relief $\geq$ 50%	Cumulative significant relief, with 3 procedures was 10.3 $\pm$0.96 weeks in patients receiving caudal epidurals.	Positive short-term and long-term relief.
Goebert et al (834) Retrospective evaluation of 113 patients.	113 patients at a tertiary care center receiving 120 injections. 94 were caudal epidural injections There were no objective signs present in the patients.	Epidural injections of 30 mL of 1% procaine combined with 125 mg of hydrocortisone acetate usually for 3 consecutive or alternate days.	Timing: 3 months Outcome measures: Pain relief	Overall good results in 72% of the patients with poor results in 17%.	Positive short-term and long-term relief.
Ciocon et al (836) Evaluation of elderly patients	30 patients with various degrees of degenerative lumbar canal stenosis treated with caudal epidural steroid injections. Mean age: 76 $\pm$ 6.7 yrs	A total of 3 caudal epidural steroid injections of 0.5% lidocaine with 80 mg of methylprednisolone administered at weekly intervals	Timing: initial and at 2-month intervals up to 10 months. Outcome measures: Pain reduction and walking capability.	The results showed significant pain reduction for up to 10 months, with satisfactory relief in 90% of the patients.	Positive short-term and long-term relief.

oroscopy. Thus, the cost-effectiveness of caudal epidural steroids is shown to be in the same range as that for transforaminal epidurals, percutaneous lysis of adhesions, and lumbar facet joint nerve blocks. Straus (39) proposed that blind epidural steroid injections performed in an office setting were superior in cost minimization analysis. However, the use of inaccurate data and the lack of cost effectiveness analysis in this review, detracts from this conclusion.

Summary of Evidence: Evidence synthesis included inclusion of 8 randomized or double blind trials, 5 of which were positive for short-term relief (820, 821, 825-827), and 5 were positive for long-term relief with multiple injections (820, 822, 825-827). Further, 3 prospective trials (593, 829, 830) and 4 retrospective trials (831, 832, 834, 836) were selected for inclusion. All of them were positive for short-term and long-term relief with multiple injections. **The combined evidence of caudal epidural steroid injections with randomized trials and non-randomized trials (prospective and retrospective trials) is strong for short-term relief and moderate for long-term relief.**

6.2.2 Interlaminar Epidural Injections

Multiple systematic reviews provided contradictory and confusing opinions. Further, all the systematic reviews utilized, combined caudal and interlaminar epidural steroid injections, thus, no reasonable conclusions may be drawn from these systematic reviews, and their conclusions may not be applied in clinical practice settings. However, studies in the literature evaluating the effectiveness of interlaminar epidural injections, specifically the lumbar epidural injections, are extensive. Multiple evaluations included 16 randomized or double blind trials (846-861), 8 non-randomized prospective trials (862-869) and multiple other observational trials (870-893).

Among the 16 randomized trials, 10 met criteria and were utilized for evidence synthesis with the elimination of 6. Excluded studies were as follows: Serrao et al (850) was not included, as they compared subarachnoid midazolam with epidural midazolam and steroid. Hernandez and Lopez (856) and Kikuchi et al (857) compared diabetic polyneuropathy and intractable post herpetic neuralgia, Buchner et al (861) evaluated only inpatients, while Rocco et al (852) failed to evaulate long-term relief. Helliwell et al (859) was also not included due to non-availability of data for review. Table 9 illustrates various characteristics and results of published randomized or double blind trials included in the evidence synthesis. Of the 8 non-randomized prospective trials, only 4 trials (862-864) were utilized for the evidence synthesis, whereas the remaining 4 were eliminated due to multiple issues.

Among the non-randomized trials, Bush and Hillier (862) evaluated the outcome of cervical radiculopathy treated with periradicular/epidural corticosteroid injections in a prospective study with an independent clinical review. Sixty-eight patients with neurological deficits were evaluated initially with a non-fluoroscopically guided interlaminar epidural steroid injection. If significant improvement was not seen after the first injection, a repeat injection was performed within 1 month transforaminally with fluoroscopic guidance. Overall, 93% of patients reported pain relief lasting 7 months with an average of 2.5 injections per patient to obtain adequate pain control. Since all the patients eventually received transforaminal epidural injections, it was difficult to determine the relief obtained with interlaminar epidural injections. Rull et al (863) evaluated 149 patients, with a clinical picture of lumbar root compression, treated by means of 3 epidural injections. The injectate included 10 ml of 0.25% bupivacaine and 80 mg of methylprednisolone acetate. All the patients had neurological sensitivity or moderate deficiency with no history of previous surgery. Sixty-three percent of the patients presented with herniated disc and 37% with spinal canal stenosis. The results were evaluated at 3 and 6 months and after the first year with an average follow-up time of 2.3 years and a maximum of 6 years. After 6 months, good results were seen in 66%, however, after a year, 78% of the patients reported long-term relief. Caglar et al (864) administered 80 mg of epidural methylprednisolone to 25 patients at 2 weekly intervals. All patients had lumbar disc herniation. Clinical parameters investigated included visual analog scale, degree of pain, posture, pain on palpation, lumbar movement, straight leg raising test, hand-floor distance measurement and functional capacity. The results showed that after the first injection, there was some response to the treatment. After second injection, healing continued by some criteria. However, after the third injection, there were no changes by the objective criteria apart from the subjective pain relief. The results of this study appear to show negative results for short-term and long-term relief. Fukasaki et al (867) evaluated the role of interlaminar epidural steroid injection in spinal stenosis and judged it to be negative. Warfield and Crews (869) evaluated the ability of epidural steroid injection to predict surgical outcome and found that there was no correlation between response to blind epidural steroids and outcome of open surgical procedures.

Cost Effectiveness: In the evaluation of cost effectiveness, Manchikanti et al (832) showed that caudal epidural steroid injections, as well as lumbar transforaminal epidural steroid injections were significantly cost effective compared to blind interlaminar epidural steroid injections. No other data of cost effectiveness are available. Straus (39) in a review article claimed that blind interlaminar epidural steroids were able to offer cost minimization. However, this was not a cost effectiveness evaluation and no systematic evaluation was performed. Further, many wrong assumptions and calculations were utilized in this assessment.

Summary of Evidence: Of the 10 randomized trials included in evaluation, 7 were positive for short-term relief, whereas only 3 were positive for long-term relief. Numerous non-randomized trials, both prospective and retrospective, reported good results in 18% to 90% of patients receiving cervical or lumbar interlaminar epidural steroid injections. Among the 3 prospective trials included for evaluation, only 1 was positive, 1 was indeterminate, and 1 was negative. Due to a multitude of randomized trials and availability of double blind, randomized, and non-randomized prospective trials, evidence from retrospective trials was not included.

In the evidence synthesis, randomized trials showed positive evidence for short-term relief and negative evidence for long-term relief. Furthermore, prospective trials were similar to randomized and double blind trials. **Hence, evidence for the overall effectiveness of interlaminar epidural steroid injections in managing chronic low back pain is moderate for short-term relief and limited for long-term relief.**

Table 9. *Characteristics of published randomized trials of interlaminar epidural injections*

Study/Methods	Participants	Interventions	Outcomes	Results	Outcomes/ Conclusion
Carette et al (846) Randomized double blind trial	158 patients with sciatica due to a herniated nucleus pulposus. 78 patients in the treatment group. 80 patients in the placebo group.	Experimental group: methylprednisolone acetate (80 mg and 8 mL of isotonic saline) Control group: isotonic saline 1 mL Frequency: 3 epidural injections 3 weeks apart	Timing: 6 weeks, 3 months, 12 months Outcome measures: Need for surgery Oswestry Disability scores	After 6 weeks, a significant difference was seen with improvement in leg pain in the methylprednisolone group. After 3 months, there were no significant differences between groups.	Positive short-term Negative long-term relief
Snoek et al (847) Randomized trial	51 patients with lumbar root compression documented by neurological deficit and a concordant abnormality noted on myelography. 27 patients in experimental group 24 patients in control group	Experimental group: 80 mg of methylprednisolone (2 mL) Control group: 2 mL of normal saline Frequency: single injection	Timing: 3 days and an average of 14 months Outcome measures: Pain, sciatic nerve stretch tolerance, subjective improvement, surgical treatment.	No statistically significant differences were noted in either group with regards to low back pain, sciatic nerve stretch tolerance, subjective improvement, and surgical treatment.	Negative short-term and long-term relief
Cuckler et al (848) Randomized double blind trial	73 patients with back pain due to either acute herniated nucleus pulposus or spinal stenosis. Duration: greater than 6 months. Experimental group = 42 patients, control group = 31 patients	Experimental group: 80 mg (2 mL) of methylprednisolone + 5 mL of procaine 1% Control group: 2 mL saline + 5 mL of procaine 1%	Timing: 24 hours and an average of 20 months Outcome measures: subjective improvement. Need for surgery.	There was no significant short-term or long-term improvement among both groups.	Negative short-term and long-term relief
Dilke et al (849) Randomized trial	100 patients with low back pain and sciatica of 1 week to more than 2 yrs. 51 patients in experimental group 48 patients in control group	Experimental group: 10 mL of saline + 80 mg of methylprednisolone Control group: 1 mL of saline Frequency: up to 2 injections separated by 1 week All patients received physical therapy with hydrotherapy and exercise	Timing: 2 weeks and 3 months Outcome measures: time of bedrest, days of hospitalization, pain relief, consumption of analgesics and resumption of work 3 months later	60% of the patients in the treatment group and 31% of the patients in the control group improved immediately after the injections. A greater proportion of actively treated patients had no pain at 3 months.	Positive short-term and long-term relief
Klinerman et al (851) Randomized trial	63 patients with sciatica i. 19 patients ii. 16 patients iii. 16 patients iv. 12 patients	Group I: 20 mL saline + 80 mg of methylprednisolone Group II: 20 mL saline Group III: 20 mL bupivacaine 0.25% Group IV: dry needling, interspinous ligament	Timing: 4 weeks Outcome measures: pain relief and subjective improvement.	No significant differences were noted among the groups. 75% of the patients improved in all groups	Negative short-term relief Long-term relief was not evaluated
Ridley et al (853) Randomized trial	35 patients with low back pain and sciatica of mean duration approximately 8 months 19 patients in experimental group 16 patients in control group	Experimental group: 10 mL of saline + 80 mg of methylprednisolone (n=19) Control group: saline 2 mL, interspinous ligament (n=16)	Timing: 1 weeks, 2 weeks, 3 months and 6 months Outcome measures: pain control improvement in straight leg raising	90% of the patients in the treated group compared to 19% in the control group showed improvement at 1 week, 2 weeks and 12 weeks.	Positive short-term relief Negative long-term relief
Rogers et al (854) Randomized single blind sequential analysis	30 patients with low back pain 15 patients in experimental group 15 patients in control group	Experimental group: local anesthetic + steroid Control group: local anesthetic alone	Timing: 1 month Outcome measures: pain relief Nerve root tension signs	With local anesthetic produced significantly better results. Long-term results were similar for both.	Positive short-term relief Negative long-term relief
Catanegra (855) Randomized trial with cervical interlaminar epidural steroid injections	24 patients with chronic cervical radicular pain. Duration of pain: $\geq$ 12 months	i. Cervical epidural 0.5% lidocaine + triamcinolone acetonide ii. Local anesthetic + steroid + 2.5 mg of morphine sulfate	Timing: 1 month, 3 months, and 12 months Outcome measures: pain relief	The success rate was 79% vs. 80% in group I and II. Overall, initial success rate was 96%, 75% at 1 month, 79% at 3 months, 6 months, and 12 months.	Positive short-term and long-term relief
Kraemer et al (858) Randomized, double-blind study.	86 patients with lumbar radicular syndromes.	Experimental group: Epidural-40 mg of triamcinolone + local anesthetic Control group: paravertebral local anesthetic injection	Timing: not mentioned Outcome measures: pain relief	Epidural steroid injection had better results than paravertebral local injection group.	Positive short-term relief. Long-term relief was not evaluated.
Stav et al (860) Randomized trial of cervical epidural steroid injections	52 patients with chronic, resistant cervical brachialgia 25 patients in experimental group 17 patients in control group	Experimental group: cervical epidural steroid and lidocaine injections Control group: steroid and lidocaine injections into the posterior neck muscles Frequency: 1 to 3 injections	Timing: 1 week and 1 year Outcome measures: pain relief, change in deep tendon reflexes or sensory loss, change in range of motion Reduction of analgesics Return to work	After 1 week, 76% of the patients in cervical epidural group compared to 36% of the patients in the neck injection group showed improvement. At 1 year, improvement was 68% of the cervical epidural group 12% of the control group.	Positive short-term and long-term relief

6.2.3 Transforaminal Epidural Injections

Throughout the twentieth century, the popularity of caudal, interlaminar, and transforaminal epidural injections has been waxing and waning as the most effective method in managing low back pain (5, 671, 902). Transforaminal epidural injections have emerged recently as a target-specific modality of treatment for management of spinal pain. In the past, caudal and interlaminar epidural injections have been the focus of most trials, as well as systematic reviews and discussions. However, transforaminal epidural injections have moved toward the center of the stage with emerging publications. Review of the literature showed 7 randomized trials (858, 903-908); 8 prospective evaluations (862, 909-915); one prospective evaluation of change in disc herniation (916); and multiple retrospective reports (679, 832, 917-928).

Among the randomized controlled trials, 3 trials were included in evidence synthesis. The trial by Kolsi et al (907) was not included for analysis since the measurements were only of short-term duration. Devulder et al (906) evaluated the effectiveness of transforaminal epidurals in post laminectomy syndrome. Karppinen et al (904, 905) used two publications to report the results of one study. Buttermann (908) presented preliminary results at a scientific meeting in 1999 without subsequent publication. In summary, there were only 3 studies (858, 903, 905), which have evaluated the effectiveness of transforaminal epidural injections. Details of the randomized trials examining the effectiveness of transforaminal epidural steroid injections in the management of spinal pain are illustrated in Table 10. All 3 studies showed effectiveness of transforaminal epidural steroids in managing nerve root pain. One study showed its ineffectiveness for disc extrusions.

Among the prospective evaluations, 3 investigations, those of Vad et al (910), Lutz et al (909), and Bush and Hillier (862) were included. Others were excluded because some were performed under CT, long-term results were not evaluated in some, and in others, multiple injections were performed in a short period of time. Further, Kikuchi et al (679) evaluated a total of 332 patients, of which 173 patients had a diagnosis of disc rupture. They studied the therapeutic effect of transforaminal nerve root injections. They reported that this procedure had therapeutic effect and substantial diagnostic value in functional as well as morphological states. They reported that 22 of 45 patients with disc ruptures, 30 of 39 patients with spondylolysis, and 5 of 6 patients with degenerative spondylolisthesis all experienced more than 6 months of pain relief and thus, were able to avoid surgical intervention. Furthermore, they reported that, over the long term, relief was seen in 64% of these patients. As shown in Table 11, 3 prospec-

Table 10. *Details of randomized trials studying the effectiveness of transforaminal epidural steroid injections for low back pain*

Study/Methods	Participants	Interventions	Outcomes	Results	Outcomes/ Conclusion
Riew et al (903) Randomized double blind trial	55 patients with lumbar disc herniations or spinal stenosis referred for surgical evaluation. All subjects had clinical indications for surgery, and radiographic confirmation of nerve root compression. All patients had failed a minimum of 6 weeks of conservative care or had unrelenting pain. 28 patients in experimental group (71%) 27 patients in control group (33%)	Experimental group: transforaminal nerve root or epidural steroid injection with 1 mL of 0.25% bupivacaine and 6 mg of betamethasone Control group: 1 mL of 0.25% bupivacaine. The patient was allowed to choose to receive as many as 4 injections at any time during the follow-up.	Timing: 1 year Outcome measures: Injections were considered to have failed if the patient opted for operative treatment. Multiple injection therapy was not considered as failure. North American Spine Society questionnaire.	Of the 28 patients in the experimental group with bupivacaine and betamethasone, 20 decided not to have the operation. Of the 27 patients in the control group receiving bupivacaine alone, 9 elected not to have the operation. They had highly significant pain relief and functional improvement.	Positive short-term and long-term relief.
Kraemer et al (827) Randomized double blind study	49 patients with lumbar radicular symptoms with 24 patients in the steroid group and 25 patients in the normal saline group.	Experimental group: transforaminal epidural with local anesthetic and 10 mg of triamcinolone. Control group: local anesthetic only. Normal saline group received IM steroid injections to avoid the systemic steroid effect.	Timing: not mentioned Outcome measures: Pain relief	Single-short epidural perineural injection was effective it the treatment of lumbar radicular pain.	Positive short-term and long-term relief.
Karppinen et al (904, 905) Randomized double blind trial	160 consecutive, eligible patients with sciatica with unilateral symptoms of 1 to 6 months duration. None of the patients have undergone surgery.	Experimental group: local anesthetic and methylprednisolone Control group: normal saline	Timing: 2 weeks, 3 months, 6 months Outcome measures: Pain relief, sick leaves, medical costs, and future surgery Nottingham Health Profile	In the case of contained herniations, the steroid injection produced significant treatment effects and short-term in leg pain, straight leg raising, disability and in Nottingham Health Profile, emotional reactions and cost effectiveness.	Positive short-term and long-term relief.

tive trials and the trial by Kikuchi et al (679) were all positive for short-term and long-term relief. Among the retrospective evaluations, 4 studies by Weiner and Fraser (924), Rosenberg et al (927), Wang et al (928) and Manchikanti et al (825) were utilized in evidence synthesis. A multitude of other studies were excluded from evidence synthesis. All retrospective evaluations showed positive short-term and long-term relief.

Cost Effectiveness: Cost effectiveness of transforaminal epidural steroid injections in the management of chronic low back pain showed that cost per 1 year improvement of quality of life was $2,927 per year with cost effectiveness of caudal epidural steroids at $3,635 and for blind interlaminar lumbar epidural steroids at $6,024 (679). Further, Karppinen et al (905) also showed that in patients treated with transforaminal steroids, operations were avoided for contained herniations, costing $12,666 less per responder in the steroid group. Cost effectiveness was also demonstrated by Riew et al (903) by avoiding surgical intervention in 77% of

Table 11. *Details and results of non-randomized trials of transforaminal epidural injections*

Study/Methods	Participants	Interventions	Outcomes	Results	Outcomes/ Conclusion
Vad et al (910) A prospective study randomized by patient choice from the private practice of a single physician.	Patients with leg pain, older than 18 years, had been symptomatic longer than 6 weeks, had undergone a lumbar spine magnetic resonance imaging scan documenting herniated nucleus pulposus or manifested clinical signs such as radicular pain and sensory or fixed motor deficits consistent with lumbar radiculopathy.	Experimental group: transforaminal epidural steroid injection. 1.5 mL each of betamethasone acetate, 9 mg and 2% preservative-free Xylocaine per level. Control group: trigger point injections. All patients received a self-directed home lumbar stabilization program consisting of four simple exercises emphasizing hip and hamstring flexibility and abdominal and lumbar paraspinal strengthening.	Timing: 3 weeks, 6 weeks, 3 months, 6 months, and 12 months. Outcome measures: Roland-Morris score, visual numeric score, finger-to-floor distance, patient satisfaction score.	Fluoroscopically guided transforaminal epidural steroid injections yielded better results compared to saline trigger point injections. The group receiving transforaminal epidural steroid injections had a success rate of 84%, as compared with the 48% for the group receiving trigger point injections.	Positive short-term and long-term relief
Lutz et al (909) A prospective case series.	69 patients with lumbar herniated nucleus pulposus and radiculopathy. 69 patients were recruited. Every patient in the case series had documented magnetic resonance imaging findings that showed disc herniation with nerve root compression.	Transforaminal epidural steroid injections with 1.5 cc of 2% Xylocaine and 9 mg of betamethasone acetate.	Timing: 28 to 144 weeks Outcome measures: At least ≥50% reduction in pre-injection and post-injection visual numerical pain scores.	A successful outcome was reported by 52 of the 69 patients (75.4%) at an average follow-up of 80 weeks (range 28-144 weeks).	Positive short-term and long-term relief
Bush and Hillier (862) Prospective evaluation of cervical interlaminar and transforaminal epidural injections	68 patients with neck pain and cervical radiculopathy.	Following the first blind cervical epidural injection, if a significant improvement was not seen, a repeat injection was performed trans foraminally with fluoroscopicguidance within 1 month. A third injection was also performed if needed in the same manner as the second injection.	Timing: 1 month to 1 year Outcome measures: Pain relief	93% of the patients were reported to have good pain relief lasting for 7 months.	Positive short-term and long-term relief
Weiner and Fraser (924) A retrospective evaluation	30 patients with lateral foraminal or extraforaminal herniation of a lumbar disc were evaluated with foraminal injection of local anesthetic and steroids for radiculopathy	Transforaminal injection of 2 mL of 1% lidocaine combined with 11.4 mg of injectable betamethasone.	Timing: 1 to 10 years Outcome measures: Pain scale Use of analgesics, work status, recreational activities.	22 had lasting relief of their symptoms. 14 had no pain allowing them to participate freely in their usual activities. Of the 17 patients at work, 13 had returned to the same job.	Positive short-term and long-term relief
Manchikanti et al (825) Compared the 3 routes of epidural steroid injections in the management of low back in retrospective manner	225 patients randomly derived from a total sample of 624 patients suffering with low back pain from a total of 972 patients referred for pain management were evaluated.	Group I: interlaminar epidurals with a midline approach without fluoroscopy. Group II: caudal epidurals under fluoroscopy. Group III: transforaminal epidural steroid injections.	Timing: 1, 3, 6, 12 months Outcome measures: Pain relief	Group III reported ≥50% relief per procedure of 7.69 ± 1.20 weeks, which was superior to blind interlaminar epidurals.	Positive short-term and long-term relief
Rosenberg et al (927) Retrospective evaluation	92 patients with radiculopathic back pain due to spinal stenosis, herniated discs, spondylolisthesis, and degenerative discs.	Group I: Previous back surgery (16%) Group II: Discogenic abnormalities: herniations, bulges or degeneration (42%) Group III: spinal stenosis (32%) Group IV: those without MRI (11%)	Timing: 2, 6 and 12 months Outcome measures: Pain relief	The pain scores for all patients improved significantly at all three points. Greater than 50% improvement after one year was seen in 23% of Group I; 59% in Group II; 35% in Group III and 67% in Group IV.	Positive short-term and long-term relief
Wang et al (928) Retrospective evaluation	69 patients with lumbar herniated discs	All patients were treated with 1-6 epidural steroid injections	Timing: NA Outcome measures: Pain relief Avoidance of surgery	77% of patients had significant improvement and refused surgery	Positive short-term and long-term relief

the patients. Thus, transforaminal epidurals appear to be clinically effective with a favorable outcome and cost effectiveness, compared both to blind interlaminar epidural steroid injections and fluoroscopically directed caudal epidural steroid injections. In addition, the cost effectiveness of transforaminal epidurals is also similar to the cost effectiveness of lumbar facet joint nerve blocks, adhesiolysis with hypertonic saline neurolysis and a multitude of other interventions provided in chronic low back pain.

Summary of Evidence: Evidence synthesis included inclusion of 3 of the 7 randomized trials (858, 903, 905), all of them showing positive short-term and long-term effectiveness of transforaminal epidural steroids in managing nerve root pain. Three prospective evaluations were included in evidence synthesis (862, 909, 910). They all showed positive short and long-term results. Four retrospective evaluations were included (825, 924, 927, 928) all of them showing positive results. **Based on the evaluation of multiple randomized and non-randomized trials, transforaminal epidural injections provided strong evidence for short-term and long-term relief.** Their effectiveness in post lumbar laminectomy syndrome and disc extrusions is inconclusive.

Safety and Complications: The most common and worrisome complications of caudal, interlaminar, and transforaminal epidural injections are of two types: those related to the needle placement and those related to drug administration. Complications include dural puncture, spinal cord trauma, infection, hematoma formation, abscess formation, subdural injection, intracranial air injection, epidural lipomatosis, pneumothorax, nerve damage, headache, death, brain damage, increased intracranial pressure, intravascular injection, vascular injury, cerebral vascular or pulmonary embolus and effects of steroids (929-1040). Spinal cord trauma, and spinal cord or epidural hematoma formation is a catastrophic complication that is rarely seen following interventional procedures in the cervical spine, thoracic spine or upper lumbar spine (688, 694, 695, 802-806, 919, 924-929). One suggestion has been to perform interventional procedures only in an awake patient and in the cervical spine by limiting the midline injection to be performed only at C7/T1 except in rare circumstances (805). Unfortunately, it has been reported that even an awake patient may not be able to detect spinal cord puncture (980). Further, the recommendation to limit midline injection only at C7/T1 is based neither on consistent clinical nor anatomical evidence.

Houten and Errico (688) reported 3 cases of paraplegia after lumbosacral nerve root block in post laminectomy patients. They reported that in each case (performed at three different facilities, in the hands of two different physicians), the needle placement was verified with injection of contrast in conjunction with computerized tomography or biplanar fluoroscopy. In each patient, paraplegia was reported suddenly after injection of a steroid solution, and in each instance, post procedure magnetic resonance imaging revealed spinal cord edema in the low thoracic region. The authors postulated that in these patients, the spinal needle penetrated or injured an abnormally low dominant radiculomedullary artery, a recognized anatomical variant. This vessel, also known as the artery of Adamkiewicz, in 85% of individuals arises between T9 and L2, usually from the left, but in a minority of people, may arise from the lower lumbar spine and rarely even from as low as S1 (688). This artery travels with the nerve root through the neural foramen, supplying the anterior spinal cord (688). Injury of the artery or injection of particulate steroid may result in infarction of the lower thoracic spinal cord.

Cousins (693) reported a similar complication (688). He described a potential complication related to inadvertent intravascular administration of particulate depo-corticosteroids producing occlusion of small end arteries, which resulted in visual defects in one case, and hearing loss in another case, after a suboccipital nerve block. It is felt that methylprednisolone acetate tends to form aggregates of steroid material when mixed with local anesthetic and may pose more of a risk for this problem than other depo-steroids.

Brouwers et al (694) reported a cervical anterior spinal artery syndrome after diagnostic blockade of right C6 nerve root with fatal cervical spinal cord infarction. Nash (695) reported that he was aware of 3 cases with persistent neurological deficit following root sleeve injections of cervical and lumbar regions.

Side effects related to the administration of steroids are generally attributed either to the chemistry or to the pharmacology of the steroids. The major theoretical 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 (1022-1034). However, Manchikanti et al (1035), in evaluating the effect of neuraxial steroids on weight and bone mass density, noted no significant difference in patients undergoing various types of interventional techniques with or without steroids. The most commonly used steroids in neural blockade in the United States, methylprednisolone acetate, triamcinolone acetonide, and betamethasone acetate and phosphate mixture have all been shown to be safe at epidural therapeutic doses in both clinical and experimental studies (1036-1045).

6.3 Epidural Adhesiolysis

Percutaneous epidural adhesiolysis or lysis of epidural adhesions or epidural adhesiolysis with a spinal endoscope (myeloscope) are interventional pain management techniques that play an active role in managing chronic intractable low back pain (411-415, 1046-1054).

The purpose of percutaneous epidural lysis of adhesions is to eliminate deleterious effects of scar formation, which can physically prevent direct application of drugs to nerves or other tissues to treat chronic back pain. The goal of percutaneous lysis of epidural adhesions is to assure delivery of high concentrations of injected drugs to the target areas. Epidural lysis of adhesions and direct deposition of corticosteroids in the spinal canal are also achieved with a 3-dimensional view provided by epiduroscopy or spinal endoscopy.

For percutaneous epidural adhesiolysis, duration of relief of less than 3 months was considered as short-term and longer than 3 months was considered as long-term. For spinal endoscopic adhesiolysis, 6 months of relief was considered as short-term and longer than 6 months was considered as long-term.

Clinical effectiveness of percutaneous adhesiolysis was evaluated in two randomized controlled trials (1055, 1056) and five retrospective evaluations (412, 1057-1060) as summarized in Table 12. Ventral epidural adhesiolysis by Hammer et al (1060), an inadequate procedure by Devulder et al (1061), an evaluation in

Table 12. *Results of published reports of percutaneous adhesiolysis and hypertonic saline neurolysis*

Study/Methods	Participants	Interventions	Outcomes	Results	Outcomes/ Conclusion
Heavner et al (1055) A randomized trial	59 patients with chronic intractable low back pain. All the patients failed conservative management, along with fluoroscopically directed epidural steroid injections.	Group I: hypertonic saline plus hyaluronidase Group II: hypertonic saline Group III: isotonic saline (0.9% NaCl) Group IV: isotonic saline plus hyaluronidase	Timing: 4 weeks, 3 months, 6 months and 12 months Outcome measures: Pain relief in 25% or more of the subjects with radiculopathy plus low back pain refractory to conventional therapies.	Percutaneous epidural neuroplasty, as part of an overall pain management strategy, reduced pain in 25% or more of patients with radiculopathy. Initially 83% of the patients showed significant improvement compared to 49% of the patients at 3 months, 43% of the patients at 6 months, and 49% of the patients at 12 months.	Positive short-term and long-term relief
Manchikanti et al (1056) A randomized clinical trial	45 patients were evaluated. 15 patients in group I were treated conservatively. 30 patients in group II were treated with percutaneous epidural adhesiolysis and hypertonic saline neurolysis.	Experimental group: Adhesiolysis, hypertonic saline neurolysis and epidural steroid injection, one or more occasions. Control group: Physical therapy exercise program and medication.	Timing: 1 month, 3 months, 6 months, 1 year. Outcome measures: Pain relief, functional status, psychological status, employment status.	Experimental group showed improvement with pain relief in 97% at 1 month, 93% at 3 months, and 47% of the patients at 1 year. Generalized anxiety disorder, somatization disorder, average pain, and functional status improved significantly in Group II.	Positive short-term and long-term relief
Racz and Holubec (412) A randomized retrospective evaluation	72 patients with chronic pain	3-day procedure with injection of steroid, hypertonic saline and hyaluronidase.	Timing: 4 weeks, 3 months, 6 months Outcome measures: Pain relief	Initial relief was reported in 65% of the patients at 4 weeks, it declined to 43% of the patients at 3 months and 13% of the patients at 6 months.	Positive short-term relief and negative long-term relief
Manchikanti et al (1058) A retrospective randomized evaluation	A retrospective randomized evaluation of the effectiveness of 1-day adhesiolysis and hypertonic saline neurolysis in 129 patients.	Adhesiolysis, hypertonic saline neurolysis and injection of steroid	Timing: 4 weeks, 3 months, 6 months, 12 months Outcome measures: Pain relief	Initial relief was reported in 79% of the patients with 68% of the patients reporting relief at 3 months, 36% at 6 months and 13% at 12 months with 1 injection.	Positive short-term relief and negative long-term relief
Manchikanti et al (1059) A retrospective evaluation	60 post lumbar laminectomy patients were included after failure of conservative management	Adhesiolysis, hypertonic saline neurolysis and injection of steroid	Timing: 3 months, 6 months, 12 months Outcome measures: Pain relief	100% of the patients reported initial relief with 1 injection, 25% at 3 months, and 10% at 6 months with 1 injection. Success rate increased with multiple injections. At1 year relief improved to 52% of the patients.	Positive short-term relief and negative long-term relief

spinal stenosis (1057) and reports by Arthur et al (1062) were not included due to multiple deficiencies.

Spinal endoscopic adhesiolysis and target delivery of steroid were evaluated in 2 prospective evaluations (1063, 1064) and 4 retrospective trials (1059, 1065-1067) and multiple case reports. The results are summarized in Table 13.

Reports by Saberski (1065) and Krasuski et al (1067) were not included. Both were retrospective studies with only 22 patients in each series.

Cost Effectiveness: Cost effectiveness of percutaneous epidural adhesiolysis was determined in 3 separate groups of patients (1056, 1058, 1059). Cost effectiveness for 1-year of improvement in the quality of life was $2,693 in a randomized clinical trial evaluation of 1-day epidural adhesiolysis (1056). In two retrospective evaluations, cost effectiveness for 1-year of improvement in the quality of life varied from $2,028 to $5,564 (1058, 1059). This was similar to the cost effectiveness of lumbar facet joint nerve blocks, transforaminal epidural steroid injections, caudal epidural steroid injections and spinal endoscopic adhesiolysis. However, the cost effectiveness was superior to various modalities of treatments managing chronic back pain patients, including discectomy fusion, medical therapy of post lumbar laminectomy patients and intrathecal infusion therapy.

The cost effectiveness of spinal endoscopy and adhesiolysis was determined in two separate groups of patients (1059, 1066). Thus, the cost effectiveness of spinal endoscopy in patients failing to respond to all conservative modalities of treatments including percutaneous lysis with a spring-guided catheter, was shown to be $7,020 to $8,127. The cost effectiveness was in the similar range as that of other interventional management including facet joint nerve blocks, caudal epidural steroid injections, transforaminal epidural steroid injections and percutaneous adhesiolysis. However, these patients failed all the less invasive modalities of treatment. Further, the cost of spinal endoscopy is less than more invasive interventional techniques, well within reasonable limits for present-day cost effectiveness compared to surgical interventions, including laminectomy, fusion, medical treatment for post lumbar laminectomy patients, and intrathecal therapy.

Table 13. *Results of published reports of spinal endoscopy*

Study/Methods	Participants	Interventions	Outcomes	Results	Outcomes/ Conclusion
Geurts et al (1063) A prospective observational study	20 chronic low back pain patients, the majority of them with post lumbar laminectomy syndrome failing to respond to other modalities of treatments.	Epiduroscopy with adhesiolysis and target delivery of 120 mg of methylprednisolone acetate, 600 IU of hyaluronidase, and 150 mcg of Clonidine.	Timing: 3, 6, 9 and 12 months. Outcome measures: Adhesiolysis and pain relief	19 of 20 patients studied showed adhesions via epiduroscopy. 55% of the patents experienced significant pain relief at 3 months, 40% at 6 months, and 35% of the patients at 12 months. Mean VAS at 3 months was significantly reduced that persisted at 12 months.	Positive short-term and long-term relief
Richardson et al (1064) A prospective case series	34 patients suffering with chronic, severe low back pain with 50% of the patients having failed back surgery syndrome.	Epidural adhesiolysis and target delivery of steroid. Adhesiolysis followed by injection of bupivacaine, Depo-Medrol, and Clonidine.	Timing: 1, 2, 6, and 12 months Outcome measures: Pain relief	A significant number of patients showed pain relief at all levels. They also reported that epidural adhesions were present in 100% of the patients, with 41% having dense adhesions. Follow-up over a 12 month period showed statistically significant reductions in pain scores and disability.	Positive short-term and long-term relief
Manchikanti et al (1059) A retrospective evaluation in post lumbar laminectomy syndrome	60 patients with post lumbar laminectomy syndrome	Spinal endoscopy with targeted delivery of steroid.	Timing: 1, 3, 6, and 12 months Outcome measures: Pain relief	100% of the patients reported relief initially, which declined to 75% at 3 months, 40% at 6 months and 22% at 12 months.	Positive short-term and negative long-term relief
Manchikanti et al (1066) A retrospective evaluation of spinal endoscopy	85 consecutive patients underwent 112 epidural endoscopic procedures.	Spinal endoscopy with targeted delivery of steroid.	Timing: 1, 3, 6, and 12 months Outcome measures: Pain relief	100% of the patients reported pain relief initially. The relief decreased to 94% at 1 to 2 months, to 77% at 2 to 3 months, to 52% at 3 to 6 months, to 21% at 6 to 12 months and 7% after 12 months.	Positive short-term and negative long-term relief

Summary of Evidence: In the evidence synthesis for percutaneous epidural adhesiolysis utilizing a spring-guided catheter with or without hypertonic saline neurolysis to evaluate the clinical effectiveness, 2 randomized controlled trials and 3 retrospective evaluations were included (412, 1058, 1059). Both randomized trials showed positive short-term and long-term relief. Among the retrospective evaluations, one retrospective evaluation (1059) showed positive short-term and long-term relief. However, the other 2 retrospective evaluations (412, 1058) showed only short-term improvement. **Eevidence of effectiveness of percutaneous adhesiolysis, based on randomized and non-randomized evaluations is moderate for short-term and long-term relief with repeat interventions.**

In the evidence synthesis for spinal endoscopic adhesiolysis there were no randomized evaluations. Two prospective evaluations were included (1063, 1064); both showed positive short-term and long-term results. Two retrospective trials (1059, 1066) were also included. Both the trials showed short-term improvement, however, they failed to show any long-term improvement. **Evidence synthesis for spinal endoscopy with prospective evaluations and retrospective evaluations showed moderate evidence for short-term relief and limited evidence for long-term relief.**

Complications: The most common and worrisome complications of adhesiolysis and spinal endoscopy with lysis of adhesions are related to dural puncture, spinal cord compression, catheter shearing, infection, steroids, hypertonic saline, hyaluronidase, instrumention with endoscope, and administration of high volumes of fluids potentially resulting in excessive epidural hydrostatic pressures. This may cause spinal cord compression, excessive intraspinal and intracranial pressures, epidural hematoma, bleeding, infection, increased intraocular pressures with resultant visual deficiencies, and even blindness and dural puncture. Unintended subarachnoid or subdural puncture with injection of local anesthetic or hypertonic saline is one of the major complications of the procedure with catheter adhesiolysis. Hypertonic saline injected into the subarachnoid space has been reported to cause cardiac arrhythmias, myelopathy, paralysis, and loss of sphincter control (1068). Aldrete (1069) attributed incidences of arachnoiditis following epidural adhesiolysis with hypertonic saline to subarachnoid leakage of hypertonic saline. However, there were multiple variations in the technique and injection of hypertonic saline, (intraoperatively or injecting in spite of subarachnoid blockade), which may be responsible for these complications (1070-1072). While there are multiple reports with experience of hypertonic saline solution, there are no controlled reports of potential adverse effects (1073-1077). Another specific complication of percutaneous epidural adhesiolysis is related to catheter shearing and its retention in the epidural space (1078, 1079). Additionally, a troublesome complication is that of excessive intraspinal pressure development with its potential to affect both local and distant profusion, and resulting in visual changes and even blindness. Even though the incidence is rare, it appears that this would be much higher with spinal endoscopic procedures with a combination of high volumes of fluid and generation of high hydrostatic pressures (1080). It is also possible with catheter based adhesiolysis if excessive amounts of fluids are injected rapidly. Spinal cord trauma or spinal cord or epidural hematoma formation is a catastrophic complication possible with both catheter based or endoscopic adhesiolysis.

However, more so with endoscopic adhesiolysis. But, there are no such case reports in the literature. Understanding fluoroscopic imaging is crucial to avoid disastrous complications (1081).

6.4 Intradiscal Therapies

Commensurate with our improved ability to identify painful discs and image spinal anatomy are the advances achieved in the treatment of spinal disorders (1082). Currently it is recognized that surgical intervention may not represent the optimum therapeutic mechanism to achieve pain relief for certain patients presenting with low back and/or leg pain. During the past few decades, numerous authors have reported upon percutaneously administered minimally invasive spinal surgery techniques to achieve disc decompression. Procedures investigated have been chymopapain injection to achieve nucleolysis, percutaneous manual nucleotomy with the nucleotome, thermal vaporization with laser, and percutaneous disc decompression with nucleotomy using coblation technology (nucleoplasty). Intradiscal electrothermal therapy (IDET) is a minimally invasive technique in which the anulus is subjected to thermal modulation (1083). Relief was defined as short-term if it was 6 months or less and long-term if over 6 months.

6.4.1 Intradiscal Electrothermal Therapy

IDET intervention is solely applicable for the patient with axial symptoms and is not indicated for radicular pain (1082). IDET is performed by introducing a flexible catheter, containing a resistive coil, into the disc. Intradiscal electrothermal therapy has been shown to provide precision temperature control (1084-1086).

Wetzel et al (1087, 1088) reviewed the effectiveness of intradiscal annuloplasty and described new directions. However, there is only one randomized double blind trial (1089). A second study included a convenient control group in two different publications (1090, 1091). Multiple prospective and retrospective trials have been published (1083, 1091-1096). Wetzel et al (1087, 1088), in their review, described that all studies share a common study design; prospective cohort with historical or non-interventional groups as controls. Similar patients were reviewed. Those with non-radicular pain of at least 3 months duration, failed conservative care, normal neurologic findings, magnetic resonance imaging revealing only non-degenerative disc disease and positive concordant discography. In this review, they noted that all patients underwent IDET lesion at one or two levels based on standard protocols. Follow-up was performed at various intervals up to 2 years. Based on the studies published to date, Wetzel et al (1087, 1088) concluded that there is a suggestion that the pain due to lumbar disc disease may be diminished by IDET. All studies to date suggested a positive therapeutic effect.

Pauza et al (1089) in a randomized, double blind, placebo controlled trial evaluating the efficacy of intradiscal electrothermal annuloplasty for the treatment of chronic discogenic low back pain reported 6-month outcomes. They reported a statistically significant greater improvement in pain, based on both the visual analog scale and bodily pain in the IDET treatment group when compared with the placebo group. On the Oswestry, reflecting the percentage of overall disability and handicap due to low back pain, they demonstrated statistically significant improvement in the treatment group compared with the control group. The IDET treated group showed a statistically significant improvement in the Beck Depression Inventory. IDET treated patients also reported significant improvement in physical functioning on SF-36. Additionally, there was a trend suggesting a greater improvement in the social function, role emotional and mental health scales of the SF-36 in the IDET treated group.

Karasek and Bogduk (1090) and Bogduk and Karasek (1084) studied 53 patients with back pain and followed through 2 years. They concluded that in carefully selected cases, IDET can eliminate or dramatically reduce the pain of internal disc disruption in a substantial proportion of patients and appears to be superior to conventional conservative care for internal disc disruption. At 24 months, 54% of the patients had achieved at least 50% relief with functional improvement. Derby et al (1092), reported their findings of IDET in 1-year pilot outcome study with 32 patients. They reported that 63% of the patients had a favorable outcome, with no change in outcome measure at 6 month and 12-month follow-ups. Saal and Saal (1083, 1084, 1091) reported results of their experience over a period of 6 months, 1 year, and 2 years. All patients underwent provocative discography, with concordant pain reproduction. A standard thermal catheter protocol was followed. Data collection was performed using multiple measures including VAS and SF-36. In the final study (1083), they reported a VAS change for the entire group of 3.2 with a mean change on the SF-36 physical function subscale of 20, and the mean change on the SF-36 bodily pain subscale of 17.8. The findings showed that 71% of the study group improved at least 7 points on the SF-36 physical function subscale.

Cost Effectiveness: Cost effectiveness of intradiscal electrothermal anuloplasty has not been evaluated.

Summary of Evidence: In the evidence synthesis, one randomized trial (1089), multiple prospective and retrospective trials were utilized (1083, 1090-1092, 1094, 1095). Randomized trials, as well as prospective and retrospective trials showed positive results. One of the prospective trials was conducted by founders of the technique. Thus, multiple questions have been raised (1096). Even then, it appears that there is credible evidence to show the effectiveness of intradiscal electrothermal annuloplasty independent of a multitude of factors. **Based on this evidence analysis, it appears that intradiscal electrothermal therapy meets the criteria for moderate evidence for short-term relief and limited evidence for long-term relief.**

Complications: Saal et al (1097) evaluated and reported on the safety of IDET in a multi-center study of 1,675 patients. Infrequent complications were reported, including catheter breakage in 19 of 35,000 catheters used (0.05%), six nerve root injuries, and six cases of post-IDET disc herniation at the treated level transpiring a 2 to 12 months post treatment. Two separate case reports of cauda equina syndrome have been reported (1098, 1099). However, it appears that there may be more cases which have not been reported because of potential litigation (1099). Saal et al (1100) evaluated the role of IDET on disc degeneration and reported no evidence of significant negative alteration of disc morphology as represented by disc space collapse. Post procedural discography in IDET treated discs conducted by Saal et al (1101) indicated significant reduction in pain perception, even in partially improved patients, and an improvement in anular morphology.

Lee et al (1102) showed lack of segmental changes in stability following IDET.

6.4.2 Percutaneous Disc Decompression

During percutaneous disc decompression (PDD) with nucleoplasty (coblation technology), RF energy is used to dissolve nuclear material through molecular dissociation. It is believed that this reduced volume of disc material results in reduced intradiscal pressure. Bipolar RF coagulation further denatures proteoglycans, changing the internal environment of the affected nucleus pulposus, which showed changes in intradiscal pressure following coblation. Percutaneous nucleoplasty achieved a significant reduction in intradiscal pressure in a disc that had less than 10% loss of disc height when compared to discs with more than 50% reduction (1103).

The effectiveness of PDD with nucleoplasty has recently been reported in two prospective and two retrospective trials (1104-1107). Singh et al (1104), evaluated 67 patients and followed 41 for 12 months, reporting that 80% of patients indicated a statistically significant reduction in pain. Improved self-reports of sitting, standing and walking ability were 62%, 59% and 60% respectively. Sharps and Isaac (1105), in a prospective cohort study of 48 patients, reported a 79% decrease in pain scores at 12-month follow up in 13 patients. Chen et al (1106) followed 10 patients for 6 months after treatment with nucleoplasty. Mean VAS scores revealed a mean change of 3.6 from pretreatment to six months. Ninety-three percent of patients did not require narcotic use after 6 months and 87% of patients were satisfied with their outcome. Slipman et al (1107) reported their 6-month results for nucleoplasty performed on a cohort of 24 patients with a presenting complaint of axial back pain. A comparison between the two groups of patients treated, those with or without a central focal disc protrusion, revealed good outcomes in the former group. Sixty-four percent of the patients in the former group realized a minimum of 75% reduction in their VAS rating. Overall, the group of patients undergoing nucleoplasty for a provocative discogram proven symptomatic central disc protrusion had a change in their VAS from 6.8 to 1.3, which was statistically significant.

Cost Effectiveness: Cost effectiveness of percutaneous disc decompression with nucleoplasty with coblation has not been evaluated.

Summary of Evidence: The 2 prospective trials available describing percutaneous disc decompression with nucleoplasty utilizing coblation were reviewed. Both showed short-term and long-term relief. Retrospective evaluations were not included. **Evidence is limited showing the effectiveness of PDD with nucleoplasty.**

Complications: No significant complications have been described. However, possibilities include neural trauma, cauda equina syndrome and other neurological complications.

6.5 Implantable Therapies

Spinal cord stimulation systems and implantable intrathecal devices are frequently used in managing chronic intractable pain (1108, 1109).

6.5.1 Spinal Cord Stimulation

Present-day spinal cord stimulation (SCS) began shortly after Melzak and Wall proposed the gate control theory in 1965 (1110). As a direct result of this theory, in 1967, Shealy et al (1111) implanted the first spinal cord stimulator device for the treatment of chronic pain. Over the course of the last 35 years, advancements in basic science research, and technology have led spinal cord stimulation to be an accepted, reliable treatment for many neuropathic and/or vascular insufficiency pain states (1112).

The mechanism of action of spinal cord stimulation is not completely understood. However, recent research has given us insight into effects occurring at the local and supraspinal levels, and through dorsal horn interneuron and neurochemical mechanisms (1113, 1114). It is interesting to note that, in light of recent findings, the theory that inspired Shealy et al (1111) to pursue spinal cord stimulation for chronic pain, may, in fact, have little relevance to its actual effect.

Despite what is known about the mechanism of action of SCS and the outcomes of many studies; much confusion remains regarding the indications for SCS. A comprehensive review of the literature demonstrates positive results in neuropathic and vascular insufficiency pain states (1114, 1115). There is, however, no credible evidence to support the use of SCS in primarily nociceptive pain conditions (degenerative disc disease, sacroiliac dysfunction, arthritis, cancer, and acute tissue injury). In fact, studies using empirical and computer modeling (1112, 1116) and those looking at the effects of SCS in animals (1117) and in man (1118) have demonstrated no significant effect on nociception at clinically relevant stimulation parameters.

In critical review of the available SCS literature, consideration must be given to the fact that most fall within the level IV (limited) or level V (indeterminate) categories out of necessity due to the invasiveness of the modality and inability to provide blinded treatment as well as other constraints noted in the introduction of this text. Recognition must also be given to the time frame within which a study was performed due to rapidly evolving SCS technology. Basic science knowledge, implantation techniques, lead placement locations, contact array designs, and programming capabilities have changed dramatically from the time of Shealy et al (1111). These improvements have led to decreased morbidity and much greater probability of obtaining adequate paresthesia coverage with subsequent improved outcomes (1119).

In the United States, the primary indications for spinal cord stimulation are failed back surgery syndrome and complex regional pain syndromes type I and type II (1120). However, in Europe, most interest in spinal cord stimulation has been in the treatment of chronic intractable angina and pain and disability due to peripheral vascular disease (1120).

There have been two systematic literature syntheses. The first by Turner et al (28) from the articles related to the treatment of failed back surgery syndrome by spinal cord stimulation, from 1966 to 1994. They reviewed 39 studies that met the inclusion criteria. The mean follow-up period was 16 months with range of 1 to 45 months. Pain relief exceeding 50% was experienced by 59% of patients with a range of 15% to 100%. Complications occurred in 42% of patients, with 30% of patients experiencing one or more stimulator-related complications. However, all the studies were case-control investigations. Based on this review, the authors concluded that there was insufficient evidence from the literature for drawing conclusions about the effectiveness of spinal cord stimulation relative to no treatment or other treatments, or about the effects of spinal cord stimu-

lation on patient work status, functional disability, and medication use.

The second by North and Wetzel (1120) consisted of a review of case control studies and two prospective control studies. They concluded that if a patient reports a reduction in pain of at least 50% during a trial, as determined by standard rating methods, and demonstrates improved or stable analgesic requirements and activity levels, significant benefit may be realized from a permanent implant. A note of caution by the authors, similar to that raised by Turner et al (28), was that although the bulk of the literature appears to support a role for spinal cord stimulation, primarily in neuropathically driven pain syndromes, the quality of the literature must be considered as it is overwhelmingly empiric. North and Wetzel (1120) concluded that on the basis of current evidence, spinal cord stimulation may represent a valuable treatment option, particularly for patients with chronic pain of predominantly neuropathic origin and topographical distribution involving the extremities. They also added that the potential treatment of other pain topographies and etiologies by spinal cord stimulation continues to be studied.

There have been two randomized controlled trials evaluating the effectiveness of spinal cord stimulation. Of these, one randomized controlled trial evaluated effectiveness of spinal cord stimulation in chronic spinal pain (1121), whereas the second study involved evaluation of spinal cord stimulation in patients with chronic reflex sympathetic dystrophy (1122). In addition, there have been two prospective trials (1123, 1124). Further, in the field of spinal cord stimulation as with other interventional techniques in chronic spinal pain management, there are numerous retrospective studies that promote the efficacy of spinal cord stimulation. These studies range in long-term efficacy from approximately 12% to greater than 90% (1125-1139).

Kemler et al (1122) reported the results of a randomized trial involving patients who carried a diagnosis of CRPS for at least 6 months. In this study, 36 patients were assigned to receive a standardized physical therapy program together with spinal cord stimulation, whereas 18 patients were assigned to receive therapy alone. In all cases, the CRPS involved the upper extremities, and all the patients underwent a percutaneous trial of at least 7 days duration. In 24 of the 36 patients, randomized to spinal cord stimulation, along with physical therapy, the trial was successful, and permanent implantation was performed. At a 6-month follow-up assessment, the patients in the spinal cord stimulation group had a significantly greater reduction in pain, and a significantly higher percentage were graded as much as improved for the global perceived effect. The authors concluded that in short-term, spinal cord stimulation can reduce pain and improve the quality of life for patients with CRPS involving the upper extremities.

North et al (1121) selected 50 patients as candidates for repeat laminectomy. All the patients had undergone previous surgery, and were excluded from randomization if they presented with severe spinal canal stenosis, extremely large disc fragments, a major neurological deficit such as foot drop, or radiographic evidence of gross instability. In addition, patients were excluded for untreated dependency on narcotic analgesics or benzodiazepines, major psychiatric comorbidity, the presence of any significant or disabling chronic pain problem, or a chief complaint of low back pain exceeding lower extremity pain. This was a preliminary report. Crossover between groups was permitted. The 6-month follow-up report included 27 patients. At this point, they became eligible for crossover. Of the 15 patients who had undergone re-operation, 67% (10 patients) crossed over to SCS. Of the 12 who had undergone SCS, 17% (2 patients) opted for crossover to re-operation. Additionally, of the 19 patients who reached their 6-month follow-up assessment after re-operation, 42% (8 patients) opted for spinal cord stimulation outside the study. For 90% of the patients, long-term (3-year follow-up) evaluation has shown that spinal cord stimulation continues to be more effective than re-operation, with significantly better outcomes by standard measures and significantly lower rates of crossover to the alternate procedure. Additionally, patients randomized to re-operation used significantly more opiate analgesics than those randomized to spinal cord stimulation. Other measures assessing activities of daily living and work status did not differ significantly. The major disadvantage of this randomized trial is that the long-term results are unpublished at the present time and are reported by authors in reviews (1130).

Two recent, prospective case studies have been done. The first, by Barolat et al (1124) examined the outcomes of patients with intractable low-back pain treated with epidural spinal cord stimulation (SCS) utilizing paddle electrodes and a radio frequency (RF) stimulator. The study was designed to collect data from 60 patients at four centers and examine their outcomes at, or up to two years post implantation. A total of 44 patients were implanted. The majority of patients reported fair to excellent pain relief in both the low back and legs. At 6 months 91.6% of the patients reported fair to excellent relief in the legs and 82.7% of the patients reported fair to excellent relief in the low back. At 1-year 88.2% of the patients reported fair to excellent relief in the legs and 68.8% of the patients reported fair to excellent relief in the low back. Significant improvement in function and quality of life was found at both the 6-month and 1-year follow-ups using the Oswestry and SIP, respectively. The majority of patients reported that the procedure was worthwhile (92% at 6-months, 88% at 1-year). No patient indicated that the procedure was not worthwhile. The authors concluded that SCS proved beneficial at one year for the treatment of patients with chronic low back and leg pain.

The second, by Burchiel et al (1123) in 1996, published the results of a multicenter prospective study investigating spinal cord stimulation. The study included 182 patients with a permanent system after a percutaneous trial. Patient evaluation of pain and functional levels was performed before implantation, then 3, 6, and 12 months after implantation. A 1-year follow-up evaluation was available for 70 patients. Pain and quality-of-life measures showed statistically significant improvement during the treatment year. Complications requiring surgical interventions were experienced by 17% (12 of 70) of the patients. Medication usage and work status were not changed significantly.

Cost Effectiveness: Cost effectiveness of spinal cord stimulation was evaluated by Kumar et al (1140). They prospectively followed 104 patients with failed back surgery syndrome. Of the 104 patients, 60 were implanted with a spinal cord stimulator using a standard selection criterion. Both groups were monitored over a period of 5 years. The stimulation group annual cost was $29,123 versus

$38,029 in the control group. The authors found 15% return to work in the stimulation group versus 0% in the control group. The higher costs were in the categories of medications, emergency center visits, x-rays, and ongoing physician visits.

Bell et al (1141) performed an analysis of the medical costs of spinal cord stimulation (SCS) therapy in the treatment of patients with failed back surgery syndrome (FBSS). The medical costs of SCS therapy were compared with an alternative regimen of surgeries and other interventions. Externally powered (external) and fully internalized (internal) SCS systems were considered separately. No value was placed on pain relief or improvements in the quality of life that successful SCS therapy can generate. The authors concluded that by reducing the demand for medical care by FBSS patients, SCS therapy can lower medical costs and found that, on average, SCS therapy pays for itself within 5.5 years. For those patients for whom SCS therapy is clinically efficacious, the therapy pays for itself within 2.1 years.

Kemler and Furnee (1142) performed a similar study but looking at "chronic reflex sympathetic dystrophy (RSD)" using outcomes and costs of care before and after the start of treatment. Fifty-four patients with chronic RSD were randomized to receive either SCS together with physical therapy (SCS+PT; n = 36) or physical therapy alone (PT; n = 18). Twenty-four SCS+PT patients responded positively to trial stimulation and underwent SCS implantation. During 12 months of follow-up, costs (routine RSD costs, SCS costs, out-of-pocket costs) and effects (pain relief by visual analogue scale, health-related quality of life (HRQL) improvement by EQ-5D) were assessed in both groups. Analyses were carried out up to 1 year and up to the expected time of death. SCS was both more effective and less costly than the standard treatment protocol. As a result of high initial costs of SCS, in the first year, the treatment per patient is $4,000 more than control therapy. However, in the lifetime analysis, SCS per patient is $60,000 cheaper than control therapy. The authors found SCS to be both more effective and less expensive as compared with the standard treatment protocol for chronic RSD.

Summary of Evidence: Spinal cord stimulation is an invasive, interventional surgical procedure. The evidence included one randomized trial (1121), two prospective trials (1123, 1124) and multiple retrospective trials. **The evidence for spinal cord stimulation in properly selected population with neuropathic pain is moderate for long-term relief.**

Complications: Complications with spinal cord stimulation range from simple, easily correctable problems, such as lack of appropriate paraesthesia coverage, to devastating complications such as paralysis, nerve injury, and death.

North et al (1119) in 1993 reported their experience in 320 consecutive patients treated with SCS between 1972 and 1990. A 5% rate of subcutaneous infection was seen and is consistent with the literature. The predominant complication consisted of lead migration or breakage. In an earlier series, bipolar leads required electrode revision in 23% of patients. The revision rate for patients with multichannel devices was 16%. Failure of the electrode lead was observed in 13% of patients and steadily declined over the course of the study. When analyzed by implant type (single-channel percutaneous, single-channel laminectomy, and multichannel), the lead migration rate for multichannel devices was approximately 7%. Analysis of hardware reliability for 298 permanent implants showed that technical failures (particularly electrode migration and malposition) and clinical failures had become significantly less common as implants had evolved into programmable, "multichannel" devices. North and Wetzel (1120), in the literature review, reported that complication rates have declined to approximately 8%, and re-operation is necessary in approximately 4% of patients. They also reported that when current percutaneous techniques are used, a lead migration rate lower than 3% may be achieved.

More recent studies by Barolat et al (1124) and May et al (1143) reported lead revision rates due to lead migration of 4.5% and 13.6% and breakage of 0% and 13.6% respectively. Infections occurred in 7% and 2.5% of cases respectively. No serious complications were seen in either study. These three studies are representative of the majority of recent studies and are an accurate reflection of present state of the art SCS therapy.

Infections range from simple infections at the surface of the wound to epidural abscess. The reported incidence of abscess is extremely rare and no reports associated with SCS were found. In review of the literature regarding temporary epidural catheters, Sarubbi et al (1144) discovered only 20 well-described cases. The mean age of these 22 patients was 49.9 years, the median duration of epidural catheter use was 3 days, and the median time to onset of clinical symptoms after catheter placement was 5 days. The majority of patients (63.6%) had major neurological deficits, and 22.7% also had concomitant meningitis.

6.5.2 Implantable Intrathecal Drug Administration Systems

Despite continuing controversy, the use of oral opioids to treat chronic non-malignant pain has gained broad acceptance over the past decade. As our understanding of spinal pain processing and the technology of implantable infusion systems has evolved, spinal administration of opioid and non-opioid medication has been increasingly advocated for those patients who fail to achieve pain relief or experience undue side effects with oral opioid regimens (1145). Continuous infusion of intrathecal medication for control of intractable pain is now a widely accepted practice among interventional pain physicians world-wide and there are well over 13,000 patients with chronic pain in the United States alone who are being managed with this technique (1146). Purported advantages of continuous intrathecal drug delivery for pain control include: 1) More powerful analgesia at a significantly lower dose of administered drug (1147); 2) More consistent analgesia with a lower incidence of somnolence, mental clouding, constipation and euphoria; 3) Advantages in treating chemically-dependent individuals with intractable nociceptive and/or neuropathic pain conditions; and 4) Implantable infusion systems offer theoretical advantages with these patients in that the intrathecal medication does not produce euphoria and cannot be manipulated by the patient. Disadvantages of implantable pain control systems include the surgical risks involved with any implanted device, the risk of spinal injury from the catheter or the infused medications, the risks of side effects specific to intrathecal drug delivery and the cost associated with this type of therapy.

Though much data exists regarding the efficacy and safety of intrathecal drug delivery and various guidelines have been proposed (1148), there is a paucity

of published level I and level II research upon which to base clinical practice. Bennett et al (1148) undertook an exhaustive review of available literature and concluded that:

> "Clearly further research into the intrathecal delivery of pain medication is warranted. Clinical efficacy in large-scale randomized controlled trials utilizing intrathecal delivery of most compounds has not been demonstrated, and variations between study designs make useful comparisons of existing studies difficult. Generally the scientific quality of the published studies is variable, with results obtained from limited numbers of prospective controlled studies (many with inadequate patient group size), uncontrolled clinical studies, case reports, retrospective studies and anecdotes."

Nonetheless, this review went on to imply that existing data was sufficiently robust to guide clinical practice when patient need was compelling and that consistent reports of good to excellent outcome in the majority of patients supported the use of intrathecal pain management in cases where more conservative approaches had proven unsatisfactory.

Two double-blind trials (1149, 1150), one prospective randomized trial (1151), multiple prospective trials (1152-1156) and numerous retrospective trials (1157-1166) were included in the evidence synthesis. Siddall et al (1149) compared the effectiveness of intrathecal morphine or clonidine, alone or combined, in the treatment of neuropathic pain after spinal cord injury. The authors found that the combination of morphine and clonidine produced significantly more pain relief than placebo 4 hs after administration; whereas morphine or clonidine alone produced less pain relief. The authors concluded that intrathecal administration of a mixture of clonidine and morphine was more effective than either drug administered alone.

van Hilten et al (1150) evaluated the use of intrathecal baclofen for the treatment of dystonia in patients with complex regional pain syndrome. The authors performed a double-blind, randomized, controlled, crossover trial of bolus intrathecal injections of 25, 50, and 75 mcg of baclofen in placebo group. The results showed that in 6 women, bolus injections of 50 and 75 mcg of baclofen resulted in complete or partial resolution of focal dystonia of the hands but little improvement in dystonia of the legs. The authors concluded that in some patients, the dystonia associated with reflex sympathetic dystrophy responded markedly to intrathecal baclofen. Although this study was well-designed, it included only seven patients.

Smith et al (1151) reported significant improvement in patients treated with intrathecal infusion systems when compared to patients treated with conventional aggressive medical management. This study was performed using a prospective, randomized, intent to treat model. The study concluded that the pump group had significantly improved pain control and quality of life demonstrated by significantly better pain scores, quality of life rating, patient satisfaction, caregiver satisfaction and nutritional status better in all classes. There was also a strong trend towards improved survival in the intrathecal infusion group.

There are several prospective studies on intrathecal pain management available for review. Hassenbusch et al (1152) in 1995, studied patients with long-standing nonmalignant pain considered to be of neuropathic origin who had undergone implantation of a programmable infusion pump for long-term intrathecal opioid therapy. Eighteen patients were followed for a mean duration of 2.4 years. Good pain control was defined as a greater than 40% pain reduction and fair pain control was defined as 25-39% pain reduction on a numeric pain scale measurement. Eleven patients (61%) reported good or fair pain control for the duration of follow up. Average numeric pain scores decreased by 39%.

In 1998, Angel et al (1153) published prospective data on 11 patients. A good to excellent analgesic response was seen in 8 (73%) patients. In the remaining three patients (27%), the analgesic response was judged to be poor. Two patients experienced bladder dysfunction requiring pump removal.

In 1999, Anderson and Burchiel (1154) reported prospectively 40 patients with chronic, intractable, nonmalignant pain. Thirty of these patients obtained greater than 50% pain relief from a trial of intrathecal morphine and were subsequently implanted with a programmable intrathecal drug delivery system. After 24 months of treatment, 36% (8 of 22 patients) reported 50% or greater reduction in pain and 50% reported at least a 25% reduction in pain. Seventy percent had discontinued oral opioids and were using intrathecal opioids exclusively. Improvements were noted on the McGill Pain scores, the Chronic Illness Problem Inventory and on VAS measurements of pain, function and coping, after 24 months. Pharmacological side effects included constipation (reported at least once in the follow up period by 31%), nausea (21%), lethargy (14%), pruritus (14%), diaphoresis (10%), mental status change (10%), urinary hesitancy (3%) and peripheral edema (3%). Five patients (16%) reported a total of 7 device-related complications resulting in 5 repeat surgeries.

In 2000, Corrado et al (1155) reported prospective data on forty patients suffering from chronic intractable low back pain who were treated with either oral medications or an implanted intrathecal infusion pump. Twenty patients were selected to receive intrathecal morphine, and 20 other subjects opted not to have the pump implanted and continued management with oral medications. The infusion pump group was compared with the non-pump control group over a 3-month period. Results of the study indicated a significant difference in pain levels between the pump and the non-pump groups, with the pump group reporting significantly lower levels of pain than the non-pump group. In terms of disability, as measured on a disability index, the group that managed with intrathecal morphine via infusion pump scored significantly less on a disability index than the control group. Overall, the intrathecal morphine group reported lower pain levels and improved functioning as compared to the non-pump group.

In 2001, Kumar et al (1156) prospectively analyzed the long-term effects of continuous intrathecal morphine infusion therapy in 16 patients with chronic nonmalignant pain syndromes. The follow-up period ranged from 13 months to 49 months (mean 29.14 months ± 12.44 months) for the patients who had implanted morphine pumps. Ten patients were satisfied with the delivery system and eleven reported improvement in their quality of life. In two patients, morphine was not able to adequately control the pain without producing undesir-

able side effects. These two patients were treated with the addition of clonidine to the infusion medication with improvement in pain control. In this series, 12 patients were considered successes and 4 patients were considered failures. In two patients, the intrathecal opioid therapy was unable to produce satisfactory pain relief and in the other two patients the pumps had to be explanted because of intolerable side effects.

Retrospective reports dominate the extant literature on intrathecal pain management, however, only a few included 50 or more patients. Among the retrospective studies, Onofrio and Yaksh (1157) studied 53 patients treated by intrathecal opioid infusion, with 67% reporting good or excellent relief and 19 of 33 patients with improved ambulation. In 1996, Paice et al (1158) published a large retrospective report which analyzed data collected from a survey of physicians at multiple centers managing patients with implanted infusion pumps. Data was analyzed from 429 patients treated with a continuous infusion of intrathecal morphine using an implantable pump for a mean duration of 14.6 months. Two-thirds of these patients suffered from various nonmalignant pain syndromes and one-third had cancer-related pain. Managing physicians retrospectively assessed their patient's experience and filled out a questionnaire describing outcomes. Physicians reported that 95% of patients experienced good to excellent pain relief based on a reduction of oral analgesic intake and an improvement in physical functioning. Improvements in activities of daily living were reported by 57% of patients. 28 patients (most with nonmalignant pain) who were not working prior to pump implantation returned to work. More than 85% of patients were satisfied with their treatment and there was no statistically significant difference in pain relief with regards to cancer pain vs. nonmalignant pain.

Winkelmüller and Winkelmüller (1159) reported on the long-term effects of continuous intrathecal opioid therapy via implantable infusion systems in 120 patients with chronic, nonmalignant pain syndromes. The follow-up period was 6 months to 5.7 years (mean 3.4 years). Deafferentation pain and neuropathic pain showed the best long-term results, with 68% and 62% pain reduction respectively, based on a visual analog scale analysis. Throughout the follow-up period, 74.2% of the patients were successfully treated with the intrathecal opiate therapy with an average pain reduction after 6 months of 67.4%. 92% of the patients were satisfied with the therapy and 81% reported an improvement in their quality of life.

In 2001, Roberts et al (1160) retrospectively reported outcomes for 88 patients (58 women and 30 men; mean age 53.4 years) treated with intrathecal opioids for an average duration of 36.2 months. These patients had chronic pain of nonmalignant origin which had been present for an average of 9.8 years. The most common diagnosis in this group was lumbar spinal or radicular pain after failed spinal surgery (n= 55, 63%). The outcome measures used included global pain relief, physical activity levels, medication consumption, work status, intrathecal opioid side-effects, proportion of patients who ceased therapy, and patient satisfaction. At the time of follow-up, mean pain relief was 60% with 74% of patients (36 of 49) reporting increased activity levels. Technical, device-related complications were common, most often catheter related, and required at least one further surgical procedure in 32 patients (40%).

Cost Effectiveness: Mueller-Schwefe et al (1161) evaluated the cost-effectiveness of intrathecal therapy for pain secondary to failed back surgery syndrome. They compared alternative therapies for achieving a defined outcome. They reported the cost of medical management to be $17,037 per year, or $1,420 per month. They also showed that intrathecal morphine delivery resulted in lower cumulative 60-month costs of $16,579 per year and $1,382 per month.

de Lisovoy et al (167) in 1997 examined the cost-effectiveness of long-term intrathecal drug delivery system in patients with failed back syndrome. The objective of this study was to estimate the direct cost of intrathecal morphine therapy delivered via an implantable pump relative to conservative medical management over a 60-month course of treatment. The cost-effectiveness of intrathecal morphine was calculated based on a report of 65% to 81% "good to excellent" pain relief relative to alternative (medical) management. With both adverse event probabilities and costs set at the most likely (base case) values, the expected total cost of intrathecal morphine over 60 months was $82,893 (an average of $1382 per month). In a sensitivity analysis, the best case (low adverse event rate, low cost) estimate was $53,468 ($891/mo), whereas the worst case (high adverse event rate, high cost) estimate was $125,102 ($2085/mo). Cost-effectiveness estimates ranged from $7212 (best case) to $12,276 (worst case) per year of pain relief. These results, derived from a computer simulation, designed to collect the costs not included in previous empiric research, indicated that intrathecal morphine was cost-effective when compared with conservative medical management for selected patients if the duration of therapy exceeded 12 to 22 months.

Summary of Evidence: Three randomized (1149-1151) and multiple nonrandomized trials (1152-1160) were included in evidence synthesis. **Based on the available literature, there is moderate evidence indicating the long-term effectiveness of intrathecal infusion systems.**

Complications: The complication rate appears to average about 20%. The most common immediate problems include post-dural puncture headache, infection, nausea, urinary retention, and pruritus. With respect to post-dural puncture headache, meticulous needle insertion technique with a single dural puncture will minimize the leakage of CSF. It has also been suggested that placement of a purse string suture around the catheter will reduce the incidence post-dural puncture headache. As with spinal cord stimulation implants, perioperative antibiotics along with close postoperative follow up may reduce the risk of infection which is estimated to be approximately 5%. Post-operative nausea, urinary retention and pruritus are usually self-limited and tend to resolve within several weeks after implant.

Longer term complications seen post implant include catheter and pump failure. The high rate of device-related complications identified in the literature is certainly concerning from a patient safety and cost-effectiveness perspective. Catheter complication rates tend to range from 10 to 40% with pump complications somewhat lower. The incidence of granuloma based on reporting to the FDA and device manufacturers appears to be less than one percent. Coffey and Burchiel (1162) comprehensively evaluated this issue in 2002. The cause of catheter granuloma remains unknown but may be related to the types and concentrations of drugs administered through the cathe-

ter. It appears from this report that serial neurological exams may lead to early identification of granuloma in susceptible patients.

Commonly reported drug-related complications include pedal edema and hormonal changes leading to decreased libido and sexual dysfunction. It is unclear whether hormonal effects are caused by the intrathecal medications or may instead be a product of the patient's underlying chronic pain. Changes in testosterone levels in males may occur and should be considered in men with fatigue, loss of body hair, and sex drive. Pedal edema appears to be related to a central effect on antidiuretic hormone, and is more commonly seen with morphine.

6.6 Emerging Technologies

Emerging technologies play an important role in how we manage patients with chronic pain and also provide the foundation for advancing care options. Many of the promising therapeutic strategies based on emerging technologies, however, have not or cannot be subjected to the "gold-standard" randomized, double-blind, placebo-controlled study due to ethical or methodologic issues (44)). Therefore, mention of an emerging strategy first appears in the literature with a single case report or a case report series. While such therapies should not be unconditionally embraced, they can reasonably be incorporated into standard practice after a careful weighing of the risks and benefits compared with conventional therapy and a thorough consideration of the scientific foundations upon which the emerging technologies are based.

Unfortunately, many insurers use the lack of evidence from a randomized, controlled trial as an excuse to deny covering the cost of emerging therapies. Paradoxically, this leads patients down the road to conventional, accepted, equally unproven, more expensive, lower yield, and higher risk procedures such as spinal fusion with instrumentation. In this particular example, when combined with the high cost of failed back surgery syndrome, it is inexplicable that insurers do not embrace less morbid and/or less expensive care options likely to yield equal or better outcomes than existing therapies.

Several new technologies arising out of the paradigm shift from fusion towards restoration of function and minimized nociceptor input from targeted pain generators hold great promise to decrease morbidity and improve outcome. These include disc replacements, bone morphogenic protein injections, culturing and injection of autologous discogenic material, novel lesioning procedures, and advanced imaging techniques. Reimbursement for these scientifically based, emerging technologies is thus essential to improved patient care, decreased morbidity, and reduced healthcare costs.

7. Evaluation and Management

7.1. Evaluation

Appropriate history, physical exami-nation, and medical decision making from the initial evaluation of a patient's presenting symptoms are essential (1163-1167). There are numerous acceptable medical methods to evaluate a chronic spinal pain patient. These methods vary from physician to physician and textbook to textbook. Following the guidelines established by the Centers for Medicare and Medicaid Services (CMS) not only would assist a physician in performing a comprehensive and complete evaluation, but also assist them to be in compliance with regulations. The guidelines of CMS provide various criteria for five levels of services. The three crucial components of evaluation and management services are: history, physical examination, and medical decision-making. Other components include: counseling, coordination of care, nature of presenting problem, and time.

History

The history includes:

- Chief complaint,
- History of present illness,
- Review of systems, and,
- Past, family, and/or social history.

Chief Complaint: The chief complaint is a concise statement describing the symptom, problem, condition, diagnosis, or other factor that is the reason for the encounter, usually stated in the patient's words.

History of Present Illness: The history of present illness is a chronological description of the development of the patient's present illness from the first sign and/or symptom. It includes the following elements:

- Location,
- Quality,
- Severity,
- Duration, timing,
- Context,
- Modifying factors, and
- Associated signs and symptoms.

Review of Systems: The review of systems is an inventory of body systems obtained through a series of questions seeking to identify signs and/or symptoms that the patient may be experiencing or has experienced.

Past, Family, and/or Social History: The past, family, and/or social history consists of a review of the past history of the patient including past experiences, illnesses, operations, injuries, and treatment; family history, including a review of medical events in the patient's family, hereditary diseases, and other factors; and social history appropriate for age reflecting past and current activities.

Past history in interventional pain management includes history of past pain problems, motor vehicle accidents, occupational, or non-occupational injuries; history of headache, neck pain, upper-extremity pain, pain in the upper, or mid back or chest wall, pain in the lower back or lower extremities, and pain in joints; and disorders such as arthritis, fibromyalgia, or systemic lupus erythematosus.

Family history includes history of pain problems in the family, degenerative disorders, familial disorders, drug dependency, alcoholism, or drug abuse; and psychological disorders such as depression, anxiety, schizophrenia, and suicidal tendencies, etc. Family history of medical problems is also important.

Social history includes environ-mental information, education, marital status, children, habits, hobbies, and occupational history, whenever available.

Physical Examination

Physical examination in interventional pain management involves general, musculoskeletal, and neurological examination.

Examination of other systems, specifically cardiovascular, lymphatic, skin, eyes, and cranial nerves is recommended based on the presenting symptomatology.

Medical Decision Making

Medical decision making refers to the complexity of establishing a diagnosis and/or selecting a management option as measured by three components, including:

1. Diagnosis/management options with a number of possible diagnoses and/or the number of management options;
2. Review of records/investigations, with number and/or complexity of medical records, diagnostic tests, and other information that must be obtained, reviewed, and analyzed; and,
3. Risk(s) of significant complications, morbidity and mortality, as well as comorbidities associated with the patient's presenting problem(s), the diagnostic procedure(s), and/or the possible management options.

Psychological evaluation, laboratory evaluation, imaging techniques, electromyography and nerve conduction and somatosensory evoked potentials are also an extension of evaluation process. It is beyond the scope of these guidelines to discuss these techniques of assessment.

Appropriate history and physical examination with the assistance of other evaluations should direct a physician to formulate a provisional diagnosis. Differentiating somatic and radicular pain and understanding various pitfalls with conventional evaluation of low back pain are important factors in interventional pain management (2). A suggested algorithm for comprehensive evaluation and management of chronic spinal pain is illustrated in Fig. 1.

7.2. Medical Necessity Management

The following criteria should be considered carefully in performing interventional techniques:

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:
   - Suspected organic problem.
   - Nonresponsiveness to less invasive modalities of treatments except in acute situations such as acute disc herniation, herpes zoster and postherpetic neuralgia, reflex sympathetic dystrophy, and intractable pain secondary to carcinoma.
   - 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 to proceed with repeat blocks or other interventions.
   - Repeating interventions only upon return of pain and deterioration in functional status.

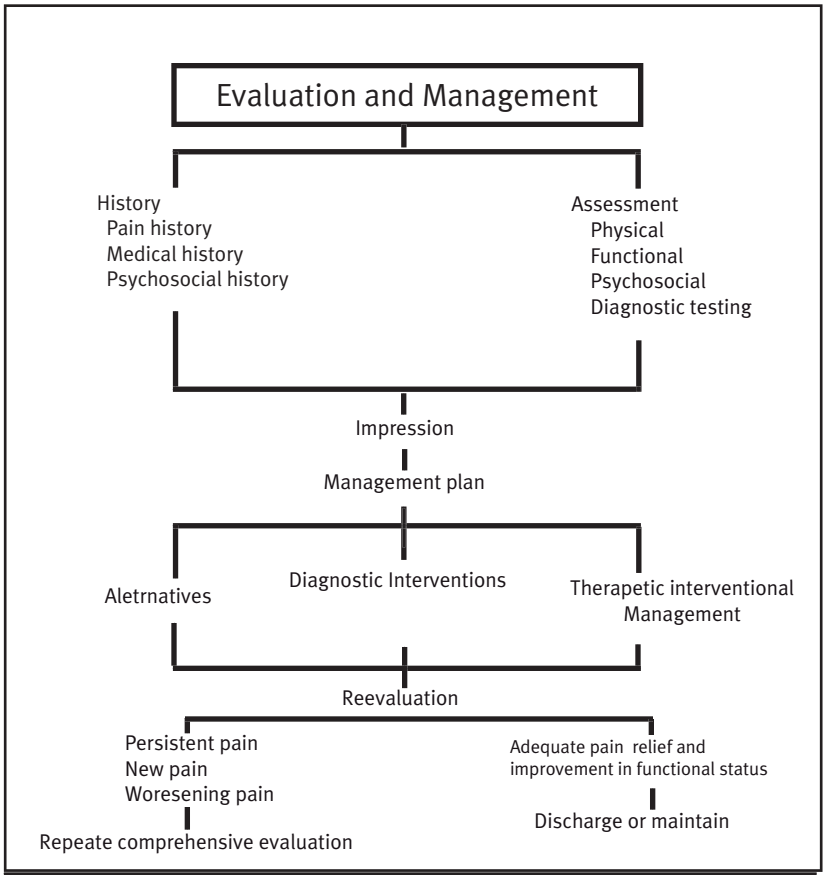


Fig. 1. *Suggested algorithm for comprehensive evaluation and management of chronic pain*

8. Delivery of Interventional Technology

There is no consensus among the interventional pain management specialists with regards to type, dosage, frequency, total number of injections, or other interventions, yet significant attention in the literature seems to be focused on the complications attributed to the use of epidural steroids in the entire arena of interventional pain management. Thus, various limitations of interventional techniques, specifically neural blockade, have arisen from basically false impressions. Based on the available literature and scientific application, the most commonly used formulations of long-acting steroids, which include methylprednisolone (Depo-Medrol®), triamcinolone diacetate (Aristocort®) triamcinolone acetonide (Kenalog®), and betamethasone acetate and phosphate mixture (Celestone Soluspan®), appear to be safe and effective (2, 1024-1045). Based on the present literature, it appears that if repeated within two weeks, betamethasone probably would be the best choice in avoiding side effects; whereas if treatment is carried out at six-week intervals or longer, any one of the four formulations will be safe and effective.

Frequency and total number of injections or interventions are a key issue, although controversial and rarely addressed. Some authors recommend one injection for diagnostic as well as therapeutic purposes; others advocate three injections in a series irrespective of the patient's progress or lack thereof; still others suggest three injections followed by a repeat course of three injections after 3-, 6-, or 12-month intervals; and, finally, there are some who propose an unlimited number of injections with no established goals or parameters. Limitation of 3 mg/kg of body weight of steroid or 210 mg per year in an average person and a lifetime dose of 420 mg of steroid, equivalent to methylprednisolone also have been advocated. While some investigators recommend one injection and do not repeat if there has been no response to the first, others recommend one or two more injections in the absence of response to the first injection. Some authors have reported good pain relief in previously unresponsive patients after an additional one or two injections. Similarly, some have believed that more than three injections do not result in additional improvement (871), whereas, others have reported the use of 6 to 10 injections if they are of benefit, however not to exceed 3 if they are not beneficial (895, 896). Such descriptions for other interventional techniques have been extrapolated from the limitations described for epidural steroid injections, even though there is no scientific basis or justification for such an extrapolation, as the techniques and type and dosage drugs are vastly different. It also has been shown in a multitude of publications that relief following multiple injections or interventions demonstrated a staircase-type phenomenon, even though it reached a plateau after three to four interventions.

The following is a description of the frequency of various types of interventional techniques. Safety and effectiveness of multiple types of interventional techniques has been established (2, 5, 19, 25, 39, 461, 593-731, 762, 763, 825, 830, 832, 834, 871, 895, 896, 924-928, 1055-1060, 1062-1066, 1169-1175). These are based on available evidence and consensus to the safety, clinical effectiveness, and cost effectiveness. However, these are not based on evidence synthesis methodology. Descriptions are provided only for some commonly used procedures.

8.1 Facet Joint Injections

- In the diagnostic phase, a patient may receive injections at intervals of no sooner than 1 week or, preferably, 2 weeks.
- In the therapeutic phase (after the stabilization is completed), the suggested frequency would be 2 months or longer between each injection, provided that at least $\geq$ 50% relief is obtained for 6 weeks.
- If the neural blockade is applied for different regions, it can be performed at intervals of no sooner than 1 week or preferably 2 weeks for most types of blocks. It is suggested therapeutic frequency remain at 2 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.
- In the diagnostic or stabilization phase, the suggested number of injections would be limited to no more than 4 times per year.
- In the treatment or therapeutic phase, the interventional procedures should be repeated only as necessary judging by the medical necessity criteria, and it is suggested that these be limited to a maximum of six times for local anesthetic and steroid blocks for a period of 1 year.
- Under unusual circumstances with a recurrent injury or cervicogenic headache, blocks may be repeated at intervals of 6 weeks after stabilization in the treatment phase.

8.2 Medial Branch Neurolysis:

- The suggested frequency would be 3 months or longer between each neurolytic procedure, provided that at least $\geq$ 50% relief is obtained for 10 to 12 weeks.
- If the neural blockade is applied for different regions, it may be performed at intervals of no sooner than 1 week or, preferably, 2 weeks for most types of blocks. The therapeutic frequency for neurolytic blocks would preferably remain at intervals of at least 3 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.

8.3 Epidural Injections:

- Epidural injections include caudal, interlaminar, and transforaminal.
- In the diagnostic phase, a patient may receive injections at intervals of no sooner than 1 week or preferably, 2 weeks, except for blockade in cancer pain or when a continuous administration of local anesthetic is employed for reflex sympathetic dystrophy.
- In the therapeutic phase (after the diagnostic phase is completed), the suggested frequency of interventional techniques would be 2 months or longer between each injection, provided that at least $\geq$50% relief is obtained for 6 to 8 weeks.
- If the neural blockade is applied for different regions, it may be performed at intervals of no sooner than 1 week and preferably 2 weeks for most type of blocks. The therapeutic frequency may remain at intervals at least 2 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.
- In the diagnostic phase, it is suggested number of injections would be limited to no more than 2 times except for reflex sympathetic dystrophy, in which case 3 times is reasonable.
- In the treatment or therapeutic phase, the interventional procedures should be repeated only as necessary judging by the medical necessity criteria, and it is suggested that these be limited to a maximum of 6 times per year.
- Under unusual circumstances with a recurrent injury, carcinoma, or reflex sympathetic dystrophy, blocks may be repeated at intervals of 6 weeks after diagnosis/stabilization in the treatment phase.

8.4 Percutaneous Lysis of Adhesions

- The number of procedures are preferably limited to:
  - With a 3-day protocol, 2 inter-ventions per year,
  - With a 1-day protocol, 4 inter-ventions per year.

8.5 Spinal Endoscopy

- The procedures are preferably limited to a maximum of 2 per year provided the relief was $\geq$ 50% for $\geq$ 4 months.

8.6 Sacroiliac Joint Injections

- In the diagnostic or stabilization phase, a patient may receive injections at intervals of no sooner than 1 week or, preferably, 2 weeks.
- In the treatment or therapeutic phase (after the stabilization is completed), the suggested frequency would be 2 months or longer between each injection, provid-

ed that at least ≥50% relief is obtained for 6 weeks.

- If the neural blockade is applied for different regions, it may be performed at intervals of no sooner than 1 week or, preferably, 2 weeks for most types of blocks. The therapeutic frequency may remain at 2 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.
- In the diagnostic or stabilization phase, the suggested number of injections would be limited to no more than 4 times per year.
- In the treatment or therapeutic phase, the interventional procedures should be repeated only as necessary judging by the medical necessity criteria, and these should be limited to a maximum of 6 times for local anesthetic and steroid blocks for a period of 1 year.

9. An Algorithmic Approach

In the changing paradigm of modern medicine, with its major focus on evidence-based medicine, interventional pain physicians are forced to learn and practice evidence-based interventional pain management. The necessary ingredients to provide evidence-based care include:

- Precise definition of the problem/diagnosis;
- Research of best evidence;
- Critical appraisal of the evidence; and
- Consideration of the evidence and its implications, in the context of the patient's condition, circumstances and values.

Even though a basic understanding of these ingredients may appear not only easy, but simple, developing expertise with the incorporation of evidence, and meticulous application of evidence to a patient's situation is difficult and time consuming. Thus, an algorithmic approach, if developed properly, may assist a physician in the clinical practice of interventional pain management.

We have developed an algorithmic approach based on the structural basis of spinal pain; moderate to strong evidence of diagnostic techniques available in arriving at a structural diagnosis of spinal pain (not available by means of radiological evaluation, physical examination, and electrodiagnostic testing); and employing effective interventional techniques available in managing chronic spinal pain. Consensus was utilized in the absence of evidence. Fig 2 describes a proposed algorithmic approach for diagnosis of chronic low back pain, whereas Fig 3 describes an algorithmic approach to management of chronic low back pain. Fig 4 describes a proposed algorithmic approach for diagnosis and management of chronic neck pain. Multiple algorithmic approaches have been described earlier (2, 6, 30, 31, 527, 1168, 1173-1175).

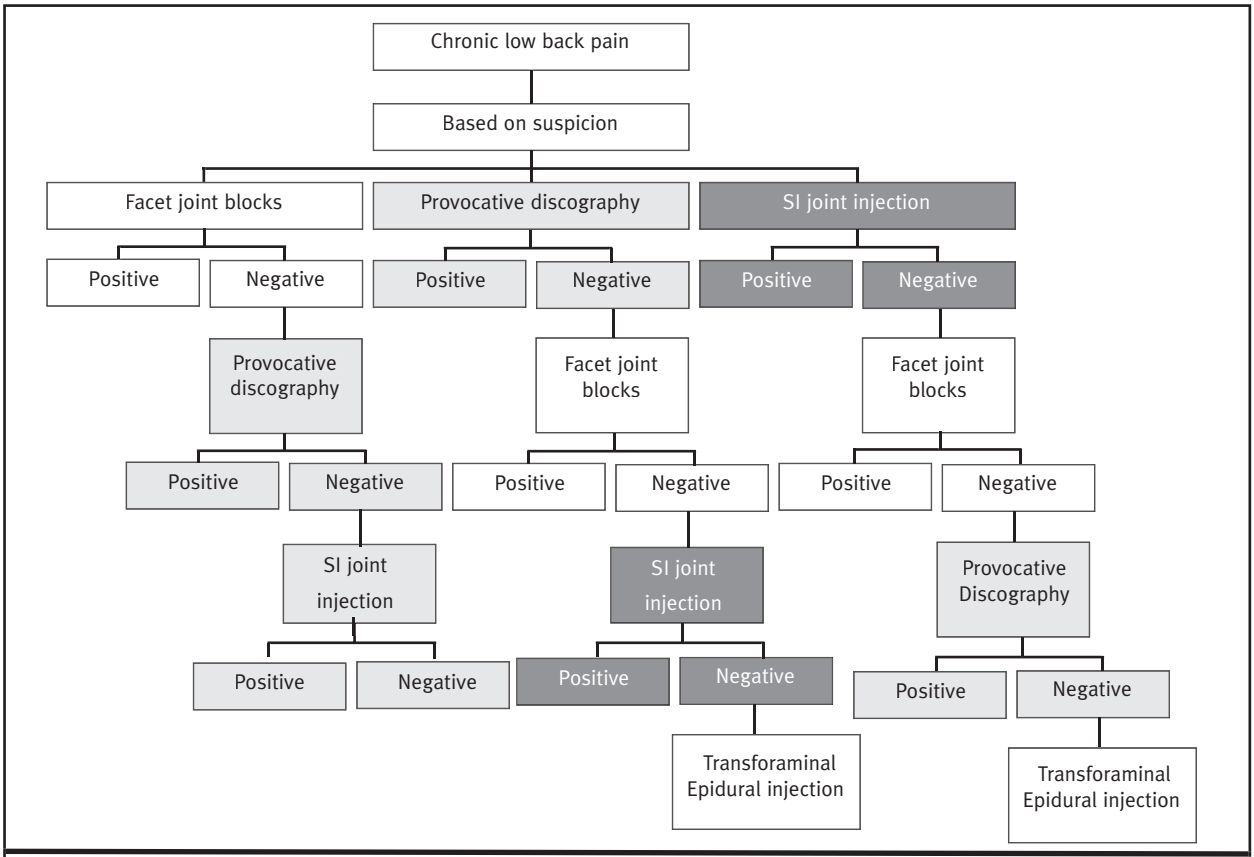


Fig. 2. *An algorithmic approach to diagnosis of chronic low back pain without disc herniation*

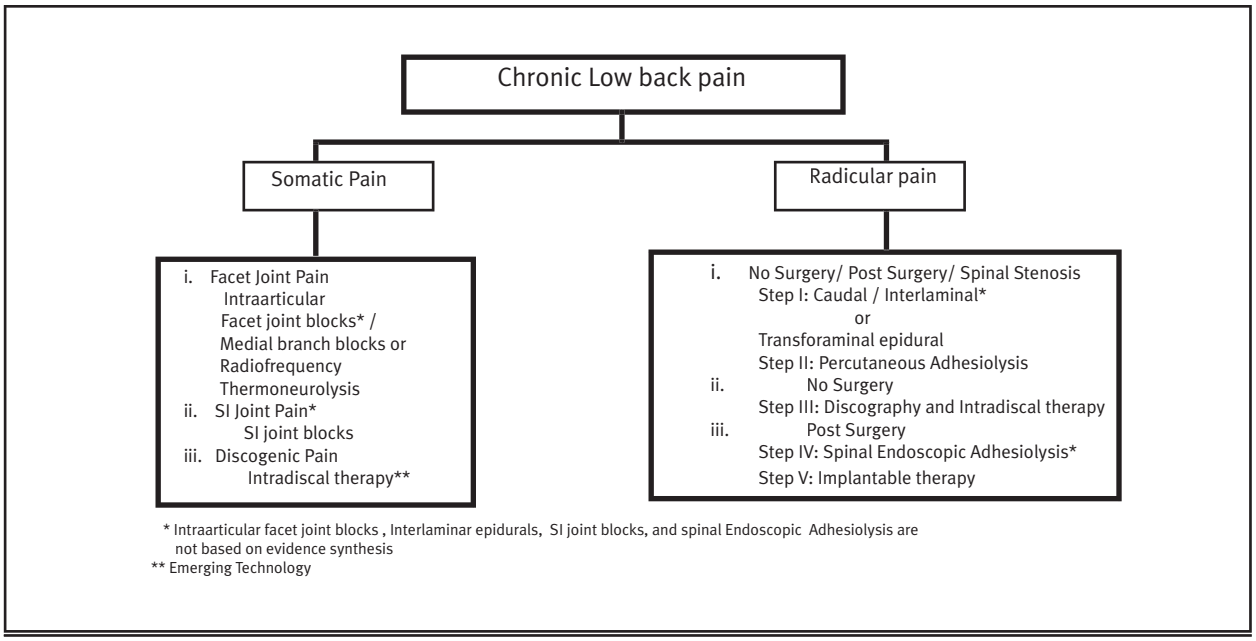


Fig. 3. *A suggested algorithm for application of therapeuetic interventional techniques in management of chornic low back pain*

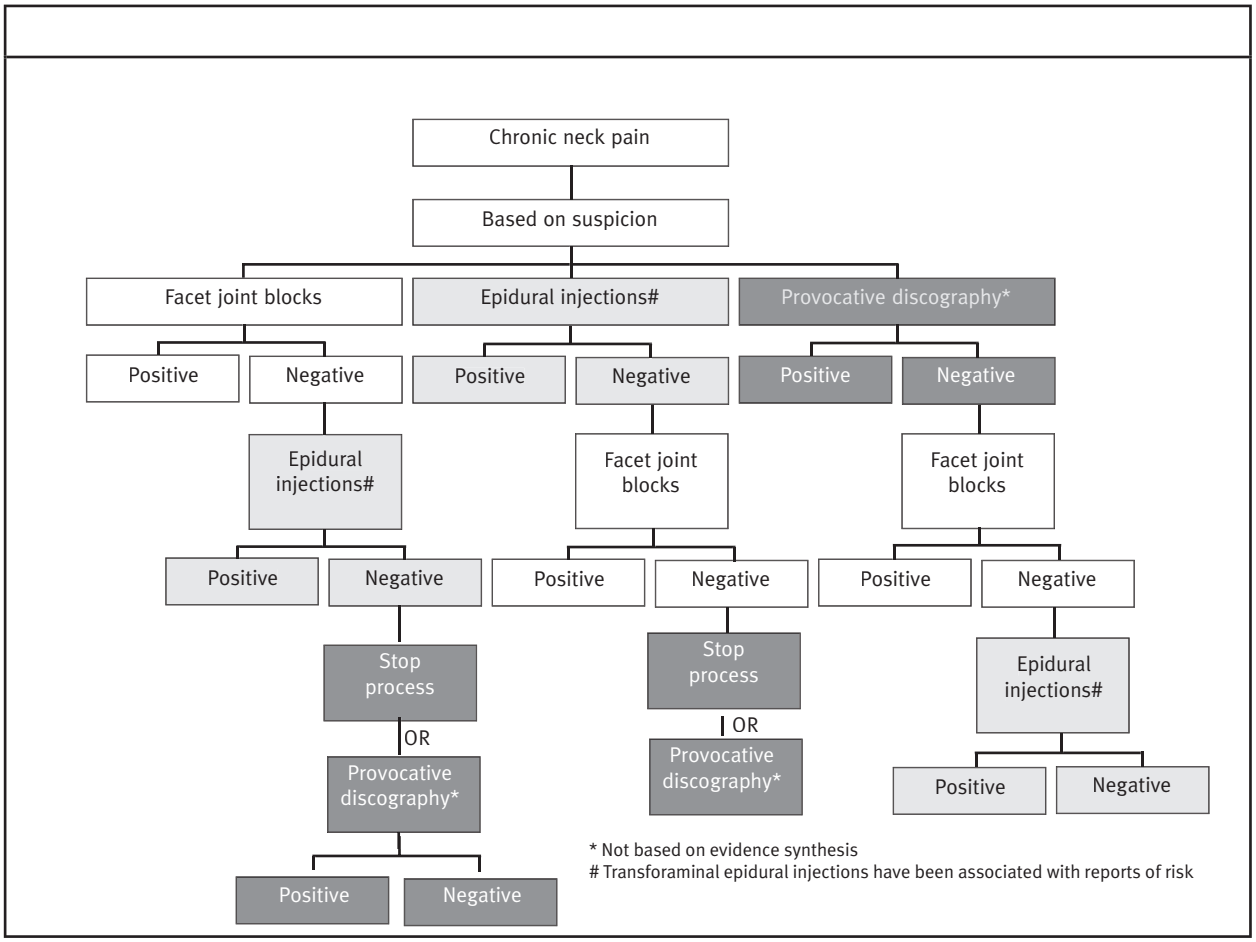


Fig. 4. *An algorithmic approach to diagnosis of chronic neck pain without disc herniation*

10. Summary

1. Interventional pain management is defined as the discipline of medicine devoted to the diagnosis and treatment of pain and related disorders with the application of interventional techniques in managing subacute, chronic, persistent, and intractable pain, independently or in conjunction with other modalities of treatments.
2. The population covered by these guidelines includes all patients suffering with chronic spinal pain eligible to undergo commonly utilized and effective interventional techniques.
3. Guidelines will be effective from February 1, 2003 to January 31, 2005. Evidence-based clinical practice guidelines for interventional techniques in the management of chronic spinal pain are statements developed to improve the quality of care, improve patient access, improve patient outcomes, improve appropriateness of care, improve efficiency and effectiveness, and achieve cost containment by improving cost-benefit ratio.
4. These guidelines address the issues of systematic evaluation and ongoing care of chronic or persistent pain. Primarily these guidelines provide information about the scientific basis of recommended procedures. These guidelines, properly applied, should increase compliance, dispel misconceptions, conduce to appropriate patient expectations, and facilitate the relationship between patients, physicians, and the payers.
5. In the development of these practice guidelines, most relevant types of evidence was utilized. In evaluating the strength of evidence, multiple types of studies used for assessing clinical and public interventions, including systematic reviews, experimental studies, nonrandomized and observational studies, and diagnostic test studies were evaluated utilizing criteria described by the Agency for Healthcare Research and Quality (AHRQ) (52). The level of evidence was designated from Level I through V.
6. Designation of levels of evidence is as follows:

   Level I - Conclusive: Research-based evidence with multiple relevant and high-quality scientific studies or consistent reviews of meta-analyses.

   Level II - Strong: Research-based evidence from at least one properly designed randomized, controlled trial of appropriate size (with at least 60 patients in smallest group); or research-based evidence from multiple properly designed studies of smaller size; or at least one randomized trial, supplemented by predominantly positive prospective and/or retrospective evidence.

   Level III – Moderate: Evidence from a well-designed small randomized trial or evidence from well-designed trials without randomization, or quasi-randomized studies, single group, pre-post cohort, time series, or matched case-controlled studies or positive evidence from at least one meta-analysis.

   Level IV – Limited: Evidence from well-designed nonexperimental studies from more than one center or research group

   Level V – Indeterminate: Opinions of respected authorities, based on clinical evidence, descriptive studies, or reports of expert committees.
7. Search strategy utilized for evidence synthesis was comprehensive and included extensive search of Index Medicus, and EMBASE; all relevant and published peer-reviewed indexed and non-indexed journals; scientific meeting proceedings, scientific newsletters; and cross-references from articles, systematic and narrative reviews.
8. In the analysis of evidence, systematic reviews, randomized clinical trials, observational reports and diagnostic test studies were utilized. A separate search strategy was designed for each subject under investigation. These included the following:
   - Study evaluation (inclusion/exclusion) algorithm (Table 2).
   - Important domains and elements for systems to rate the quality of individual articles describing systematic reviews, randomized controlled clinical trials, observational studies, and diagnostic test studies described in Table 3 and adapted from (52).
9. As recommended by the National Health and Medical Research Council (51) and Shaneyfelt et al (40), the present guidelines include the following:
   - Documentation of the purpose of the guidelines;
   - Description of the natural history of chronic spinal pain and treatments and various interventional techniques that are available;
   - Identification of various conditions where recommendations might not apply;
   - Detailed description of the probable outcomes;
   - Maintenance of flexibility and comprehensive nature of the guidelines;
   - Description of the support services required for each potential treatment;
   - Inclusion of the information for consumers and clinicians, on all special clinical training or equipment that is needed;
   - Cost-effectiveness and cost comparisons of various options;
   - Reference to the type and strength of evidence on which recommendations are based;
   - Documentation of certainty or uncertainty of any conclusions;
   - Documentation of the economic appraisals used in formulating the guidelines; and
   - Acknowledgment of consensus-based recommendations whenever applied.
10. Prevalence of chronic pain.
    - In a Gallup Survey of "Pain in America," more than 4 out of 10 adults (42%) said they experienced pain on a daily basis. Moulin et al (78) in a 2002 publication, reported chronic non-cancer pain in 29% of Canadians, with average duration of pain of 10.7 years and 80% of them reporting moderate to severe pain. Elliott et al (79) in a 4-year follow-up study, concluded that chronic pain is a common, persistent problem in the community with a relatively high incidence and a low recovery rate. Yeung et al (80) in a cross-sectional study of prevalence of musculoskeletal symptoms in single and multiple body regions showed that musculoskeletal symptoms for multiple body parts were more prevalent (64% of all workers) than those for single body regions (19%). Henderson et al (81) reported incidence of persistent pain for 6 months and 49% of adult population, with functional disability in 13%.
    - Cassidy et al (112) and Côté et al (116) showed that a total of 13% of the population with low back pain and 5% of the population with neck pain suffer with high pain intensity coupled with moderate or severe disability. An additional 12% with low back involvement and 9% with neck involvement suffer with high

pain intensity but with low disability. The studies evaluating chronic low back pain estimated the average of age related prevalence of persistent low back pain as 12% in children and adolescents, 15% in adults, and 27% in the elderly (67, 69, 87, 88).

- It has been shown that chronic pain continues to persist for long periods of time. Seventy-nine percent of those with chronic pain at baseline still had it at follow-up after 4 years (79). Modern evidence showed that prevalence of low back pain ranged from 32% to 79% at 3 months and 35% to 75% at 12 months (111, 147-155). Chronicity also has been demonstrated with neck pain with chronic persistent pain resulting in 26% to 44% of the patients after an initial episode of neck pain or whiplash (133-136, 156-158).

11. Chronic spinal pain is recognized as a multidimensional problem with both sensory and affective components. The multidimensional mechanism of pain in multidisciplinary management has taken different meanings for different specialties, ignoring fundamental facts that pain is not explained by pure theories of either physical or psychological origins. Recently, significant weight has been afforded to structural basis of pain and concept of "medically unexplained" pain has been questioned. Now the challenge remains for proponents of medically unexplained pain to provide empirical evidence to prove that psychopathology causes pain and, in doing so, to specify the mechanisms by which it is generated (172). Modern technology, including magnetic resonance imaging, computed tomographic axial scanning (CT), neurophysiologic testing, and comprehensive physical examination with psychological evaluation, can identify the cause of low back pain in only 15% of patients in the absence of disc herniation and neurological deficit (2, 173).

12 Structural Basis

- Kuslich et al (178) identified facet joints, ligaments, fascia, muscles, intervertebral discs, and nerve root dura as tissues capable of transmitting pain in the low back. Facet joint, discogenic pain, and sacroiliac joint pain have been proven to be a common cause of pain with proven diagnostic techniques (177, 179).
- Cavanaugh et al (180) in a series of neurophysiologic and neuroanatomic studies showed the evidence in support of facet pain, discogenic pain, and sciatica.
- Pang et al (181) by applying spinal pain mapping, prospectively evaluated consecutive adult patients with intractable low back pain (who had failed conservative therapy) of undetermined etiology after medical history, physical examination, x-ray, CT, MRI, EMG/NCV evaluation of lumbar spine, and determined that the source of pain was facet joint(s) in 24%, combined lumbar nerve root and facet disease in 24%, combined facet(s) and sacroiliac joint(s) in 4%, lumbar nerve root irritation in 20%, internal disc disorder in 7%, sacroiliac joint in 6%, and sympathetic dystrophy in 2% of the patients. Pain mapping failed to demonstrate causes of pain in the remaining 13% of the patients.
- Manchikanti et al (182) evaluated the relative contributions of various structures in patients with chronic low back pain who have failed to respond to conservative modalities of treatments, including physical therapy, chiropractic and drug therapy, with lack of radiological evidence to indicate disc protrusion or radiculopathy and determined with the precision diagnostic injections that 40% of the patients suffered from facet joint pain, 26% from discogenic pain, 2% from sacroiliac joint pain, and possibly 13% from segmental dural/nerve root pain with no cause identified in 19% of the patients.
- Post lumbar laminectomy syndrome, or pain following operative procedures of the spine, appears quite common (383-409). Etiologies of failed back surgery syndrome are surgical and non-surgical. Surgical diagnoses included stenosis, internal disc disruption, recurrent disc herniation, or retained disc fragment, spondylolisthesis, etc., whereas non-surgical diagnoses included epidural or intraneural fibroses, degenerative disc disease, radiculopathy, radicular pain, deconditioning, facet joint pain, sacroiliac joint pain, discitis, and arachnoiditis, etc.
- Spinal stenosis also is a frequent cause of spinal pain and disability (431).

13. Diagnostic Interventional Techniques

- Bogduk (177) postulated that diagnostic blockade of a structure with a nerve supply with the ability to generate pain, can be performed to test the hypothesis that the target structure is a source of the patient's pain. Commonly used interventional diagnostic techniques include facet joint blocks, discography, transforaminal epidural injections, and sacroiliac joint injections. Diagnostic neural blockade rests on three premises:
  - First, pathology causing pain is located in an exact peripheral location, and impulses from this site travel via unique and consistent neural route.
  - Second, injection of local anesthetic totally abolishes sensory function of intended nerves and does not affect other nerves.
  - Third, relief of pain after local anesthetic block is attributable solely to blockade of target afferent neural pathway.
- In a series of neurophysiologic and neuroanatomic studies, the evidence has been presented in support of the facet pain, pain of disc origin, possible mechanisms of sciatica, and sacroiliac joint pain.
- It has been determined that provocation of pain in any structure is an unreliable criterion except in provocative discography.
- Ideally, all controlled blocks should include placebo injections of normal saline, but it may be neither logistical nor ethical to use placebo injections of normal saline in conventional practice in each and every patient. As an alternative, comparative local anesthetic blocks, in which on two separate occasions, the same joint is anesthetized using two local anesthetics with different duration of actions, have been proposed. The use of comparative local anesthetic blocks has been validated and found to be robust against challenge with placebo with facet joint injections (482, 483). It is essential to identify false-positives in each and every case.

i. Facet Joint Diagnostic Blocks

- Based on multiple evaluations, the validity, specificity and sensitivity of facet joint nerve blocks are considered strong in the diagnosis of facet joint pain. Based on multiple evaluations, facet or zygapophysial joints

have been implicated as the source of chronic spinal pain in 15% to 45% of the heterogenous groups of patients with chronic low back pain (182, 233-238), 48% of the patients with thoracic pain (243), and 54% to 67% of the patients with chronic neck pain (239-242). Reported false-positive rates varied from 27% to 63% in cervical spine, 58% in thoracic spine and 22% to 47% in lumbar spine.

ii. Provocative Discography

Extensive evidence of provocative discography was reviewed on normal volunteers (538-540, comparison of discography findings on post mortem specimens (541, 542), comparison with computed tomography and magnetic resonance imaging (541, 544-560, 563-567), high-intensity zone identification (578-582, 584, 586, 587), evidence of discogenic pain or internal disc disruption (181, 182, 363) and false-positives in patients with low back pain or with psychological abnormalities (624-647). Based on the cumulative analysis of the literature, the evidence for cervical and thoracic discography is limited. However, the evidence for lumbar discography is strong for discogenic pain provided that lumbar discography is performed based on the history, physical examination, imaging data, and analysis of other precision diagnostic techniques. There is no evidence to support discography without other non-invasive or less invasive modalities of treatments or other precision diagnostic injections.

iii. Transforaminal Epidural Injections

Review of the available evidence included 13 studies of transforaminal epidural injections or selective nerve root blocks evaluating their role as a diagnostic entity in conjunction with other diagnostic tests (181, 182, 668, 672-677, 679, 680, 681, 687). The current evidence provides moderate evidence of transforaminal epidural injections in the preoperative evaluation of patients with negative or inconclusive imaging studies and clinical findings of nerve root irritation. The present review of the available literature (181, 182) provides limited evidence as to the role of transforaminal epidural injections in the diagnosis of segmental dural-nerve root pain in the absence of disc herniation and negative provocative discography.

iv. Sacroiliac Joint Blocks

Review of sacroiliac joint diagnostic blocks led to the inclusion of four studies: Pang et al (181), Schwarzer et al (381), Maigne et al (382) and Manchikanti et al (182). Schwarzer et al (381) utilized a single local anesthetic block in select population. Thus, the value of this evaluation is unknown. Pang et al (181) also utilized single block with prevalence report of 10% of chronic low back pain patients. Maigne et al (382), even though utilized a double block paradigm, which validated the diagnostic ability of the test with false-positive rates, failed to provide the prevalence rate in chronic spinal pain populations, as it was performed in a select group of patients with suspicion of sacroiliac joint pain. Finally, Manchikanti et al (182) showed a low prevalence of sacroiliac joint pain with a double block paradigm. The study was performed in patients suffering with low back pain and negative for other sources of pain. Even though sacroiliac joint block is considered as a gold standard based on the short-term relief, there was no blinded comparison of the test and reference standard in evaluation of these investigations. Thus, the evidence for specificity and validity of sacroiliac joint diagnostic injections is moderate.

14. Therapeutic Interventional Techniques

The rationale for therapeutic interventional techniques in the spine is based upon several considerations. First, cardinal source(s) of chronic spinal pain, namely discs and joints, are accessible to neural blockade. Second, removal or correction of structural abnormalities of the spine may fail to cure and may even worsen painful conditions. Third, degenerative processes of the spine and the origin of spinal pain are complex. Fourth, the effectiveness of a large variety of therapeutic interventions in managing chronic spinal pain has not been demonstrated conclusively. Interventional techniques in the management of chronic spinal pain include neural blockade and minimally invasive surgical procedures ranging from epidural injections, facet joint injections, and neuroablation techniques, to intradiscal thermal therapy, disc decompression, morphine pump implantation, and spinal cord stimulation.

i. Facet Joint Pain

A preponderance of evidence supports the existence of facet joint pain. Facet joint pain may be managed by either intraarticular injections, medical branch blocks, or neurolysis of medial branches. Relief with intraarticular injections or medial branch blocks was considered as short term if it was documented for less than 3 months and long-term if it was documented for longer than 3 months. Relief was considered short-term if it was less than 6 months and long-term it if was longer than 6 months for medial branch neurotomy.

a. Intraarticular Injections: Based on the present review, only one randomized trial by Carette et al (718) is considered as positive in contrast to the second randomized trial by Barnsley et al (723) which is considered negative. Among the non-randomized trials, positive results were noted for short-term relief in all the studies, however, long-term relief was noted only in 3 of the 5 studies.

The evidence of intraarticular injections of local anesthetics and steroids from randomized trials, complimented with that of non-randomized trials (prospective and retrospective evaluations) provided moderate evidence of short-term relief and limited evidence of long-term relief of chronic neck and low back pain.

b. Medial Branch Blocks: Based on the present review, one randomized trial by Manchikanti et al (728) showed positive short-term and long-term results. Among the non-randomized evaluations, both of them showed positive effect for short-term relief (237, 492). **Combined evidence of medial branch blocks from one randomized trial, complimented with two non-randomized trials (one prospective and one retrospective evaluation) provided strong evidence of short-term relief and moderate evidence of long-term relief of pain of facet joint origin.**

c. Medial Branch Neurotomy: Evidence synthesis for medial branch neurotomy included one systematic evaluation by Manchikanti et al (19) providing strong evidence that radiofrequency denervation offered short-term, and moderate evidence of long-term relief, chronic neck, thoracic and low back pain of facet joint origin. Two randomized trials included were of Lord et al (729) and van Kleef et al (731) also providing positive short and long-term effect. In addition, 4 prospective studies (730, 732, 761, 762) and 3 retrospective evaluations (492, 745, 763) showed positive short-term and long-term results. **Considering the one systematic review, two random-**

ized trials, four prospective evaluations, and three retrospective evaluations, combined evidence of radiofrequency neurotomy of medial branches provided strong evidence of short-term relief and moderate evidence of long-term relief of chronic spinal pain of facet joint origin.

ii. Epidural Injections

Epidural injection of corticosteroids is one of the commonly used interventions in managing chronic spinal pain (2). Several approaches are available to access the lumbar epidural space: caudal, interlaminar and transforaminal (2). Epidural administration of corticosteroids is one of the subjects most studied in interventional pain management with the most systematic reviews available.

Epidural injections may be performed by three approaches. There are substantial differences between the three approaches (2, 417, 689-691, 779-819). The interlaminar entry is directed more closely to the assumed site of pathology requiring less volume than the caudal route. The caudal entry is relatively easily achieved, with minimal risk of inadvertent dural puncture. The transforaminal approach is target specific with smallest volume in fulfilling the aim of reaching the primary site of pathology; namely ventrolateral epidural space.

a. Caudal Epidural Injections: Evidence synthesis included inclusion of 8 randomized or double blind trials, 5 of which were positive for short-term relief (820, 821, 825-827), and 5 were positive for long-term relief with multiple injections (820, 822, 825-827). Further, 3 prospective trials (593, 829, 830) and 4 retrospective trials (831, 832, 834, 836) were selected for inclusion. All of them were positive for short-term and long-term relief with multiple injections. **The combined evidence of caudal epidural steroid injections with randomized trials and non-randomized trials (prospective and retrospective trials) is strong for short-term relief and moderate for long-term relief.**

b. Interlaminar Epidural Injections: Of the 10 randomized trials included in the evaluation, 7 were positive for short-term relief, whereas only 3 were positive for long-term relief. Numerous non-randomized trials, both prospective and retrospective, reported good results in 18% to 90% of patients receiving cervical or lumbar interlaminar epidural steroid injections. Among the 3 prospective trials included for evaluation, only 1 was positive, 1 was indeterminate, and 1 was negative. Due to a multitude of randomized trials and availability of double blind, randomized, and non-randomized prospective trials, evidence from retrospective trials was not included.

In the evidence synthesis, randomized trials showed positive evidence for short-term relief and negative evidence for long-term relief. Furthermore, prospective trials were similar to randomized and double blind trials. **Hence, evidence for the overall effectiveness of interlaminar epidural steroid injections in managing chronic low back pain is moderate for short-term relief and limited for long-term relief.**

c. Transforaminal epidural injections:Evidence synthesis included inclusion of 3 of the 7 randomized trials (858, 903, 905), all of them showing positive short-term and long-term effectiveness of transforaminal epidural steroids in managing nerve root pain. Three prospective evaluations were included in evidence synthesis (862, 909, 910). They all showed positive short and long-term results. Four retrospective evaluations were included (825, 924, 927, 928) all of them showing positive results. **Based on the evaluation of multiple randomized and non-randomized trials, transforaminal epidural injections provided strong evidence for short-term and long-term relief. Their effectiveness in post lumbar laminectomy syndrome and disc extrusions is inconclusive.**

iii. Epidural Adhesiolysis

In the evidence synthesis for percutaneous epidural adhesiolysis utilizing a spring-guided catheter with or without hypertonic saline neurolysis to evaluate the clinical effectiveness, 2 randomized controlled trials and 3 retrospective evaluations were included (412, 1058, 1059). Both randomized trials showed positive short-term and long-term relief. Among the retrospective evaluations, one retrospective evaluation (1059) showed positive short-term and long-term relief. However, the other 2 retrospective evaluations (412, 1058) showed only short-term improvement. **Evidence of effectiveness of percutaneous adhesiolysis, based on randomized and non-randomized evaluations is moderate for short-term and long-term relief with repeat interventions.**

In the evidence synthesis for spinal endoscopic adhesiolysis there were no randomized evaluations. Two prospective evaluations were included (1063, 1064); both showed positive short-term and long-term results. Two retrospective trials (1059, 1066) were also included. Both the trials showed short-term improvement, however, they failed to show any long-term improvement. **Evidence synthesis for spinal endoscopy with prospective evaluations and retrospective evaluations showed moderate evidence for short-term relief and limited evidence for long-term relief.**

iv. Intradiscal Therapies

Commensurate with our improved ability to identify painful discs and image spinal anatomy are the advances achieved in the treatment of spinal disorders (1082). Currently it is recognized that surgical intervention may not represent the optimum therapeutic mechanism to achieve pain relief for certain patients presenting with low back and/or leg pain. During the past few decades, numerous authors have reported upon percutaneously administered minimally invasive spinal surgery techniques to achieve disc decompression. Procedures investigated have been chymopapain injection to achieve nucleolysis, percutaneous manual nucleotomy with the nucleotome, thermal vaporization with laser, and percutaneous disc decompression with nucleotomy using coblation technology (nucleoplasty). Intradiscal electrothermal therapy (IDET) is a minimally invasive technique in which the anulus is subjected to thermal modulation (1083). Relief was defined as short-term if it was 6 months or less and long-term if over 6 months.

a. Intradiscal Electrothermal Therapy: In the evidence synthesis, one randomized trial (1089), multiple prospective and retrospective trials were utilized (1083, 1090-1092, 1094, 1095). Randomized trials, as well as prospective and retrospective trials showed positive results. One of the prospective trials was conducted by founders of the technique. Thus, multiple questions have been raised (1096). Even then, it appears that there is credible evidence to show the effectiveness of intradiscal electrothermal anuloplasty independent of a multitude of factors. **Based on this evidence analysis, it appears**

that intradiscal electrothermal therapy meets the criteria for moderate evidence for short-term relief and limited evidence for long-term relief.

b. Nucleoplasty: The 2 prospective trials available describing percutaneous disc decompression with nucleoplasty utilizing coblation were reviewed. Both showed short-term and long-term relief. Retrospective evaluations were not included. **Evidence is limited showing the effectiveness of PDD with nucleoplasty.**

v. Implantable Therapies

Spinal cord stimulation systems and implantable intrathecal devices are frequently used in managing chronic intractable pain (1108, 1109).

a. Spinal Cord Stimulation: Present-day spinal cord stimulation (SCS) began shortly after Melzak and Wall proposed the gate control theory in 1965 (1110). As a direct result of this theory, in 1967, Shealy et al (1111) implanted the first spinal cord stimulator device for the treatment of chronic pain. Over the course of the last 35 years, advancements in basic science research, and technology have led spinal cord stimulation to be an accepted, reliable treatment for many neuropathic and/or vascular insufficiency pain states (1112).

Spinal cord stimulation is an invasive, interventional surgical procedure. The evidence included one randomized trial (1121), two prospective trials (1123, 1124) and multiple retrospective trials. **The evidence for spinal cord stimulation in properly selected population with neuropathic pain is moderate for long-term relief.**

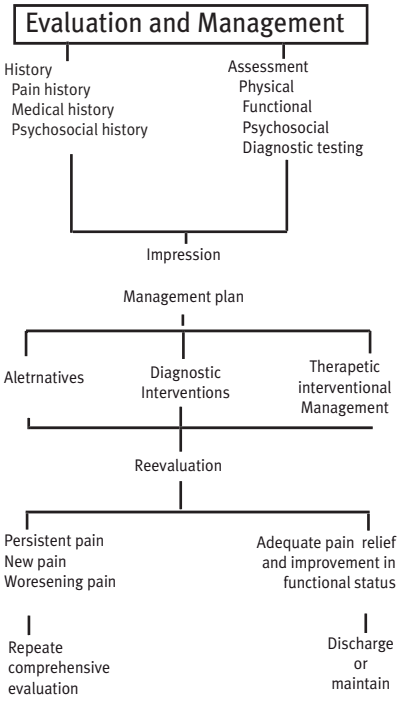
b. Implantable Intrathecal Drug Administration System: As our understanding of spinal pain processing and the technology of implantable infusion systems has evolved, spinal administration of opioid and non-opioid medication has been increasingly advocated for those patients who fail to achieve pain relief or experience undue side effects with oral opioid regimens (1145).

Three randomized (1149-1151), and multiple non-randomized trials (1152-1160) were included in evidence synthesis. **Based on the available literature, there is moderate evidence indicating the long-term effectiveness of intrathecal infusion systems.**

15. Evaluation

Appropriate history, physical examination, and medical decision making from the initial evaluation of a patient's presenting symptoms are essential (1163-1167). There are numerous acceptable medical methods to evaluate a chronic spinal pain patient. These methods vary from physician to physician and textbook to textbook. Following the guidelines established by the Centers for Medicare and Medicaid Services (CMS) not only would assist a physician in performing a comprehensive and complete evaluatation, but also assist them to be in compliance with regulations. The guidelines of CMS provide various criteria for five levels of services. The three crucial components of evaluation and management services are: history, physical examination, and medical decision-making.

16. Suggested Algorithm for Comprehensive Evaluation and Management of Chronic Pain



17. The following criteria should be considered carefully in performing interventional techniques:

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:

- Suspected organic problem.
- Nonresponsiveness to less invasive modalities of treatments except in acute situations such as acute disc herniation, herpes zoster and postherpetic neuralgia, reflex sympathetic dystrophy, and intractable pain secondary to carcinoma.
- 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 to proceed with repeat blocks or other interventions.
- Repeating interventions only upon return of pain and deterioration in functional status.

18. Delivery of Interventional Technology

Following is the description of frequency of various types of interventional techniques. Safety and effectiveness of multiple types of interventional techniques have been established (2, 5, 19, 25, 39, 461, 593-731, 762, 763, 825, 830, 832, 834, 871, 895, 896, 924-928, 1055-1060, 1062-1066, 1163, 1168). These are based on available evidence and consensus to the safety, clinical effectiveness, and cost effectiveness. However, these are not based on evidence synthesis methodology. Descriptions are provided only for some commonly used procedures.

i. Facet Joint Injections

- In the diagnostic phase, a patient may receive injections at intervals of no sooner than 1 week or, preferably, 2 weeks.
- In the therapeutic phase (after the stabilization is completed), the suggested frequency would be 2 months or longer between each injection, provided that at least $\geq$ 50% relief is obtained for 6 weeks.
- If the neural blockade is applied for different regions, it can be performed at intervals of no sooner than 1 week or preferably 2 weeks for most types of blocks. It is suggested therapeutic frequency remain at 2 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.
- In the diagnostic or stabilization phase, the suggested number of injections would be limited to no more than 4 times per year.
- In the treatment or therapeutic phase, the interventional procedures should be repeated only as necessary judging by the medical necessity criteria, and it is suggested that these be limited to a maxi-

mum of six times for local anesthetic and steroid blocks for a period of 1 year.
- Under unusual circumstances with a recurrent injury or cervicogenic headache, blocks may be repeated at intervals of 6 weeks after stabilization in the treatment phase.

iii. Medial Branch Neurolysis:

- The suggested frequency would be 3 months or longer between each neurolytic procedure, provided that at least $\geq$ 50% relief is obtained for 10 to 12 weeks.
- If the neural blockade is applied for different regions, it may be performed at intervals of no sooner than 1 week or, preferably, 2 weeks for most types of blocks. The therapeutic frequency for neurolytic blocks would preferably remain at intervals of at least 3 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.

iii. Epidural Injections:

- Epidural injections include caudal, interlaminar, and transforaminal.
- In the diagnostic phase, a patient may receive injections at intervals of no sooner than 1 week or preferably, 2 weeks, except for blockade in cancer pain or when a continuous administration of local anesthetic is employed for reflex sympathetic dystrophy.
- In the therapeutic phase (after the diagnostic phase is completed), the suggested frequency of interventional techniques would be 2 months or longer between each injection, provided that at least $\geq$50% relief is obtained for 6 to 8 weeks.
- If the neural blockade is applied for different regions, it may be performed at intervals of no sooner than 1 week and preferably 2 weeks for most type of blocks. The therapeutic frequency may remain at intervals at least 2 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.
- In the diagnostic phase, it is suggested number of injections would be limited to no more than 2 times except for reflex sympathetic dystrophy, in which case 3 times is reasonable.
- In the treatment or therapeutic phase, the interventional procedures should be repeated only as necessary judging by the medical necessity criteria, and it is suggested that these be limited to a maximum of 6 times per year.
- Under unusual circumstances with a recurrent injury, carcinoma, or reflex sympathetic dystrophy, blocks may be repeated at intervals of 6 weeks after diagnosis/stabilization in the treatment phase.

iv. Percutaneous Lysis of Adhesions:

- The number of procedures are preferably limited to:
  - With a 3-day protocol, 2 inter-ventions per year,
  - With a 1-day protocol, 4 inter-ventions per year.

v. Spinal Endoscopy
- The procedures are preferably limited to a maximum of 2 per year provided the relief was $\geq$ 50% for $\geq$ 4 months.

vi. Sacroiliac Joint Injections:
- In the diagnostic or stabilization phase, a patient may receive injections at intervals of no sooner than 1 week or, preferably, 2 weeks.
- In the treatment or therapeutic phase (after the stabilization is completed), the suggested frequency would be 2 months or longer between each injection, provided that at least $\geq$ 50% relief is obtained for 6 weeks.
- If the neural blockade is applied for different regions, it may be performed at intervals of no sooner than 1 week or, preferably, 2 weeks for most types of blocks. The therapeutic frequency may remain at 2 months for each region. It is further suggested that all regions be treated at the same time, provided all procedures are performed safely.
- In the diagnostic or stabilization phase, the suggested number of injections would be limited to no more than 4 times per year.
- In the treatment or therapeutic phase, the interventional procedures should be repeated only as necessary judging by the medical necessity criteria, and these should be limited to a maximum of 6 times for local anesthetic and steroid blocks for a period of 1 year.

19. An Algorithmic Approach

In the changing paradigm of modern medicine, with its major focus on evidence-based medicine, interventional pain physicians are forced to learn and practice evidence-based interventional pain management. The necessary ingredients to provide evidence-based care include:

- Precise definition of the problem/diagnosis;
- Research of best evidence;
- Critical appraisal of the evidence; and
- Consideration of the evidence and its implications, in the context of the patient's condition, circumstances and values.

Even though a basic understanding may appear not only easy, but simple, developing expertise with the incorporation of evidence, and meticulous application of evidence to a patient's situation is difficult and time consuming. Thus, an algorithmic approach, if developed properly, may assist a physician, in the clinical practice of interventional pain management.

We have developed an algorithmic approach based on the structural basis of spinal pain; moderate to strong evidence of diagnostic techniques available in arriving at a structural diagnosis of spinal pain (not available by means of radiological evaluation, physical examination, and electrodiagnostic testing); and employing effective interventional techniques available in managing chronic spinal pain. Consensus was utilized in the absence of evidence. Figures 2 and 3 describe proposed algorithmic approach for diagnosis and management of chronic low back pain, whereas Figure 4 describes a proposed algorithmic approach for diagnosis and management of chronic neck pain. Multiple algorithmic approaches have been described earlier (2, 6, 30, 31, 527, 1165, 1168-1170).

20. Conclusion

Evidence-based practice guidelines for interventional techniques in the management of spinal pain were developed by 21 interventionalists from all settings, with 1175 references with comprehensive descriptions of various aspects of chronic spinal pain.

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APPENDIX-A

Laxmaiah Manchikanti, MD, Medical Director, Pain Management Center of Paducah, 2831 Lone Oak Road, Paducah, KY 42003, phone (270) 554-8373, fax (270) 554-8987, or e-mail drm@apex.net

Peter S. Staats, MD, Director, Division of Pain Medicine, Associate Professor of Anesthesiology and Critical Care Medicine and of Oncology, John Hopkins University School of Medicine, 550 N. Broadway, Suite 301, Baltimore, MD 21205, phone (410) 955-1818, or e-mail pstaats@jhmi.edu

Vijay Singh, MD, Medical Director, Pain Diagnostics Associates, 1601 Roosevelt Road, Niagara, WI 54151, phone (715) 251-1780, fax (715) 251-1787, or e-mail vijsin@netnet.net

David M. Schultz, MD, Medical Director, Medical Advanced Pain Specialists, Assistant Professor of Anesthesiology, University of Minnesota, 2104 Northdale Blvd NW, Suite 220, Minneapolis, MN 55433, phone (763) 537-6000, fax (763) 537-6666, or e-mail dschultz@painphysicians.com

Bradley D. Vilims, MD, Denver Pain Management, 10050 W. 41st Avenue, Wheat Ridge, CO 80033, phone (303) 367-0600, fax (303) 265-9157, or e-mail bvilims@denverpainmanagement.com.

Joseph F. Jasper, MD, Medical Director, Advanced Pain Medicine Physicians, 1628 South Mildred Street, Suite #105, Tacoma, WA 98465-1613, phone (253) 564-2009, fax (253) 564-7420, or e-mail apmedicine@qwest.net.

David S. Kloth, MD, Medical Director, Connecticut Pain Care, 69 Sand Pit Road, Suite 204, Danbury, CT, 06810, phone (203) 792-5118, fax (203) 792-9636, or e-mail dkmd@ctpaincare.com.

Andrea M. Trescot, MD, Medical Director, Pain Center, 1895 Kingsley Ave. Suite 903, Orange Park, FL 32073, phone (904) 276-9311, fax (904) 276-4462, or e-mail amt57@aol.com

Hans C. Hansen, MD, Medical Director, The Pain Relief Centers, PA, 3451 Greystone Place SW, Conover, NC 28613, phone (828) 261-0467, fax (828) 261-7293, or e-mail hans@hippocrates.org

Thomas D. Falasca, DO, 411 Sybil Drive, Erie, PA 16505, phone (814) 833-0329, e-mail espresso@erie.net

Gabor B. Racz, MD, Grover Murray Professor, Professor and Chair Emeritus, Director Pain Services, Texas Tech University Health Sciences Center, Lubbock, TX 79430-0001, phone (806) 743-3112, fax (806) 743-2984, or e-mail anepjb@ttuhsc.edu

Timothy R. Deer, MD, Medical Director, The Center for Pain Relief, 400 Court Street, Suite 304, Charleston, WV 25301, phone (304) 347-6120, fax (304) 347-6126, or e-mail DocTDeer@aol.com

Allen W. Burton, MD, U.T.M.D., Anderson Cancer Center, Dept. Anesthesiology-Box 42, 1515 Holcombe Blvd., Houston, TX 77030, phone (713) 745-7246, fax (713) 745-0177, or e-mail awburton@mdanderson.org.

Standiford Helm II, MD, Medical Director, Pacific Coast Pain Management Center, 23792 Rockfield, Suite 101, Lake Forest, CA 92630-2865, P.O. Box 2549, Mission Viejo CA 92690-0549, phone (949) 462-0560, fax (949) 462-3910, or e-mail drhelm@pcpmc.com

Leland Lou MD,MPH, Associate Professor, Director of the Eugene McDermott Pain Center, UT-Southwestern, 5323 Harry Hines Blvd, Dallas, TX 75390, Phone (214)648-0660, fax (214)648-0693, or e-mail leland.lou@utsouthwestern.edu.

Cyrus E. Bakhit, MD, Medical Director, Pain Management Center of Roanoke, 1215 3rd Street, Roanoke, VA 24016, phone (504) 345-4230, fax (540) 345-6458, or e-mail cbakhit@pmcr.org

Elmer E. Dunbar, MD, Medical Director, Pain Control Network, 6400 Dutchman Parkway, Suite 60, Louisville KY 40205, phone (502) 897-3500, fax (502) 721-7991, or e-mail pcn@edpain.cncdsl.com.

Sairam L. Atluri, MD, Medical Director, Tri-State Pain Management Institute, 10160 Meadowknoll Drive, Loveland, OH 45140, phone (513) 624-7525, fax (513) 624-0578, or e-mail atluri_ps@sprynet.com.

Aaron K. Calodney, MD, Director of Pain Management, Research Coordinator NeuroCare Network, 816 S. Fleishel, Tyler, TX 75605, phone (903) 597-3472, fax (903) 595-5682, or e-mail acmd2001@cs.com.

Samuel J. Hassenbusch, MD, Professor of Neurosurgery, University of Texas, UT HD Anderson Cancer Center, 1515 Holcombe Blvd., Unit 442, Houston, TX 77030, phone (713) 792-2400, fax (713) 794-4950, or e-mail samuel@neosoft.com.

Claudio A. Feler, MD, Assistant Professor Department of Neurosurgery University of Tennessee Center for Health Sciences, Neurosurgeon, Semmes-Murphey Neurologic & Spine Institute, 1211 Union Avenue, Suite 200, Memphis, TN 38104, phone (901) 259-5340, fax (901) 259-5307, or e-mail cfeler@midsouth.rr.com.