CHAPTER 39
Lower Back Pain and Disorders of Intervertebral Discs
Keith D. Williams • Ashley L. Park

Epidemiology, ***
General disc and spine anatomy, ***
  Neural elements, ***
  Anatomical proportions, ***
Natural history of disc disease, ***
  Nonspecific lumbar pain, ***
Diagnostic studies, ***
  Roentgenography, ***
  Myelography, ***
  Computed tomography, ***
  Magnetic resonance imaging, ***
  Positron emission tomography, ***
  Other diagnostic tests, ***
Injection studies, ***
  Epidural cortisone injections, ***
  Cervical epidural injection, ***
  Thoracic epidural injection, ***
  Lumbar epidural injection, ***
Zygapophyseal (facet) joint injections, ***
  Cervical facet joint, ***
  Lumbar facet joint, ***
  Sacroiliac joint, ***
Discography, ***
  Lumbar discography, ***
  Thoracic discography, ***
  Cervical discography, ***
Psychological testing, ***
  Cervical disc disease, ***
  Signs and symptoms, ***
  Differential diagnosis, ***
  Confirmatory testing, ***
  Myelography, ***
  Nonoperative treatment, ***
  Operative treatment, ***
  Removal of posterolateral herniations by posterior approach (posterior cervical foraminotomy), ***
  Anterior approach to cervical disc, ***
  Thoracic disc disease, ***
  Signs and symptoms, ***
  Confirmatory testing, ***
  Treatment results, ***
  Operative treatment, ***
  Anterior approach for thoracic disc excision, ***
  Thoracic endoscopic disc excision, ***
  Lumbar disc disease, ***
  Signs and symptoms, ***
  Physical findings, ***
  Differential diagnosis, ***
  Confirmatory imaging, ***
Nonoperative treatment, ***
  Epidural steroids, ***
  Operative treatment, ***
  Ruptured lumbar disc excision, ***
  Microlumbar disc excision, ***
  Endoscopic techniques, ***
  Additional exposure techniques, ***
  Lumbar root anomalies, ***
  Results of open (micro or standard) surgery for disc herniation, ***
  Complications of open disc excision, ***
  Dural repair augmented with fibrin glue, ***
  Free fat grafting, ***
  Chemonucleolysis, ***
  Spinal instability from degenerative disc disease, ***
  Disc excision and fusion, ***
  Lumbar vertebral interbody fusion, ***
  Anterior lumbar interbody fusion, ***
  Posterior lumbar interbody fusion, ***
  Failed spine surgery, ***
  Repeat lumbar disc surgery, ***

Humans have been plagued by back and leg pain since the beginning of recorded history. Primitive cultures attributed such pain to the work of demons. The early Greeks recognized the symptoms as a disease and prescribed rest and massage for the ailment. The Edwin Smith papyrus, the oldest surgical text dating to 1500 BC, includes a case of back strain. Unfortunately, the text does not include the treatment rendered by the ancient Egyptians. In the fifth century AD, Aurelius clearly described the symptoms of sciatica. He noted that sciatica arose from either hidden causes or observable causes, such as a fall, a violent blow, pulling, or straining. In the eighteenth century Cotugno (Cotunnus) attributed the pain to the sciatic nerve. Gradually, as medicine advanced as a science, the number of specific diagnoses capable of causing back and leg pain increased dramatically.

Several physical maneuvers were devised to isolate the true problem in each patient. The most notable of these is the Lasègue sign, or straight leg raising test, described by Forst in 1881 but attributed to Lasègue, his teacher. This test was devised to distinguish hip disease from sciatica. Although sciatica was widespread as an ailment, little was known about it because only rarely did it result in death, allowing examination at autopsy. Virchow (1857), Kocher (1896), and Middleton and Teacher (1911) described acute traumatic ruptures of the intervertebral disc that resulted in death. The correlation between the disc rupture and sciatica was not appreciated by these examiners. Goldthwait in 1911 attributed back pain to posterior displacement of the disc. Oppenheim and Krause in 1909 performed the first successful surgical excision of a herniated intervertebral disc. Unfortunately, they did not
recognize the excised tissue as disc material and interpreted it as an enchondroma. Oil-contrast myelography was serendipitously introduced when iodized poppy seed oil, injected to treat sciatica in 1922, was inadvertently injected intradurally and was noted to flow freely. Dandy in 1929 and Alajouanine in the same year reported removal of a “disc tumor,” or chondroma, from patients with sciatica. The commonly held opinion of that time was that the disc hernia was a neoplasm. Mixter and Barr in their classic paper published in 1934 attributed sciatica to lumbar disc herniation. This report also included a series of four patients with thoracic disc herniations, and four patients with cervical disc herniations. They suggested surgical treatment. Myelography was not used for confirmation of disc disease because of toxicity of the agents used in the years that followed. Myelography was refined with the development of nonionic contrast media, and the test was combined with CT; however, even this appears to have been supplanted by MRI of the spine.

The standard procedure for disc removal was a total laminectomy followed by a transdural approach to the disc. In 1939 Sennes presented a new procedure to remove the ruptured intervertebral disc that included subtotal laminectomy and retraction of the dural sac to expose and remove the ruptured disc with the patient under local anesthesia. Love in 1939 Semmes presented a new procedure to remove the ruptured disc with the patient under local anesthesia. Love in the same year also described this same technique independently. This procedure, now the classic approach for the removal of an intervertebral disc, has been improved with the use of microscopic and video imaging. Kambin, Onik, and Helms and others have popularized minimally invasive techniques for selected disc hernias.

As more people were treated for herniated lumbar discs, it became obvious that surgery was not universally successful. Over the past several decades, studies of patients with back or leg pain have led to improved treatment of those in whom a specific diagnosis was possible. Unfortunately, this group remains the minority of patients who are evaluated for low back or leg pain. Complex psychosocial issues, depression, and secondary gain are but a few of the nonanatomical problems that must be considered when evaluating these patients. In addition, the number of anatomical causes for these symptoms has increased as our understanding and diagnostic capabilities have increased. In an attempt to identify other causes of back pain Mooney and Robertson popularized facet injections, thus resurrecting an idea proposed originally in 1911 by Goldthwait. Smith et al. in 1963 approached the problem by suggesting a radical departure in treatment—enzymatic dissolution of the disc by injection of chymopapain. Although this technique is still used in Europe, it rarely is used in the United States because of medicolegal concerns.

The anatomical dissections and clinical observations of Kirkaldy-Willis and associates identified pathological processes associated with or complicating the process of spinal aging as primary causes of disc disease. Additional information about this process and its treatment continues to be collected.

A thorough and complete history of all aspects of lumbar spinal surgery was compiled by Wiltse in 1987.

---

**Epidemiology**

Back pain, the ancient curse, is now an international health issue of major significance. Hult estimated that up to 80% of people are affected by this symptom at some time in their lives. Impairments of the back and spine are ranked as the most frequent cause of limitation of activity in people younger than 45 years by the National Center for Health Statistics. Physicians who treat patients with spinal disorders and spine-related complaints must distinguish the complaint of back pain, which several epidemiological studies reveal to be relatively constant, from disability attributed to back pain. In 1984, disability was noted by Waddell to be exponentially increasing in the United Kingdom (Fig. 39-1). Conversely, an insurance industry study revealed a trend toward decreasing claim rates for low back pain in the United States from 1987 to 1995.

Although back pain as a presenting complaint may account for only 2% of the patients seen by a general practitioner, Dillane, Fry, and Kalton reported that in 79% of men and 89% of women the specific cause was unknown. Svensson and Andersson noted the lifetime incidence of low back pain to be 61% and the prevalence to be 31% in a random sample of 40- to 47-year-old men. They noted that 40% of those reporting back pain also reported sciatica. In women 38 to 64 years of age the lifetime incidence of low back pain was 66% with a prevalence of 35%. Svensson and Anderson noted psychological variables associated with low back pain to be dissatisfaction with the work environment and a higher degree of worry and fatigue at the end of the workday. The cost to society and the patient in the form of lost work time, compensation, and treatment is staggering. Snook reported that Liberty Mutual Insurance Company paid $247 million for compensable back

---

**Fig. 39-1** Forty-year trends in chronic low back disability. United Kingdom statistics for sickness and invalidity benefits for back incapacities from 1953-1954 to 1993-1994 (based on statistics supplied by the Department of Social Security). (From Waddell G: *Spine* 21:2820, 1996.)
CHAPTER 39 ◆ Lower Back Pain and Disorders of Intervertebral Discs

pain in 1980. Because this company represents only 9% of the insured workers’ compensation market, Webster and Snook estimated the compensable costs of low back pain in the United States to be $11.1 billion in 1989. They reported that the mean cost of each reported claim of low back pain at Liberty Mutual had increased from $6807 in 1986 to $8321 in 1989, although they suggested that an increase in premiums sold, not an increase in low back pain claims, was the reason for this rise. More recent data from Liberty Mutual estimates that $8.8 billion was paid annually in the United States for claims related to low back pain. Of the billions of dollars spent annually in the United States because of back complaints, it was estimated that only about 39% was spent for medical treatment; the remaining costs were for disability payments. This did not include the losses from absenteeism. Although absenteeism because of back pain varies with the type of work, it rivals the common cold in total workdays lost.

Saal and Saal noted an 18% incidence of chronic back pain in 1135 adults; 80% of those reporting chronic pain did not report limitation of activity, and fewer than 4% reported significant limitation of activity. Females reported back pain more frequently than males. There were no racial differences, but the lower the educational level of those interviewed the greater the proportion of those reporting back pain. In 1992 Carey et al. interviewed 4437 North Carolinians by telephone and noted an incidence of 3.9% chronic low back pain. Of those who reported having chronic low back pain, 34% said that they were permanently disabled. These authors concluded that chronic back pain is common and associated with high costs. In the Netherlands van Doorn noted that the low back pain disability claims for self-employed dentists, veterinarians, physicians, and physical therapists increased 211% from 1977 to 1989, and the cost increased 13% over that same time period. Frymoyer and Cats-Baril noted an increase of 2500% in awards for back pain disability by the Social Security Disability Insurance from 1957 to 1976. They estimated that the total cost of low back pain was $25 billion to $100 billion per year, with 75% of those costs attributed to the 5% who became permanently disabled.

Multiple factors affect the development of back pain. Frymoyer et al. noted that risk factors associated with severe lower back pain include jobs requiring heavy and repetitive lifting, the use of jackhammers and machine tools, and the operation of motor vehicles. They also noted that patients with severe pain were more likely to be cigarette smokers and had a greater tobacco consumption. In an earlier study Frymoyer et al. noted that patients complaining of back pain reported more episodes of anxiety and depression; they also had more stressful occupations. Women with back pain had a greater number of pregnancies than those who did not. Jackson, Simmons, and Stripinis noted that adult patients with scoliosis are more likely to have back pain and that the pain persists and progresses. Deyo and Bass noted a strong relationship between smoking and back pain in patients younger than 45 years of age. They also noted a greater tendency for back pain in those patients who were the most obese. Other investigators, however, have found no relationship between obesity and back pain. Svensson and Anderson associated low back pain with cardiovascular risk factors, including calf pain on exertion, high physical activity at work, smoking, frequent worry, tension, and monotonous work.

The incidence of back pain appears to be constant. Efforts are being made to decrease the physical risk factors that may lead to low back pain. However, as shown by Boos et al., nonanatomical factors, specifically work perception and psychosocial factors, are intimately intertwined with physical complaints. Compounding diagnostic and treatment difficulties is the high incidence of significant abnormalities demonstrated by imaging studies, which in asymptomatic matched controls is as high as 76%.

General Disc and Spine Anatomy

The development of the spine begins in the third week of gestation and continues until the third decade of life. Formation of the primitive streak marks the beginning of spinal development, which is followed by the formation of the notochordal process. This process induces neurectodermal, ectodermal, and mesodermal differentiation.

Somites form in the mesodermal tissue adjacent to the neural tube (neurectoderm) and notochord. They number 42 to 44 in humans. The somites begin to migrate in preparation for the formation of skeletal structures. At the same time, the portion of the somites around the notochord separates into a sclerotome with loosely packed cells cephalad and densely packed cells caudally. Each sclerotome then separates at the junction of the loose and densely packed cells. The caudal dense cells migrate to the cephalad loose cells of the next more caudal sclerotome (Fig. 39-2).

The space where the sclerotome separates eventually forms the intervertebral disc. Vessels that originally were positioned between the somites now overlie the middle of the vertebral body. As the vertebral bodies form, the notochord that is in the center degenerates. The only remaining notochordal remnant forms the nucleus pulposus. Pazzaglia, Salisbury, and Byers reviewed the involution of the notochord in fetal and embryonic spines by several histological methods and concluded that all chordal cells disappear by early childhood. Notochordal remnants usually are not distinguishable in the adult nucleus pulposus.

The intervertebral disc in adults is composed of the annulus fibrosus and the nucleus pulposus. The annulus fibrosus is composed of numerous concentric rings or layers of fibrocartilaginous tissue. Fibers in each ring cross diagonally, and the rings attach to each other with additional radial fibers. The rings are thicker anteriorly (ventrally) than posteriorly (dorsally). The nucleus pulposus, a gelatinous material, forms the center of the disc. Because of the structural imbalance of the annulus, the nucleus is slightly posterior (dorsal) in relation to the disc as a whole. The discs vary in size and shape with their position in the spine. Discs also decrease in volume, resulting in a 16% to
21% loss in disc height after 6 hours of standing or sitting. T2-weighted MRI signals increase as much as 25% after a night of bed rest. This diurnal variation has been substantiated by Botsford et al. and Paajanen et al.

The nucleus pulposus is composed of a loose, nonoriented, collagen fibril framework supporting a network of cells resembling fibrocytes and chondrocytes. This entire structure is embedded in a gelatinous matrix of various glucosaminoglycans, water, and salts. This material usually is under considerable pressure and is restrained by the crucible-like annulus. Inoue demonstrated that the cartilage endplate contains no fibrillar connection with the collagen of the subchondral bone of the vertebra. This lack of interconnection between the endplate and the vertebra may render the disc biomechanically weak against horizontal shearing forces. Inoue also demonstrated that the collagen fibrils in the outer two thirds of the annulus fibrosus are firmly anchored into the vertebral bodies (Fig. 39-3).

The intervertebral disc in the adult is avascular. Rudert and Tillmann were able to demonstrate blood vessels in the annulus until the age of 20 years and within the cartilage endplates until the age of 7 years. The cells within the disc are sustained by diffusion of nutrients into the disc through the porous central concavity of the vertebral endplate. Histological studies have shown regions where the marrow spaces are in direct contact with the cartilage and that the central portion of the endplate is permeable to dye. Motion and weight-bearing are believed to be helpful in maintaining this diffusion. The metabolic turnover of the disc is relatively high when its avascularity is considered but slow compared with other tissues. The glycosaminoglycan turnover in the disc is quite slow, requiring 500 days. Inoue postulated that the degeneration of the disc may be prompted by decreased permeability of the cartilage endplate, which is normally dense.
NEURAL ELEMENTS

The organization of the neural elements is strictly maintained throughout the entire neural system, even within the conus medullaris and cauda equina distally. Wall et al. noted that the orientation of the nerve roots in the dural sac and at the conus medullaris follows a highly organized pattern, with the most cephalad roots lying lateral and the most caudal lying centrally. The motor roots are ventral to the sensory roots at all levels. The arachnoid mater holds the roots in these positions.

The pedicle is the key to understanding surgical spinal anatomy. The relation of the pedicle to the neural elements varies by region within the spinal column. In the cervical region, there are seven vertebrae but eight cervical roots. Therefore, accepted nomenclature allows each cervical root to exit cephalad to the pedicle of the vertebral for which it is named (e.g., the C6 nerve root exits above or cephalad to the C6 pedicle). This relationship changes in the thoracic spine because the eighth cervical root exits between the C7 and T1 pedicles, requiring the T1 root to exit caudal or below the pedicle for which it is named. This relationship is maintained throughout the remaining more caudal segments. Of importance, the naming of the disc levels is different, in that all levels where discs are present are named for the vertebral level immediately cephalad (i.e., the C6 disc is immediately cephalad to the C6 vertebra and disc pathology at that level typically would involve the C7 nerve root). In the lumbar spine classically a similar relationship exists in that disc pathology most commonly affects the nerve root one segment caudal (e.g., an L4 disc herniation would be expected to cause L5 root symptoms and findings) (Fig. 39-4).

At the level of the intervertebral foramen is the dorsal root ganglion. The ganglion lies within the outer confines of the foramen. Distal to the ganglion three distinct branches arise; the most prominent and important is the ventral ramus, which supplies all structures ventral to the neural canal. The second branch, the sinu-vertebral nerve, is a small filamentous nerve that originates from the ventral ramus and progresses medially over the posterior aspect of the disc and vertebral bodies, innervating these structures and the posterior longitudinal ligament. The third branch is the dorsal ramus. This branch courses dorsally, piercing the interspinous ligament near the pars interarticularis. Three branches from the dorsal ramus innervate the structures dorsal to the neural canal. The lateral and intermediate branches provide innervation to the posterior musculature and skin. The medial branch separates into three branches to innervate the facet joint at that level and the adjacent levels above and below (Fig. 39-5).

Pedersen, Blunk, and Gardner noted that the clinically significant function of the sinu-vertebral nerves and the posterior rami is the transmission of pain. The proprioceptive functions of these nerves are not known but assumed.

Studies by Bogduk and others demonstrated neural fibers in the outer layers of the annulus. These fibers are branches of the sinu-vertebral nerve dorsally. Ventral branches arise from the sympathetic chain that courses anterolaterally over the vertebral bodies. Rhalmi et al., using histological methods, demonstrated neural elements in all spinal ligaments. In the ligamentum flavum the nerve fibers are close to blood vessels and fat globules.

ANATOMICAL PROPORTIONS

Variation in the ratio of the cross-sectional area of the neural elements to the cross-sectional area of the spinal canal at various levels is relatively large. This is particularly true in patients with developmental stenosis in whom otherwise relatively minor intrusion into the spinal canal by pathological anatomy may cause compression of the neural structures. Many studies have documented that the changes in the foraminal dimensions increase with flexion and decrease with extension. Also, disc space narrowing causes significant volumetric decreases in the neural foramen at all levels.

Natural History of Disc Disease

The natural process of spinal aging has been studied by Kirkaldy-Willis and Hill and by others through observation of clinical and anatomical data. One theory of spinal degeneration assumes that all spines degenerate and that our current methods of treatment are for symptomatic relief, not for a cure.

The degenerative process has been divided into three separate stages with relatively distinct findings. The first stage
is dysfunction, which is seen in those 15 to 45 years of age. It is characterized by circumferential and radial tears in the disc annulus and localized synovitis of the facet joints. Varlotta et al. noted a familial predisposition to lumbar disc herniation in patients who had disc herniation before the age of 21 years. In this group the familial incidence was 32% compared with a matched control group of asymptomatic individuals in whom the rate was only 7%. A case control study of familial degenerative disc disease revealed a similar incidence of degenerative changes between first-order relatives of those with documented lumbar disc herniations and those without such a family history. However, the first-order relatives did have statistically significant more severe degenerative change.

The next stage is instability. This stage, found in 35- to 70-year-old patients, is characterized by internal disruption of the disc, progressive disc resorption, degeneration of the facet joints with capsular laxity, subluxation, and joint erosion. The final stage, present in patients older than 60 years, is stabilization. In this stage the progressive development of hypertrophic bone about the disc and facet joints leads to segmental stiffening or frank ankylosis (Table 39-1).

Each spinal segment degenerates at a different rate. As one level is in the dysfunction stage, another may be entering the stabilization stage. Disc herniation in this scheme is considered a complication of disc degeneration in the dysfunction and instability stages. Spinal stenosis from degenerative arthritis in this scheme is a complication of bony overgrowth compromising neural tissue in the late instability and early stabilization stages. Mayoux-Benhamou et al. noted that a 4-mm collapse of the disc produces sufficient narrowing of the foramen to threaten the nerve.

The stages and progression of degeneration have been confirmed by histological studies. Miller, Schmatz, and Schultz noted that disc degeneration progresses histologically as age increases. Males were found to have more degeneration than females. L4-5 and L3-4 disc levels showed the greatest degree of disc degeneration. Urban and McMullin noted that the hydration of disc material decreased with age. The relationship between the change in hydration and swelling pressure was dependent on the composition of the disc rather than on the age of the patient or the degree of degeneration. In their study L1-2 and L5-S1 discs had the lowest hydration. Yasuma et al. noted progressive histological changes in the prolapsed discs when compared with protruded discs. Urovitz and Fornasier were unable to detect any evidence of autoimmune reaction in human disc tissue, but they did detect evidence of the response to mechanical injury. Using postmyelogram CT scans, Takata et al. found that the cauda equina and affected nerve roots were swollen in 17 of 28 patients studied. The affected roots returned to normal size after disc excision. Ziv et al. reported coarsely fibrillated and ulcerated spinal facet joints in young patients, and this finding continued through progressive aging. The cartilage of the superior facets is thicker and has a higher water content than the inferior facets, indicating more frequent

Before a discussion of diagnostic studies, axial spine pain must be considered. Neumann et al. suggested that the amount of bone tissue in the spine may be functionally related to the structural properties of the spinal ligaments.

Long-term follow-up studies of lumbar disc herniations by Haklilus in 1970, Weber in 1983, and Seal in 1996 consistently documented several principles, the foremost being that generally symptomatic lumbar disc herniation (which is only one of the consequences of disc degeneration) has a favorable outcome in most patients. This was pointed out by Weber, who noted that the primary benefit of surgery was early on in the first year, but that with time the statistical significance of the improvement was lost. In addition, the review by Saal supported an active care approach, minimizing centrally acting medications. The judicious use of epidural steroids also is supported. Nonprogressive neurological deficits (except cauda equina syndrome) can be treated nonoperatively with expected improvement clinically. If surgery is necessary, it usually can be delayed 6 to 12 weeks to allow adequate opportunity for improvement. These principles are consistent with clinical findings and treatment practices at this clinic. Clearly, some patients are best treated surgically, and this is discussed in the section dealing specifically with lumbar disc herniation. Similar principles are valid regarding cervical disc herniations, which also generally can be treated nonoperatively. The important exceptions are patients with cervical myelopathy, who are best treated surgically.

The natural history of disc disease is one of recurrent episodes of pain followed by periods of significant or complete relief. Biering-Sorensen and Hilden noted that the memory of painful low back episodes was short. At initial evaluation and at 6 months’ follow-up the question of ever having had low back pain was answered by patients with a yes or no and 84% answered consistently on the two occasions. However, in a questionnaire at 12 months only two thirds of those interviewed answered consistently. They questioned the long-term analysis of data from this standpoint and noted that the clinician should be aware of the potential vagueness and unreliability of a history of previous back injury.

Before a discussion of diagnostic studies, axial spine pain with radiation to one or more extremity must be considered. Also, our understanding of certain pathophysiological entities must be juxtaposed to other entities of which we have only a rudimentary understanding. It is doubtful if there is any other area of orthopaedics in which accurate diagnosis is as difficult or the proper treatment as challenging as in patients with persistent neck and arm or low back and leg pain, despite appropriate evaluation and care. Although there are many patients with clear diagnoses properly arrived at by careful history and physical examination with confirmatory imaging studies, more patients with pain have absent neurological findings other than sensory changes and have normal imaging studies or studies that do not support the clinical complaints and findings. Inability to easily demonstrate an appropriate diagnosis in a patient does not relieve the physician of the obligation to recommend treatment or to direct the patient to a setting where such treatment is available. Careful assessment of these patients to determine if they have problems that can be orthopaedically treated (nonsurgically or surgically) is imperative to avoid overtreatment as well as undertreatment. Surgical treatment can benefit a patient if it corrects a deformity, corrects instability, or relieves neural compression, or treats a combination of these problems. Obtaining a history and completing a physical examination to determine a diagnosis that should be supported by other diagnostic studies is a very useful approach; conversely, matching the diagnosis and treatment to the results of diagnostic studies, as is done in other subspecialties of orthopaedics, is fraught with difficulty.

As pointed out by Waddell, most patients with nonspecific complaints and findings are best treated by their primary care physicians. For those with significant findings, evaluation and treatment by a specialist is appropriate. For a small minority of patients (although they are responsible for a much more significant portion of health care utilization) a multidisciplinary approach is best.

**NONSPECIFIC LUMBAR PAIN**

Nonspecific low back pain occurs at some point in the lives of most people. In Western societies a lifetime incidence of approximately 80% has been documented. A study of 1389

---

Table 39-1  Spectrum of Pathological Changes in Facet Joints and Discs and the Interaction of These Changes

<table>
<thead>
<tr>
<th>Phases of Spinal Degeneration</th>
<th>Facet Joints</th>
<th>Pathological Result</th>
<th>Intervertebral Disc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysfunction</td>
<td>Synovitis</td>
<td>Dysfunction</td>
<td>Circumferential tears</td>
</tr>
<tr>
<td></td>
<td>Hypermobility</td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuing degeneration</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Instability</td>
<td>Capsular laxity</td>
<td>→ Herniation</td>
<td>→ Instability</td>
</tr>
<tr>
<td></td>
<td>Subluxation</td>
<td></td>
<td>← Internal disruption</td>
</tr>
<tr>
<td>Stabilization</td>
<td>Enlargement of articular processes</td>
<td>→ One-level stenosis</td>
<td>← Disc resorption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>← Multilevel spondylosis and stenosis</td>
<td></td>
</tr>
</tbody>
</table>

adolescents aged 13 to 16 years recorded low back pain in nearly 60%. The incidence and severity of this problem has remained fairly constant since the early 1980s. Appropriate treatment for what can be at times excruciating pain generally should begin with evaluation for significant spinal pathology. This being absent, a brief (1 to 3 days) period of bed rest with institution of an antinflammatory regimen and rapid progression to an active exercise regimen with an anticipated return to full activity should be expected and encouraged. Diagnostic studies, including roentgenograms, often are unnecessary because they add little information. More sophisticated imaging with CT scans and MRI or other studies have even less utility initially. An overdependence on the diagnosis of disc herniation occurred with early use of these diagnostic studies that show disc herniations in 20% to 36% of normal volunteers. This incidence increased to 76% of asymptomatic controls when they were matched to a population at risk for work-related lumbar pain complaints. Imaging guidelines have been set forth by Bigos et al. (Table 39-2). Generally, patients treated in this manner improve significantly in 4 to 8 weeks. Patients should understand that persistence of some pain is not indicative of treatment failure, necessitating further measures; however, it is important for treating physicians to recognize that the longer a person is limited by pain, the less likely is a return to full activity. Once a patient is out of work for 6 months, there is only a 50% chance that he will return to his previous job (Fig. 39-6).

For patients who do not respond to treatment regimens, early recognition that other issues may be involved is essential. Careful reassessment of complaints and reexamination for new information or findings as well as inconsistencies are necessary. Many studies of occupational back pain have revealed that depression, occupational mental stress, job satisfaction, intensity of concentration, anxiety, and marital status can be related to complaints of pain and disability. The role of these factors as causally or consequentially of the symptoms remains an area of continued study; however, there is certainly some evidence that the psychological stresses occur before complaints of pain in some patients. Another finding that is evident from the literature is the inability of physicians to detect psychosocial factors adequately without using specific instruments designed for this purpose in patients with back pain. In one particular study by Grevitt et al. experienced spinal surgeons were able to identify distressed patients only 26% of the time based on patient interviews. Given the difficulty of identifying patients with psychosocial distress, being aware of the high incidence of incidental abnormal findings on imaging studies underscores the need for critical individual review of these studies by treating physicians. Severe nerve compression demonstrated by MRI or CT correlates with symptoms of distal leg pain; however, mild to moderate nerve compression (Table 39-3), disc degeneration or bulging, and central stenosis do not significantly correlate with specific pain patterns.

A review of the pertinent literature reveals that similar psychological factors are important in patients with neck pain. As confounding as these psychological risk factors are, reasonable and logical measures are available that assist in evaluation and treatment.

### Diagnostic Studies

#### ROENTGENOGRAPHY

The simplest and most readily available diagnostic tests for back or neck pain are anteroposterior and lateral roentgenograms of the involved spinal segment. These simple roentgenograms show a relatively high incidence of abnormal findings. Ford and Goodman reported only 7.3% normal spine roentgenograms in a group of 1614 patients evaluated for back pain. Scavone, Latshaw, and Rohrer reported a 46% incidence of abnormal incidental findings in lumbar spine films taken over...
Table 39-3  Classification for Spinal Nerve and Thecal Sac Deformation

<table>
<thead>
<tr>
<th>SPINAL NERVE DEFORMATION IN LATERAL RECESS OR INTERVERTEBRAL FORAMEN</th>
<th>THECAL SAC DEFORMATION IN VERTEBRAL CANAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0—Absent</td>
<td>0—Absent</td>
</tr>
<tr>
<td>I—Minimal</td>
<td>I—Minimal</td>
</tr>
<tr>
<td>II—Moderate</td>
<td>II—Moderate</td>
</tr>
<tr>
<td>III—Severe</td>
<td>III—Severe</td>
</tr>
</tbody>
</table>


1 year in a university hospital. Unfortunately, when these roentgenographic abnormalities are critically evaluated with respect to the patients’ complaints and physical findings, the correlation is very low. Fullenlove and Williams clearly identified the lack of definition between roentgenographic findings in symptomatic, asymptomatic, and operated patients. Rockey et al. and Liang and Komaroff concluded that spinal roentgenograms on the initial visit for acute low back pain do not contribute to patient care and are not cost effective. They recommended that plain roentgenograms be taken only after the initial therapy fails, especially in patients younger than 45 years of age.

There is insignificant correlation between back pain and the roentgenographic findings of lumbar lordosis, transitional vertebra, disc space narrowing, disc vacuum sign, and claw spurs. In addition, the entity of disc space narrowing is extremely difficult to quantify in all but the operated backs or in obviously abnormal circumstances. Frymoyer et al. in a study of 321 patients found that only when traction spurs or obvious disc space narrowing or both were present did the incidence of severe back and leg pain, leg weakness, and numbness increase. These positive findings had no relationship to heavy lifting, vehicular exposure, or exposure to vibrating equipment. Other studies have shown some relationship between back pain and the findings of spondylolisthesis, spondyloitis, and adult scoliosis, but these findings also can be observed in spine roentgenograms of asymptomatic patients.

Special roentgenographic views can be helpful in further defining or disproving the initial clinical roentgenographic impression. Oblique views are useful in further defining spondylolisthesis and spondyloysis but are of limited use in facet syndrome and hypertrophic arthritis of the lumbar spine. Conversely, in the cervical spine hypertrophic changes about the foramina are easily outlined. Lateral flexion and extension roentgenograms may reveal segmental instability. Hayes et al. attempted to identify the pathological level of abnormal lumbar spine flexion, but they found a wide range of motion in asymptomatic patients. They also found that translational movements of 2 to 3 mm were frequent, which means that there is little correlation between abnormal motion and pathological instability. No standards are available to make this distinction. Unfortunately, the interpretation of these views depends on patient cooperation, patient positioning, and reproducible technique. Knutsson, Farfan, Kirkaldy-Willis, Stokes et al., Macnab, and Bigos are excellent references on this topic. The Ferguson view (20-degree caudocephalic anteroposterior roentgenogram) has been shown by Wilte et al. to be of value in the diagnosis of the “far out syndrome,” that is, fifth root compression produced by a large transverse process of the fifth lumbar vertebra against the ala of the sacrum. Abel, Smith, and Allen note that angled caudal views localized to areas of concern may show evidence of facet or laminar pathological conditions.

† MYELOGRAPHY

The value of myelography is the ability to check all disc levels for abnormality and to define intraspinal lesions; it may be unnecessary if clinical and CT findings are in complete agreement. The primary indications for myelography are suspicion of an intraspinal lesion or questionable diagnosis resulting from conflicting clinical findings and other studies. In addition, myelography is of value in a previously operated spine and in patients with marked bony degenerative change that may be underestimated on MRI. Myelography is improved by the use of postmyelography CT scanning in this setting, as well as in evaluating spinal stenosis. Bell et al. found myelography more accurate than CT scanning for identifying herniated nucleus pulposus and only slightly more accurate than CT scanning in the detection of spinal stenosis. Szypryt et al. found myelography slightly less accurate than MRI in detecting spinal abnormalities.

Several contrast agents have been used for myelography: air, oil contrast, and water-soluble (absorbable) contrast including metrizamide (Amipaque), iohexol (Omnipaque), and iopamidol (Isovue-M). Since these nonionic agents are absorbable, the discomfort of removing them and the severity of the postmyelographic headache have been decreased.

Isophendylate (Pantopaque) was the contrast agent of choice from 1944 to the late 1970s (Fig. 39-7). This agent required aspiration at the conclusion of the study and was more of a meningeal irritant than the nonionic materials currently available. Occasionally, older patients are seen with small amounts of residual Pantopaque within the subarachnoid space. Rarely, patients have severe reactions such as transient paralysis, cauda equina syndrome, or focal neurological deficits.
Arachnoiditis is a severe complication that has been attributed on occasion to the combination of isophendylate and blood in the cerebrospinal fluid (CSF). Unfortunately, this diagnosis usually is confirmed only by repeat myelography. Attempts at surgical neurolysis have resulted in only short-term relief and a return of symptoms within 6 to 12 months after the procedure. Fortunately, time may decrease the effects of this serious problem in some patients, but progressive paralysis has been reported in rare instances. Arachnoiditis also can be caused by tuberculosis and other types of meningitis.

Arachnoiditis has not been noted to be related to the use of water-soluble contrast, with or without injection, in the presence of a bloody tap. Myelography remains the best diagnostic study to evaluate arachnoiditis.

Water-soluble contrast media are now the standard agents for myelography (Fig. 39-8). Their advantages include absorption by the body, enhanced definition of structures, tolerance, absorption from other soft tissues, and the ability to vary the dosage for different contrasts. Like isophendylate they are meningeal irritants, but they have not been associated with arachnoiditis. The complications of these agents include nausea, vomiting, confusion, and seizures. Rare complications include stroke, paralysis, and death. Iohexol and iopamidol have significantly lower complication rates than metrizamide. The more common complications appear to be related to patient hydration, phenothiazines, tricyclics, and migration of contrast into the cranial vault. Many of the reported complications can be prevented or minimized by using the lowest possible dose to achieve the desired degree of contrast. Adequate hydration and discontinuation of phenothiazines and tricyclic drugs before, during, and after the procedure should also minimize the incidence of the more common reactions. Likewise, maintenance of at least a 30-degree elevation of the patient’s head until the contrast is absorbed also should help prevent reactions. Complete information about these agents and the dosages required is found in their package inserts.

Iohexol (Omnipaque) is a nonionic contrast medium approved for thoracic and lumbar myelography. The incidence of reactions to this medium is low. The most common reactions are headache (less than 20%), pain (8%), nausea (6%), and vomiting (3%). Serious reactions are very rare and include mental disturbances and aseptic meningitis (0.01%). Good hydration is essential to minimize the common reactions. The use of phenothiazine antinauseants is contraindicated when this medium is employed. Management before and after the procedure is the same as for metrizamide.

Air contrast is used rarely and probably should be used only in situations in which myelography is mandatory and the patient is extremely allergic to iodized materials. The resolution from such a procedure is poor. Air epidurography in conjunction with CT has been suggested in patients in whom further definition between postoperative scar and recurrent disc material is required.

Myelographic technique begins with a careful explanation of the procedure to the patient before its initiation. Hydration of the patient before the procedure may minimize postmyelographic complaints. Heavy sedation rarely is needed. Proper equipment, including a fluoroscopic unit with a spot film device, image intensification, tiltable table, and television monitoring, is useful. The type of needle selected also influences the risk of postdural puncture headaches (PDPH), which can be severe. Smaller gauge needles (22 or 25 gauge)
have been found to result in a lower incidence of PDPH. Also, use of a Whitacre-type needle with a more blunt tip and side port opening results in fewer PDPH complaints.

**TECHNIQUE 39-1**

Place the patient prone on the fluoroscopic table. Use of an abdominal pillow is optional. Prepare the back in the usual surgical fashion. Determine needle placement by the suspected pathological level. Placement of the needle cephalad to L2-3 is more dangerous because of the risk of damaging the conus medullaris.

Infiltrate the selected area of injection with a local anesthetic. Use the smallest-gauge needle that can be well placed. If a Whitacre-type needle is used, a 19-gauge needle may be placed through the skin, subcutaneous tissue, and fascia to form a track, since this relatively blunt needle may not penetrate these structures well. Midline needle placement usually minimizes lateral nerve root irritation and epidural injection. Advance the needle with the bevel parallel to the long axis of the body. Subarachnoid placement can be enhanced by tilting the patient up to increase intraspinal pressure and minimize the epidural space.

Once the dura and arachnoid have been punctured, turn the bevel of the needle cephalad. A clear continuous flow of CSF should continue with the patient prone. Manometric studies can be performed at this time if desired or indicated. Remove a volume of CSF equal to the planned injection volume for laboratory evaluation as indicated by the clinical suspicions. In most patients a cell count, differential white cell count, and protein analysis are performed.

Inject a test dose of the contrast material under fluoroscopic control to confirm a subarachnoid injection. If a mixed subdural-subarachnoid injection is suspected, change the needle depth; occasionally a lateral roentgenogram may be required to confirm the proper depth. If flow is good, inject the contrast material slowly.

Be certain of continued subarachnoid injection by occasionally aspirating as the injection continues. The usual dose of iohexol for lumbar myelography in an adult is 10 to 15 ml with a concentration of 170 to 190 mg/ml. Higher concentrations of water-soluble contrast are required if higher areas of the spine are to be demonstrated. Consult the package insert of the contrast used. The needle can be removed if a water-soluble contrast (iohexol) is used. The needle must remain in place and be covered with a sterile towel if isophendylate is used.

Allow the contrast material to flow caudally for the best views of the lumbar roots and distal sac. Make spot films in the anteroposterior, lateral, and oblique projections. A full lumbar examination should include thoracic evaluation to about the level of T7 because lesions at the thoracic level may mimic lumbar disc disease. Take additional spot films as the contrast proceeds cranially.

If a total or cervical myelogram is desired, allow the contrast to proceed cranially. Extend the neck and head maximally to prevent or minimize intracranial migration of the contrast medium.

If isophendylate (oil contrast) was used, remove the contrast medium by extracting through the original needle or a multiholed stylet inserted through the original needle or by inserting another needle if extraction through the first needle is difficult. A small amount of medium occasionally is retained, but remove as much as possible.

If blood is present in the initial tap, abandon the procedure if oil contrast is to be used. It can be attempted again in several days if the patient has no symptoms related to the first tap and is well hydrated. If the proper needle position is confirmed in the anteroposterior and lateral views and CSF flow is minimal or absent, suspect a neoplastic process. Then place the needle at a higher or lower level as indicated by the circumstances. If attempts to obtain CSF continue to fail, abandon the procedure and reevaluate the clinical situation.

The most common technical complications of myelography are significant retention of contrast medium (oil contrast only), persistent headache from a dural leak, and epidural injection. These problems usually are minor. Persistent dural leaks usually are responsive to a blood patch. With the use of a water-soluble contrast medium, the persistent abnormalities caused by retained medium and epidural injection are eliminated.

**COMPUTED TOMOGRAPHY**

Computed tomography revolutionized the diagnosis of spinal disease (Fig. 39-9). Most clinicians now agree that CT is an extremely useful diagnostic tool in the evaluation of spinal disease.

The current technology and computer software have made possible the ability to reformat the standard axial cuts in almost any direction and magnify the images so that exact measurements of various structures can be made. Software is available to evaluate the density of a selected vertebra and compare it with vertebrae of the normal population to give a numerically reproducible estimate of vertebral density to quantitate osteopenia.

Numerous types of CT studies for the spine are available. These studies vary from institution to institution and even within institutions. One must be careful in ordering the study to be certain that the areas of clinical concern are included.

Several basic routines are used in most institutions. The most common routine for lumbar disc consists of making serial cuts through the last three lumbar intervertebral discs. If the equipment has a tilting gantry, an attempt is made to keep the axis of the cuts parallel with the disc. However, frequently the gantry cannot tilt enough to allow a parallel beam through the lowest disc space. This technique does not allow demon-
stration of the canal at the pedicles. Another method involves making cuts through the discs without tilting the gantry. Once again, the entire canal is not demonstrated, and the lower cuts frequently have the lower and upper endplates of adjacent vertebrae superimposed in the same view.

The final and most complex method consists of making multiple parallel cuts at equal intervals. This allows computer reconstruction of the images in different planes—usually sagittal and coronal. These reformatted views allow an almost three-dimensional view of the spine and most of its structures. The greatest benefit of this technique is the ability to see beyond the limits of the dural sac and root sleeves. Thus the diagnosis of foraminal encroachment by bone or disc material can now be made in the face of a normal myelogram. The proper procedure can be chosen that fits all the pathological conditions involved.

Optimal reformatted CT should include enlarged axial and sagittal views with clear notation as to laterality and sequence of cuts. Several sections of the axial cuts should include the local soft tissue and contiguous abdominal contents. Finally, a set of images adjusted for improved bony detail should be included for evaluation of the facet joints as well as the lateral recesses. Naturally this study should be centered on the level of greatest clinical concern. The study can be enhanced further if done after water contrast myelography or with intravenous contrast medium. Enhancement techniques are especially useful if the spine being evaluated has been operated on previously.

This noninvasive, painless, outpatient procedure can supply more information about spinal disease than was previously available with a battery of invasive and noninvasive tests usually requiring hospitalization. Unfortunately, CT does not demonstrate intraspinal tumors or arachnoiditis and is unable to differentiate scar from recurrent disc herniation. Bell et al. compared myelography with CT scanning and noted that myelography was more accurate. They did not compare the
results of postmyelogram CT scanning. Weiss et al. and Teplick and Haskin in separate reports suggested that the use of intravenous contrast medium (Fig. 39-9, E) followed by CT can improve the definition between scar and disc herniation. Myelography is still required to demonstrate intraspinal tumors and to “run” the spine to detect occult or unsuspected lesions. The development of low-dose metrizamide or iohexol myelography with reformatted CT done as an outpatient procedure allows a maximum of information to be obtained with a minimum of time, risk, discomfort, and cost.

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging (MRI) is the newest technological advance in spinal imaging. This technique uses the interaction of an unpaired electron with an external oscillating electromagnetic field that is changing as a function of time at a particular frequency. Energy is absorbed and subsequently released by selected nuclei at particular frequencies after excitation with radiofrequency electromagnetic energy. The released energy is recorded and formatted by computer in a pattern similar to CT. Current MRI techniques concentrate on imaging the proton (hydrogen) distribution present as H2O primarily. The advantage of this technique include the ability to demonstrate intraspinal tumors, examine the entire spine, and identify degenerative discs based on decreased H2O content. Unfortunately, the equipment required for this procedure is costly and requires specially constructed facilities (Fig. 39-10).

Szypryt et al. found MRI slightly better than myelography in the identification of spinal lesions. The accuracy of MRI in their study was 88% and that of myelography was 75%; combined accuracy was 94%. MRI is clearly superior in the detection of disc degeneration, tumors, and infections. Most MRI scans allow evaluation of a complete spinal region (such as cervical, thoracic, or lumbar) rather than three segments. They also can clearly view areas in the foramen and the paraspinal soft tissues.

MRI is so accurate that a significant number of lesions can be identified in asymptomatic patients. Gibson et al. found disc degeneration in all symptomatic adolescent patients and in 4 of 20 asymptomatic adolescents. Boden et al. found cervical spinal abnormalities in 14% of asymptomatic patients younger than 40 years of age and in 28% of asymptomatic patients over the age of 40 years. Cervical disc degeneration was found in 25% of those younger than 40 years of age and in 60% of those 60 years and older. They studied lumbar MRI scans of 67 asymptomatic patients and found that 20% of those younger than 60 years of age had herniated nuclei pulposi, which were also present in 36% of those over the age of 60 years. Asymptomatic abnormalities were found in 57% of those 60 years of age or older. Lumbar disc degeneration was found in 35% of those from 20 to 39 years of age and in 100% of those over 50 years of age. Therefore the demonstrated findings must be carefully correlated with the clinical impression.

POSITRON EMISSION TOMOGRAPHY

Positron emission tomography (PET) and single photon emission CT (SPECT) are other similar techniques that may offer additional diagnostic information. Collier et al. and others reported that SPECT is more sensitive than planar bone scintigraphy in the identification of symptomatic sites in spondylolysis. PET scanners are considered experimental by most third-party payers at this time. Their use currently is limited to relatively few centers.

Currently, imaging capabilities exceed clinical abilities to identify the source of pain. However, some patients may have nonanatomical causes for their pain and there is no imaginable explanation for their symptoms. In these patients, imaging studies are useful to rule out significant pathology that may explain their symptoms, such as with spinal cord tumors, infections, polyradiculopathies, or myeloradiculopathies.

OTHER DIAGNOSTIC TESTS

Numerous diagnostic tests have been used in the diagnosis of intervertebral disc disease in addition to roentgenography, myelography, and CT. The primary advantage of these tests is to rule out diseases other than primary disc herniation, spinal stenosis, and spinal arthritis.

Electromyography is the most notable of these tests. One advantage of electromyography is in the identification of peripheral neuropathy and diffuse neurological involvement indicative of higher or lower lesions. Electromyography and nerve conduction velocity can be helpful if a patient has a history and physical examination suggestive of radiculopathy at either the cervical or lumbar level with inconclusive imaging...
studies. Macnab et al. reported that denervation of the paraspinal muscles is found in 97% of previously operated lumbar spines as a result of the surgery. Therefore paraspinal muscles in a patient with a previous posterior operation usually are abnormal and are not a reliable diagnostic finding.

The somatosensory evoked potentials (SSEP) test is another diagnostic tool that can identify the level of root involvement. Unlike electromyography this test can only indicate a problem between the cerebral cortex and the end organs; the test cannot pinpoint the level of the lesion. This procedure is of benefit during surgery to avoid neurological damage. Both electromyography and SSEP depend on the skill of the technician and interpreter. Delamarter et al. used cortical evoked potentials to monitor experimentally induced spinal stenosis. They noted changes in the cortical response at 25% constriction. This was the only change noted in this group. Higher degrees of constriction were accompanied by much more significant changes. The SSEP is an extremely sensitive monitoring technique.

Bone scans are another procedure in which positive findings usually are not indicative of intervertebral disc disease, but they can confirm neoplastic, traumatic, and arthritic problems in the spine. Various laboratory tests such as a complete blood count, differential white cell count, biochemical profile, urinalysis, and sedimentation rate are extremely good screening procedures for other causes of pain in the spine. Rheumatoid screening studies such as rheumatoid arthritis latex, antinuclear antibody, lupus erythematosus cell preparation, and HLA-B27 also are useful when indicated by the clinical picture.

Some tests that were developed to enhance the diagnosis of intervertebral disc disease have been surpassed by the more advanced technology. Lumbar venography and sonographic measurement of the intervertebral canal are two examples.

Injection Studies

Whenever a diagnosis is in doubt and the complaints appear real or the pathological condition is diffuse, identification of the source of pain is problematic. The use of local anesthetics or contrast media in various specific anatomical areas can be useful. These agents are relatively simple, safe, and minimally painful. Contrast media such as diatrizoate meglamine (Hypaque), iohalamate meglumine (Conray), iohexol (Omnipaque), iopamidol, and metrizamide (Amipaque) have been used for discography and blocks with no reported ill effects. Reports of neurological complications with contrast media used for discography and subsequent chymopapain injection are well documented. The best choice of a contrast medium for documenting structures outside the subarachnoid space is an absorbable medium with low reactivity because it might be injected inadvertently into the subarachnoid space. Iohexol and metrizamide are the least reactive, most widely accepted, and only other injectable medium used frequently about the spine with no reported adverse reactions.

When discrete, well-controlled injection techniques directed at specific targets in and around the spine are used, grading the degree of pain before and after selective spinal injection is helpful in determining the location of the pain generator. The patient is asked to grade the degree of pain on a 0 to 10 scale before and at various intervals after the selective spinal injection (Box 39-1). If a selective spinal injection done under fluoroscopic control results in a 50% or more decrease in the level of pain, which corresponds to the duration of action of the anesthetic agent used, then the target area injected is presumed to be the pain generator.

EPIDURAL CORTISONE INJECTIONS

Epidural injections in the cervical, thoracic, and lumbosacral spine were developed to diagnose and treat spinal pain. Information obtained from epidural injections can be helpful in confirming pain generators that are responsible for a patient’s discomfort. Structural abnormalities do not always cause pain and diagnostic injections can help to correlate abnormalities seen on imaging studies with associated pain complaints. In addition, epidural injections can provide pain relief during the recovery of disc or nerve root injuries and allow patients to increase their level of physical activity. Because severe pain from an acute disc injury with or without radiculopathy often is time-limited, therapeutic injections help to manage pain and may alleviate or decrease the need for oral analgesics.

Epidural injections were first done in the lumbar region. In 1901 the first reports were published of epidural injections of cocaine for low back pain and sciatica. In 1930 Evans reported good results in 22 of 40 patients treated with procaine and saline injection into the sacral epidural space for unilateral sciatica, and in the early 1950s Robecchi and Capral were the first to report epidural injection of cortisone into the first sacral neuroforamen for the treatment of low back pain. The earliest references for cervical epidural injections were published by Catchlove and Braha and Shulman et al. No historical information on thoracic epidural injections has been published.
BOX 39-1 • Pain Scale and Diary

<table>
<thead>
<tr>
<th>Activity</th>
<th>Comments</th>
<th>Location of Pain</th>
<th>Time</th>
<th>Severity of Pain (0 to 10)</th>
</tr>
</thead>
</table>

From White AH: Back school and other conservative approaches to low back pain, St Louis, 1983, Mosby.

The efficacy of epidural injections is not reliably known because of the lack of well-controlled studies. Inconsistencies in indications and protocols are striking among reports, and many epidural steroid injection studies were done without fluoroscopic-guided needle placement to confirm correct positioning, adding another variable to the interpretation of the results. Nevertheless, more than 40, mostly uncontrolled, studies on more than 4000 patients have been published on the efficacy of lumbar and caudal epidural corticosteroid injections, and according to Bogduk, only 4 recommended against the use of lumbosacral epidural corticosteroids in the management of radicular pain in the lumbosacral spine. Kepes and Duncalf calculated the average favorable response rate obtained with lumbar epidural steroid injections to be 60%, whereas White calculated the favorable response rate to be 75%. Several studies reported the usefulness of transforaminal epidural corticosteroid injections (selective epidural or selective nerve root block) to identify or confirm a specific nerve root as a pain generator when the diagnosis is not clear based on clinical evidence.

Few serious complications occur in patients receiving epidural corticosteroid injections; however, epidural abscess, epidural hematoma, durocutaneous fistula, and Cushing syndrome have been reported as individual case reports. The most adverse immediate reaction during an epidural injection is a vasovagal reaction. Dural puncture has been estimated to occur in 0.5% to 5% of patients having cervical or lumbar epidural steroid injections. The anesthesiology literature reported a 7.5% to 75% incidence of postdural puncture (positional) headaches, with the highest estimates associated with the use of 16- and 18-gauge needles. Headache without dural puncture has been estimated to occur in 2% and is attributed to air injected into the epidural space, increased intrathecal pressure from fluid around the dural sac, and possibly an undetected dural puncture. Some of the minor, more common complaints caused by corticosteroid injected into the epidural space include nonpositional headaches, fascial flushing, insomnia, low-grade fever, and transient increased back or lower extremity pain. Epidural corticosteroid injections are contraindicated in the presence of infection at the injection site, septicemia, bleeding diathesis, uncontrolled diabetes mellitus, and congestive heart failure.

We do epidural corticosteroid injections in a fluoroscopy suite equipped with resuscitative and monitoring equipment. Intravenous access is established in all patients with a 20-gauge angiocatheter placed in the upper extremity. Mild sedation is achieved through intravenous access. We recommend the use of fluoroscopy for diagnostic and therapeutic epidural injections for several reasons. Epidural injections performed without fluoroscopic guidance are not always made into the epidural space or the intended interspace. Even in experienced hands, needle misplacement occurs in up to 40% of caudal and 30% of lumbar epidural injections when done without fluoroscopic guidance. Accidental intravascular injections also can occur, and the absence of blood return with needle aspiration before injection is not a reliable indicator of this complication. In the presence of anatomical anomalies, such as a midline epidural septum or multiple separate epidural compartments, the desired flow of epidural injectants to the presumed pain generator will be restricted and remain undetected without fluoroscopy. In addition, if an injection fails to relieve pain, it would be impossible without fluoroscopy to determine whether the failure was caused by a genuine poor response or by improper needle placement.

Cervical Epidural Injection

Cervical epidural steroid injections have been used with some success to treat cervical spondylosis associated with acute disc disruption and radiculopathies, cervical strain syndromes with associated myofascial pain, postlaminectomy cervical pain, reflex sympathetic dystrophy, postherpetic neuralgia, acute viral brachial plexitis, and muscle contraction headaches.
The best results with cervical epidural steroid injections have been in patients with acute disc herniations or well-defined radicular symptoms and in patients with limited myofascial pain.

**Interlaminar Approach**

**TECHNIQUE 39-2**

Place the patient prone on a pain management table. We use a low-attenuated carbon fiber table top that allows better imaging and permits unobstructed C-arm viewing. For optimal placement and comfort, place the patient’s face in a cervical prone cutout cushion. Cervical epidural injections using a paramedian approach should be done routinely at the C7-T1 interspace unless previous surgery of the posterior cervical spine has been done at that level, in which case the C6-C7 or T1-T2 level is injected. Aseptically prepare the skin area with isopropyl alcohol and povidone-iodine several segments above and below the laminar interspace to be injected. If the patient is allergic to povidone-iodine, then substitute with chlorhexidine gluconate (Hibiclens). Drape the patient in sterile fashion. Using anteroposterior fluoroscopic imaging, identify the target laminar interspace. With the use of a 27½-gauge needle, anesthetize the skin so that a skin wheal is raised over the target interspace on the side of the patient’s pain with 1 to 2 ml of 1% preservative-free Xylocaine without epinephrine. To diminish the burning discomfort of the anesthetic, mix 3 ml of 8.4% sodium bicarbonate in a 30-ml bottle of 1% preservative-free Xylocaine without epinephrine. Nick the skin with an 18-gauge hypodermic needle. Under fluoroscopic control insert and advance a 3½-inch, 22-gauge spinal needle in a vertical fashion until contact is made with the upper edge of the T1 lamina 1 to 2 mm lateral to the midline.

Anesthetize the lamina with 1 to 2 ml of 1% preservative-free Xylocaine without epinephrine. Then anesthetize the soft tissues with 2 ml of 1% preservative-free Xylocaine without epinephrine as the spinal needle is withdrawn. Insert a 3½-inch, 18-gauge Tuohy epidural needle and advance it vertically within the anesthetized soft tissue track until contact is made with the T1 lamina under fluoroscopy. “Walk off” the lamina with the Tuohy needle onto the ligamentum flavum. Remove the stylet from the Tuohy needle and attach a 10-ml syringe filled halfway with air and sterile saline. Advance the Tuohy needle into the epidural space using the loss of resistance technique. Once loss of resistance has been achieved, aspirate to check for blood or spinal fluid. If neither is evident, remove the syringe from the Tuohy needle and attach a 5-ml syringe containing 1.5 ml of nonionic contrast dye. Confirm epidural placement by producing an epidurogram with the nonionic contrast agent (Fig. 39-11). To further confirm proper placement adjust the C-arm to view the area from a lateral perspective. A spot roentgenogram can be obtained to document placement. Inject a test dose of 1 to 2 ml of 1% preservative-free Xylocaine without epinephrine and wait 3 minutes. If the patient is without complaints of warmth, burning, significant paresthesias, or signs of apnea, place a 10-ml syringe on the Tuohy needle and slowly inject 2 ml of 1% preservative-free Xylocaine without epinephrine and 2 ml of 6 mg/ml Celestone Soluspan slowly into the epidural space. If Celestone Soluspan cannot be obtained, 40 mg/ml of triamcinolone is a good substitute.

Fig. 39-11  Posteroanterior view cervical interlaminar epidurogram demonstrating characteristic C7 to T1 epidural contrast flow pattern.

Copyright 2003, Elsevier Science (USA). All Rights Reserved.
Transforaminal Approach

**TECHNIQUE 39-3**

Place the patient in a modified lateral decubitus position with the painful side up on a pain management table. Aseptically prepare the skin area with isopropyl alcohol and povidone-iodine several segments above and below the neuroforamen to be injected. Drape the patient in sterile fashion. Identify the foramen level to be injected under fluoroscopy, orienting the beam so that it is slightly tilted caudal to cephalad and anterior to posterior to maximize the view of the neuroforamen. Insert and slowly advance a 3 1/2-inch 25-gauge spinal needle until contact is made with the lower aspect of the superior articular process under fluoroscopy. Stay posterior to the foramen to avoid the vertebral artery. To maximize posterior positioning of the spinal needle bevel, orient the needle notch anteriorly. Orient the C-arm so that the fluoroscopy beam is in an anteroposterior projection. Redirect the spinal needle and “walk off” bone into the foramen 3 to 4 mm but no farther medially than the midpoint of the articular pillar on anteroposterior imaging. Remove the stylet. After a negative aspiration, inject 0.5 ml of nonionic contrast dye under fluoroscopy. Once an acceptable dye pattern is seen (filling of the oval neuroforamen and flow of contrast along the exiting nerve root), inject slowly a 1-ml volume, containing 0.5 ml of 2% to 4% preservative-free Xylocaine without epinephrine and 0.5 ml of 6 mg/ml Celestone Soluspan.

Thoracic Epidural Injection

Epidural steroid injections in the thoracic spine have been shown to provide relief from thoracic radicular pain secondary to disc herniations, trauma, diabetic neuropathy, herpes zoster, and idiopathic thoracic neuralgia, although reports in the literature are few.

Interlaminar Approach

**TECHNIQUE 39-4**

A paramedian rather than a midline approach is used because of the angulation of the spinous processes. Place the patient prone on a pain management table. The preparation of the patient and equipment is identical to that used for interlaminar cervical epidural injections. Aseptically prepare the skin area several segments above and below the interspace to be injected. Drape the patient in sterile fashion. Identify the target laminar interspace using anteroposterior visualization under fluoroscopic guidance. Anesthetize the skin over the target interspace on the side of the patient’s pain. Under fluoroscopic control, insert and advance a 3 1/2-inch, 22-gauge spinal needle to the superior edge of the target lamina. Anesthetize the lamina and the soft tissues as the spinal needle is withdrawn. Mark the skin with an 18-gauge hypodermic needle and then insert a 3 1/2-inch, 18-gauge Tuohy epidural needle and advance it at a 50- to 60-degree angle to the axis of the spine and a 15- to 30-degree angle toward the midline until contact with the lamina is made. To better view the thoracic interspace, position the C-arm so that the fluoroscopy beam is in the same plane as the Tuohy epidural needle. “Walk off” the lamina with the Tuohy needle into the ligamentum flavum. Remove the stylet from the Tuohy needle and, using the loss of resistance technique, advance it into the epidural space. Once loss of resistance has been achieved, aspirate to check for blood or spinal fluid. If neither is evident, inject 1.5 ml of nonionic contrast dye to confirm epidural placement. To further confirm proper placement, adjust the C-arm to view the area from a lateral projection (Fig. 39-12). A spot roentgenogram or epidurogram can be obtained. Inject 2 ml of 1% preservative-free Xylocaine without epinephrine and 2 ml of 6 mg/ml Celestone Soluspan slowly into the epidural space.

---

**Fig. 39-12** A, Anteroposterior view of thoracic interlaminar epidurogram demonstrating characteristic contrast flow pattern. B, Lateral roentgenogram of thoracic interlaminar epidurogram.

Lumbar Epidural Injection

Certain clinical trends are apparent with lumbar epidural steroid injections. When nerve root injury is associated with a disc herniation or lateral bony stenosis, most patients who received substantial leg pain relief from a well-placed transforaminal injection, even if temporary, will benefit from surgery for the radicular pain. Patients who do not respond and who have had radicular pain for at least 12 months are unlikely to benefit from surgery. Patients with back and leg pain of an acute nature (less than 3 months) respond better to epidural corticosteroids. Unless a significant reinjury results in an acute disc or nerve root injury, postsurgical patients tend to respond poorly to epidural corticosteroids.

Interlaminar Approach

**TECHNIQUE 39-5**

Place the patient prone on a pain management table. Aseptically prepare the skin area with isopropyl alcohol and povidone-iodine several segments above and below the laminar interspace to be injected. Drape the patient in a sterile fashion. Under anteroposterior fluoroscopy guidance, identify the target laminar interspace. Using a 27½-gauge needle, anesthetize the skin over the target interspace on the side of the patient’s pain with 1 to 2 ml of 1% preservative-free Xylocaine without epinephrine. Insert a 3½-inch, 22-gauge spinal needle vertically until contact is made with the upper edge of the inferior lamina at the target interspace, 1 to 2 cm lateral to the caudal tip of the inferior spinous process under fluoroscopy. Anesthetize the lamina with 2 ml of 1% preservative-free Xylocaine without epinephrine. Then anesthetize the soft tissue with 2 ml of 1% Xylocaine as the spinal needle is withdrawn. Nick the skin with an 18-gauge hypodermic needle and then insert a 3½-inch, 17-gauge Tuohy epidural needle and advance it vertically within the anesthetized soft tissue track until contact with the lamina has been made under fluoroscopy. “Walk off” the lamina with the Tuohy needle onto the ligamentum flavum. Remove the stylet from the Tuohy needle and attach a 10-ml syringe filled halfway with air and sterile saline to the Tuohy needle. Advance the Tuohy needle into the epidural space using the loss of resistance technique. Avoid lateral needle placement to decrease the likelihood of encountering an epidural vein or adjacent nerve root. Remove the stylet once loss of resistance has been achieved. Aspirate to check for blood or spinal fluid. If neither is present, remove the syringe from the Tuohy needle and attach a 5-ml syringe containing 2 ml of nonionic contrast dye. Confirm epidural placement by producing an epidurogram with the nonionic contrast agent (Fig. 39-13). A spot roentgenogram can be taken to document placement. Remove the 5-ml syringe and place on the Tuohy needle a 10-ml syringe containing 2 ml of 1% preservative-free Xylocaine and 2 ml of 6 mg/ml Celestone Soluspan. Inject the corticosteroid preparation slowly into the epidural space.

Transforaminal Approach

**TECHNIQUE 39-6**

Place the patient prone on a pain management table. Aseptically prepare the skin area with isopropyl alcohol and povidone-iodine several segments above and below the

---

Fig. 39-13  Anteroposterior and lateral view of lumbar interlaminar epidurogram demonstrating characteristic contrast flow pattern.
interspace to the injected. Drape the patient in sterile fashion. Under anteroposterior fluoroscopic guidance, identify the target interspace. Anesthetize the soft tissues over the lateral border and midway between the two adjacent transverse processes at the target interspace. Insert a 4½-inch, 22-gauge spinal needle and advance it within the anesthetized soft tissue track under fluoroscopy until contact is made with the lower edge of the superior transverse process near its junction with the superior articular process. Retract the spinal needle 2 to 3 mm and redirect it toward the base of the appropriate pedicle and advance it slowly to the 6-o’clock position of the pedicle under fluoroscopy. Adjust the C-arm to a lateral projection to confirm the position then return the C-arm to the anteroposterior view. Remove the stylet. Inject 1 ml of nonionic contrast slowly to produce a perineurosheathogram (Fig. 39-14). After an adequate dye pattern is obtained, inject slowly a 2-ml volume containing 1 ml of 0.75% preservative-free Marcaine and 1 ml of 6 mg/ml Celestone Soluspan.

The S1 nerve root also can be injected using the transforaminal approach. Place the patient prone on the pain management table. After appropriate aseptic preparation, direct the C-arm so that the fluoroscopy beam is in a cephalocaudal and lateral-to-medial direction so that the anterior and posterior S1 foramina are aligned. Anesthetize the soft tissues and the dorsal aspect of the sacrum with 2 to 3 ml of 1% preservative-free Xylocaine without epinephrine. Insert a 3½-inch, 22-gauge spinal needle and advance it within the anesthetized soft tissue track under fluoroscopy until contact is made with posterior sacral bone slightly lateral and inferior to the S1 pedicle. “Walk” the spinal needle off the sacrum into the posterior S1 foramen to the medial edge of the pedicle. Adjust the C-arm to a lateral projection to confirm the position and then return it to the anteroposterior view. Remove the stylet. Inject 1 ml of nonionic contrast slowly to produce a perineurosheathogram. After an adequate dye pattern of the S1 nerve root is obtained, insert a 2-ml volume containing 1 ml of 0.75% preservative-free Marcaine and 1 ml of 6 mg/ml Celestone Soluspan.

**Caudal Approach**

**TECHNIQUE 39-7**

Place the patient prone on a pain management table. Aseptically prepare the skin area from the lumbosacral junction to the coccyx with isopropyl alcohol and povidone-iodine. Drape the patient in sterile fashion. Try to identify by palpation the sacral hiatus, which is located between the two horns of the sacral cornu. The sacral hiatus can best be observed by directing the fluoroscopic beam laterally. Anesthetize the soft tissues and the dorsal aspect of the sacrum with 2 to 3 ml of 1% preservative-free Xylocaine without epinephrine. Keep the C-arm positioned so that the fluoroscopic beam remains lateral. Insert a 3½-inch, 22-gauge spinal needle between the sacral cornu at about 45 degrees, with the bevel of the spinal needle facing ventrally until contact with the sacrum is made. Using fluoroscopic guidance, redirect the spinal needle more cephalad, horizontal and parallel to the table, advancing it into the sacral canal through the sacrococcygeal ligament and into the epidural space. Remove the stylet. Aspirate to check for blood or spinal fluid. If neither is evident, inject 2 ml of nonionic contrast dye to confirm placement. Move the C-arm into the anteroposterior position and look for the characteristic “Christmas tree” pattern of epidural flow (Fig. 39-15). If a vascular pattern is seen, reposition the spinal needle and again confirm epidural placement with nonionic contrast dye. Once the correct contrast pattern is obtained, inject slowly a 10-ml volume containing 3 ml of 1% preservative-free Xylocaine without epinephrine, 3 ml of 6 mg/ml Celestone Soluspan, and 4 ml of sterile normal saline.

**ZYGAPOPHYSEAL (FACET) JOINT INJECTIONS**

The facet joint can be a source of back pain; the exact cause of the pain remains unknown. Theories include menisicoid entrapment and extrapment, synovial impingement, chondromalacia facetae, capsular and synovial inflammation, and mechanical injury to the joint capsule. Osteoarthritis is another cause of facet joint pain; however, the incidence of facet joint arthropathy is equal in both symptomatic and asymptomatic patients. As with other osteoarthritic joints, roentgenographic changes correlate poorly with pain.
Although the history and physical examination may suggest that the facet joint is the cause of spine pain, no noninvasive pathognomonic findings distinguish facet joint–mediated pain from other sources of spine pain. Fluoroscopically guided facet joint injections therefore are commonly considered the gold standard for isolating or excluding the facet joint as a source of spine or extremity pain.

Clinical suspicion of facet joint pain by a spine specialist remains the major indicator for diagnostic injection, which should be done only in patients who have had pain for more than 4 weeks and only after appropriate conservative measures have failed to provide relief. Facet joint injection procedures may help to focus treatment on a specific spinal segment and provide adequate pain relief to allow progression in therapy. Either intraarticular or medial branch blocks can be used for diagnostic purposes. Although injection of cortisone into the facet joint was a popular procedure through most of the 1970s and 1980s, many investigators have found no evidence that this effectively treats low back pain caused by a facet joint. The only controlled study on the use of intraarticular corticosteroids in the cervical spine found no added benefit from intraarticular betamethasone over bupivacaine.

**Cervical Facet Joint**
- **Medial Branch Block Injection**

**TECHNIQUE 39-8**

Place the patient prone on the pain management table. Rotate the patient’s neck so that the symptomatic side is down. This allows the vertebral artery to be positioned farther beneath the articular pillar, creates greater accentuation of the cervical waists, and prevents the jaw from being superimposed. Aseptically prepare and drape the side to be injected. Identify the target location using anteroposterior-directed fluoroscopy. Each cervical facet joint from C3-4 to C7-T1 is supplied from the medial nerve branch above and below that joint which curves consistently around the “waist” of the articular pillar of the same numbered vertebrae (Fig. 39-16). For example, to block the C6 facet joint nerve supply, anesthetize the C6 and C7 medial branches. Insert a 22- or 25-gauge, 3½-inch spinal needle perpendicular to the pain management table and advance it under fluoroscopic control ventrally and medially until contact is made with periosteum. Direct the spinal needle laterally until the needle tip reaches the lateral margin of the waist of the articular pillar and then direct the needle until it rests at the deepest point of the articular pillar’s concavity under fluoroscopy. Remove the stylet. If there is a negative aspirate, inject 0.5 ml of 0.75% preservative Marcaine.

**Lumbar Facet Joint**
- **Intraarticular Injection**

**TECHNIQUE 39-9**

Place the patient prone on a pain management table. Aseptically prepare and drape the patient. Under fluoroscopic guidance, identify the target segment to be injected. Upper lumbar facet joints are oriented in the sagittal (vertical) plane and often can be seen on direct anteroposterior views, whereas the lower lumbar facet joints, especially at L5-S1, are obliquely oriented and require an
ipsilateral oblique rotation of the C-arm to be seen. Position the C-arm under fluoroscopy until the joint silhouette first appears. Insert and advance a 22- or 25-gauge, 3½-inch spinal needle toward the target joint along the axis of the fluoroscopy beam until contact is made with the articular processes of the joint. Enter the joint cavity through the softer capsule and advance the needle only a few millimeters. Capsular penetration is perceived as a subtle change of resistance. If midpoint needle entry is difficult, redirect the spinal needle to the superior or inferior joint recesses. Confirm placement with less than 0.1 ml of nonionic contrast dye with a 3-ml syringe to minimize injection pressure under fluoroscopic guidance. Once intraarticular placement has been verified, inject a total volume of 1 ml of injectant (local anesthetic with or without corticosteroids) into the joint.

**Medial Branch Block Injection**

**TECHNIQUE 39-10**

Place the patient prone on a pain management table. Aseptically prepare and drape the patient. Because there is dual innervation of each lumbar facet joint, two medial branch blocks are required. It is important to remember that the medial branches cross the transverse processes below their origin (Fig. 39-17). For example, the L4-5 facet joint is anesthetized by blocking the L3 medial branch at the transverse process of L4, and the L4 medial branch at the transverse process of L5. In the case of the L5-S1 facet joint, anesthetize the L4 medial branch as it passes over the L5 transverse process and the L5 medial branch as it passes across the sacral ala. Using anteroposterior fluoroscopic imaging, identify the target transverse process. For L1 through L4 medial branch blocks, penetrate the skin using a 22- or 25-gauge, 3½-inch spinal needle lateral and superior to the target location. Under fluoroscopic guidance, advance the spinal needle until contact is made with the dorsal superior and medial aspects of the base of the transverse process so that the needle top rests against the periosteum. To ensure optimal spinal needle placement, reposition the C-arm so that the fluoroscopy beam is ipsilateral oblique and the “Scotty dog” is seen. Position the spinal needle in the middle of the “eye” of the “Scotty dog.” Slowly inject (over 30 seconds) 0.5 ml of 0.75% Marcaine.

To inject the L5 medial branch (more correctly, the L5 dorsal ramus), position the patient prone on the pain management table with the fluoroscopic beam in the anteroposterior projection. Identify the sacral ala. Rotate the C-arm 15 to 20 degrees ipsilateral obliquely to maximize exposure between the junction of the sacral ala and the superior process of S1. Insert a 22- or 25-gauge, 3½-inch spinal needle directly into the osseous landmarks approximately 5 mm below the superior junction of the sacral ala with the superior articular process of the sacrum under fluoroscopy. Rest the spinal needle on the periosteum and position the bevel of the spinal needle medial and away from the foramen to minimize flow through the L5 or S1 foramen. Slowly inject 0.5 ml of 0.75% Marcaine.

**Sacroiliac Joint**

The sacroiliac joint remains a controversial source of primary low back pain despite validated scientific studies. It often is overlooked as a source of low back pain because its anatomical location makes it difficult to examine in isolation and many provocative tests place mechanical stresses on contiguous structures. In addition, several other structures may refer pain to the sacroiliac joint.

The sacroiliac joint, like other synovial joints, moves; however, sacroiliac joint movement is involuntary and is caused by shear, compression, and other indirect forces. Muscles involved with secondary sacroiliac joint motion include the erector spinae, quadratus lumborum, psoas major and minor, piriformis, latissimus dorsi, obliquus abdominis, and gluteal. Imbalances in any of these muscles as a result of central facilitation may cause them to function in a shortened state that tends to inhibit their antagonists reflexively.
Theoretically, dysfunctional movement patterns may result. Postural changes and body weight also can create motion through the sacroiliac joint. Because of the wide range of segmental innervation (L2-S2) of the sacroiliac joint, there is a myriad of referral zone patterns. In studies of asymptomatic subjects, the most constant referral zone was localized to a 3 × 10 cm area just inferior to the ipsilateral posterior superior iliac spine (Fig. 39-18); however, pain may be referred to the buttocks, groin, posterior thigh, calf, and foot.

Sacroiliac dysfunction, also called sacroiliac joint mechanical pain or sacroiliac joint syndrome, is the most common painful condition of this joint. The true prevalence of mediated pain from sacroiliac joint dysfunction is unknown; however, several studies indicated that it is more common than expected. Because no specific or pathognomonic historical facts or physical examination tests accurately identify the sacroiliac joint as a source of pain, diagnosis is one of exclusion. However, sacroiliac joint dysfunction should be considered if an injury was caused by a direct fall on the buttocks, a rear-end motor vehicle accident with the ipsilateral foot on the brake at the moment of impact, a broadside motor vehicle accident with a blow to the lateral aspect of the pelvic ring, or a fall in a hole with one leg in the hole and the other extended outside. Lumbar rotation and axial loading that can occur during ballet or ice skating is another common mechanism of injury. Although somewhat controversial, the risk of sacroiliac joint dysfunction may be increased in individuals with lumbar fusion or hip pathology. Other causes include insufficiency stress fractures, fatigue stress fractures, metabolic processes, such as deposition diseases, degenerative joint disease, infection, and inflammatory conditions, such as ankylosing spondylitis, psoriatic arthritis, and Reiter’s disease. The diagnosis of sacroiliac joint pain can be confirmed if symptoms are reproduced upon distention of the joint capsule by provocative injection and subsequently abated with an analgesic block.

**TECHNIQUE 39-11**

Place the patient prone on a pain management table. Aseptically prepare and drape the side to be injected. Rotate the C-arm until the medial (posterior) joint line is seen. Use a 27 1/2-gauge needle to anesthetize the skin of the buttock 1 to 3 cm inferior to the lowest aspect of the joint. Using fluoroscopy insert a 3 1⁄2-inch, 22-gauge spinal needle until the needle rests 1 cm above the most posteroinferior aspect of the joint (Fig. 39-19). Rarely, a larger spinal needle is required in obese patients. Advance the spinal needle into the sacroiliac joint until capsular penetration occurs. Confirm intraarticular placement under fluoroscopy with 0.5 ml of nonionic contrast dye. A spot roentgenogram can be taken to document placement. Inject a 2-ml volume containing 1 ml of 0.75% preservative-free Marcaine and 1 ml of 6 mg/ml Celestone into the joint.

**DISCOGRAPHY**

Discography has been used since the late 1940s for the experimental and clinical evaluation of disc disease in both the cervical and lumbar regions of the spine. Since that time discography has had a limited but important role in the evaluation of suspected disc pathology.
The clinical usefulness of the data obtained from discography remains controversial. In 1968 Holt published a landmark study that showed a 37% false-positive rate. He concluded that lumbar discography was an unreliable diagnostic tool. However, Holt's studies had numerous design flaws, including suboptimal imaging equipment, neurotoxic contrast agents, inadequate needle placement, and failure to determine if pain responses were concordant or discordant with patients' typical pain patterns. Using modern techniques, Walsh et al. in 1990 published a well-controlled prospective study that, unlike Holt's study, required an abnormal nucleogram and a concordant pain response to indicate a positive provocative discogram. The investigators of this study found a 0% false-positive rate for discography compared with 37% reported by Holt. These authors concluded that, with current technique and standardized protocol, discography was a highly reliable test.

In independent studies, Cloward and Smith emphasized that reproduction of a patient's pain was the key feature of cervical discography. In 1964 Holt reported that cervical discography had no diagnostic value because pain reproduction and fissuring were features of cervical discs in normal volunteers. Later investigatory work by Simmons and Segil demonstrated the importance of discriminating between painful and nonpainful discs, while avoiding pain reproduction and disc morphology as absolute entities. Carrying this idea further, Roth in 1976 introduced analgesic cervical discography with the rationale that once a painful disc is identified, pain relief should occur by injecting a local anesthetic into the disc. He reported a high success rate for anterior disc excision and fusion using this form of precision diagnostic testing.

The most important aspect of discography is provocative testing for concordant pain (that which corresponds to a patient's usual pain) to provide information regarding the clinical significance of the disc abnormality. Although difficult to standardize, this distinguishes discography from other anatomical imaging techniques. If the patient is unable to distinguish customary pain from any other pain, the procedure is of no value. In patients who have a concordant response without evidence of a radial annular fissure on discography, CT should be considered because some discs that appear normal on discography show disruption on CT scan.

Indications for lumbar discography include surgical planning of spinal fusion, testing of the structural integrity of an adjacent disc to a known abnormality such as spondylolisthesis or fusion, identifying a painful disc among multiple degenerative discs, ruling out secondary internal disc disruption or suspected lateral or recurrent disc herniation, and determining the primary symptom-producing level when chemonucleolysis is being considered. Thoracic discography is a useful tool in the investigation of thoracic, chest, and upper abdominal pain. Degenerative thoracic disc disease, with or without herniation, has a highly variable clinical presentation, frequently mimicking visceral conditions, as well as causing back or musculoskeletal pain. In the cervical spine, discography is an important adjunct for diagnosing primary discogenic pain and determining which disc is affected and will require surgery. Discography also may be justified in medicolegal situations to establish a definitive diagnosis even though treatment may not be planned on that disc.

Compression of the spinal cord, stenosis of the roots, bleeding disorders, allergy to the injectable material, and active infection are contraindications to diagnostic discography procedures. Although the risk of complications from discography is low, potential problems include discitis, nerve root injury, subarachnoid puncture, chemical meningitis, bleeding, and allergic reactions. In addition, in the cervical region, retropharyngeal and epidural abscess can occur. Pneumothorax is a risk in both the cervical and thoracic regions.

**Lumbar Discography**

Lumbar discography originally was done using a transdural technique in a manner similar to myelography with a lumbar puncture. The difference between lumbar myelography and discography was that the needle used for the latter was advanced through the thecal sac. The technique later was modified, consisting of an extradural, extralaminar approach that avoided the thecal sac, and it was refined further to enable entry into the L5-S1 disc using a two-needle technique to maneuver around the iliac crest.

A patient's response during the procedure is the most important aspect of the study. Pain alone does not determine if a disc is the cause of the back pain. The concordance of the pain in regard to the quality and location are paramount in determining whether the disc is a true pain generator. A control disc is necessary to validate a positive finding on discography.

**TECHNIQUE 39-12 (Falco)**

Place the patient on a procedure or fluoroscopic table. Insert an angiocatheter into the upper extremity and infuse intravenous antibiotics to prevent discitis. Some physicians prefer to give antibiotics intradurally during the procedure in lieu of the intravenous route. Place the patient in a modified lateral decubitus position with the symptomatic side down to avoid having the patient confuse the pain caused by the needle with the actual pain on that same side. This position also allows for easier fluoroscopic imaging of the intervertebral discs and mobilizes the bowel away from the needle path. Lightly sedate the patient with an intravenous opioid and short-acting benzodiazepine. Prepare and drape the skin sterilely, including the lumbosacral region.

Under fluoroscopic control, identify the intervertebral discs. Adjust the patient's position or the C-arm so that the lumbar spine is in an oblique position with the superior articular process, dividing the intervertebral space in half (Fig. 39-20). Anesthetize the skin overlying the superior articular process with 1 to 2 ml of 1% lidocaine if necessary. Advance a single 6-inch spinal needle (or longer, depending on the patient's size) through the skin and deeper soft tissues to the outer annulus of the disc. The disc entry point is just
anterior to the base of the superior articular process and just above the superior endplate of the vertebral body, which allows the needle to safely pass by the exiting nerve root (Fig. 39-21). Advance the needle into the central third of the disc, using anteroposterior and lateral fluoroscopic imaging. Confirm the position of the needle tip within the central third of the disc with anteroposterior and lateral fluoroscopic imaging. Inject either saline or nonionic contrast dye into each disc. Record any pain that the patient experiences during the injection as none, dissimilar, similar, or exact in relationship to the patient’s typical low back pain. Record intradiscal pressures to assist in determining if the disc is the cause of the pain. Obtain roentgenograms of the lumbar spine upon completion of the study, paying particular attention to the contrast-enhanced disc. Obtain a CT scan if necessary to assess disc anatomy further.

An alternative method is a two-needle technique in which a 6- or 8-inch spinal needle is passed through a shorter introducer needle (typically 3½ inches in length) into the disc in the same manner as a single needle. This approach may reduce the incidence of infection by allowing the procedure needle to pass into the disc space without ever penetrating the skin. The introducer needle also may assist in more accurate needle placement, reducing the risk of injuring the exiting nerve root. The two-needle approach may require more time than the single-needle technique, and the larger introducer needle could cause more pain to the patient.

The two-needle technique often is used to enter the L5-S1 disc space with one modification. The procedure needle typically is curved (Fig. 39-22). To bypass the iliac crest, the introducer needle is advanced at an angle that places the needle tip in a position that does not line up with the L5-S1 disc space, which makes it difficult if not impossible for a straight procedure needle to advance into the L5-S1 disc. A curved procedure needle, on the other hand, allows the needle tip to align with the L5-S1 disc as it is advanced towards and into the disc adjusting for malalignment.

**Thoracic Discography**

Thoracic discography has been refined to provide a technique that is reproducible and safe. A posterolateral extralaminar
approach similar to lumbar discography is used with a single-needle technique. The significant difference between thoracic and lumbar discography is the potential for complications because of the surrounding anatomy of the thoracic spine. In contrast to lumbar discography, which typically is performed in the mid to lower lumbar spine below the spinal cord and lungs, thoracic discography has the inherent risk of pneumothorax and direct spinal cord trauma; other complications include discitis and bleeding.

Essentially the same protocol is used for thoracic discography as for lumbar discography.

**TECHNIQUE 39-13 (Falco)**

Place the patient in a modified lateral decubitus position on the procedure table with the symptomatic side down. Begin antibiotics through the intravenous catheter. Alternatively, intradiscal antibiotics may be given during the procedure. Lightly sedate the patient and prepare and drape the skin in a sterile manner.

Using fluoroscopic imaging, identify the intervertebral thoracic discs. Move the patient or adjust the C-arm obliquely to position the superior articular process so that it divides the intervertebral space in half (Fig. 39-23). At this point, the intervertebral discs and endplates, subjacent superior articular process, and adjacent rib head should be in clear view. The endplates, the superior articular process, and the rib head form a “box” (Fig. 39-24) that delineates a safe pathway into the disc, avoiding the spinal cord and lung. Keep the needle tip within the confines of this “box” while advancing it into the annulus.

After proper positioning and exposure, anesthetize the skin overlying the superior articular process with 1 to 2 ml of 1% lidocaine if necessary. Advance a single 6-inch spinal needle (a shorter or longer needle can be used, depending on the patient’s size) through the skin and the deeper soft tissues into the outer annulus within the “box” just anterior to the base of the superior articular process and just above the superior endplate. Continue into the central third of the disc, using anteroposterior and lateral fluoroscopic guidance.

Inject either saline or a nonionic contrast dye into each disc in the same manner as for lumbar discography. Record any pain response and analyze for reproduction of concordant pain using the same protocol as for lumbar discography. Obtain roentgenograms and CT imaging of the thoracic spine upon completion of the study.

**Cervical Discography**

The approach to the cervical spine is distinctly different from the approaches used for discography of the lumbar and thoracic spine. The cervical spine is approached anteriorly rather than posteriorly. Complications associated with cervical discography because of the surrounding anatomy include injury to the trachea, esophagus, carotid artery, and jugular veins, as well as spinal cord injury and pneumothorax. As with lumbar and thoracic discography, discitis also is a concern in the cervical spine, although the disc infection often originates from the gram-negative and anaerobic flora of the esophagus as opposed to the gram-positive skin flora seen in lumbar discography.

Traditionally, the approach to the cervical intervertebral discs has been via a paralaryngeal route that requires displacement of the trachea and esophagus away from the site of entry. A more lateral approach that is gaining popularity bypasses these structures and does not require such displacement.
The same protocol for lumbar and thoracic discography is used in cervical discography.

**TECHNIQUE 39-14 (Falco)**

Place the patient supine on the procedure table. Insert an angiocatheter into the upper extremity and begin intravenous antibiotic infusion. Alternatively, intradiscal antibiotics can be given during surgery. Sedate the patient and prepare and drape the skin steriley, including the anterolateral aspect of the neck.

Under fluoroscopic imaging, identify the intervertebral discs with aligned endplates and sharp margins of the intervertebral discs. Approach the paralaryngeal area from the right, using a finger to displace the esophagus and trachea to the left and the carotid artery to the right side. With the other hand, insert a 2- or 3½-inch spinal needle over the finger through the skin and into the outer annulus of the disc. Advance the needle into the center of the disc, using anteroposterior and lateral fluoroscopic guidance.

An alternative method is a more lateral approach to the cervical spine using a single needle. This approach may reduce the incidence of infection by passing the needle posterior to the trachea and esophagus en route to the disc space. Position the patient or the C-arm to place the cervical spine in an oblique position for optimal foraminal exposure and continue adjusting until the endplates, disc space, and uncovertebral process are in sharp focus (Fig. 39-25). Insert a 2- or 3½-inch needle into the skin and advance it until the tip makes contact with the subjacent uncovertebral process. “Walk off” the needle just anterior to the uncovertebral process. Advance the needle into the center of the disc, using anteroposterior and lateral fluoroscopic guidance.

After needle placement with either technique, the rest of the procedure is essentially the same as that described for thoracic or lumbar discography. Inject either saline or a nonionic contrast dye into each disc. Record any pain response and analyze for concordance using the same protocol employed for lumbar and thoracic discography. Obtain roentgenograms and CT imaging of the cervical spine upon completion of the study.

**Psychological Testing**

As discussed previously in this section, pain in some patients is the result of nonanatomical causes. Many, but not all, patients report the onset of their symptoms after a work-related incident, which may have been relatively minor. Some patients present acutely, and for these patients treatment as outlined for nonspecific back pain should be followed. It is known that patients who do not return to work in 6 months are at increased risk for long-term disability. Patients with acute injuries or with history of chronic pain require closer evaluation. Increasing evidence suggests that the preeminence of psychosocial factors over physical variables is responsible for prolonged disability.

Over the past several decades extensive studies have been done on various evaluation tools for patients with “abnormal illness behavior.” Waddell et al. defined this as “maladaptive overt illness-related behavior which is out of proportion to the underlying physical disease and more readily attributable to associated cognitive and affective disturbances.” Waddell et al. also developed clinical tools designed to detect the presence of “abnormal illness behavior” by identifying physical signs or symptoms and descriptions that are nonorganic in nature. Five nonorganic signs and seven nonorganic symptom descriptions (Table 39-4) have been identified. Waddell initially described these for use in patients with chronic pain and suggested that the presence of three signs was required to determine “abnormal illness behavior.” Several studies evaluated the ability of these signs and symptom descriptions to predict return to work but have proved inconclusive; nevertheless, they appear to be useful in detecting patients at increased risk for poor outcome with surgical intervention.

The Minnesota Multiphasic Personality Inventory (MMPI) has been used for psychological assessment in many previous studies and has been demonstrated to be a reasonable predictor of surgical and conservative treatment results regardless of the spinal pathological condition. Unfortunately, the MMPI is lengthy and difficult to administer in an orthopaedic clinical setting and probably is best given by a psychiatrist or psychologist. By comparison, the Distress and Risk Assessment Method (DRAM) is relatively easily administered and scored and has been validated in clinical settings with regard to patients with back pain. The DRAM consists of the Modified Somatic Perception Questionnaire (MSPQ) and the Zung Depression Index (ZDI). With this simplified method, patients
especially spinal fusion. The MMPI is one of the most reliable abnormalities and are being evaluated for surgical treatment, have symptoms seemingly out of proportion to their anatomical MMPI, which we routinely use for assessment of patients who have chronic pain but no clear cause of their symptoms; whether the clinical evaluation be used preoperatively in patients who have more likely to have a poor outcome after any form of treatment. This test is predictive of preinjury susceptibility to back injury and the potential for failure of conservative and surgical treatment. Wiltse and Rocchio demonstrated that elevations of the hysteria (Hs) and hypochondriasis (Hy) T scores above 75 are indicative of a poor postoperative response (16% good results). Their study evaluated patients treated with chymopapain, and their clinical results are illustrated in Tables 39-5 and 39-6.

Table 39-5 indicates the rate of good or excellent results using the MMPI test Hs and Hy scores alone in the study by Wiltse and Rocchio. Table 39-6 illustrates the lack of statistical significance between the MMPI scores and the presence of the following objective findings: reflex changes, motor weakness, sensory deficits, positive myelogram, positive electromyogram, and elevated CSF protein.

Similar studies of surgically and conservatively treated patients have had similar findings. Written reports are helpful, but the raw T score read on the far right or left side of the standard test result sheet is the simplest guide to postoperative outcome. If surgery is necessary in a patient with an elevated Hs or Hy score, then psychiatric or psychological assistance before and after the procedure can be helpful, but a poor result should be anticipated. Gentry observed a group of patients with objective evidence of psychological disturbance as indicated by the MMPI. Those patients who had surgery were less likely to return to work, less likely to have a reduction in their pain, and more likely to have greater disability than similar patients who did not have surgery. Wiltse and Rocchio recommended restraint and conservative treatment in these patients. Elevation of the Hs and Hy scores on the MMPI should be a relative contraindication to elective spinal surgery.

Additional material on this test can be found in the excellent articles by Dennis et al., Wiltse and Rocchio, and Southwick and White. Numerous other tests are available, but none has been shown to be as predictive of surgical outcome as the Hs and Hy scores on the MMPI. Riley et al. investigated a MMPI-2 and found that the results replicated those of the older MMPI.


identified as psychologically distressed are three to four times more likely to have a poor outcome after any form of treatment. It is our recommendation that some type of formal psychological evaluation be used preoperatively in patients who have chronic pain but no clear cause of their symptoms; whether the MMPI or the DRAM is used is less important.

The experience at this clinic has been primarily with the MMPI, which we routinely use for assessment of patients who have symptoms seemingly out of proportion to their anatomical abnormalities and are being evaluated for surgical treatment, especially spinal fusion. The MMPI is one of the most reliable and well-documented tests used for this purpose. This test is predictive of preinjury susceptibility to back injury and the potential for failure of conservative and surgical treatment. Wiltse and Rocchio demonstrated that elevations of the hysteria (Hs) and hypochondriasis (Hy) T scores above 75 are indicative of a poor postoperative response (16% good results). Their study evaluated patients treated with chymopapain, and their clinical results are illustrated in Tables 39-5 and 39-6.

Table 39-5 indicates the rate of good or excellent results using the MMPI test Hs and Hy scores alone in the study by Wiltse and Rocchio. Table 39-6 illustrates the lack of statistical significance between the MMPI scores and the presence of the following objective findings: reflex changes, motor weakness, sensory deficits, positive myelogram, positive electromyogram, and elevated CSF protein.

Similar studies of surgically and conservatively treated patients have had similar findings. Written reports are helpful, but the raw T score read on the far right or left side of the standard test result sheet is the simplest guide to postoperative outcome. If surgery is necessary in a patient with an elevated Hs or Hy score, then psychiatric or psychological assistance before and after the procedure can be helpful, but a poor result should be anticipated. Gentry observed a group of patients with objective evidence of psychological disturbance as indicated by the MMPI. Those patients who had surgery were less likely to return to work, less likely to have a reduction in their pain, and more likely to have greater disability than similar patients who did not have surgery. Wiltse and Rocchio recommended restraint and conservative treatment in these patients. Elevation of the Hs and Hy scores on the MMPI should be a relative contraindication to elective spinal surgery.

Additional material on this test can be found in the excellent articles by Dennis et al., Wiltse and Rocchio, and Southwick and White. Numerous other tests are available, but none has been shown to be as predictive of surgical outcome as the Hs and Hy scores on the MMPI. Riley et al. investigated a MMPI-2 and found that the results replicated those of the older MMPI.
Patients with MMPI and MMPI-2 findings of depressed-pathological profile and a conversion V profile reported greater dissatisfaction with surgical outcome.

Similar outcomes have been noted for nonoperative treatment of these patients. Gatchel et al. noted similar problems in patients with acute back pain who were questioned 6 months later.

The main problem with the MMPI is that it requires the ability to read and comprehend the material. Pincus et al. also noted that the MMPI questions may be in line with natural disease processes such as rheumatoid arthritis. Patients with chronic diseases may, by the nature of their disease symptoms, have MMPI elevations. Chronic back pain without a specific disease association should not be considered as similar to chronic disease such as rheumatoid arthritis. Chapman and Pemberton noted that the MMPI failed to predict the subjective outcome as reported by patients with chronic back pain who were in an interdisciplinary pain-management program.

A simple test that is a good screening aid is the pain drawing. The pain drawing correlates well with the Hs and Hy scores. This test also requires some ability to follow simple directions (Fig. 39-26). Additional information can be found in the articles by Rainsford, Cairns, and Mooney and by Dennis et al. Udén and Landin found that the pain drawing correlated well with clinical results. Ohnmeiss reported that the pain drawing remained consistent over 8 months in patients who reported no change in their symptoms. Also, the intraevaluator repeatability was found to be high in this as in other studies. Patients with low Rainsford scores were most likely to have definite pathological conditions and those with high Rainsford scores were least likely to have a demonstrable pathological condition. Cummings and Routan warned that the pain drawing should not be used to identify areas of somatic disturbance in chronic pain patients.

### Cervical Disc Disease

Herniation of the cervical intervertebral disc with spinal cord compression has been identified since Key detailed the pathological findings of two cases of cord compression by “intervertebral substance” in 1838. During the late 1800s and early 1900s there were many reports of chondromas of the cervical spine. Stookey described the clinical findings and anatomical location of cervical disc herniation in 1928 but attributed the lesion to a cervical chondroma. Mixter and Barr reported lumbar disc herniation in 1934 and included four cervical disc protrusions.

The classic approach to discs in this region has been posteriorly with laminectomy. This approach had been used as a standard exposure for extradural tumors. In 1943 Semmes and Murphey reported four patients in whom cervical disc rupture simulated coronary disease and introduced the concept that cervical disc disease usually manifested itself in root symptoms and not cord compression symptoms. Bailey and Badgley, Cloward, and Smith and Robinson in the 1950s popularized the anterior approach coupled with interbody fusion. Robertson in 1973, after the initial report by Hirsch in 1960, reported anterior cervical disectomy without fusion. He showed that simple anterior disc excision without fusion can give results similar to anterior cervical disc excision with anterior interbody fusion. More recently, Yamamoto et al. reported the long-term (2 to 13 year) results of anterior cervical disc excision without fusion. They noted 81% improvement in patients with soft disc hernias but only 47% improvement in patients with spondylolisthesis; 49% had neck and scapular pain as new postoperative symptoms for the first 4 weeks after surgery (Table 39-7). Spontaneous fusion was noted in 79% at 29 months. Currently, anterior cervical disectomy with fusion is the procedure of choice when the disc is removed anteriorly to avoid disc space collapse, prevent painful and abnormal cervical motion, and to speed intervertebral fusion. Foraminotomy is the procedure of choice when the disc fragment is removed posteriorly.

In an epidemiological study of acute cervical disc prolapse, Kelsey et al. indicated that cervical disc rupture was more common in men by a ratio of 1.4 to 1. Factors associated with the injury were frequent heavy lifting on the job, cigarette smoking, and frequent diving from a board. The use of vibrating equipment and time spent in motor vehicles were not positively associated with this problem. Participation in sports other than diving, frequent wearing of shoes with high heels, frequent twisting of the neck on the job, time spent sitting on the job, and smoking of cigars and pipes were not associated with cervical intervertebral disc collapse. Horal reported that 40% of the population in Sweden were sometimes affected by neck pain during their lives. Patients with cervical disc disease are also likely to have lumbar disc disease. MRI studies have shown increasing cervical disc degeneration with age.

---

**Table 39-6** Hs and Hy T Scores of Patients with Good or Excellent Results Versus Number of Preexisting Objective Deficits

<table>
<thead>
<tr>
<th>Hs and Hy T scores</th>
<th>Number of Patients</th>
<th>Percentage Good or Excellent Results</th>
<th>Percentage with the No. of Preinjection Objective Deficits Indicated*</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 and over</td>
<td>42</td>
<td>25</td>
<td>95.0 57.5 30.0 7.5 2.5</td>
</tr>
<tr>
<td>64 and below</td>
<td>57</td>
<td>87</td>
<td>95.2 64.4 32.6 8.7 2.2</td>
</tr>
</tbody>
</table>


* X² <0.001.
The pathophysiology of cervical disc disease is the same as degenerative disc disease in other areas of the spine. Disc swelling is followed by progressive annular degeneration. Frank extrusion of nuclear material can occur as a complication of this normal degenerative process. Kramer postulated that hydraulic pressure on the disc rather than excessive motion produces traumatic disc herniation. As the disc degeneration proceeds, hypermobility of the segment can result in instability or degenerative arthritic changes or both. Unlike in the lumbar spine, these hypertrophic changes are predominantly at the uncovertebral joint (uncinate process) (Fig. 39-27). Hypertrophic changes eventually develop about the facet joints and vertebral bodies. As in lumbar disease, progressive stiffening of the cervical spine and loss of motion are the usual result in the end stages. Hypertrophic spurring anteriorly occasionally results in dysphagia. Kang et al. identified the production of increased amounts of matrix metalloproteinases, nitric oxide, prostaglandin E2, and interleukin-6 in disc material removed from cervical disc hernias. They suggested that these products are involved in the biochemistry of disc degeneration. These substances also are implicated in pain production. These findings are similar to those in the lumbar spine. Kauppila and Penttila reported the presence of degenerative changes in the common arteries that supply the cervico-brachial area, and they suggested that impaired blood flow may play a part in cervico-brachial disorders.

Table 39-7  Postoperative Neck or Scapular Pain

<table>
<thead>
<tr>
<th>Follow-up Period</th>
<th>Soft Disc</th>
<th>Percentage</th>
<th>Spondylosis</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>4/11</td>
<td>36</td>
<td>8/34</td>
<td>53</td>
</tr>
<tr>
<td>1 year</td>
<td>1/11</td>
<td>9</td>
<td>10/29</td>
<td>34</td>
</tr>
<tr>
<td>2 years</td>
<td>0/10</td>
<td>0</td>
<td>6/24</td>
<td>25</td>
</tr>
<tr>
<td>4 years</td>
<td>0/5</td>
<td>0</td>
<td>4/21</td>
<td>19</td>
</tr>
</tbody>
</table>

SIGNS AND SYMPTOMS

The signs and symptoms of intervertebral disc disease are best separated into symptoms related to the spine itself, symptoms related to nerve root compression, and symptoms of myelopathy. Several authors reported that, when the disc is punctured anteriorly for the purpose of discography, pain is noted in the neck and shoulder. Complaints of neck pain, medial scapular pain, and shoulder pain are therefore probably related to primary pain about the disc and spine. Anatomical studies have indicated cervical disc and ligamentous innervations. This has been inferred to be similar in the cervical spine to that of the lumbar spine with its sinu-vertebral nerve. Tamura noted cranial symptoms such as headache, vertigo, tinnitus, and ocular problems associated with C3-4 root sleeve defects on myelography. Dwyer, Aprill, and Bogduk completed a two-stage investigation of the facet joints of the cervical spine as possible sources of pain. By injecting contrast medium into the facet joints of normal volunteers under roentgenographic control to the point of pain production, a topographical map was produced. Although the number of volunteers was small, the findings were consistent (Fig. 39-28). The second stage of the study included a small number of patients who had therapeutic injections based on the location of their pain, as it related to the previously constructed pain map. Pain relief occurred immediately and completely in 9 of 10 patients who had prior evaluation and failed other treatments. These pain patterns are not predicted by accepted dermatomal maps.

Symptoms of root compression usually are associated with pain radiating into the arm or chest with numbness in the fingers and motor weakness. Cervical disc disease also can mimic cardiac disease with chest and arm pain. Usually the radicular symptoms are intermittent and combined with the more frequent neck and shoulder pain.

The signs of midline cervical spinal cord compression (myelopathy) are unique and varied. The pain is poorly localized and aching in nature; pain may be only a minor complaint. Occasional sharp pain or generalized tingling may be described with neck extension. This is not unlike the Lhermitte sign in multiple sclerosis. The pain can be in both the shoulder and pelvic girdles; it is occasionally associated with a generalized feeling of weakness in the lower extremities and a feeling of instability.

In patients with predominant cervical spondylisis, symptoms of vertebral artery compression also may be found. These symptoms consist of dizziness, tinnitus, intermittent blurring of vision, and occasional episodes of retroocular pain.

The signs of lateral root pressure from a disc or osteophytes are predominantly neurological (Boxes 39-2 to 39-6). By evaluating multiple motor groups, multiple levels of deep
tendon reflexes, and sensory abnormalities, the level of the lesion can be localized as accurately as any other lesion in the nervous system. The multiple innervation of muscles can sometimes lead to confusion in determining the exact root involved. For this reason, myelography or other studies done for roentgenographic confirmation of the clinical impression usually are helpful.

Rupture of the C4-5 disc with compression of the C5 nerve root should result in weakness in the deltoid and biceps muscles. The deltoid is almost entirely innervated by C5, but the biceps has dual innervation. The biceps reflex may be diminished with injury to this nerve root, although it also has a C6 component, and this must be considered. Sensory testing should show a patch on the lateral aspect of the proximal arm to be diminished (Fig. 39-29).

Rupture of the C5-6 disc with compression of the C6 root can be confused with other root levels because of dual innervation of structures. Weakness may be noted in the biceps and extensor carpi radialis longus and brevis. As mentioned above, the biceps is dually innervated by C5 and C6, whereas the long extensors are dually innervated by C6 and C7. The brachioradialis and biceps reflexes also may be diminished at this level. Sensory testing usually indicates a decreased sensibility over the lateral proximal forearm, thumb, and index finger.

Rupture of the C6-7 disc with compression of the C7 root frequently results in weakness of the triceps. Weakness of the wrist flexors, especially the flexor carpi radialis, also is more indicative of C7 root problems. Extensor digitorum communis weakness also can indicate C7 root involvement and may be more readily apparent because of the normal relative weakness of this muscle compared to the triceps. Weakness of the flexor carpi ulnaris usually is caused more by C8 lesions. As mentioned above, finger extensors also may be weakened in that they have both C7 and C8 innervation. The triceps reflex may be diminished. Sensation is lost in the middle finger. C7 sensibility is variable because it is so narrow and overlap is prominent. Strong sensibility change can be difficult to document.
Rupture between C7 and T1 with compression of the C8 nerve root results in no reflex changes. Weakness may be noted in the finger flexors and in the interossei of the hand. Sensibility is lost on the ulnar border of the palm, including the ring and little fingers. Compression of T1 produces weakness of the interosseous muscles, decreased sensibility about the medial aspect of the elbow, and no reflex changes.

The clinical series of Odom, Finney, and Woodhall noted considerable variability in the level of compression and the neurological findings. Change in the triceps reflex was the predominant reflex change with compression of the sixth cervical root (56%). It also was the predominant reflex change in seventh root compression (64%). Similarly the index finger was the predominant digit with sensory change, with evidence of hypalgesia in both sixth (68%) and seventh (70%) cervical root compression.

Care should be taken in the examination of the extremity when radicular problems are encountered to rule out more distal compression syndromes in the upper extremities such as thoracic outlet syndrome, carpal tunnel syndrome, and cubital tunnel syndrome. The lower extremities should be examined with special attention to long tract signs indicative of myelopathy.

No tests for the upper extremity correspond with straight leg raising tests in the lower extremity. Davidson, Dunn, and Metzmaker described the shoulder abduction relief sign. This can be helpful in the diagnosis of cervical root compression syndromes. The test consists of shoulder abduction and elbow flexion with placement of the hand on the top of the head. This should relieve the arm pain caused by radicular compression. It is interesting to note that if this position is allowed to persist for a minute or two and pain is increased, then more distal compressive neuropathies such as a tardy ulnar nerve syndrome (cubital tunnel syndrome) or primary shoulder pathological conditions often are the cause. Viikari-Juntura, Porras, and Laasonen noted that the shoulder abduction, axial compression, and manual axial traction tests are related to disc disease, but the sensitivity of these tests is low.

Cervical paraspinal spasm and limitation of neck motion are frequent findings of cervical spine disease but are not indicative of a specific pathological process. Special maneuvers involving neck motion can be helpful in the selection of conservative treatment and identification of pathological processes. The distraction test, which involves the examiner placing his hands on the occiput and jaw and distracting the cervical spine in the neutral position, can relieve root compression pain but also can increase pain caused by ligamentous injury. Neck extension and flexion with or without traction can be helpful in selecting conservative therapies.

Patients relieved of pain with the neck extended, with or
without traction, usually have hypertensive syndromes with ligamentous injury posteriorly, whereas patients relieved of pain with distraction and neck flexion are more likely to have nerve root compression caused by either a soft ruptured disc or most likely hypertrophic spurs in the neural foramina. Pain usually is increased in any condition with compression. One must be careful before applying compression or distraction to be sure no cervical instability or fracture is present. One must also be careful in interpreting the distraction test to be certain the temporomandibular joint is not diseased or injured because distraction also will increase the pain in this area.

The signs of midline disc herniation are those of spinal cord compression. If the lesion is high in the cervical region, paresthesias, weakness, atrophy, and occasionally fasciculations may occur in the hands. Also present may be a Hoffman’s sign (upper cervical spinal cord) or the inverted radial reflex (typically indicating C5-6 pathology). Most commonly, however, the first and most prominent symptoms are those of involvement of the corticospinal tract; less commonly the posterior columns are affected. The primary signs are sustained clonus, hyperactive reflexes, and the Babinski reflex. Lesser findings are varying degrees of spasticity, weakness in the legs, and impairment of proprioception. Equilibrium may be grossly disturbed, but sense of pain and temperature sense rarely are lost and usually are of little localizing value.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of cervical disc disease is best separated into extrinsic and intrinsic factors. Extrinsic factors generally include disease processes extrinsic to the neck resulting in symptoms similar to primary neck problems. Included in this group are tumors of the chest, nerve compression syndromes distal to the neck, degenerative processes such as shoulder and upper extremity arthritis, temporomandibular joint syndrome, and lesions about the shoulder such as acute and chronic rotator cuff tears and impingement syndromes. Intrinsic problems primarily consist of lesions directly associated with the cervical spine, the most common being cervical disc degeneration with a concomitant complication of disc herniation and later development of hypertrophic arthritis. Congenital factors such as spinal stenosis in the cervical region also may produce symptoms. Primary and secondary tumors of the cervical spine and fractures of the cervical vertebrae also should be considered as intrinsic lesions.

Cervical disc disease has been categorized by Odom et al. into four groups: (1) unilateral soft disc protrusion with nerve root compression, (2) foraminal spur, or hard disc, with nerve root compression, (3) medial soft disc protrusion with spinal cord compression, and (4) transverse ridge or cervical spondylosis with spinal cord compression. Soft disc herniations usually affect one level, whereas hard disc herniations can affect multiple levels. Central lesions usually result in cord compression symptoms, and lateral lesions usually result in radicular symptoms.

Odom et al. reported that most of the soft disc herniations in their series occurred at the sixth cervical interspace (70%) and fifth cervical interspace (24%). Only six occurred at the seventh interspace. Foraminal spurs also were found predominantly at the sixth interspace (48%). The fifth interspace (39%) and seventh interspace (13%) accounted for the remaining levels where foraminal spurs were found. They also noted the incidence of medial soft disc protrusion with myelopathy to be rare (14 of 246 patients).

Disc material sometimes is extruded into the midline of the spinal canal anteriorly, with compression of the spinal cord and without nerve root involvement. Occasionally this is caused by a violent injury to the cervical spine, with or without fracture-dislocation, and at times it is associated with immediate quadriplegia. However, in some instances the symptoms are progressive and may be suggestive of spinal cord tumor or degenerative diseases of the spinal cord, such as amyotrophic lateral sclerosis, posterolateral sclerosis, and multiple sclerosis. In most of these ailments no block of the spinal canal has been reported, and for many years the mechanism causing the cervical cord compression was not understood. However, in the rare patients whom we have observed, spinal fluid block could be produced by hyperextending the neck, although with the neck in the neutral or flexed position the canal was completely open. This finding has been previously reported. It has since been observed that during operation on such patients when the neck is hyperextended, the superior edge of the lamina compresses the cord against the herniated disc, and it is therefore probable that repeated hyperextension of the neck over a period of weeks, months, or years gradually damages the spinal cord.

In view of the disturbances of the spinal fluid dynamics just mentioned, jugular compression should be carried out during lumbar puncture with the neck in the flexed, neutral, and hyperextended positions. Roentgenographically there is more often than not little or no alteration in the cervical curve. MRI usually demonstrates the abnormality without the need for myelography.

CONFIRMATORY TESTING

Roentgenographic evaluation of the cervical spine frequently shows loss of normal cervical lordosis. Disc space narrowing and hypertrophic changes frequent increase with age but are not indicative of cervical disc rupture. Usually roentgenograms are most helpful to rule out other problems. Oblique roentgenograms of the cervical spine may reveal foraminal encroachment.

MRI of the cervical spine has rapidly become the major diagnostic procedure for neck, arm, and shoulder symptoms. Maruyama evaluated the cervical discs in 36 cadavers using MRI and anatomical dissection and concluded that degeneration appeared to parallel T2 low intensity, but the incidence of false-positive posterior protrusion on MRI was remarkably high. MRI should confirm the objective clinical findings. Asymptomatic findings should be expected to increase with the
age of the patient. Cervical myelography usually is indicated only after noninvasive evaluation by MRI fails to reveal the cause or level of the lesion. If MRI is inconclusive, electromyography or nerve conduction velocity may be indicated to demonstrate active radiculopathy before proceeding with myelography, especially if the history and physical examination are not strongly supportive of the presence of radiculopathy. Cervical myelography usually is more precise than lumbar myelography, regardless of the contrast medium used. Postmyelogram CT scanning with block imaging and thin cuts is very helpful.

Cervical discography is a highly controversial technique with limited benefits. It is not indicated in frank disc rupture, spondylosis, or spinal stenosis. The primary use is in patients with persistent neck pain without localized neurological findings in whom standard MRI, myelographic, and CT scan studies are negative. Some investigators maintain that isolated painful discs can be identified in some patients by discography. Certainly a degenerative disc without pain on injection is not the source of the patient’s complaint. Cervical discography requires considerable care and caution. It should be considered a preoperative test in those patients in whom an anterior disc excision and interbody fusion are considered for primary neck and shoulder pain. Assessing the psychosocial well-being of a patient is recommended before proceeding with surgical treatment. Great care is required both in the technique and interpretation if reproducible results are desired. Cervical root blocks also have been suggested for the localization and confirmation of symptomatic root compression when used in conjunction with cervical discography. Facet joint injections also should be considered before fusion as a therapeutic as well as diagnostic procedure.

**Myelography**

When a component of dynamic cord compression is present, myelography remains a valuable tool, although dynamic MRI has reduced the role of myelography. Myelography is performed in the same way as for ruptured lumbar discs except that considerable attention must be paid to the flow of the column of contrast medium with the neck in hyperextended, neutral, and flexed positions. One cannot conclude that spinal cord compression is not present until one is certain that the cephalad flow of the medium is not obstructed with the neck acutely hyperextended. The neck should be hyperextended carefully because of the danger of further damage to the spinal cord.

**NONOPERATIVE TREATMENT**

As discussed earlier, most patients with symptomatic cervical disc herniations respond well to nonoperative treatment, including some patients with nonprogressive radicular weakness. Reasonably good evidence shows that acute disc herniations actually decrease in size over time in the cervical region. Many conservative treatment methods for neck pain are used for multiple diagnoses. The primary purpose of the cervical spine and associated musculature is to support and mobilize the head while providing a conduit for the nervous system. The forces on the cervical spine are therefore much smaller than on the lower spinal levels. The cervical spine is vulnerable to muscular tension forces, postural fatigue, and excessive motion. Most nonoperative treatments focus on one or more of these factors. The best primary treatment is short periods of rest, massage, ice, and antiinflammatory agents with active mobilization as soon as possible. The position of the neck for comfort is essential for relief of pain. The position of greatest relief may suggest the offending pathological process or mechanism of injury. Patients with hyperflexion injuries usually are more comfortable with the neck in extension over a small roll under the neck. No specific position is indicative of lateral disc herniation, although most tolerate the neutral position best. Patients with spondylosis (hard disc) are most comfortable with the neck in flexion.

Cervical traction can be helpful in selected patients. Care must be exercised in instructing the patient in the proper use of the traction. It should be applied to the head in the position of maximal pain relief. Traction never should be continued if it increases pain. The weights should rarely exceed 10 pounds (weight of the head). The proper head halter and duration of traction sessions should be chosen to prevent irritation of the temporomandibular joint. Traction applied by a patient-controlled pneumatic force, which is more mobile than halter-type units, avoids irritation of temporomandibular joint. Traction also should allow general relaxation of the patient. “Poor man’s” traction is a simple method of evaluating the efficacy of cervical traction. It uses the weight of the unsupported head for the traction weight (about 10 pounds). For extension traction, the patient is supine and the head is allowed to gently extend off the examining table or bed. For flexion the same procedure is repeated in the prone position. The patient continues the exercise in the position that is most comfortable for 5 to 10 minutes several times daily.

The postural aspects of neck pain can be treated with more frequent changes in position and ergonomic changes in the work area to prevent fatigue and encourage good posture. Techniques to minimize or relieve tension also are helpful.

Cervical braces usually limit excessive motion. Like traction, they should be tailored to the most comfortable neck position. They may be most helpful for patients who are very active.

Neck and shoulder exercises are most beneficial as the acute pain subsides. Isometric exercises are helpful in the acute phase. Occasionally, shoulder problems such as adhesive capsulitis may be found concomitantly with cervical spondylosis; therefore complete immobilization of the painful extremity should be avoided.

**OPERATIVE TREATMENT**

The primary indications for operative treatment of cervical disc disease are (1) failure of nonoperative pain management, (2) increasing neurological deficit, and (3) cervical myelopathy...
that will predictably progress, based on natural history studies. In most patients the persistence of pain is the primary indication. Intuitively, the level of persistent pain should be severe enough to consistently interfere with the patient’s desired activity and greater than would reasonably be expected after operative treatment. The choice of approach should be determined by the position and type of lesion. Soft lateral discs are easily removed from the posterior approach, whereas soft central or hard discs (central or lateral) probably are best treated with an anterior approach. Any controversy that existed relative to the need for fusion with anterior discectomy essentially has been resolved with long-term follow-up studies of patients without fusion, such as that by Yamamoto et al. mentioned previously. Osteophytes that were not removed at surgery have been shown frequently to be reabsorbed at the level of fusion. The use of a graft also prevents the collapse of the disc space and maintains adequate foraminal size.

**Removal of Posterolateral Herniations by Posterior Approach (Posterior Cervical Foraminotomy)**

**TECHNIQUE 39-15**

With the patient under general endotracheal anesthesia in the prone position and the face in a Mayfield positioner, flex the neck to obliterate the cervical lordosis as much as possible. The upright position for surgery decreases venous bleeding, but concern regarding the possibility of air embolism and cerebral hypoxia in the event of a significant drop in blood pressure makes us reluctant to recommend its use. Usually a slight reverse Trendelenburg position works well in posterior cervical surgery coupled with careful dissection to minimize bleeding. The shoulders are retracted inferiorly with tape if roentgenograms of the lower cervical levels are contemplated.

Appropriately prepare and drape the operative field. Make a midline incision 2.5 cm lower than the interspace to be explored (Fig. 39-30). Retract the edges of this incision and the skin will withdraw in a cephalad direction so that the wound becomes properly placed. Divide the ligamentum nuchae longitudinally to expose the tips of the spinous processes above and below the designated area. The correct position is reasonably well ensured by palpation of the last bith spine, which usually is the sixth cervical vertebra. However, it should be verified intraoperatively by a marker attached to the spinous process and documented on the lateral cervical spine roentgenogram. Dissect subperiosteally the paravertebral muscles from the laminae on the side of the lesion and retract them with a self-retaining retractor or with the help of an assistant using a Hibbs retractor.

With a small high-speed drill, grind away the caudal edge of the lateral portion of the lamina cephalad to the interspace. Usually minimal bone removal from the cephalad edge of the lateral portion of the caudal lamina is needed. Only a small amount of the medial portion of the facet needs to be removed in most patients. A small Kerrison rongeur (1 to 2 mm) can be used to enlarge this keyhole as needed. Sharply excise the ligamentum flavum with a small Kerrison rongeur and identify the nerve root, which is commonly displaced posteriorly and flattened by pressure from the underlying disc fragments. Removal of additional bone along the dorsal aspect of the foramen and immediately above and below the nerve root often is beneficial at this point. Once the bony removal has been completed, we prefer to use the operative microscope for the remainder of the procedure. This allows more delicate work around the neural elements while minimizing additional bone removal and allows better hemostasis.

The herniated nucleus pulposus most often lies slightly caudal to the center of the nerve root but occasionally cephalad. Gently retract the nerve root superiorly to expose the extruded nuclear fragments or a distended posterior longitudinal ligament. The nerve root should not be retracted in a caudal direction. If additional exposure is needed, remove more bone rather than risk nerve root or spinal cord injury from traction on the root. To control troublesome venous oozing at this point use bipolar cautery if possible. Otherwise, place tiny pledgets of cotton and thrombin-soaked Gelfoam above and below the nerve root. Take care not to pack the pledgets tightly around the nerve. The nerve root then can be retracted slightly in a cephalad direction to allow incision of the posterior longitudinal ligament over the herniated nucleus pulposus in a cruciate manner to permit the removal of the disc fragments.

After removal of all visible loose fragments, it is imperative to make a thorough search for additional fragments, both laterally and medially. It is equally important to be sure that the nerve root is thoroughly decompressed by inserting a probe in the intervertebral foramen. If the nerve root still seems to be tight, remove more bone from the articular facets until the nerve root is completely free. Since recurrence is so rare, do not curet the intervertebral space. Remove any cotton pledgets and Gelfoam after meticulous hemostasis has been achieved. Hemostasis must be complete because postoperative hemorrhage can produce cord compression and quadriplegia. Close the wound by suturing the fascia to the supraspinous ligament and allows better hemostasis.

**AFTERTREATMENT.** Neurological function is closely monitored after surgery. Discharge is permitted when the patient can walk and void. Pain should be controlled with oral medication. Currently most patients are discharged within 24 hours after surgery. Radicular pain relief usually is dramatic and prompt, although hypesthesia can persist for weeks or months. The patient is allowed to return to clerical work when comfortable...
and to manual labor after 6 weeks. As a rule, neither support nor physical therapy is necessary, and the patient’s future activity is not restricted. Isometric neck exercises, upper extremity range-of-motion exercises, and posterior shoulder girdle exercises can be useful for patients in whom atrophy or inactivity has been considerable. A soft cervical collar can help relieve immediate postoperative pain.

**Results.** In few if any operations in orthopaedic surgery are the results better than after the removal of a lateral herniated cervical disc. In the series of 250 operations reported by Simmons there were no deaths or major complications involving the brain or spinal cord. Three patients had reflex sympathetic dystrophy postoperatively. Two of these completely recovered and one almost so. Two patients continued to have arm pain after operation and were reexplored during the initial hospital stay; in each, several more fragments of disc were found and removed. It is assumed that these fragments were overlooked at the initial operation. One patient had a recurrent extrusion at the same level. Two other patients had soft extrusions on the opposite side at another level, also requiring a second operation.

Murphey, Simmons, and Brunson analyzed the results in a series of 150 patients who returned questionnaires concerning the success or failure of the operation. They were asked to state the percentage of benefit they derived from the procedure (Table 39-8), whether they were performing the same work as they had done preoperatively, and if not, whether the change of work had resulted from neck trouble. Approximately 90% had extremely good results, and there were none who were not significantly improved, as the data concerning work done confirm. Only 7 (6%) of the 125 patients who answered this part of the questionnaire found a change of work necessary because of neck trouble.

**Anterior Approach to Cervical Disc**

Smith and Robinson in 1955 were the first to recommend an anterior approach to the cervical spine in the treatment of cervical disc disease. They described an anterolateral discectomy with interbody fusion (Fig. 39-31). This pro-
Procedure attained widespread acceptance and application after Cloward in 1958 modified the procedure and introduced new instrumentation.

Three basic techniques are used for anterior cervical disc excision and fusion. The Cloward technique involves making a round hole centered at the disc space. A slightly larger, round iliac crest plug is then inserted into the disc space hole. The Smith-Robinson technique involves inserting a tricortical plug of iliac crest into the disc space after removing the disc and cartilaginous endplate. The graft is inserted with the cancellous side facing the cord (posterior). Bloom and Raney modified this technique by fashioning the tricortical graft to be thicker in its midportion and then inserting the graft with the cancellous portion facing anteriorly. The Bailey-Badgley technique involves the creation of a slot in the superior and inferior vertebral bodies. This technique is most applicable to reconstruction when one or more vertebral bodies are excised for tumor, stenosis, or other extensive pathological conditions. Simmons and Bhalla modified this technique by using a keystone graft that increases the surface area of the graft by 30% and allows more complete locking of the graft. Biomechanically, the Smith-Robinson technique provides the greatest stability and least risk of extrusion, compared to the Cloward or Bailey-Badgley type fusions.

White et al. reported relief of pain in 90% of 65 patients undergoing anterior cervical spine fusion for spondylosis with the technique of Smith and Robinson. Analysis of 90 patients with anterior cervical discectomies and fusion for cervical spondylosis with radiculopathy using the Cloward technique showed good or excellent results in 82% in the study by Jacobs, Krueger, and Levy. These investigators did not use discography. Others also have found that discography does not statistically improve the results. The Smith-Robinson technique is used almost exclusively at this clinic for anterior cervical discectomy procedures.

The choice of right- or left-sided approach to the cervical spine is somewhat controversial. The right side of the neck is preferred by some right-handed surgeons because of the ease of dissection. The reported increased risk of recurrent laryngeal nerve trauma when operating on the right is not judged by those who use it to be a significant deterrent to choosing this exposure. Exposure from the left is more inconvenient for a right-handed surgeon but decreases the risk of recurrent laryngeal nerve injury. This nerve on the left consistently descends with the carotid sheath and exits from the carotid sheath and vagus nerve intrathoracically. The nerve then courses under the arch of the aorta and ascends in the neck beside the trachea and esophagus. The course of the nerve on the right is not as consistent. The nerve usually descends with the carotid sheath and then loops around the subclavian artery and ascends between the trachea and esophagus. Occasionally the right recurrent laryngeal nerve exits the carotid sheath early and crosses anteriorly behind the thyroid. A large series of anterior cervical procedures implicated the endotracheal tube in combination with self-retaining retractors as the cause of

---

**Table 39-8** Results of Removal of Lateral Herniated Discs in Cervical Region (Patient’s Estimate of Percent Improvement)

<table>
<thead>
<tr>
<th>Relief (%)</th>
<th>Patients Improved (%)</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>95-100</td>
<td>65.3</td>
<td>98</td>
</tr>
<tr>
<td>90-94</td>
<td>23.3</td>
<td>35</td>
</tr>
<tr>
<td>75-89</td>
<td>8.0</td>
<td>12</td>
</tr>
<tr>
<td>50-74</td>
<td>3.3</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>150</td>
</tr>
</tbody>
</table>


---

Microsurgical Anterior Cervical Foraminotomy

An anterior foraminotomy has been performed in several reports of microsurgical anterior foraminotomy to treat unilateral foraminal nerve compression from soft disc herniations or uncovertebral joint degenerative change. Verbiest first described this technique; Jho reported a modification, and Johnson reported a small clinical series. This technique appears to allow adequate decompression of the ventral aspect of the foramen unilaterally while removing the lateral portion of the disc, thus preserving the remaining disc. The long-term results are not yet available to compare this technique with anterior discectomy with fusion. We do not have any clinical experience with this technique.

Microsurgical Anterior Cervical Foraminotomy

TECHNIQUE 39-16 (Jho)

After anesthesia has been administered by means of endotracheal intubation, place the patient supine, with a bolster placed behind both shoulders to maintain gentle extension of the cervical spine. Position the head with the midline upright. Gently pull both shoulders caudally and fix with tape for a good lateral view of the cervical spine on intraoperative roentgenogram. Do not use a cervical traction device. Prepare the anterior neck with antiseptic solution and drape.

Make a 3- to 5-cm long transverse incision in a skin crease ipsilateral to the radiculopathy. The first two thirds of the incision should be medial to the sternocleidomastoid muscle and the remainder should be lateral to the medial border of that muscle. Incise the subcutaneous tissue and platysma muscle along the line of the skin incision. Cleanly undermine the loose connective tissue layer under the platysma muscle to provide space in which to work. Use a combination of sharp and blunt dissection to access the anterior column of the cervical spine. Keep the carotid artery and the sternocleidomastoid muscle lateral and the strap muscle, trachea, and esophagus medial. Open the prevertebral fascia and expose the anterior column of the cervical spine. Confirm the correct level roentgenographically.

Use an anterior cervical discectomy retractor system to expose the ipsilateral longus colli muscle (Fig. 39-32, A). Use only smooth-tipped retractor blades to avoid injury to the trachea and esophagus medially and the carotid artery and vagus nerve laterally. Use the operating microscope at this stage and excise the medial portion of the longus colli muscle to expose the medial parts of the transverse processes of the upper and lower vertebrae (Fig. 39-32, B). Expose the vertebral artery anterior to the C7 transverse process. When operating at C6-7 take care not to injure the vertebral artery while removing the medial portion of the longus colli muscle. For operations above C6-7, the vertebral artery is not exposed purposely at this point.

Once the medial parts of the transverse processes of the upper and lower vertebrae have been identified, the ipsilateral uncovertebral joint between them can be seen. The interface of the uncovertebral joint is angled approximately 30 degrees cephalad from the horizontal line of the intervertebral disc. Make a sharp vertical incision of the disc at the medial margin of the ipsilateral uncovertebral joint to prevent inadvertent internal disruption of the remaining disc. While drilling the bone, repeated sharp cutting of the deeper disc may be required. Remove the thin layer of disc material located at the uncovertebral joint.

Drill between the transverse processes of the uncovertebral joint using a high-speed microdrill attached to an angled handpiece (Fig. 39-32, B). To prevent injury to the vertebral artery, leave the thin cortical bone attached to the ligamentous tissue covering the medial portion of this artery. Continue drilling down to the posterior longitudinal ligament (Fig. 39-32, C). While drilling posteriorly, gently incline medially. When the posterior longitudinal ligament is exposed, a piece of thin cortical bone remains attached lateral to the ligamentous tissue covering the vertebral artery. Dissect the lateral remnant of the uncinate process from the ligamentous tissue and fracture it at the base of the uncinate process (Fig. 39-32, D). Further dissect it from the surrounding soft tissue and remove it. The vertebral artery can be identified by its pulsation between the transverse processes of the vertebrae. Drilling at the base of the uncinate process must proceed cautiously because the nerve root lies just behind it. After the uncinate process becomes loosened at its base, remove the remaining thin bone of the uncinate process by fracturing it from its base rather than by continued drilling. Once the remaining piece of uncinate process is removed, the compressed nerve root will be distended forward by bone decompression (Fig. 39-32, E). The size of the hole that is made by drilling at the uncovertebral joint usually is approximately 5 to 8 mm wide transversely and 7 to 10 mm wide vertically. If there is no ruptured herniated disc fragment behind the posterior longitudinal ligament, this will end the nerve root decompression.

At this point the posterior longitudinal ligament still covers the nerve root and the lateral margin of the spinal cord. If the disc fragment has ruptured through the posterior longitudinal ligament, the tail of the disc material will be visible. Remove this disc fragment at this time. To avoid overlooking a hidden disc fragment, use a no. 15 blade knife or micro scissors to incise the ligament and remove any fragment with a 1- or 2-mm foot-plated bone punch. The
ipsilateral one third to one half of the spinal cord is thus exposed and the nerve root can be seen laterally as it exits behind the vertebral artery (Fig. 39-32, F).

Jho reported excision of the posterior longitudinal ligament in selected cases because it is unlikely that a hidden ruptured disc fragment could be present without disruption of this ligament. Removal of the ligament sometimes is complicated by epidural bleeding. If the ligament is not removed, the procedure is much simpler and the operating time is shorter. If epidural bleeding occurs during removal of the posterior longitudinal ligament, use bipolar coagulation. To avoid any potential compressive material coming into contact with the nerve root or spinal cord, do not use hemostatic agents. Although epidural bleeding usually is not a problem, removing the posterior longitudinal ligament is the most difficult part of this procedure. The disc within the intervertebral space remains untouched and preserved.

Close the platysma with interrupted 3-0 absorbable stitches and approximate the skin with subcuticular sutures. The operation can be performed at multiple levels. To minimize postoperative incisional pain, inject a few milliliters of local anesthetic subcutaneously.

**Thoracic Disc Disease**

The thoracic spine is the least common location for disc pathology. C.A. Key has been credited with the first report of a spinal cord injury caused by thoracic disc herniation, which appeared in 1838 in the Guy’s Hospital Report. In the early twentieth century several reports of enchondromata, chondromata, or echondromata appeared. In their study in 1934 Mixter and Barr included four patients with a thoracic location of the herniated nucleus pulposus. Of the four patients in this series, three were treated operatively and one nonoperatively. The patient with nonoperative treatment died soon after diagnosis. Of the surgical group, two had complete paraplegia postoperatively. The third surgical patient died several months later for unknown reasons. These three were treated with posterior laminectomy. This initial report not only described the condition, but also revealed some of the difficulties of treatment.
Since the 1960s many other approaches have been described and validated through clinical experience. It is apparent that posterior laminectomy has no role in the surgical treatment of this problem. Other posterior approaches, such as costotransversectomy, have good indications. Fessler and Sturgill, as well as Vanichkachorn and Vaccaro, chronicled the history and treatment evolution for thoracic disc disease.

Symptomatic thoracic disc herniations remain relatively rare, with an estimated incidence of 1 in 1,000,000 persons per year. They represent 0.25% to 0.75% of the total incidence of symptomatic disc herniations. The most common age of onset is between the fourth and sixth decades. As with the other areas of the spine, the incidence of asymptomatic disc herniations is high. Wood et al. reviewed MRI studies in 90 asymptomatic patients and found thoracic disc abnormalities in 73%. Of these, 37% had frank herniations and 29% showed cord compression. At a mean follow-up of 26 months with repeat MRI of some of these patients none had become symptomatic. Also, Wood et al. noted that small herniations often increased, whereas the larger herniations often regressed. Operative treatment of thoracic disc herniations is indicated in the rare patient with acute disc herniation with myelopathic findings attributable to the lesion, especially progressive neurological symptoms.

SIGNS AND SYMPTOMS

Fortunately, the natural history of symptomatic thoracic disc disease is similar to that in other areas, in that symptoms and function typically improve with conservative treatment and time. However, the clinical course can be quite variable, and a high index of suspicion must be maintained to make the correct diagnosis. The differential diagnosis for the symptoms of thoracic disc herniations is fairly extensive and includes nonspecific causes occurring with the cardiopulmonary, gastrointestinal, and musculoskeletal systems. Spinal causes of similar symptoms can occur with infectious, neoplastic, degenerative, and metabolic problems within the spinal column as well as the spinal cord.

Two general patient populations have been documented in the literature. The smaller group of patients is younger and has a relatively short history of symptoms, often with a history of trauma. Typically, an acute soft disc herniation with either acute spinal cord compression or radiculopathy is present. Outcome generally is favorable with operative or nonoperative treatment. The larger group of patients has a longer history, often more than 6 to 12 months of symptoms, which result from chronic spinal cord or root compression. Disc degeneration, often with calcification of the disc, is the underlying process.

Pain is clearly the most common presenting feature of thoracic disc herniations. There appear to be two patterns of pain: one is axial and the other is bandlike radicular pain along the course of the intercostal nerve. The T10 dermatomal level is the most commonly reported distribution, regardless of the level of involvement. This is a band extending around the lower lateral thorax and caudally to the level of the umbilicus. This pattern is more common with upper thoracic and lateral disc herniations. Some axial pain often occurs with this pattern as well. Associated sensory changes of paresthesias and dysesthesia in a dermatomal distribution also occur. Other radicular patterns as well. Associated sensory changes of paresthesias and dysesthesia in a dermatomal distribution also occur. (Fig. 39-33). High thoracic discs (T2 to T5) can present similarly to cervical disc disease with upper arm pain, paresthesias, radiculopathy, and even Horner’s syndrome. Myelopathy also may occur. Complaints of weakness, which may be generalized by the patient, typically involving both lower extremities present in the form of mild paraparesis. The presence of sustained clonus, a positive Babinski sign, and wide-based and spastic gait are all signs of myelopathy. Bowel and bladder dysfunction occur in only about 15% to 20% of these patients. The neurological evaluation of patients with thoracic disc herniations must be meticulous because there are few localizing findings. Abdominal reflexes, cremasteric reflex, dermatomal sensory evaluation, rectus abdominis contraction symmetry, lower extremity reflex, strength, and sensory examinations, as well as determination of long tract findings, are all important.

CONFIRMATORY TESTING

Plain roentgenograms are of some help to evaluate traumatic injuries and to determine potential osseous morphological variations that may help to localize findings, especially on intraoperative films, if these become necessary. MRI is the most important and useful imaging method to demonstrate thoracic disc herniations. In addition to the disc herniation, neoplastic or infectious pathology can be seen. The presence of intradural pathology, including disc fragments, also usually is demonstrated on MRI. The spinal cord signal may indicate the
presence of inflammation or myelomalacia as well. Despite all these advantages, MRI may underestimate the thoracic disc herniation, which often is calcified and thus has low signal intensity on T1 and T2 sequences.

Myelography followed by CT scanning also can be useful in evaluating the bony anatomy, as well as more accurately assessing the calcified portion of the herniated thoracic disc. Regardless of the imaging methods used, the appearance and presence of a thoracic disc herniation must be carefully considered and correlated with the patient’s complaints and detailed examination findings.

TREATMENT RESULTS

As mentioned previously, nonoperative treatment usually is effective. Brown reported that 63% of patients improved using a combination of nonoperative treatments. A specific regimen cannot be recommended for all patients; however, the principles of short-term rest, pain relief, antiinflammatory agents, and progressive directed activity restoration appear most appropriate. These measures generally should be continued at least 6 to 12 weeks if feasible. If neurologic deficits progress or present as myelopathy, or if pain remains at an intolerable level, surgery should be recommended. The initial procedure recommended for this lesion was posterior thoracic laminectomy and disc excision. At least half of the lesions have been identified as being central, making the excision from this approach extremely difficult, and the results were somewhat disheartening. Most series reported fewer than half of the patients improving, with some becoming worse after posterior laminectomy and discectomy. Most recent studies suggest that lateral rhachiotomy (modified costotransversectomy) or an anterior transthoracic approach for discectomy produces considerably better results with no evidence of worsening after the procedure. Video-assisted thoracic surgery (VATS) has been used in several series to successfully remove central thoracic disc herniations without the need for a thoracotomy or fusion. Bohlman and Zdeblick reported the results of anterior transthoracic approach extremely difficult. Make a skin incision along the line of the rib involved intervertebral disc except for approaches to the upper five thoracic segments, where the approach is through the third rib. Choose the skin incision by inspection of the anteroposterior roentgenogram. Cut the rib subperiosteally at its posterior and anterior ends and then insert a rib retractor. Save the rib for grafting later in the procedure. One can then decide on an extrapleural or transpleural approach depending on familiarity and ease. Exposure of the thoracic vertebrae should give adequate access to the front and opposite side. Dissect the great vessels free of the spine.

Costotransversectomy

Costotransversectomy is probably best suited for thoracic disc herniations that are predominantly lateral or herniations that are suspected to be extruded or sequestered. Central disc herniations are probably best approached transthoracically. Some surgeons have recommended subsequent fusion after disc removal anteriorly or laterally.

TECHNIQUE 39-17

The operation usually is done with the patient under general anesthesia with a cuffed endotracheal tube or a Carlen tube to allow lung deflation on the side of approach. Place the patient prone and make a long midline incision or a curved incision convex to the midline centered over the side of involvement. Expose the spine in the usual manner out to the ribs. Remove a section of rib 3 to 7.5 cm long at the level of involvement, taking care to avoid damage to the intercostal nerve and artery. Carry the resection into the lateral side of the disc, exposing it for removal. Additional exposure can be made by laminectomy and excision of the pedicle and facet joint. Fusion is unnecessary unless more than one facet joint is removed. Close the wound in layers.

AFTERTREATMENT. The aftertreatment is similar to that for lumbar disc excision without fusion (Technique 39-21).

Anterior Approach for Thoracic Disc Excision

Because of the relative age of patients with thoracic disc ruptures, special care must be taken to identify those with pulmonary problems. In these patients the anterior approach can be detrimental medically, making a posterolateral approach safer. Patients with midline protrusions probably are best treated with the transthoracic approach to ensure complete disc removal.

TECHNIQUE 39-18

The operation is done with the patient under general anesthesia, using auffed endotracheal tube or Carlen tube for lung deflation on the side of the approach. Place the patient in a lateral recumbent position. A left-sided anterior approach usually is preferred, making the operative procedure easier. Make a skin incision along the line of the rib that corresponds to the second thoracic vertebra above the involved intervertebral disc except for approaches to the upper five thoracic segments, where the approach is through the third rib. Choose the skin incision by inspection of the anteroposterior roentgenogram. Cut the rib subperiosteally at its posterior and anterior ends and then insert a rib retractor. Save the rib for grafting later in the procedure. One can then decide on an extrapleural or transpleural approach depending on familiarity and ease. Exposure of the thoracic vertebrae should give adequate access to the front and opposite side. Dissect the great vessels free of the spine.
Ligate the intersegmental vessels near the great vessels and not near the foramen. One should be able to insert the tip of a finger against the opposite side of the disc when the vascular mobilization is complete. Exposure of the intervertebral disc without disturbing more than three segmental vessels is preferable to avoid ischemic problems in the spinal cord. In the thoracolumbar region strip the diaphragm from the eleventh and twelfth ribs. The anterior longitudinal ligament usually is sectioned to allow spreading of the intervertebral disc space. Remove the disc as completely as possible if fusion is planned. The use of the operating microscope or loupe magnification eases the removal of the disc near the posterior longitudinal ligament. Use curets and nibbling instruments to remove the disc up to the posterior longitudinal ligament. Then place a finger on the opposite side of the disc to avoid penetration when removing disc material on the more distant side. Carefully inspect the posterior longitudinal ligament for tears and extruded fragments. Remove the posterior longitudinal ligament only if necessary. Significant bleeding can occur if the venous plexus near the dura is torn. After removal of the disc, strip the endplates of their cartilage. Make a slot in one vertebral endplate.
body and a hole in the body on the opposite side of the disc space to accept the graft material. Make the hole large enough to accept several sections of rib, but make the slot large enough to accept only one rib graft at a time. Then insert iliac, tibial, or rib grafts into the disc space. Tie the grafts together with heavy suture material when the maximal number of grafts have been inserted. Close the wound in the usual manner and employ standard chest drainage. As an alternative, if fusion is not desired a more limited resection using the operating microscope can be done. After the vascular mobilization, resect the rib head to allow observation of the pedicle and foramen caudal to the disc space. The pedicle can be removed with a high-speed burr and Kerrison rongeurs, thus exposing the posterolateral aspect of the disc. This allows careful, blunt development of the plane ventral to the dura with removal of the disc herniation and preservation of the anterior majority of the disc, as well as limiting the need for fusion. A similar technique using VATS is described in Technique 39-19.

The transthoracic approach removing a rib two levels above the level of the lesion can be used up to T5. The transthoracic approach from T2 to T5 is best made by excision of the third or fourth rib and elevation of the scapula by sectioning of attachments of the serratus anterior and trapezius from the scapula. The approach to the T1-2 disc is best made from the neck with a sternal splitting incision.

**AFTERTREATMENT.** Postoperative care is the same as for a thoracotomy. The patient is allowed to walk after the chest tubes are removed. Extension in any position is prohibited. A brace or body cast that limits extension should be used if the stability of the graft is questionable. The graft usually is stable without support if only one disc space is removed. Postoperative care is the same as for anterior corpectomy and fusion if more than one disc level is removed. If no fusion is done, the patient is mobilized as pain permits without a brace.

**Thoracic Endoscopic Disc Excision**

Microsurgical and endoscopic surgical techniques are being applied to the anterior excision of thoracic disc herniation. Rosenthal et al. and Horowitz et al. first performed these procedures on cadavers to perfect the technique. Because these methods are highly technical, they should be performed by a surgeon who is proficient in this technique and in the use of endoscopic equipment and with the assistance of an experienced thoracic surgeon. Ideally the procedure should be done on cadavers or live animals first. Regan et al. also described this technique, with different portal positions.

**TECHNIQUE 39-19 (Rosenthal et al.)**

(Figs. 39-35 and 39-36)

Place the patient in the left lateral decubitus position to allow a right-sided approach and displacement of the aorta and heart to the left. Insert four trocars in a triangular fashion along the middle axillary line converging on the disc space. Introduce a rigid endoscope with a 30-degree optic angle attached to a video camera into one of the trocars, leaving the other three as working channels. Deflate the lung using a Carlin tube or similar method. Split the parietal pleura starting at the medial part of the intervertebral space and extending up to the costovertebral process. Preserve and mobilize the segmental arteries and sympathetic nerve out of the operating field. Drill away the rib head and lateral
portion of the pedicle. Remove the remaining pedicle with Kerrison rongeurs to improve exposure to the spinal canal. Removing the superior posterior portion of the vertebra caudal to the disc space allows safer removal of the disc material, which then can be pulled anteriorly and inferiorly away from the spinal canal to be removed. Use endoscopic instruments for surgery in the portals. Remove the disc posteriorly and the posterior longitudinal ligament, restricting bone and disc removal to the posterior third of the intervertebral space and costovertebral area to maintain stability. Insert chest tubes in the standard fashion and set them to water suction; close the portals.

**AFTERTREATMENT.** The patient is rapidly mobilized as tolerated by the chest tubes. Discharge is possible once the chest tubes have been removed and the patient is ambulating well.

### Lumbar Disc Disease

#### SIGNS AND SYMPTOMS

Although back pain is common from the second decade of life on, intervertebral disc disease and disc herniation are most prominent in otherwise healthy people in the third and fourth decades of life. Most people relate their back and leg pain to a traumatic incident, but close questioning frequently reveals that the patient has had intermittent episodes of back pain for many months or even years before the onset of severe leg pain. In many instances the back pain is relatively fleeting and is relieved by rest. This pain often is brought on by heavy exertion, repetitive bending, twisting, or heavy lifting. In other instances an exacerbating incident cannot be elicited. The pain usually begins in the lower back, radiating to the sacroiliac region and buttocks. The pain can radiate down the posterior thigh. Back and posterior thigh pain of this type can be elicited from many areas of the spine, including the facet joints, longitudinal ligaments, and the periosteum of the vertebra. Radicular pain, on the other hand, usually extends below the knee and follows the dermatome of the involved nerve root.

The usual history of lumbar disc herniation is of repetitive lower back and buttock pain, relieved by a short period of rest. This pain is then suddenly exacerbated by a flexion episode, with the sudden appearance of leg pain much greater than back pain. Most radicular pain from nerve root compression caused by a herniated nucleus pulposus is evidenced by leg pain equal to, or in many cases much greater than, the degree of back pain. Whenever leg pain is minimal and back pain is predominant, great care should be taken before making the diagnosis of a symptomatic herniated intervertebral disc. The pain from disc herniation usually is intermittent, increasing with activity, especially sitting. The pain can be relieved by rest, especially in the semi-Fowler position, and can be exacerbated by straining, sneezing, or coughing. Whenever the pattern of pain is bizarre or the pain itself is constant, a diagnosis of symptomatic herniated disc should be viewed with some skepticism.

Other symptoms of disc herniation include weakness and paresthesias. In most patients the weakness is intermittent, variable with activity, and localized to the neurological level of involvement. Paresthesias also are variable and limited to the dermatome of the involved nerve root. Whenever these complaints are generalized, the diagnosis of a simple unilateral disc herniation should be questioned.

Numbness and weakness in the involved leg and occasionally pain in the groin or testicle can be associated with a high or midline lumbar disc herniation. If a fragment is large or the herniation is high, symptoms of pressure on the entire cauda equina can be elicited. These include numbness and weakness in both legs, rectal pain, numbness in the perineum, and paralysis of the sphincters. This diagnosis should be the primary consideration in patients who complain of sudden loss of bowel or bladder control. Whenever the diagnosis of a cauda equina syndrome or acute midline herniation is suspected, evaluation and treatment should be aggressive.

### PHYSICAL FINDINGS

The physical findings in back pain with disc disease are variable because of the time intervals involved. Usually patients with acute pain show evidence of marked paraspinal spasm that is sustained during walking or motion. A scoliosis or
a list in the lumbar spine may be present, and in many patients the normal lumbar lordosis is lost. As the acute episode subsides, the degree of spasm diminishes remarkably, and the loss of normal lumbar lordosis may be the only telltale sign. Point tenderness may be present over the spinous process at the level of the disc involved, and in some patients pain may extend laterally.

If there is nerve root irritation, it centers over the length of the sciatic nerve, both in the sciatic notch and more distally in the popliteal space. In addition, stretch of the sciatic nerve at the knee should reproduce buttock, thigh, and leg pain (i.e., pain distal to the knee). A Lasègue sign usually is positive on the involved side. A positive Lasègue sign or straight leg raising should elicit buttock or leg pain distal to the knee or both on the side tested. Occasionally if leg pain is significant the patient will lean back from an upright sitting position and assume the tripod stance to relieve the pain. Contralateral leg pain produced by straight leg raising should be regarded as pathognomonic of a herniated intervertebral disc. The absence of a positive Lasègue sign should make one skeptical of the diagnosis, although older individuals may not have a positive Lasègue sign. Likewise, inappropriate findings and inconsistencies in the examination usually are nonorganic in origin (see discussion of nonspecific back pain). If the leg pain has persisted for any length of time, atrophy of the involved limb may be present, as demonstrated by asymmetrical girth of the thigh or calf. The neurological examination will vary as determined by the level of root involvement (Boxes 39-7 to 39-9).

Smith et al. examined the motion of the spinal roots in cadavers. They observed 0.5 to 5 mm of linear motion and 2% to 4% strain on the nerves at L4, L5, and S1. With increased strain, the roots moved lateral to the pedicle.

Unilateral disc herniation between L3 and L4 usually compresses the fourth lumbar root as it crosses the disc before exiting at the L4 intervertebral foramen. Pain may be localized around the medial side of the leg. Numbness may be present over the anteromedial aspect of the leg. The tibialis anterior may be weak as evidenced by inability to heel walk. The quadriceps and hip adductor group, both innervated from L2, L3, and L4, also may be weak and, in extended ruptures, atrophic. Reflex testing may reveal a diminished or absent patellar tendon reflex (L2, L3, and L4) or tibialis anterior tendon reflex (L4). Sensory testing may show diminished sensibility over the L4 dermatome, the isolated portion of which is the medial leg (Fig. 39-37), and the autonomous zone of which is at the level of the medial malleolus.

Unilateral disc herniation between L4 and L5 results in compression of the fifth lumbar root. Fifth lumbar root radiculopathy should produce pain in the dermatomal pattern. Numbness, when present, follows the L5 dermatome along the sciatic notch and more distally in the popliteal space. In addition, stretch of the sciatic nerve at the knee should reproduce buttock, thigh, and leg pain (i.e., pain distal to the knee). A Lasègue sign usually is positive on the involved side. A positive Lasègue sign or straight leg raising should elicit buttock or leg pain distal to the knee or both on the side tested. Occasionally if leg pain is significant the patient will lean back from an upright sitting position and assume the tripod stance to relieve the pain. Contralateral leg pain produced by straight leg raising should be regarded as pathognomonic of a herniated intervertebral disc. The absence of a positive Lasègue sign should make one skeptical of the diagnosis, although older individuals may not have a positive Lasègue sign. Likewise, inappropriate findings and inconsistencies in the examination usually are nonorganic in origin (see discussion of nonspecific back pain). If the leg pain has persisted for any length of time, atrophy of the involved limb may be present, as demonstrated by asymmetrical girth of the thigh or calf. The neurological examination will vary as determined by the level of root involvement (Boxes 39-7 to 39-9).

Smith et al. examined the motion of the spinal roots in cadavers. They observed 0.5 to 5 mm of linear motion and 2% to 4% strain on the nerves at L4, L5, and S1. With increased strain, the roots moved lateral to the pedicle.

Unilateral disc herniation between L3 and L4 usually compresses the fourth lumbar root as it crosses the disc before exiting at the L4 intervertebral foramen. Pain may be localized around the medial side of the leg. Numbness may be present over the anteromedial aspect of the leg. The tibialis anterior may be weak as evidenced by inability to heel walk. The quadriceps and hip adductor group, both innervated from L2, L3, and L4, also may be weak and, in extended ruptures, atrophic. Reflex testing may reveal a diminished or absent patellar tendon reflex (L2, L3, and L4) or tibialis anterior tendon reflex (L4). Sensory testing may show diminished sensibility over the L4 dermatome, the isolated portion of which is the medial leg (Fig. 39-37), and the autonomous zone of which is at the level of the medial malleolus.

Unilateral disc herniation between L4 and L5 results in compression of the fifth lumbar root. Fifth lumbar root radiculopathy should produce pain in the dermatomal pattern. Numbness, when present, follows the L5 dermatome along the anterolateral aspect of the leg and the dorsum of the foot, including the great toe. The autonomous zone for this nerve is the dorsal first web of the foot and the dorsum of the third toe. Weakness may involve the extensor hallucis longus (L5), gluteus medius (L5), or extensor digitorum longus and brevis (L5). Reflex change usually is not found. A diminished tibialis posterior reflex is possible but difficult to elicit.

With unilateral rupture of the disc between L5 and S1 the findings of an S1 radiculopathy are noted. Pain and numbness involve the dermatome of S1. The S1 dermatome includes the lateral malleolus and the lateral and plantar surface of the foot, occasionally including the heel. There is numbness over the lateral aspect of the leg and, more important, over the lateral aspect of the foot, including the lateral three toes. The...
autonomous zone for this root is the dorsum of the fifth toe. Weakness may be demonstrated in the peroneus longus and brevis (S1), gastrocnemius-soleus (S1), or gluteus maximus (S1). In general, weakness is not a usual finding in S1 radiculopathy. Occasionally, mild weakness may be demonstrated by asymmetrical fatigue with exercise of these motor groups. The ankle jerk usually is reduced or absent.

Massive extrusion of a disc involving the entire diameter of the lumbar canal or a large midline extrusion can produce pain in the back, legs, and occasionally perineum. Both legs may be paralyzed, the sphincters may be incontinent, and the ankle jerks may be absent. Tay and Chacha in 1979 reported that the combination of saddle anesthesia, bilateral ankle areflexia, and bladder symptoms constituted the most consistent symptoms of cauda equina syndrome caused by massive intervertebral disc extrusion at any lumbar level. In these instances a cystometrogram may show bladder denervation.

More than 95% of the ruptures of the lumbar intervertebral discs occur at L4 or L5. Ruptures at higher levels in many patients are not associated with a positive straight leg raising test. In these instances, a positive femoral stretch test can be helpful. This test is carried out by placing the patient prone and acutely flexing the knee while placing the hand in the popliteal fossa. When this procedure results in anterior thigh pain, the result is positive and a high lesion should be suspected. In addition, these lesions may occur with a more diffuse neurological complaint without significant localizing neurological signs.

Often the neurological signs associated with disc disease vary over time. If the patient has been up and walking for a period of time, the neurological findings may be much more pronounced than if he has been at bed rest for several days, thus decreasing the pressure on the nerve root and allowing the nerve to resume its normal function. In addition, various conservative treatments can change the physical signs of disc disease.

Comparative bilateral examination of a patient with back and leg pain is essential in finding a clear-cut pattern of signs and symptoms. It is not uncommon for the evaluation to change. Adverse changes in the examination may warrant more aggressive therapy, whereas improvement of the symptoms or signs should signal a resolution of the problem. Early symptoms or signs suggestive of cauda equina syndrome or severe or progressive neurological deficit should be treated aggressively from the onset. McLaren and Bailey warn that the cauda equina syndrome is more frequent when disc excision is performed in the presence of an untreated spinal stenosis at the same level.
DIFFERENTIAL DIAGNOSIS

The differential diagnosis of back and leg pain is extremely lengthy and complex. It includes diseases intrinsic to the spine and those involving adjacent organs but causing pain referred to the back or leg. For simplicity, lesions can be categorized as being extrinsic or intrinsic to the spine. Extrinsic lesions include diseases of the urogenital system, gastrointestinal system, vascular system, endocrine system, nervous system not localized to the spine, and the extrinsic musculoskeletal system. These lesions include infections, tumors, metabolic disturbances, congenital abnormalities, and the associated diseases of aging. Intrinsic lesions involve those diseases that arise primarily in the spine. They include diseases of the spinal musculoskeletal system, the local hematopoietic system, and the local neurological system. These conditions include trauma, tumors, infections, diseases of aging, and immune diseases affecting the spine or spinal nerves.

Although the predominant cause of back and leg pain in healthy people usually is lumbar disc disease, one must be extremely cautious to avoid a misdiagnosis, particularly given the high incidence of disc herniations present in asymptomatic patients as discussed previously. Therefore a full physical examination must be completed before making a presumptive diagnosis of herniated disc disease. Common diseases that can mimic disc disease include ankylosing spondylitis, multiple myeloma, vascular insufficiency, arthritis of the hip, osteoporosis with stress fractures, extradural tumors, peripheral neuropathy, and herpes zoster. Infrequent but reported causes of sciatica not related to disc hernia include synovial cysts, rupture of the medial head of the gastrocnemius, sacroiliac joint dysfunction, lesions in the sacrum and pelvis, and fracture of the ischial tuberosity.

CONFIRMATORY IMAGING

Although the diagnosis of a herniated lumbar disc can be suspected from the history and physical examination, imaging studies are necessary to rule out other causes, such as a tumor or infection. Plain roentgenograms are of limited use in the diagnosis because they do not show disc herniations or other intraspinal lesions, but they can demonstrate infection, tumors, or other anomalies and should be obtained, especially if surgery is planned. Currently, the most useful test for diagnosing a herniated lumbar disc is MRI. Since the advent of MRI, myelography is used much less frequently, although in some situations it may help to demonstrate subtle lesions. When myelography is used, it should be followed with a CT scan.

NONOPERATIVE TREATMENT

The number and variety of nonoperative therapies for back and leg pain are overwhelming. Treatments range from simple rest to expensive traction apparatus. All these therapies are reported with glowing accounts of miraculous “cures”; unfortunately, few have been evaluated scientifically. In addition, the natural history of disc disease is characterized by exacerbations and remissions with eventual improvement regardless of treatment. Finally, several distinct symptom complexes appear to be associated with disc disease. Few if any studies have isolated the response to specific and anatomically distinct diagnoses.

The simplest treatment for acute back pain is rest. Deyo, Diehl, and Rosenthal reported that 2 days of bed rest were better than a longer period. Biomechanical studies indicate that lying in a semi-Fowler position (i.e., on the side with the hips and knees flexed) with a pillow between the legs should relieve most pressure on the disc and nerve roots. Muscle spasm can be controlled by the application of ice, preferably with a massage over the muscles in spasm. Pain relief and antiinflammatory effect can be achieved with nonsteroidal antiinflammatory drugs (NSAIDs). Most acute exacerbations of back pain respond quickly to this therapy. As the pain diminishes, the patient should be encouraged to begin isometric abdominal and lower extremity exercises. Walking within the limits of comfort also is encouraged. Sitting, especially riding in a car, is discouraged. Malmivaara et al. compared the efficacy of bed rest alone, back extension exercises, and continuation of ordinary activities as tolerated in the treatment of acute back pain. They concluded that continuation of ordinary activities within the limits permitted by pain led to a more rapid recovery.

Education in proper posture and body mechanics is helpful in returning the patient to the usual level of activity after the acute exacerbation is eased or relieved. This education can take many forms, from individual instruction to group instruction. Back education of this type is now usually referred to as “back school.” Although the concept is excellent, the quality and quantity of information provided may vary widely. The work of Bergquist-Ullman and Larsson and others indicates that patient education of this type is extremely beneficial in decreasing the amount of time lost from work initially but does little to decrease the incidence of recurrence of symptoms or length of time lost from work during recurrences. Certainly the combination of back education and combined physical therapy is superior to placebo treatment. Cohen et al. reviewed 13 studies on group back education and concluded that the evidence was insufficient to recommend group education. A study by Galm et al. regarding sacroiliac joint dysfunction in patients with image-proven herniated nucleus pulposus and sciatica but without motor or sensory deficits found that 75% improved with respect to sciatic and back pain with intensive physiotherapy.

Numerous medications have been used with varied results in subacute and chronic back and leg pain syndromes. The current trend appears to be moving away from the use of strong narcotics and muscle relaxants in the outpatient treatment of these syndromes. This is especially true in the instances of chronic back and leg pain where drug habituation and increased depression are frequent. Oral steroids used briefly can be beneficial as potent antiinflammatory agents. The many types of NSAIDs also are helpful when aspirin is not tolerated or is
of little help. Numerous NSAIDs are available for the treatment of low back pain. When depression is prominent, mood elevators such as amitriptyline can be beneficial in reducing sleep disturbance and anxiety without increasing depression. In addition, amitriptyline also decreases the need for narcotic medication.

Physical therapy should be used judiciously. The exercises should be fitted to the symptoms and not forced as an absolute group of activities. Patients with acute back and thigh pain eased by passive extension of the spine in the prone position can benefit from extension exercises rather than flexion exercises. Improvement in symptoms with extension is indicative of a good prognosis with conservative care. On the other hand, patients whose pain is increased by passive extension may be improved by flexion exercises. These exercises should not be forced in the face of increased pain. This may avoid further disc extrusion. Any exercise that increases pain should be discontinued. Lower extremity exercises can increase strength and relieve stress on the back, but they also can exacerbate lower extremity arthritis. The true benefit of such treatments may be in the promotion of good posture and body mechanics rather than of strength. Hansen et al. compared intensive, dynamic back muscle exercises, conventional physiotherapy (manual traction, flexibility, isometric and coordination exercises, and ergonomics counseling), and placebo-control treatment in a randomized, observer blind trial. Regardless of the method used, patients who completed therapy reported a decrease in pain. However, physiotherapy appeared to have better results in men, and intensive back exercises gave better results in women. Patients with hard physical occupations responded better to physiotherapy, whereas patients with sedentary occupations responded better to intensive back exercises.

Numerous treatment methods have been advanced for the treatment of back pain. Some patients respond to the use of transcutaneous electrical nerve stimulation (TENS). Others do well with traction varying from skin traction in bed with 5 to 8 pounds to body inversion with forces of over 100 pounds. Back braces or corsets may be helpful to other patients. Ultrasound and diathermy are other treatments used in back pain. The scientific efficacy of many of these treatments has not been proved. In addition, all therapy for disc disease is only symptomatic.

**EPIDURAL STEROIDS**

The epidural injection of a combination of a long-acting steroid with an epidural anesthetic is an excellent method of symptomatic treatment of back and leg pain from discogenic disease and other sources. Most studies show a 60% to 85% short-term success rate that falls to a 30% to 40% long-term (6-month) good result rate. The local effect of the steroids has been shown to last at least 3 weeks at a therapeutic level. In a well-controlled study Berman et al. found that the best results were obtained in patients with subacute or chronic leg pain with no prior surgery. They also found that the worst results were in patients with motor or reflex abnormalities (12% to 14% good results). A negative myelogram also was associated with a better result. Cuckler et al. in a double-blind, randomized study of epidural steroid treatment of disc herniation and spinal stenosis found no difference in the results at 6 months between placebo and a single epidural injection. Our experience parallels that of Berman et al. We agree that epidural steroids are not a cure for disc disease, but they do offer relatively prolonged pain relief without excessive narcotic intake if conservative care is elected. Hopwood and Abram observed that factors associated with poor surgical outcome also were associated with a poor outcome from epidural steroid injection. These factors included lower educational levels, smoking, lack of employment, constant pain, sleep disruption, nonradiacular diagnosis, prolonged duration of pain, change in recreational activities, and extreme values on psychological scales.

In experienced hands the complication rate from this procedure should be small. White, Derby, and Wynne reported that the most common problem is a 25% rate of failure to place the material in the epidural space. Renfrew et al. and el-Khoury et al. observed that the use of fluoroscopic control dramatically decreased the failure rate. Another technique-related problem is intrathecal injection with inadvertent spinal anesthesia. Other reported complications include transient hypotension, difficulty in voiding, severe paresthesias, cardiac angina, headache, and transient hypercorticoidism. Kushner and Olson reported retinal hemorrhage in several patients who had epidural steroid injection for chronic back pain. They recommended careful consideration of this procedure in patients who have bleeding problems and in patients who have only one eye. DeSio et al. reported facial flushing and generalized erythema in patients after epidural steroid injection. The most serious complication reported was bacterial meningitis. The total complication rate in most series is about 5%, and the complications are almost always transient.

This procedure is contraindicated in the presence of infection, neurological disease (such as multiple sclerosis), hemorrhagic or bleeding diathesis, cauda equina syndrome, and a rapidly progressive neural deficit. Rapid injections of large volumes or the use of large doses of steroid also can increase the complication rate. The exact effects of intrathecal injection of steroids are not known. This technique must be used only in the low lumbar region. We prefer to abort the procedure if a bloody tap is obtained or if CSF is encountered.

We prefer to do the procedure in a room equipped for resuscitation and with the capability to monitor the patient. This procedure lends itself well to outpatient use, but the patient must be prepared to spend several hours to recover from the block. Methylprednisolone (Depo-Medrol) is the usual steroid injected. The dosage may vary from 80 to 120 mg. The anesthetics used may include lidocaine, bupivacaine, or procaine. Our current protocol is to inject the patient three times. These injections are made at 7- to 10-day intervals. This ensures at least one good epidural injection and decreases the volume of material injected at each procedure.
TECHNIQUE 39-20 (Brown)
The equipment needed includes material for an appropriate skin preparation, sterile rubber gloves, a 3½-inch, 20-gauge or 22-gauge disposable spinal needle (45-degree blunt- or curve-tipped epidural needles are preferred), several disposable syringes, bacteriostatic lidocaine, and methylprednisolone acetate, 40 mg/ml. The injection may be done with the patient in the sitting or lateral decubitus position. Anesthetize the skin near the midline. Advance the needle until the resistance of the ligamentum flavum is encountered. Then attach a syringe and slowly advance the needle while applying light pressure on the syringe. When the epidural space is encountered, the resistance is suddenly lost and the epidural space will accommodate the air. Remove the syringe and inspect the needle opening for blood or spinal fluid. If there is no flow out of the needle, then inject 3 ml of 1% lidocaine or other appropriate anesthetic. This may be preceded or followed by the chosen dosage of methylprednisolone.

Several variations also can be used. Some physicians use a sterile balloon to indicate the proper space. Others use the “disappearing drop” technique, which involves placing a drop of sterile saline over the hub of the needle. When the epidural space is entered, the drop disappears. Caudal injection also is used, but this may require larger volumes to wash the steroid up to the involved level. This method is safer but less reliable than an injection at L4-5.

OPERATIVE TREATMENT
If nonoperative treatment for lumbar disc disease fails, the next consideration is operative treatment. Before this step is taken, the surgeon must be sure of the diagnosis. The patient must be certain that the degree of pain and impairment warrants such a step. Both the surgeon and the patient must realize that disc surgery is not a cure but may provide symptomatic relief. It neither stops the pathological processes that allowed the herniation to occur nor restores the back to a normal state. The patient must still practice good posture and body mechanics after surgery. Activities involving repetitive bending, twisting, and lifting with the spine in flexion may have to be curtailed or eliminated. If prolonged relief is to be expected, then some permanent modification in the patient’s lifestyle may be necessary.

The key to good results in disc surgery is appropriate patient selection. The optimal patient is one with predominant, if not only, unilateral leg pain extending below the knee that has been present for at least 6 weeks. The pain should have been decreased by rest, antiinflammatory medication, or even epidural steroids but should have returned to the initial levels after a minimum of 6 to 8 weeks of conservative care. Some managed care plans now insist on a trial of physiotherapy. The work of Hansen et al. is indicative of the problems with such requirements, not only because of gender and occupation variations in response to physiotherapy and intensive back exercises, but also because no therapy appeared to have the same or better results. Physical examination should reveal signs of sciatic irritation and possibly objective evidence of localizing neurological impairment. CT, lumbar MRI, or myelography should confirm the level of involvement consistent with the patient’s examination.

Surgical disc removal is mandatory and urgent only in cauda equina syndrome with significant neurological deficit, especially bowel or bladder disturbance. All other disc excisions should be considered elective. This should allow a thorough evaluation to confirm the diagnosis, level of involvement, and the physical and psychological status of patient. Frequently, if there is a rush to the operating room to relieve pain without proper investigation, both the patient and physician later regret the decision.

Regardless of the method chosen to treat a disc rupture surgically, the patient should be aware that the procedure is predominantly for the symptomatic relief of leg pain. Patients with predominant back pain may not be relieved of their major complaint—back pain. Spangfort, in reviewing 2504 lumbar disc excisions, found that about 30% of the patients complained of back pain after disc surgery. Failure to relieve sciatica was proportional to the degree of herniation. The best results of 99.5% complete or partial pain relief were obtained when the disc was free in the canal or sequestered. Incomplete herniation or extrusion of disc material into the canal resulted in complete relief for 82% of patients. Excision of the bulging or protruding disc that had not ruptured through the annulus resulted in complete relief in 63%, and removal of the normal or minimally bulging disc resulted in complete relief in 38%, which is near the stated level for the placebo response. Likewise, the incidence of persistent back pain after surgery was inversely proportional to the degree of herniation. In patients with complete extrusions the incidence was about 25%, but with minimal bulges or negative explorations the incidence rose to over 55% (Figs. 39-38 and 39-39).

General Principles for Open Disc Surgery
Most disc surgery is performed with the patient under general endotracheal anesthesia, although local anesthesia has been used with minimal complications. Patient positioning varies with the operative technique and surgeon. To position the patient in a modified kneeling position, a specialized frame or custom frame modified from the design of Hastings is popular. Positioning the patient in this manner allows the abdomen to hang free, minimizing epidural venous dilation and bleeding (Fig. 39-40). A head lamp allows the surgeon to direct light into the lateral recesses where a large proportion of the surgery may be required. The addition of loupe magnification also greatly improves the identification and exposure of various structures. Some surgeons also use the operative microscope to further improve visibility. The primary benefit of the operating microscope compared with loupes is the view afforded the
assistant. Roentgenographic confirmation of the proper level is necessary. Care should be taken to protect neural structures. Epidural bleeding should be controlled with bipolar electrocautery. Any sponge, pack, or cottonoid patty placed in the wound should extend to the outside. Pituitary rongeurs should be marked at a point equal to the maximal allowable disc depth to prevent accidental biopsy of viscera or aorta. Considerable research has gone into techniques to prevent epidural fibrosis. Hoyland et al. noted dense fibrous connective tissue about previously operated nerve roots. They also found fibrillar foreign material within the scar in 55% of patients. This finding should remind the surgeon to minimize the use of cotton patties. The placement of autogenous fat appears to be a reasonable although not foolproof or complication-free tech-

Fig. 39-38 Percentage relief of sciatica with type of disc herniation. (From Spangfort E: Acta Orthop Scand Suppl 142:1, 1972.)


Fig. 39-40 Kneeling position for lumbar disc excision allows abdomen to be completely free of external pressure.
technique of minimizing postoperative epidural fibrosis. Commercially available products may reduce scar volume, but clinical benefit remains uncertain.

- **Ruptured Lumbar Disc Excision (Open Technique)**

  **TECHNIQUE 39-21**

  After thoroughly preparing the back, identify the spinous processes of L3, L4, L5, and S1 by palpation. Make a midline incision 5 to 8 cm long, centered over the interspace where the disc herniation is located. Incise the supraspinous ligament; then, by subperiosteal dissection, strip the muscles

  ![Fig. 39-41](https://example.com/fig39-41.png)

Fig. 39-41  Technique of lumbar disc excision. A, With lamina and ligamentum flavum exposed, use curet to remove the ligamentum flavum from inferior surface of lamina. Kerrison rongeur is used to remove bone. B, Elevate ligamentum flavum at upper corner and carefully dissect it back to expose dura and epidural fat below. Patties should be used to protect dura during this procedure. C, Expose dura and root. Remove additional bone if there is any question about adequacy of exposure. D, Retract nerve root and dural sac to expose disc. Inspect capsule for rent and extruded nuclear material. If obvious ligamentous defect is not visible, then carefully incise capsule of disc. If disc material does not bulge out, press on disc to try to dislodge herniated fragment. E, Carefully remove disc fragments. It is safest to avoid opening pituitary rongeur until it is inserted into disc space. F, After removing disc, carefully explore foramen, subligamentous region, and beneath dura for additional fragments of disc. Obtain meticulous hemostasis using bipolar cauterization.

from the spinous processes and laminae of these vertebrae on the side of the lesion. Retract the muscles either with a self-retaining retractor or with the help of an assistant and expose one interspace at a time. Verify the location with a roentgenogram so that no mistake is made regarding the interspaces explored. Secure hemostasis with electrocautery, bone wax, and packs. Leave a portion of each pack completely outside the wound for ready identification.

Denude the laminae and ligamentum flavum with a curet (Fig. 39-41). Commonly the lumbosacral interspace is large enough to permit exposure and removal of a herniated nucleus pulposus without removal of any bone. If not,

*continued*
remove a small part of the inferior margin of the fifth lumbar lamina. Exposure of the disc at higher levels usually requires removal of a portion of the inferior lamina. Thin the ligamentum flavum using a pituitary rongeur to remove the superficial layer. Detach the ligamentum from its cephalad or caudal laminar attachment using a small curet. Use care to keep the cutting edges of the curet directed posteriorly to minimize the chance of dural laceration. Using an angled Kerrison rongeur, preferably one with a thin foot plate and appropriate width, remove the detached ligamentum laterally and preserve the more medial ligamentum. Keep the Kerrison rongeur oriented parallel to the direction of the nerve root to minimize the risk of root injury, and the root will be more posterior than is normal due to the displacement caused by the herniated disc fragment. An alternative technique that can be used with good lighting and magnified visual aid is to divide the ligamentum parallel with its fibers using a no. 11 blade knife. Once the full thickness of the ligamentum has been divided, bluntly extend the division across the interspace with a Penfield 4 dissector and remove the lateral portion of the ligamentum. The lateral shelving portion of the ligamentum should be excised, often with a portion of the medial inferior facet to gain access to the lateral aspect of the nerve root. Next, retract the dura medially and identify the nerve root. If the root is compressed by a large extruded fragment, it commonly will be displaced posteriorly. Retract the nerve root, once identified, medially so that the underlying extruded fragment or bulging posterior longitudinal ligament can be seen. Occasionally the nerve root adheres to the fragment or to the underlying ligamentous structures and requires blunt dissection from these structures. If the position of the root is not known for certain, remove the lamina posterior to the root and medial to the pedicle until the root is clearly identified. Bipolar cautery on a low setting can be used to coagulate the epidural veins and maintain hemostasis. Gelfoam and small cottonoid wicks are also useful. Take care to minimize packing about the nerve root. Retract the root or dura, identify any bleeding vein, and cauterize it with a bipolar cautery. Earlier insertion of cotton patties may well displace fragments from view. The underlying disc should be clearly visible at this time.

Gently retract the nerve with a Love root retractor or a blunt dissector, thus exposing the herniated fragment or posterior longitudinal ligament and annulus. If an extruded fragment is not seen, carefully palpate the posterior longitudinal ligament and seek a defect or hole in the ligamentous structures. A microblunt hook can be used for this. If no obvious abnormality is detected, follow the root around the pedicle or even outside the canal in search of fragments that may have migrated far laterally. Additional searching in the root axilla helps ensure that fragments that have migrated inferiorly are not missed. If the expected pathology is not found, obtain another roentgenogram with a blunt dissector at the level of the disc to be certain of the proper level and review preoperative imaging studies to confirm proper sidedness.

If the herniated fragment is especially large, it is much better to sacrifice a portion of the facet to obtain a more lateral exposure than to risk injury to the root or cauda equina by excessive medial retraction. With such a lateral exposure the nerve root usually can be elevated, and the herniated fragment can be teased from beneath the nerve root and cauda equina, even when the fragment is large enough to block the entire canal. If the fragment is very large as with cauda equina lesions typically, a bilateral laminectomy is preferred to allow safer removal. If the disc cannot be teased from under the root, make a cruciate incision in the disc laterally. Gently remove disc fragments until the bulge has been decompressed to allow gentle retraction of the root over the defect.

If the herniation is upward or downward, further removal of bone from the lamina and facet edges may be required. The herniated nucleus pulposus may be covered by a layer of posterior longitudinal ligament or may have ruptured through this structure. In the latter event, carefully lift the loose fragments out by suction, blunt hook, or pituitary forceps. If the ligament is intact, incise it in a cruciate fashion and remove the loose fragments. The tear or hole in the annulus should then be identifiable in most instances. The cavity of the disc can be entered through this hole, or occasionally the hole may need to be enlarged to allow insertion of the pituitary forceps. Remember that the anterior part of the annulus is adjacent to the aorta, vena cava, or iliac arteries and veins and that one of these structures can be injured if one proceeds too deeply. Remove other loose fragments of nucleus pulposus with the pituitary forceps and remove additional nuclear material along with the central portion of the cartilaginous plates, both above and below as necessary.

When placing instruments into the disc space do not penetrate beyond a depth of 15 mm to avoid injury to the anterior viscera. Then carry out a complete search for additional fragments of nucleus pulposus, both inside and outside the disc space. Additional fragments commonly migrate medially beneath the posterior longitudinal ligament but outside the annulus and can easily be missed. Then remove all cotton pledgets and control residual bleeding with Gelfoam and bipolar cautery. Forcefully irrigate any loose fragments from the disc space using a syringe with a spinal needle placed into the disc space under direct vision until no fragments are returned with the irrigating solution. Close the wound routinely with absorbable sutures in the supraspinous ligament and subcutaneous tissue. Various absorbable sutures are most commonly used in routine skin closure. Staples are avoided for patient comfort.

**AFTERTREATMENT.** Neurological function is closely monitored after surgery. The patient is allowed to turn in bed at will and to select a position of comfort such as a semi-Fowler...
position. Pain should be controlled with oral medication. Muscle relaxants are used postoperatively as well. Bladder stimulants can be used to assist voiding. The patient is allowed to stand with assistance on the evening after surgery to go to the bathroom. Discharge is permitted when the patient is able to walk and void. Currently most patients are discharged within 24 hours after surgery. Isometric abdominal and lower extremity exercises are started. The patient is instructed to minimize sitting and riding in a vehicle. Increased walking on a daily basis is recommended. Lifting, bending, and stooping are prohibited for the first several weeks. As the patient’s strength increases, gentle isotonic leg exercises are started.

Between the fourth and sixth postoperative week, back school instruction is resumed or started, provided that pain is minimal. Lifting, bending, and stooping are gradually restarted after the sixth week. Increased sitting is allowed as pain permits, but long trips are to be avoided for at least 4 to 6 weeks. Lower extremity strength is increased from the eighth to twelfth postoperative weeks. Patients with jobs requiring much walking without lifting are allowed to return to work within 2 to 3 weeks. Patients with jobs requiring prolonged sitting usually are allowed to return to work within 4 to 6 weeks provided minimal lifting is required. Patients with jobs requiring heavy labor or long periods of driving are not allowed to return to work until 6 to 8 weeks and then to a modified duty. Some patients with jobs requiring exceptionally heavy manual labor may have to permanently modify their occupation or seek a lighter occupation. Keeping the patient out of work beyond 3 months rarely improves recovery or pain relief.

**Microlumbar Disc Excision**

Microlumbar disc excision has replaced the standard open laminectomy as the procedure of choice for herniated lumbar disc. This procedure can be done on an outpatient basis and allows better lighting, magnification, and angle of view with a much smaller exposure. Because of the limited dissection required there is less postoperative pain and a shorter hospital stay. Zahrawi reported 103 outpatient microdiscectomies, noting 88% excellent and good results in the 83 who responded. Newman reported 75 conventional laminectomies done on an outpatient basis and noted 2 complications unrelated to the procedure or the outpatient setting. Kelly et al. noted less pulmonary morbidity and temperature elevation in patients after microlumbar discectomy. Numerous other investigators such as Silvers, Zahrawi, Lowell et al., and Moore et al. reported excellent results with low morbidity and early return to activity using microlumbar disc excision. Williams, the originator of the term, questioned its current usage, since the concept of the technique has changed over the years.

Microlumbar discectomy requires an operating microscope with a 400-mm lens, special retractors, a variety of small-angled Kerrison rongeurs of appropriate length, micro instruments, and preferably a combination suction–nerve root retractor. The procedure is performed with the patient prone. A vacuum pack is molded around the patient, and an inflatable pillow is positioned under the abdomen and is removed after evacuation of the vacuum pack. Alternatively, the Andrew’s type frame previously described can be used. The microscope can be used from skin incision to closure. However, the initial dissection can be done under direct vision. A lateral roentgenogram is taken to confirm the level.

### TECHNIQUE 39-22 (Williams, Modified)

Make the incision from the spinous process of the upper vertebra to the spinous process of the lower vertebra at the involved level. This usually results in a 1-inch (2.5-cm) skin incision (Fig. 39-42). Maintain meticulous hemostasis with electrocautery as the dissection is carried to the fascia. Incise the fascia at the midline using electrocautery. Then insert a periosteal elevator in the midline incision. Using gentle lateral movements separate the deep fascia and muscle subperiosteally from the spinal processes and lamina. Obtain a lateral roentgenogram with a metal clamp attached to the spines to verify the level. Now, using a Cobb elevator gently sweep the remaining muscular attachments off in a lateral direction exposing the interlaminar space and the edge of each lamina. Meticulously cauterize all bleeding points. Insert the microlumbar retractor into the wound and adjust the microscope. Identify the ligamentum flavum and lamina. Use a pituitary rongeur to remove the superficial leaf of the ligamentum. Using a no. 15 blade with the microscope, carefully incise the thinned ligamentum flavum superficially. Then use a Penfield no. 4 dissector to perforate the ligamentum. Minimal force should be used in this maneuver to prevent penetration of the dura. Once the ligamentum is open, use a 45-degree Kerrison rongeur to remove the ligamentum flavum laterally. The lamina, facet, and facet capsule should remain intact. However, one must remove the ligamentum flavum and bone from the lamina as needed to clearly identify the nerve root. Once identified, carefully mobilize the root medially; this may require some bony removal. Gently dissect the nerve free from the disc fragment to avoid excessive traction on the root. Bipolar cautery for hemostasis is very helpful. Once mobilized, retract the root medially. Maintain the orientation of the Kerrison parallel to that of the nerve root at all times. Once identified, the nerve root can be gently mobilized and retracted medially. Then make an extradural exploration using a 90-degree hook. In large herniations the nerve root appears as a large, white, glistening structure and can easily be mistaken for a ruptured disc. Follow the root to the pedicle if necessary to be certain of its location. The small opening and magnification can make the edge of the dural sac appear as the nerve root. When using bipolar cautery make sure only one side is in contact with the nerve root to avoid thermal injury to the nerve. Also, when using a Kerrison rongeur for bone or ligamentum removal, orient it parallel to the course of the nerve root as much as possible to minimize the risk of nerve root or dural injury. Epidural fat is not removed in this procedure. Insert the suction–nerve root retractor, with its tip turned medially under the nerve root, and hold the manifold between the thumb and index...
finger. With the nerve root retracted, the disc will now be visible as a white, fibrous, avascular structure. Small tears may be visible in the annulus under the magnification. Now enlarge the annular tear with a Penfield no. 4 dissector and remove the disc material with the microdisc forceps. Do not insert the instrument into the disc space beyond the angle of the jaws, which usually is about 15 mm, to minimize the risk of anterior perforation and vascular injury. Remove the exposed disc material. Do not curet the disc space. Inspect the root and adjacent dura for disc fragments. Irrigate the

A disc that is far lateral may require exposure outside the spinal canal. This area is approached by removing the intertransverse ligament between the superior and inferior transverse processes lateral to the spinal canal. The disc hernia usually is anterior to the nerve root that is found in a mass of fat below the ligament. A microsurgical approach or a percutaneous approach are good methods for dealing with this problem. Maroon et al. also recommended discography to confirm the lesion before surgery. Epstein noted little difference between lateral intertransverse exposure, facetectomy, and a more extensive hemilaminectomy with medial facetectomy. Donaldson et al. recommended the lateral approach after first finding the root medially and dissecting laterally down to a probe on top of the root (Fig. 39-43), and Strum et al. recommended an anterolateral approach.

**Lumbar Root Anomalies**

Lumbar nerve root anomalies (Figs. 39-44 to 39-47) are more common than may be expected, and they rarely are correctly identified with myelography. Kadish and Simmons identified lumbar nerve root anomalies in 14% of 100 cadaver examinations. They noted nerve root anomalies in only 4% of 100 consecutive metrizamide myelograms. They identified four types of anomalies. Type I is an intradural anastomosis between rootlets at different levels. Type II is an anomalous origin of the nerve roots. They separated this type into four subtypes: (1) cranial origin, (2) caudal origin, (3) combination of cranial and caudal origin, and (4) conjoined nerve roots. Type III is an extradural anastomosis between roots. Type IV is the extradural division of the nerve root. The surgeon must be aware of the possibility of anomalous roots hindering the disc excision. This may require a wider exposure. Sectioning of these roots results in irreversible neurological damage. Traction on anomalous nerve roots has been suggested as a cause of sciatic symptoms without disc herniation.
Results of Open (Micro or Standard) Surgery for Disc Herniation

Numerous retrospective and some prospective reviews of open disc surgery are available. The results of these series vary greatly with respect to patient selection, treatment method, evaluation method, length of follow-up, and conclusions. Good results range from 46% to 97%. Complications range from none to over 10%. The reoperation rate ranges from 4% to over 20%. The detailed studies of Spangfort, Weir, and Rish are suggested for more detailed analysis. A comparison between techniques also reveals similar reports.

Several points do stand out in the analysis of the results of lumbar disc surgery. Patient selection appears to be extremely important. Several studies noted that a low educational level is significantly related to poor results of surgery. The works of Wiltse and Rocchio, and Gentry indicate that valid results of the MMPI (hysteria and hypochondriasis T scores) are very good indicators of surgical outcome regardless of the degree of the pathological condition. The extremely detailed work of Weir suggests that the duration of the current episode, the age of the patient, the presence or absence of predominant back pain, the number of previous hospitalizations, and the presence or absence of compensation for a work injury are factors affecting final outcome. Spangfort's work also indicates that the softer the findings for disc herniation clinically and at the time of surgery, the lower the chance for a good result.

Complications of Open Disc Excision

The complications associated with standard disc excision and microlumbar disc excision are similar. Spangfort's series (Table 39-9) of 2503 open disc excisions lists a postoperative mortality of 0.1%, a thromboembolism rate of 1.0%, a postoperative infection rate of 3.2%, and a deep disc space infection rate of 1.1%. Postoperative cauda equina lesions developed in five patients. Laceration of the aorta or iliac artery also has been described as a rare complication of this operation. Rish, in a more recent report with a 5-year follow-up, noted a total complication rate of 4% in a series of 205 patients. The major complication in his series involved a worsening neuropathy postoperatively. There was one disc space infection...
and one wound infection. Dural tears with CSF leaks, pseudomeningocele formation, CSF fistula formation, and meningitis also are possible but are more likely after reoperation. The complications of microlumbar disc excision appear to be lower than with standard laminectomy. Alexander reviewed patients who had sustained incidental duralotomy at the time of disc surgery and found no perioperative morbidity or compromise of results if the dura was repaired. They noted a 4% incidence of this complication in 450 discectomies.

The presence of a dural tear or leak results in the potentially serious problems of pseudomeningocele, CSF leak, and meningitis. Eismont, Wiesel, and Rothman suggested that 4% incidence of this complication in 450 discectomies. The presence of glucose in drainage fluid is not a reliable diagnostic test. On rare occasions a pseudomeningocele has been implicated as a cause of persistent pain from pressure on a nerve root by the cystic mass.

### Complications of Lumbar Disc Surgery

<table>
<thead>
<tr>
<th>Complication</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cauda equina syndrome</td>
<td>0.2</td>
</tr>
<tr>
<td>2. Thrombophlebitis</td>
<td>1.0</td>
</tr>
<tr>
<td>3. Pulmonary embolism</td>
<td>0.4</td>
</tr>
<tr>
<td>4. Wound infection</td>
<td>2.2</td>
</tr>
<tr>
<td>5. Pyogenic spondylitis</td>
<td>0.07</td>
</tr>
<tr>
<td>6. Postoperative discitis</td>
<td>2.0 (1122 patients)</td>
</tr>
<tr>
<td>7. Dural tears</td>
<td>1.6</td>
</tr>
<tr>
<td>8. Nerve root injury</td>
<td>0.5</td>
</tr>
<tr>
<td>9. Cerebrospinal fluid fistula</td>
<td>*</td>
</tr>
<tr>
<td>10. Laceration of abdominal vessels</td>
<td>*</td>
</tr>
<tr>
<td>11. Injury to abdominal viscera</td>
<td>*</td>
</tr>
</tbody>
</table>


*Dram occurrence (numbers 10 and 11 not identified in Spangfort’s study but reported elsewhere.)*

The development of headaches on standing and a stormy postoperative period should alert one to the possibility of an undetected CSF leak. This can be confirmed by MRI studies. The presence of glucose in drainage fluid is not a reliable diagnostic test. On rare occasions a pseudomeningocele has been implicated as a cause of persistent pain from pressure on a nerve root by the cystic mass.

### Dural Repair Augmented with Fibrin Glue

Dural repair can be augmented with fibrin glue. Pressure testing of a dural repair without fibrin glue reveals that the dura is able to withstand 10 mm of pressure on day 1 and 28 mm on day 7. With fibrin glue the dura is able to withstand 28 mm on day 1 and 31 mm on day 7. Fibrin glue also can be used in areas of troublesome bleeding or difficult access for closure such as the ventral aspect of the dura.

#### TECHNIQUE 39-23

Mix 20,000 U of topical thrombin and 10 ml of 10 calcium chloride. Draw the mixture up into a syringe. In another syringe, draw 5 U of cryoprecipitate and inject equal quantities of each onto the dural repair or tear. Allow the glue to set to the consistency of “Jello” (Box 39-10). Commercially available kits also are available.

### Free Fat Grafting

Fat grafting for the prevention of postoperative epidural scarring has been suggested by Kiviluoto; Jacobs, McClain, and Neff; and Bryant, Bremer, and Nguyen. The study by Jacobs et al. indicated that free fat grafts were superior to Gelfoam in the prevention of postoperative scarring. The current rationale for free fat grafting appears to be the possibility of making any reoperation easier. Unfortunately, the benefit of reduced scarring and its relationship to the prevention of postoperative pain have not been established, neither has the increased ease of reoperation in patients in whom fat grafting was performed. Caution should be taken in applying a fat graft to a large laminar defect because this has been reported to result in an acute cauda equina syndrome in the early postoperative period. We currently reserve the use of a fat graft (or fascial grafts) for dural repairs and small laminar defects where the graft is supported by the bone. A study by Jensen et al. found...
that fat grafts decreased the dural scarring but not radicular scar formation. The clinical outcome was not improved.

The technique of free fat grafting is straightforward. At the end of the procedure, just before closing, take a large piece of subcutaneous fat and insert it over the laminectomy defect. If the patient is thin, a separate incision over the buttock may be required to get sufficient fat to fill the defect.

**CHEMONUCLEOLYSIS**

Chemonucleolysis has been used in the United States for more than 30 years. The enzyme was released for general use by the Food and Drug Administration (FDA) in December of 1982. Before its release in the United States it was used extensively in Europe and Canada. A wealth of experimental and clinical information exists concerning the technique and the enzyme. Specific guidelines have been suggested by the FDA regarding the use of the enzyme in the United States. The initial enthusiasm for the use of chymopapain has all but vanished in the United States; however, the use of this enzyme is still popular in Europe and elsewhere, with therapeutic results similar to surgery.

Because of the disclosure of neurological sequelae and other complications, the original guidelines issued in January of 1983 were radically changed. Those interested in performing the technique should contact the pharmaceutical companies that

---

**BOX 39-10 • Fibrin Glue**

**INGREDIENTS**
- Two vials of topical thrombin, 10,000 U each
- 10 ml of calcium chloride
- 5 U of cryoprecipitate
- Two 5-ml syringes
- Two 22-gauge spinal needles

**INSTRUCTIONS**
- Do not use saline that comes with thrombin
- Mix thrombin and calcium chloride
- Draw mixture into syringe
- Draw cryoprecipitate into second syringe
- Apply equal amounts to area of need
- Allow to set to a “Jello” consistency
produce the drug for information regarding training and certification in the technique. Treating physicians also are encouraged to frequently check the package insert accompanying the drug and the information bulletins sent out by the FDA and the pharmaceutical companies regarding any new changes in the protocol or use of the enzyme. Careful patient selection and proficiency in performing this procedure are mandatory.

The indications for the use of chemonucleolysis are the same as for open surgery for disc herniation. Fraser reported the results of 60 patients treated for lumbar disc herniation in a 2-year double-blind study of chemonucleolysis. At 2 years 77% of the patients treated with chymopapain were improved, whereas only 47% of the saline injection group were improved. At 2 years from injection 57% of the chymopapain group were improved, whereas only 47% of the saline injection group were improved. Numerous other studies of the efficacy of the drug place the good or excellent results between 40% and 89%, which is comparable to the clinical reports for open surgery (Table 39-10). Tregonning et al. reviewed 145 patients who had received chymopapain injection and 91 patients who had laminectomy at 10-year follow-up and concluded that the surgically treated group had slightly better results than the chymopapain group. Javid compared 100 patients who had laminectomy with 100 patients who had chemonucleolysis and reported that patients who had received chymopapain had better results with respect to 6-month overall improvement, short-term improvement in numbness and motor strength, and longer improvement in sensory status. Also, chymopapain was significantly less expensive than laminectomy. Nordby and Wright reviewed 45 clinical studies of chymopapain and laminectomy. They concluded that chemonucleolysis was somewhat less effective than open disc excision, but it did avoid the trauma of surgery and postoperative fibrosis.

As with open disc surgery, this technique is not applicable in all lumbar disc herniations. The use of the drug is limited to the lumbar spine. The patient optimally has predominantly unilateral leg pain and localized neurological findings consistent with confirmatory testing with MRI, CT, or myelography. Patients with moderate lateral recess or foraminal stenosis may worsen after the procedure because of collapse of the disc space and narrowing of the foraminal opening. Large disc herniations may not shrink sufficiently to result in relief of symptoms, and sequestered discs may be untouched by the enzyme. Smith et al. reported cauda equina syndromes in three patients after chymopapain was injected after a myelogram revealed a complete block.

Chymopapain injection is specifically contraindicated in patients with a known sensitivity to papaya, papaya derivatives, or food containing papaya, such as meat tenderizers. Other contraindications include severe spondylolisthesis, severe, progressive neurological deficit or paralysis, and evidence of spinal cord tumor or a cauda equina lesion. The enzyme cannot be injected in a patient who has been previously injected, regardless of the level injected. Use of chymopapain is limited to the lumbar intervertebral discs. Relative contraindications include allergy to iodine or iodine contrast material, use of the enzyme in a previously operated disc, patients with elevated allergy studies such as radioallergosorbent (RAST), ChymoFast, and skin testing with the drug, and patients with a severe allergic history, especially with a previous anaphylactic attack.

### Spinal Instability from Degenerative Disc Disease

Farfan defined spinal instability (caused by degenerative disc disease) as a clinically symptomatic condition without new injury, in which a physiological load induces abnormally large deformations at the intervertebral joint. Biomechanical studies have revealed abnormal motion at vertebral segments with degenerative discs and the transmission of the load to the facet joints. Numerous attempts at roentgenographic definition of spinal instability with disc disease have resulted in more controversy than agreement as to a standard method of measurement. The method described by Knutsson is simple and relatively efficient in determining anteroposterior motion. The

---

Table 39-10 Results and Complications of Chemonucleolysis and Open Disc Excision

<table>
<thead>
<tr>
<th>Technique</th>
<th>Year</th>
<th>No. Performed</th>
<th>Excellent</th>
<th>Partial/Good</th>
<th>None</th>
<th>Worse</th>
<th>Complications</th>
<th>Reoperation</th>
<th>Persistent Back Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Disc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semmes</td>
<td>1955</td>
<td>1440</td>
<td>53.6</td>
<td>43.3</td>
<td>1.7</td>
<td>1.4</td>
<td>NA</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>Spangfort</td>
<td>1972</td>
<td>2503</td>
<td>76.9</td>
<td>17.0</td>
<td>5.0</td>
<td>0.5</td>
<td>8.0</td>
<td></td>
<td>31.5</td>
</tr>
<tr>
<td>Weir</td>
<td>1979</td>
<td>100</td>
<td>73.0</td>
<td>22.0</td>
<td>3.0</td>
<td>1.0</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Rish</td>
<td>1984</td>
<td>57</td>
<td>74.0</td>
<td>17.0</td>
<td>9.0</td>
<td></td>
<td>4.0</td>
<td>18.0</td>
<td></td>
</tr>
<tr>
<td>Chemonucleolysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois trial</td>
<td>1982</td>
<td>273</td>
<td>90.0</td>
<td></td>
<td>10.0</td>
<td></td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Javid</td>
<td>1983</td>
<td>40</td>
<td>82.0</td>
<td></td>
<td>18.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nordby</td>
<td>1983</td>
<td>641</td>
<td>55.0</td>
<td>25.0</td>
<td>20.0</td>
<td></td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>
DISC EXCISION AND FUSION

The necessity of lumbar fusion at the same time as disc excision was first suggested by Mixter and Barr. In the first 20 years after their discovery the combination of disc excision and lumbar fusion was common. More recent data comparing disc excision alone with the combination of disc excision and fusion by Frymoyer et al. and others indicate that there is little if any advantage to the addition of a spinal fusion to the treatment of simple disc herniation. These studies do indicate that spinal fusion increases the complication rate and lengths recovery. The indications for lumbar fusion should be independent of the indications for disc excision for sciatica.

LUMBAR VERTEBRAL INTERBODY FUSION

Anterior lumbar intervertebral fusion (ALIF) and posterior lumbar intervertebral fusion (PLIF) have been suggested as definitive procedures for lumbar disc disease. Biomechanically the lumbar interbody fusion offers the greatest stability. It also eliminates the disc segment as a further source of pain. The primary problems are the more involved and potentially dangerous dissection, the risk of graft extrusion, and pseudarthrosis.

Most series of these fusions include a significant number of salvage procedures and complex pathological conditions, thus making direct comparison with primary disc surgery difficult. The routine use of such procedures for simple lumbar disc herniation with sciatica is not justified.

Most often, different types of grafts are taken from the iliac crest; however, hollow, perforated cylinders filled with autologous bone are now available for use in posterior and anterior lumbar intervertebral fusion. These cylinders are not indicated for spondylolisthesis greater than grade 1, osteopenia, malignancy, or gross obesity. Kuslich and Dowdle reported 98% fusion at one level anteriorly and 89% fusion at two levels with a slightly better functional improvement than the fusion rates using this device. This device also can be introduced by a percutaneous, laparoscopic anterior approach. The laparoscopic approach requires a team consisting of a laparoscopic general surgeon, spine surgeon, anesthesiologist, camera operator, scrub nurse, circulating nurse, and a radiology technician. It is strongly advised that the team attend a course on this technique or observe several cases before attempting such a procedure.

Anterior Lumbar Interbody Fusion

TECHNIQUE 39-24

Place the patient supine on a radiolucent operating table. Support the lumbar spine with a rolled sheet or inflatable bag. Prepare and drape the patient’s abdomen from upper chest to groin, leaving the iliac crests exposed for obtaining bone grafts. Expose the lumbar spine through a transabdominal or retroperitoneal approach as desired. Mobilize the great vessels over the segment to be excised. Ligate the median artery and vein at the bifurcation of the aorta to prevent tearing this structure when exposing the disc at L4-5 or L5-S1.

Identify and inspect all major structures before and after disc excision and fusion. Use anteroposterior fluoroscopy to confirm the proper disc level. Then incise the anterior longitudinal ligament superiorly or inferiorly over the edge of the vertebral body. Elevate the ligament as a flap if possible. Next remove the annular and nuclear material of the disc. The use of magnification can be beneficial as the dissection nears the posterior longitudinal ligament. Remove all nuclear material from the disc space.
Techniques for fusion vary. Some prefer to use dowel grafts to fill the space. Others prefer to use tricortical iliac grafts (Fig. 39-50). Obtain the grafts from the iliac crest as described for anterior cervical fusions (Chapter 36). Prepare the graft area for the desired grafting technique. We prefer tricortical grafts for this fusion. Good results using fibular grafts and banked bone also have been reported. Prepare the vertebrae by curetting the endplates to cancellous bone posteriorly. Then carefully make a slot in the vertebra to accommodate the grafts; use an osteotome slightly larger than the width of the disc space for this purpose and direct the cut toward the inferior vertebral body. Try to leave the upper and lower lips of the vertebral bodies intact. Remove enough tricortical iliac bone to allow insertion of at least three individual grafts. Fashion the grafts to fit snugly in the space with a laminar spreader in place. Insert the grafts so that the cancellous portions face the decorticated endplates. The grafts should be 3 to 4 mm shorter than the anteroposterior diameter of the vertebral body. Impact the grafts and seat them behind the anterior rim of the vertebral bodies. Usually three such grafts can be inserted. Add additional cancellous chips around the grafts. Suture the anterior longitudinal ligament and abdomen in the usual manner.

**AFTERTREATMENT.** The patient is allowed to sit as soon as possible. Extension of the lumbar spine is prohibited for at least 6 weeks. Bracing or casting is left to the discretion of the surgeon after considering the stability of the grafts and reliability of the patient.

**Posterior Lumbar Interbody Fusion**

**TECHNIQUE 39-25 (Cloward)**

Position the patient in the prone or kneeling position as desired. Expose the spine through a midline incision centered over the level of the pathological condition. Strip the muscle subperiosteally from the lamina bilaterally. Insert the laminar spreader between the spinous processes at the level of pathological findings. Open and remove the ligamentum flavum from the midline laterally. Enlarge the opening laterally by removing the lower one third of the inferior facet and the medial two thirds of the superior facet (Fig. 39-51, A). The upper lamina also can be thinned by undercutting to increase the anteroposterior diameter of the canal. Retract the lower nerve root and dura to the midline and protect it with the self-retaining nerve root retractor. Cauterize the epidural vessels with bipolar cautery. Cut out the disc and vessels over the annulus laterally. Remove as

---

*Fig. 39-50*  Anterior lumbar intervertebral fusion (ALIF) can be performed using tricortical iliac crest graft (A) or fibular grafts (B). (A from Ruge D, Wiltse LL: Spinal disorders: diagnosis and treatment, Philadelphia, 1977, Lea & Febiger; B from Wiltse LL: Instr Course Lect 28:207, 1979.)
much disc material as possible (Fig. 39-51, B). Remove a thin layer of the endplates posteriorly. Repeat this process on the opposite side. Remove the remaining anterior edges of the endplates to the anterior longitudinal ligament. This must be done under direct vision to avoid injury to the great vessels. Prepare a surface of bleeding cancellous bone on both vertebral bodies. Obtain tricortical iliac crest grafts as previously noted from the posterior iliac crest. (Cloward used frozen human cadaver bone grafts.) Shape the grafts to be slightly shorter and the same height or slightly higher than the disc shape. Tamp the first graft in place and lever it medially to allow insertion of the remaining grafts. Repeat the procedure on the opposite side (Fig. 39-51, C). Remove the laminar spreader and check the graft for stability. Close the wound in the usual fashion.

AFTERTREATMENT. Aftertreatment is the same as for lumbar discectomy (p. ****). Early walking is encouraged.

Failed Spine Surgery

One of the greatest problems in orthopaedic surgery and neurosurgery is the treatment of failed spine surgery. Numerous reasons for the failures have been advanced. The best results from repeat surgery for disc problems appear to be related to the discovery of a new problem or identification of a previously undiagnosed or untreated problem. Waddell et al. suggested that the best results from repeat surgery occur when the patient had experienced 6 months or more of complete pain relief after the first procedure, when leg pain exceeded back pain, and when a definite recurrent disc could be identified. They identified adverse factors such as scarring, previous infection, repair of pseudarthrosis, and adverse psychological factors. Similar factors were identified by Lehmann and LaRocca and Finnegan et al. Satisfactory results from reoperation have been reported to be from 31% to 80%. Patients should expect improvement in the severity of symptoms rather than complete relief of pain. As the frequency of repeat back surgeries increases, the chance of a satisfactory result drops precipitously. Spengler et al. and Long et al. observed that the major cause of failure is improper patient selection.

The recurrence or intensification of pain after disc surgery should be treated with the usual conservative methods initially. If these methods fail to relieve the pain, the patient should be completely reevaluated. Frequently a repeat history and physical examination will give some indication of the problem. Additional testing should include psychological testing, myelography, MRI to check for tumors or a higher disc herniation, and reformatted CT scans to check for areas of foraminal

---

**Fig. 39-51** Posterior lumbar interbody fusion technique. A, Bilateral laminotomy with preservation of facets. Control of epidural hemorrhage. Dipolar or insulated coagulation forceps are used on left side. On right side, epidural hemorrhage is controlled by impacted surgical tampons. Impacted surgical tampons also push nerve root medially and expose disc space without need for nerve root retractor. B, After intervertebral rims are removed, cleavage of disc attachment to cortical plate is identified. Curved, up-bite curet is used to remove concave centrum of lower cartilaginous plate. Then detached large chunks of disc material are removed with rongeur. C, Medial graft advancement with single chisel. (From Cauthen JC: *Lumbar spine surgery*, Baltimore, 1983, Williams & Wilkins.)
sténosis or for lateral herniation. The use of the differential spinal, root blocks, facet blocks, and discograms also can help identify the source of pain. The presence of abnormal psychological test results or an abnormal differential spinal should serve as a modifier to any suggested treatment indicated by the other testing. Satisfactory nonoperative treatment of this problem should be attempted before additional surgery is performed, provided that this surgery is elective. A distinct, surgically correctable, anatomical problem should be identified before surgery is contemplated. The surgery should be tailored specifically to the anatomical problem(s) identified.

**REPEAT LUMBAR DISC SURGERY**

The technique of repeat lumbar disc surgery at the same level and side as the previous procedure is nearly the same as for initial surgery. The procedure is longer and involves more meticulous dissection.

**TECHNIQUE 39-26**

Approach the spine using the method described previously. Identify normal tissue first. Use a curet to carefully remove scar from the edges of the lamina. Then remove additional bone as necessary to expose normal dura. Identify the pedicles superiorly and inferiorty if there is any question of position and status of the root. Carry the dissection from the pedicles to identify each root. This will allow the development of a normal plane between the dura and scar. Maintain meticulous hemostasis with bipolar cautery. Then remove disc material as indicated by the preoperative evaluation. Meticulously check the roots, dura, and posterior longitudinal ligament after removal of the offending disc herniation. Spinal fusion is not performed unless an unstable spine is created by the dissection or was identified preoperatively as a correctable and symptomatic problem.

**AFTERTREATMENT.** Aftetreatment is the same as for disc excision (p. xxxx).

**References**

**HISTORY**

Alajouanine TH: From the presidential address for Professor Jean Cauchoux before the annual meeting of the International Society for the Study of the Lumbar Spine, San Francisco, June 1978.

Aurelianus C: Acute diseases and chronic diseases, Chicago, 1950, University of Chicago Press.


Catchlove RF, Braha R: The use of cervical epidural nerve blocks in the evaluation. Meticulously check the roots, dura, and posterior longitudinal ligament after removal of the offending disc herniation. Spinal fusion is not performed unless an unstable spine is created by the dissection or was identified preoperatively as a correctable and symptomatic problem.

**EPIDEMIOLOGY**


Middelton GS, Teacher JH: Injury of the spinal cord due to rupture of an intervertebral disc during muscular effort, Glasgow Med J 76:1, 1911.

GENERAL DISC AND SPINE ANATOMY

Jayson MIV: Compression stresses in the posterior elements and pathologic consequences, Spine 8:338, 1983.

Saal JA: Natural history and nonoperative treatment of lumbar disc herniation, Spine 21:2596.

DIAGNOSTIC STUDIES
Delamarter RB, Leventhal MR, Bohlander HH: Diagnosis of recurrent lumbar disc herniation vs postoperative scar by gadolinium-DTPA-enhanced magnetic resonance imaging (unpublished data).


Williams PC: Reduced lumbosacral joint space: its relation to sciatic irritation, JAMA 99:1677, 1932.


Teeple E, Scott DL, Ghia JN: Intrathecal normal saline without preservative does not have a local anesthetic effect, Pain 14:3, 1982.


CHAPTER 39 Lower Back Pain and Disorders of Intervertebral Discs

THORACIC DISC DISEASE

Antoni N: Fall av kronisk rotkompression med ovansitt orsak, hernia nuclear pulposi disci intervertebralis, Sv Lakartidn 28:436, 1931.


LUMBAR DISC DISEASE: ETIOLOGY, DIAGNOSIS, AND CONSERVATIVE TREATMENT


American Medical Association: Guides to the evaluation of permanent impairment, ed 4, Chicago, 1993, American Medical Association.


Cauthen C: Lumbar spine surgery, Baltimore, 1983, Williams & Wilkins.


de Sève S: Sciatic “banale” et disques lombo-sacrés, La Presse Medicale 51:52-570, 1940.


Troup JDG: Straight leg raising (SLR) and the qualifying tests for increased root tension: their predictive value after back and sciatic pain, Spine 6:526, 1981.


LUMBAR DISC DISEASE: SURGICAL TREATMENT AND RESULTS


Delamarter RB, Leventhal MR, Bohlin HH: Diagnosis of recurrent lumbar disc herniation vs postoperative scar by gadolimum-DTPA enhanced magnetic resonance imaging (unpublished data).


**CHEMONEUROLYSIS**


CHAPTER 39  Lower Back Pain and Disorders of Intervertebral Discs


PERCUTANEOUS LUMBAR DISCECTOMY


COMPLICATIONS OF LUMBAR SPINE SURGERY


FAILED SPINE SURGERY


Cauthen C: Lumbar spine surgery, Baltimore, 1983, Williams & Wilkins.


Lehmann TR, LaRocca AS: Repeat lumbar surgery: a review of patients with failure from previous lumbar surgery treated by spinal cord exploration and lumbar spinal fusion, Spine 6:615, 1981.


Copyright 2003, Elsevier Science (USA). All Rights Reserved.