CQ HAND + UPPER LIMB
SPECIALIST ORTHOPAEDIC SURGEON

EVIDENCE SUMMARY

Lumbar disc herniation

Overview

PATHOGENESIS AND NATURAL HISTORY

- Genetic factors are more important than mechanical stresses in the development of disc herniations [5].
- The development of a disc herniation is one of several pathways that a degenerative disc may follow [5].
- A degenerative disc may become the primary source of pain rather than the nerve root, a condition known as discogenic pain [5].
- Discogenic pain is most attributable to internal disc derangement (IDD) that accompanies the degenerative process [5].
- IDD is defined as a pathologic condition resulting in axial spine pain with no or minimal deformation of spinal alignment or disc contour [5].
- IDD is distinguished from measurable instability associated with fractures, traumatic ligamentous disruptions, degenerative listhesis, or scoliosis [5].
- There are no defined criteria for IDD [5].
- The diagnosis of IDD requires a compilation of findings consistent with IDD and the elimination of other diagnostic possibilities [5].
- Patients with IDD are usually relatively young, in the third to sixth decades of life [5].
- Pain in IDD is usually chronic with symptoms present for several years, although it may have become constant or very frequent only in the previous several months [5].
- Pain in IDD is primarily axial, often with buttock and posterior thigh (sclerotomal) pain [5].
- Pain distal to the knee indicates either different or coexistent pathology [5].
- Positions and activities that increase intradiscal pressure, such as sitting or flexion, exacerbate IDD symptoms [5].
- Recumbency, especially in the fetal position, often decreases IDD pain [5].
- A pattern of variable pain intensity is constant in IDD [5].
- Pain that is constant but has little or no variation in intensity or only random fluctuations probably is not caused by IDD [5].

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- Examination for IDD reveals no weakness or reflex changes if IDD is the only diagnosis [5].
- Lumbar range of motion in IDD is mildly limited, especially in flexion, caused by lumbosacral pain or tightness [5].
- Straight-leg raising in IDD typically causes back and buttock pain but no pain distal to the knee [5].
- There is no spasm in the paraspinal musculature in IDD [5].
- Extension usually gives some temporary relief in IDD [5].
- The presence of three or more Waddell signs suggests an alternative diagnosis to IDD [5].
- The examination for IDD must include the hip joints as a possible cause of buttock and thigh pain [5].
- Imaging studies for IDD should include a lumbar spine series and dynamic films to assess deformities, measurable instability, or destructive lesions [5].

TREATMENT AND OUTCOMES

- Treatment options for IDD include fusions, disc arthroplasty, nucleoplasty, and dynamic stabilization procedures [5].
- The number of fusion operations in the United States has consistently increased since the 1970s and is significantly higher than in other developed countries [5].
- The indication for most fusion operations is IDD [5].
- There are currently three lumbar disc replacement prostheses approved by the FDA [5].
- The sole indication for lumbar disc replacement prostheses is to treat symptomatic degenerative disc disease [5].
- Implants currently in development for nucleoplasty are ultimately for the treatment of IDD [5].
- There is no consensus of diagnostic criteria regarding symptom type or severity, physical examination, or diagnostic imaging criteria for IDD [5].
- Few prospective randomized data exist on outcomes for the numerous operative or nonoperative treatment options for IDD [5].
- Good results of open disc surgery range from 46% to 97% [23].
- Complications of open disc surgery range from none to more than 10% [23].
- The reoperation rate for open disc surgery ranges from 4% to more than 20% [23].
- No particular technique of discectomy yields consistently superior results [23].
- Technical procedural differences are of minimal importance with regard to outcome in disc surgery [23].
- A low educational level is significantly correlated to poor results of surgery [23].
- Valid results of the Minnesota Multiphasic Personality Inventory (MMPI) hysteria and hypochondriasis T-scores are good indicators of surgical outcome regardless of the degree of the pathologic condition [23].
- Factors affecting final outcome in lumbar disc surgery include the duration of the current episode, age, presence or absence of predominant back pain, number of previous hospitalizations, and presence or absence of compensation for a work injury [23].

- In the 2008 Spine Patient Outcomes Research Trial (SPORT) report on lumbar disc herniation, patients treated operatively had far less pain, better physical function, and less disability than patients who did not have surgery [23].
- The validity of SPORT conclusions has been questioned due to high crossover rates in randomized intent-to-treat studies and variability of the patient population, nonoperative treatments, and operative procedures [23].
- The durability of operative results was demonstrated at 4-year follow-up in the SPORT study [23].
- In patients with degenerative spondylolisthesis and spinal stenosis who had operative treatment, those with predominant leg pain had a better prognosis than those with predominant back pain [23].

COMPLICATIONS

- The incidence of cauda equina syndrome following lumbar disc surgery is 0.2% [23].
- The incidence of thrombophlebitis following lumbar disc surgery is 1% [23].
- The incidence of pulmonary embolism following lumbar disc surgery is 0.4% [23].
- The incidence of wound infection following lumbar disc surgery is 2.2% [23].
- The incidence of pyogenic spondylitis following lumbar disc surgery is 0.07% [23].
- The incidence of postoperative discitis following lumbar disc surgery is 2% in a cohort of 1122 patients [23].
- The incidence of dural tears following lumbar disc surgery is 1.6% [23].
- The incidence of nerve root injury following lumbar disc surgery is 0.5% [23].
- Cerebrospinal fluid fistula is a rare occurrence following lumbar disc surgery [23].
- Laceration of abdominal vessels is a rare occurrence following lumbar disc surgery [23].
- Injury to abdominal viscera is a rare occurrence following lumbar disc surgery [23].

Anatomy & Pathophysiology

DISC STRUCTURE AND COMPOSITION

- The human spine possesses 23 intervertebral disks that separate the vertebrae and provide flexibility [34].
- Intervertebral disks account for about 20% to 30% of the length of the spine and increase in size from the cervical to the lumbar regions [34].
- The intervertebral disk contains a central gelatinous nucleus pulposus (NP) surrounded by a fibrous ring called the anulus fibrosus (AF) [34].
- Each vertebral body has cartilage end plates, which are a thin layer of hyaline cartilage tissue that separate the adjacent vertebrae [34].
- The nucleus pulposus consists mainly of a high concentration of proteoglycans and water surrounded by a loose type II collagen network [34].

- In the nucleus pulposus, collagen fibrils assume a random orientation and are interspersed in a matrix rich in proteoglycans and water [34].
- The anulus fibrosus has a low proteoglycan and water content and a high concentration of type I collagens as well as a small concentration of type II collagens [34].
- The anulus fibrosus is organized into concentric lamellae, described as possessing 20 to 25 lamellae rich in collagen fibrils arranged in a parallel fashion [34].
- In each adjacent lamella of the anulus fibrosus, the collagen fibrils along the axis are fashioned in the opposite direction to create an alternating pattern between the lamellae [34].
- The content of water and proteoglycan concentration within the disk increases when progressing from the anulus fibrosus to the nucleus pulposus [34].
- The content of collagen within the disk decreases from the outer anulus to the nucleus [34].
- With increasing age, the proteoglycan and water content of the nucleus decrease [34].
- The collagen content of the nucleus is highest in the cervical disks and lowest in the lumbar disks [34].
- The proteoglycan content of the disk shows an opposite trend to collagen content when evaluating spinal levels [34].

NEURAL ELEMENTS AND INNERVATION

- The orientation of 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 caudad lying centrally [28].
- Motor roots are ventral to the sensory roots at all levels [28].
- The arachnoid mater holds the nerve roots in their specific positions within the dural sac [28].
- In the thoracic and lumbar spine, the named nerve root exits below the named pedicle [28].
- Discs are formally named for the vertebral bodies between which they lie, such as the L4-5 disc being between the L4 and L5 vertebral bodies [28].
- In the lumbar spine, lateral recess pathology such as posterolateral disc herniation typically involves the next nerve root exiting caudal to that disc [28].
- An L4-5 posterolateral disc herniation is expected to cause L5 nerve root symptoms [28].
- The dorsal root ganglion (DRG) lies within the outer confines of the intervertebral foramen [28].
- Distal to the DRG, three distinct branches arise: the ventral ramus, the sinuvertebral nerve, and the dorsal ramus [28].
- The sinuvertebral 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 [28].
- The sinuvertebral nerve innervates the posterior disc, vertebral bodies, and posterior longitudinal ligament [28].
- The dorsal ramus courses dorsally, piercing the intertransverse ligament near the pars interarticularis [28].
- The medial branch of the dorsal ramus separates into three branches to innervate the facet joint at that level and the adjacent levels above and below [28].

- Disc innervation is through afferent axons with cell bodies within the DRG [28].
- Animal studies have revealed two paths between the annulus and the DRG: one from the sinuvertebral nerve and another along the paravertebral sympathetic trunk [28].
- The disc is innervated by fibers from multiple levels [28].
- In animal models, the lateral annulus was found to be innervated by fibers coursing from the index level and two additional superior levels through the sinuvertebral nerves [28].
- Innervation of the disc also occurs through the sympathetic trunk by the DRG from three levels even more superior than the sinuvertebral innervations [28].
- Contralateral DRG involvement occurs through both the sinuvertebral and sympathetic pathways [28].
- Similar nonsegmental, multilevel innervation patterns have been reported for the ventral disc surface [28].
- Innervations of the disc from the vertebral endplate have been shown [28].
- Intraosseous nerves follow the osseous vasculature to provide endplate innervation through the sinuvertebral nerve and basivertebral nerve [28].
- The density of innervation at the vertebral endplate is similar to that seen in the outer annulus [28].

LUMBAR VERTEBRAL ANATOMY

- The vertebral bodies of the lumbar spine are large, with a transverse diameter greater than the anterior-posterior diameter [31].
- Lumbar pedicles arise from the superior aspect of the vertebral bodies and project more horizontally than thoracic pedicles [31].
- L1 pedicles are only minimally medially angled, but as one progresses down the lumbar spine the orientation becomes more medial, particularly at L5 [31].
- Lumbar transverse processes project more perpendicular relative to the vertebral body and are large and flat in the upper lumbar spine [31].
- The L4 and L5 transverse processes are often smaller than those in the upper lumbar spine [31].
- Lumbar spinous processes are thick and project straight dorsally [31].
- The superior articular facet arises at the junction of the pedicle and lamina and is oriented such that the articular surface faces dorsomedially [31].
- The inferior facet extends down from the lamina and nestles snugly on the medial side of the superior facet [31].
- The sagittal orientation of the lumbar facet joints allows flexion and extension while providing resistance to axial rotation and translation [31].

DEGENERATIVE PATHOPHYSIOLOGY

- The degenerative process has been divided into three separate stages with relatively distinct findings [8].
- The first stage of spinal degeneration is dysfunction, seen in individuals 15 to 45 years old, characterized by circumferential and radial tears in the disc annulus and localized synovitis of the facet joints [8].

- The second stage of spinal degeneration is instability, found in 35- to 70-year-old patients, characterized by internal disruption of the disc, progressive disc resorption, and degeneration of the facet joints with capsular laxity, subluxation, and joint erosion [8].
- The final stage of spinal degeneration is stabilization, present in patients older than 60 years, characterized by progressive development of hypertrophic bone around the disc and facet joints leading to segmental stiffening or frank ankylosis [8].
- Each spinal segment degenerates at a different rate, so one level may be in the dysfunction stage while another is entering the stabilization stage [8].
- Disc herniation is considered a complication of disc degeneration in the dysfunction and instability stages [8].
- Spinal stenosis from degenerative arthritis is a complication of bony overgrowth compromising neural tissue in the late instability and early stabilization stages [8].
- Current research shows that genetic factors are more important than mechanical stresses in the development of disc herniations [5].
- The development of a disc herniation is only one of the pathways that the degenerative disc may follow [5].
- The disc may become the primary source of pain rather than the nerve root, a condition known as internal disc derangement (IDD) [5].
- There are no defined criteria for IDD, and the diagnosis requires a compilation of findings consistent with IDD and elimination of other diagnostic possibilities [5].
- Pain in IDD is axial primarily, often with buttock and posterior thigh (sclerotomal) pain [5].
- Pain distal to the knee indicates either different or coexistent pathology in IDD [5].
- Positions and activities that increase intradiscal symptoms, such as sitting or flexion, exacerbate IDD symptoms [5].
- There is no spasm in the paraspinal musculature in IDD, and extension usually gives some relief temporarily [5].
- If three or more Waddell signs are present, an alternative diagnosis to IDD is more likely [5].
- The natural history of degenerative disc disease is one of recurrent episodes of pain followed by periods of significant or complete relief [10].
- Generally symptomatic lumbar disc herniation has a favorable outcome in most patients [10].
- The primary benefit of surgery for lumbar disc herniation has been noted to occur early on in the first year after surgery, but with time the statistical significance of the improvement appears to be lost [10].
- Nonprogressive neurologic deficits originating from the lumbar spine, except cauda equina syndrome, can be treated nonoperatively with expected clinical improvement [10].
- If surgery is necessary for nonprogressive neurologic deficits, it usually can be delayed 6 to 12 weeks to allow adequate opportunity for improvement [10].
- IDD is a complicated multifactorial process characterized by altered biomechanics of loading, an imbalance of extracellular matrix synthesis and degradation, increased secretion of proinflammatory cytokines, and increased apoptosis and senescence in the nucleus pulposus cells [29].

- Mechanical progression and associated disk space narrowing leads to adjacent level pedicle approximation with narrowing of the superior-inferior dimensions of the intervertebral foraminal canal [29].
- Laxity of associated ligaments and vertebral column translates into altered loading mechanics and an altered pressure relationship on the vertebral bone and joint surfaces, influencing osteophyte formation and facet joint hypertrophy [29].
- Altered biomechanics lead to further degenerative changes and osteophyte formation, which has the potential to cause lumbar central and foraminal stenosis leading to symptomatic nerve compression and radiculopathy [29].
- TNF-α, interleukin-1β (IL-1β), and interleukin-6 (IL-6) can be found in the facet joint tissues in degenerative lumbar disorders [45].
- IL-6 from the synovium and cartilage of the facet joints is elevated mainly in lumbar spinal canal stenosis and related degenerative conditions [45].
- IL-1β is present in higher concentrations with lumbar spinal stenosis and degenerative changes compared with lumbar herniated disks [45].
- Higher expression of IL-1β has a higher association with leg pain and declining quality of life in lumbar degenerative patients compared with other inflammatory cytokines [45].
- IL-1β stimulates the production of matrix metalloproteinases (MMPs) through activation signaling pathways [45].
- IL-1β and MMPs are markedly increased in degenerative facets, leading to further proteoglycan degeneration and destruction of the cartilage and joint [45].
- Adiponectin has been identified in the process of facet joint osteoarthritis and shown to have greater expression for facet joint osteoarthritis when compared with IL-1β and TNF-α [45].
- High-molecular-weight (HMW) adiponectin has a proinflammatory response whereas the low-molecular-weight (LMW) isoform has an anti-inflammatory function [45].
- Adiponectin has the potential to be a catabolic mediator of osteoarthritis by increasing several MMPs and inducible nitric oxide synthase (iNOS) [45].

CLINICAL PRESENTATION AND PHYSICAL FINDINGS

- Intervertebral disc disease and disc herniation are most prominent in otherwise healthy people in the third and fourth decades of life [19].
- Most people relate their back and leg pain to a traumatic incident, but close questioning frequently reveals intermittent episodes of back pain for many months or even years before the onset of severe leg pain [19].
- Heavy exertion, repetitive bending, twisting, or heavy lifting often brings on axial back pain [19].
- The pain usually begins in the lower back, radiating to the sacroiliac region and buttocks, and can radiate down the posterior thigh [19].
- Radicular pain usually extends below the knee and follows the dermatome of the involved nerve root [19].

- Most radicular pain from nerve root compression caused by a herniated nucleus pulposus is evidenced by leg pain equal to, or in many cases greater than, the degree of back pain [19].
- 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 [19].
- Pain from disc herniation usually varies, increasing with activity, especially sitting and driving [19].
- Pain can be decreased by rest, especially in the semi-Fowler position, and can be exacerbated by straining, sneezing, or coughing [19].
- Weakness and paresthesias are other symptoms of disc herniation [19].
- In most patients with disc herniation, weakness is intermittent, varies with activity, and is localized to the neurologic level of involvement [19].
- Paresthesias vary and are limited to the dermatome of the involved nerve root [19].
- Numbness and weakness in the involved leg and occasionally pain in the groin or testis can be associated with a high or midline lumbar disc herniation [19].
- Symptoms of pressure on the entire cauda equina can occur if a fragment is large or the herniation is high, including numbness and weakness in both legs, rectal pain, numbness in the perineum, and paralysis of the sphincters [19].
- Patients with acute disc herniation pain usually show evidence of marked paraspinal spasm that is sustained during walking or motion [19].
- A scoliosis or a list in the lumbar spine may be present, and in many patients the normal lumbar lordosis is lost [19].
- As the acute episode subsides, the degree of spasm diminishes remarkably, and the loss of normal lumbar lordosis may be the only telltale sign [19].
- Point tenderness may be present over the spinous process at the level of the disc involved [19].
- If there is nerve root irritation, it centers over the length of the sciatic nerve, in the sciatic notch, and more distally in the popliteal space [19].
- Stretch of the sciatic nerve at the knee should reproduce buttock, thigh, and leg pain distal to the knee [19].
- A Lasègue sign usually is positive on the involved side [19].
- A positive Lasègue sign or straight-leg raising should elicit buttock and leg pain distal to the knee [19].
- Contralateral leg pain produced by straight-leg raising should be regarded as pathognomonic of a herniated intervertebral disc [19].
- The absence of a positive Lasègue sign should make one skeptical of the diagnosis, although older individuals may not have a positive Lasègue sign and tend toward more claudicatory symptoms [19].
- If leg pain has persisted for any length of time, atrophy of the involved limb may be present, as shown by asymmetric girth of the thigh or calf [19].
- Unilateral disc herniation at L3-4 usually compresses the L4 root as it crosses the disc before exiting at the L4-5 intervertebral foramen below the L4 pedicle [19].
- Pain from L3-4 disc herniation may be localized around the medial side of the leg [19].

- Numbness from L3-4 disc herniation may be present over the anteromedial aspect of the leg [19].
- The anterior tibial muscle may be weak in L3-4 disc herniation, evidenced by inability to perform specific movements [19].
- Unilateral disc herniation at L4-5 results in compression of the L5 root [44].
- L5 root radiculopathy should produce pain in the dermatomal pattern [44].
- Numbness from L5 root compression follows the L5 dermatome along the anterolateral aspect of the leg and the dorsum of the foot, including the great toe [44].
- The autonomous zone for the L5 nerve is the dorsal first web of the foot and the dorsum of the third toe [19].
- Weakness from L5 root compression may involve the extensor hallucis longus, gluteus medius, or extensor digitorum longus and brevis [19].
- Reflex change usually is not found in

Clinical Presentation

HISTORY AND SYMPTOMS

- Peak incidence of lumbar disc herniation is in the fourth and fifth decades of life [51].
- Men are three times more likely to sustain lumbar disc herniation than women [51].
- Only 4% to 6% of lumbar disc herniations become symptomatic [51].
- Most patients relate their back and leg pain to a traumatic incident, but close questioning frequently reveals intermittent episodes of back pain for many months or years before the onset of severe leg pain [19].
- The usual history of lumbar disc herniation is repetitive lower back and buttock pain relieved by a short period of rest, which is suddenly exacerbated by a flexion episode with the appearance of leg pain [19].
- Most radicular pain from nerve root compression caused by a herniated nucleus pulposus is evidenced by leg pain equal to, or greater than, the degree of back pain [19].
- Pain from disc herniation usually increases with activity, especially sitting and driving [19].
- A diagnosis of symptomatic disc should be viewed with skepticism if the pattern of pain is bizarre or the pain is uniform in intensity [19].
- Weakness associated with disc herniation is usually intermittent, varies with activity, and is localized to the neurologic level of involvement [19].
- Paresthesias associated with disc herniation vary and are limited to the dermatome of the involved nerve root [19].
- Generalized weakness or paresthesias should prompt questioning of the diagnosis of a simple unilateral disc herniation [19].
- Cauda equina syndrome symptoms include numbness and weakness in both legs, rectal pain, numbness in the perineum, and paralysis of the sphincters [19].

- Sudden loss of bowel or bladder control should prompt primary consideration of cauda equina syndrome [19].
- The presence of sciatica is the most sensitive and specific finding for lumbar disc herniation [51].
- Diskogenic pain related to disk degeneration or disk herniation may be worse in flexion, while sitting, or with prolonged axial loading and is often described in a diffuse, bandlike distribution [55].
- Within 3 months of symptom onset, approximately 90% of patients with lumbar disc herniation will experience symptomatic improvement without surgery [51].
- Most lumbar disc herniations, particularly contained ones, resorb and diminish in size over time [51].

PHYSICAL EXAMINATION

- Patients with acute pain from disc disease usually show evidence of marked paraspinal spasm that is sustained during walking or motion [19].
- A scoliosis or a list in the lumbar spine may be present in patients with disc disease [19].
- Loss of normal lumbar lordosis may be the only telltale sign as an acute episode of disc disease subsides [19].
- The absence of a positive Lasègue sign should make one skeptical of the diagnosis, although older individuals may not have a positive Lasègue sign [19].
- Inappropriate findings and inconsistencies in the examination usually are nonorganic in origin [19].
- Atrophy of the involved limb, shown by asymmetric girth of the thigh or calf, may be present if leg pain has persisted for any length of time [19].
- The ipsilateral hip and knee may be flexed and externally rotated to relieve root tension [51].
- Pain with straight leg raise testing results from increased nerve root tension and a lack of normal excursion of the root at the herniation site [51].
- A positive crossed straight leg raise test has a higher specificity than a positive ipsilateral test, but the sensitivity varies [51].
- For the purpose of detecting lumbar disk herniation, the straight leg raise is more sensitive but less specific than the contralateral straight leg raise in patients with single leg radicular pain [55].
- Unilateral disc herniation at L3-4 usually compresses the L4 root as it crosses the disc before exiting at the L4-5 intervertebral foramen [19].
- Pain from an L3-4 disc herniation may be localized around the medial side of the leg [19].
- Numbness from an L3-4 disc herniation may be present over the anteromedial aspect of the leg [19].
- Weakness involving the extensor hallucis longus, gluteus medius, or extensor digitorum longus and brevis may occur with L5 root involvement [19].
- Reflex change usually is not found with L5 root involvement, though a diminished posterior tibial reflex is possible but difficult to elicit [19].
- The diagnosis of recurrent disc herniation is significantly more difficult than that of primary disc herniation [6].

- The clinical presentation of recurrent disc herniation may be identical to that of primary herniation but usually has a larger component of axial pain [6].
- Most recurrences of disc herniation happen in the relatively early postoperative period, primarily the first 6 months after surgery [6].
- The incidence of recurrent disc herniations is reported in 3% to 7% of patients [6].
- Low back pain is a common report of the young, active patient and most often will be a self-limiting episode without underlying etiology [21].
- Red flag signs indicating potential underlying pathology include fevers, chills, weight loss, a history of cancer, immunosuppression, and/or intravenous drug abuse [55].
- Reports of clumsiness, gait instability, bowel, bladder, or sexual dysfunction should prompt assessment for causes of spinal cord dysfunction such as cervical or thoracic myelopathy [55].
- Presence of three or more Waddell signs should prompt evaluation for other etiologies such as depression, hypochondriasis, or secondary gain issues [55].
- Presence of three or more Waddell signs is associated with higher pain scores and poorer treatment outcomes overall [55].

Investigations

MRI

- MRI is the standard for advanced imaging of the spine and is superior to CT in most circumstances, particularly for identifying infections, tumors, and degenerative changes within discs [37].
- MRI is superior to CT for directly imaging neural structures and the intervertebral disc [37].
- MRI allows imaging of the nerve root in the foramen, which is difficult with postmyelography CT because contrast does not fully extend through the foramen [37].
- MRI evidence of lumbar disc degeneration is found in 35% of patients aged 20 to 39 years and in 100% of patients older than 50 years [37].
- MRI findings must be carefully correlated with the clinical impression because the modality detects asymptomatic anatomic abnormalities [37].
- Meaningful clinical information from MRI is obtained by posing specific questions derived from history and physical examination regarding neural compression, instability, or deformity [37].
- For discogenic back pain, MRI typically reveals decreased signal intensity in the disc space on T2-weighted imaging (dark disc), with or without annular tear or high-intensity zone (HIZ) [3].
- For recurrent disc herniation, MRI with intravascular contrast material is helpful in identifying the recurrence [6].
- It is difficult to distinguish peridural scar from a small recurrent herniation on MRI [6].

RADIOGRAPHY

- Radiographs are negative for instability in discogenic back pain but may show disc space narrowing or other stigmata of spondylosis [3].
- Imaging studies for internal disc derangement should include a lumbar spine series and dynamic films to assess deformities, measurable instability, or destructive lesions [5].

DISCOGRAPHY

- Discography is a controversial study designed as a preoperative test to correlate MRI findings with a clinically significant pain generator [3].
- A reliably positive discography result requires the procedure to elicit pain similar to that usually described by the patient (concordant pain) [3].
- The discography study should involve at least one minimally painful, nonconcordant level [3].
- The study should be performed at multiple levels to include all abnormal levels and one or more normal levels as identified on MRI [3].
- Evidence suggests that annular tears created by the needle during discography may accelerate the rate of symptomatic disc degeneration [3].
- Discography is falling out of favor due to the risk of accelerating symptomatic disc degeneration [3].
- Provocative discography to evaluate adjacent levels in spondylolisthesis patients has not been found to be reliable [17].

MYELOGRAPHY AND CT

- Myelography may be unnecessary if clinical and CT or MRI findings are in complete agreement [42].
- Primary indications for myelography include inability to obtain MRI, suspicion of an intraspinal lesion, presence of spinal instrumentation causing artifact, or questionable diagnosis from conflicting findings [42].
- Myelography is improved by the use of postmyelography CT, particularly in evaluating spinal stenosis and previously operated spines [42].
- CT is the diagnostic imaging modality of choice for thoracic, lumbar, and sacral spine injuries [41].
- In thoracolumbar injuries, MRI has a limited role and added very little to the management of patients with CT-proven injuries [39].

INJECTION STUDIES

- Epidural injections are used in the treatment of lumbar central spinal stenosis [1].
- Fluoroscopically directed epidural injections have been evaluated for complications in a series of 10,000 cases [1].
- Transforaminal injection of corticosteroids for lumbar radiculopathy has been subject to systematic review and meta-analysis [1].
- Facet joint injections have been evaluated in randomized controlled trials for low back pain [1].

- Pars injection with a small volume of long-acting local anesthetic is a helpful diagnostic tool when evaluating patients with extensive degenerative changes at multiple levels in addition to isthmic spondylolisthesis [17].

ELECTRODIAGNOSTICS

- EMG may be helpful to distinguish peripheral neuropathy from lumbar spinal stenosis [15].
- Needle EMG has a lower false positive rate than MRI in asymptomatic older adults being evaluated for lumbar spinal stenosis [16].

Treatment

NON-OPERATIVE MANAGEMENT

- More than half of patients who seek treatment for low back pain recover in 1 week, and 90% recover within 1 to 3 months [3].
- Conservative management for discogenic back pain includes NSAIDs, physical therapy, and conditioning [3].
- Patient education about the self-limiting nature of discogenic back pain is an important component of conservative treatment [3].
- The literature supports an active care approach that minimizes centrally acting medications for lumbar disc disease [8].
- Nonprogressive neurologic deficits originating from the lumbar spine, excluding cauda equina syndrome, can be treated nonoperatively with expected clinical improvement [10].
- Multiple modalities for conservative management of lumbar radiculopathy include NSAIDs, muscle relaxants, short-term narcotics, antineuropathic medications, physical therapy, and epidural or transforaminal steroid injections [49].
- There is no consensus on the optimum conservative treatment strategy for lumbar radiculopathy secondary to disk herniation [49].
- For acutely painful patients with thoracic disk herniation, physical therapy should initially be restricted to passive treatment modalities such as heat, ultrasonography, and massage [48].
- As symptoms lessen in thoracic disk herniation patients, more active therapy such as extension-based exercises, core strengthening, and range of motion can be introduced [48].
- Nonsurgical treatment for thoracic disk herniation should be undertaken for a minimum of 4 to 6 weeks before surgical consideration, except in cases of acutely progressive myelopathy [48].
- Continued nonsurgical treatment strategies are not cost-effective after 6 weeks of treatment in patients with imaging-confirmed spine pathology and lumbar disk herniation [49].

EPIDURAL AND INJECTION THERAPIES

- Epidural steroid injections in the treatment of disc herniation and radiculitis are performed based on the pathophysiologic mechanism of reducing inflammation [20].
- Evidence suggests that local anesthetics with or without steroids are equally as effective as steroids alone in many settings for epidural injections [20].
- Therapeutic injections help manage pain and may alleviate or decrease the need for oral analgesics in severe pain from acute disc injury [20].
- A prospective randomized controlled trial demonstrated a greater than 50% reduction in pain at 1 month in 54% of patients who received a transforaminal steroid injection, which was significantly better than those receiving normal saline or local anesthetic injections [49].
- Repeat epidural steroid injections are less likely to provide significant relief compared to initial injections [49].
- The judicious use of epidural steroids is supported for short-term relief, but long-term results and repeated use are questionable [10].
- Preoperative epidural steroid injection does not influence surgical outcome for lumbar disk herniation [49].
- In a study of 17 NFL players treated with epidural steroid injections for lumbar radiculopathy secondary to lumbar disk herniation, 89% returned to play with an average loss of 2.8 practices and 0.6 games [49].
- Three NFL players who received epidural steroid injections for lumbar disk herniation eventually required surgery and were noted to have sequestered disk herniations along with weakness [49].

OPERATIVE TREATMENT

- The primary indication for surgery in patients with spinal stenosis is increasing pain that is resistant to conservative measures [11].
- Operative intervention for lumbar spinal stenosis is expected to give good relief of claudicatory leg pain with variable response to back pain [11].
- Most series report a 64% to 91% rate of improvement after surgery for lumbar spinal stenosis, with 42% improvement in patients with diabetes [11].
- Reoperation rates for lumbar spinal stenosis vary from 6% to 23% [11].
- Prognostic factors for better surgical results in lumbar spinal stenosis include disc herniation, stenosis at a single level, weakness of less than 6 weeks' duration, monoradiculopathy, and age younger than 65 years [11].
- Depression, psychiatric disease, cardiovascular disease, higher body mass index, scoliosis, and disorders affecting ambulation are associated with a poorer surgical prognosis for lumbar spinal stenosis [11].
- Radiographic findings alone are never an indication for surgery [11].
- Decompression by laminectomy or a fenestration procedure is the treatment of choice for lumbar spinal stenosis [11].
- Fusion is required after decompression if excessive bony resection compromises stability or if isthmic or degenerative spondylolisthesis, scoliosis, or kyphosis is present [11].

- Laminectomy may be preferable in older patients with severe, multilevel stenosis, whereas fenestration procedures are an alternative in younger patients with intact discs [11].
- The benchmark for surgical treatment of lumbar disk herniation is diskectomy [49].
- Multiple systematic reviews have failed to demonstrate a consistent benefit of any one surgical technique (open diskectomy, microdiskectomy, tubular microdiskectomy, percutaneous or endoscopic diskectomy) over any other for lumbar disk herniation [49].
- Surgery demonstrated improvements in all primary outcome measures at 2, 4, and 8 years in the observational arm of the Spine Patient Outcomes Research Trial for lumbar disk herniation [49].
- Patients with symptoms greater than six months, sequestered fragments, increased back pain, and who were not working had relatively increased benefits from surgery for lumbar disk herniation [49].
- Obesity is associated with less clinical benefit from surgical or nonsurgical treatment for lumbar disk herniation [49].
- More proximal disk herniations are associated with a greater degree of postoperative improvement [49].
- Surgical treatment is appropriate for thoracic disk herniation patients with radicular pain recalcitrant to prolonged nonsurgical management, weakness, and acute myelopathy [48].
- Approximately 4% of thoracic disk herniations present with acute myelopathy with severe functional limitations [48].
- A more aggressive, urgent approach to surgical decompression and stabilization has been advocated for thoracic disk herniation patients with acute myelopathy [48].
- The decision to instrument and fuse in thoracic disk herniation surgery is dependent on the degree of instability imparted by the surgical approach [48].
- Total disk replacement is an option for younger patients with the theoretical advantage of saving motion segments and minimizing adjacent segment disease when compared with fusion [49].
- Multiple clinical trials have determined lumbar total disk replacement to be not-inferior to circumferential lumbar fusion, though there is significant concern for bias in many of these studies [49].
- In a cohort of 39 young individuals involved in athletics, 95% returned to sporting activity after lumbar total disk replacement, with 85% reporting improved performance from preoperative status [49].
- Total disc arthroplasty is a surgical option for patients with degenerative disc disease at a single level (L4–L5 or L5–S1) in the lumbar spine with the absence of spondylolisthesis and no relief from 6 months of nonoperative therapy [3].
- In direct comparison with anterior interbody fusion, total disc arthroplasty showed equivalent clinical results and no catastrophic failures at 2-year follow-up [3].
- Significant concerns regarding total disc arthroplasty include long-term results, design issues, cost, and the safety of revision procedures [3].
- Currently no good surgical option is available that reliably reduces symptoms of discogenic back pain [3].
- Surgery should be avoided whenever possible for discogenic back pain, and conservative measures should be exhausted before any consideration is given to surgical intervention [3].

- Intradiscal electrotherapy involves percutaneously heating the fibers of the annulus fibrosus to reconfigure the collagen fibers, thus restoring the mechanical integrity of the disc [3].
- Intradiscal electrotherapy may be effective in early conditions with less than 50% loss of disc height but not in more advanced disease [3].
- Long-term follow-up suggests that symptomatic improvement from intradiscal electrotherapy often lasts less than 1 year, and this procedure has been largely abandoned [3].
- Interbody fusion is a surgical option for discogenic back pain, performed with structural constructs such as femoral ring allografts or interbody fusion cages in the disc space [3].
- Approaches for interbody fusion in discogenic back pain include anterior retroperitoneal, direct lateral, posterior midline lumbar, or posterior transforaminal lumbar interbody fusion [3].
- The primary benefit of surgery for symptomatic lumbar disc herniation has been noted to occur early on in the first year after surgery, but with time the statistical significance of the improvement appears to be lost [10].
- No operative technique has been shown to reduce the incidence of recurrent disc herniations, which is reported in 3% to 7% of patients [6].
- More aggressive disc removal does not reduce the incidence of recurrent disc herniations and does not reduce the motion segment [6].
- MRI with intravascular contrast material has been helpful in identifying recurrent lumbar disc herniations [6].
- It is difficult to distinguish a peridural scar from a small recurrent herniation on MRI [6].
- The principles of identifying and protecting the nerve root and then removing the herniation for recurrent disc herniation are the same as for a primary discectomy [6].
- The area of exposure for recurrent disc herniation surgery generally should be larger than for primary surgery, although the procedure usually can still be done on an outpatient basis [6].
- The transforaminal endoscopic approach can be used for recurrence after a traditional microdiscectomy [6].
- If both the primary and recurrence approaches are transforaminal, the total level of invasiveness is typically less than a primary microscopic approach because there is no violation of the facet joint [6].
- Spinal fusion is not performed during repeat lumbar disc excision unless an unstable spine is created by the dissection or was identified preoperatively as a correctable and symptomatic problem [6].

Complications

SURGICAL COMPLICATIONS

- The overall complication rate for lumbar disc surgery ranges from none to more than 10% [23].
- The reoperation rate for lumbar disc surgery ranges from 4% to more than 20% [23].
- Cauda equina syndrome occurs in 0.2% of lumbar disc surgery cases [23].
- Thrombophlebitis occurs in 1% of lumbar disc surgery cases [23].

- Pulmonary embolism occurs in 0.4% of lumbar disc surgery cases [23].
- Wound infection occurs in 2.2% of lumbar disc surgery cases [23].
- Pyogenic spondylitis occurs in 0.07% of lumbar disc surgery cases [23].
- Postoperative discitis occurs in 2% of lumbar disc surgery cases, based on a cohort of 1122 patients [23].
- Dural tears occur in 1.6% of lumbar disc surgery cases [23].
- Nerve root injury occurs in 0.5% of lumbar disc surgery cases [23].
- Cerebrospinal fluid fistula is a rare complication of lumbar disc surgery [23].
- Laceration of abdominal vessels is a rare complication of lumbar disc surgery [23].
- Injury to abdominal viscera is a rare complication of lumbar disc surgery [23].
- Vascular injury, nerve root injury, infection, discitis, cauda equine syndrome, and dural tears are complications of lumbar disc herniation surgery [53].
- Infection occurs in 1% of lumbar disc herniation surgery cases, with an increased rate in diabetics [53].
- Treatment of dural tears includes bedrest and subarachnoid drain placement [53].
- Clinical outcomes are generally unaffected if dural tears are adequately repaired [53].

RECURRENT HERNIATION AND REOPERATION

- Recurrent disc herniation is reported in 3% to 7% of patients following lumbar disc surgery [6].
- Most recurrent disc herniations occur in the first 6 months after surgery [6].
- No operative technique has been shown to reduce the incidence of recurrent disc herniations [6].
- More aggressive disc removal does not reduce the incidence of recurrent disc herniations [6].
- More aggressive disc removal does not reduce the motion segment [6].
- MRI with intravascular contrast material is helpful in identifying recurrent herniations [6].
- Complications for repeat spine surgery are reported to be three to five times higher than for primary surgeries [58].
- Satisfactory results from reoperation for failed spine surgery have been reported to be 31% to 80% [58].
- As the frequency of repeat back surgeries increases, the chance of a satisfactory result decreases precipitously [58].

EPIDURAL INJECTION COMPLICATIONS

- Dural puncture occurs in 0.5% to 5% of patients having cervical or lumbar epidural steroid injections [56].
- Epidural abscess, epidural hematoma, durocutaneous fistula, and Cushing syndrome have been reported as individual case reports following epidural corticosteroid injections [56].
- Vasovagal reaction is the most adverse event imputed during an epidural injection [56].
- Nonpositional headaches, facial flushing, insomnia, low-grade fever, and transient increased back or lower extremity pain are minor complaints caused by corticosteroid injected into the epidural space [56].

- In large series involving nearly 5000 patients with over 8000 transforaminal lumbar epidural injections, no major adverse events were reported [56].
- In large series involving nearly 5000 patients with over 8000 transforaminal lumbar epidural injections, the incidence of postinjection headache was less than 1% [56].
- In large series involving nearly 5000 patients with over 8000 transforaminal lumbar epidural injections, increased leg or back pain occurred in less than 1% of patients [56].
- Needle misplacement occurs in 40% of caudal epidural injections when done without fluoroscopic guidance [56].
- Needle misplacement occurs in 30% of lumbar epidural injections when done without fluoroscopic guidance [56].

DIAGNOSTIC PROCEDURE COMPLICATIONS

- Annular tears created by the needle during discography may accelerate the rate of symptomatic disc degeneration [3].

Recovery

NATURAL HISTORY AND PROGNOSIS

- The natural history of degenerative disc disease is characterized by recurrent episodes of pain followed by periods of significant or complete relief [10].
- The primary benefit of surgery for lumbar disc herniation occurs early in the first year after surgery [10].
- With time, the statistical significance of surgical improvement for lumbar disc herniation appears to be lost [10].
- The frequency and intensity of symptoms helps determine the aggressiveness of intervention [8].
- Long-term follow-up studies document that the primary benefit of surgery is noted early, but statistical significance of improvement is lost over time [10].

CONSERVATIVE MANAGEMENT

- The literature supports an active care approach that minimizes centrally acting medications [8].
- The judicious use of epidural steroids is supported for short-term relief but does not have an effect on long-term outcomes [8].
- The judicious use of epidural steroids is supported, but long-term results and repeated use are questionable [10].
- Delaying surgical treatment for a trial of nonoperative treatment has not been shown to affect outcome [11].
- One study reported less favorable results in patients who had symptoms for more than 33 months [11].

- Conservative management is warranted indefinitely in a patient with good function and manageable symptoms [11].

SURGICAL OUTCOMES AND PROGNOSTIC FACTORS

- Most series report a 64% to 91% rate of improvement after surgery for spinal stenosis [11].
- Most series report a 42% rate of improvement in patients with diabetes after surgery for spinal stenosis [11].
- Most patients still have some minor complaints after surgery, usually referable to preexisting degenerative arthritis of the spine [11].
- Neurologic findings, if present, improve inconsistently after surgery [11].
- Patients whose predominant complaint was leg pain improved significantly more with operative treatment than those whose predominant complaint was low back pain [11].
- Both patients with predominant leg pain and those with predominant low back pain improved significantly with operative treatment compared with conservative treatment [11].
- Reoperation rates vary from 6% to 23% [11].
- Better results are associated with a disc herniation, stenosis at a single level, weakness of less than 6 weeks' duration, monoradiculopathy, and age younger than 65 years [11].
- Depression, psychiatric disease, cardiovascular disease, higher body mass index, scoliosis, and disorders affecting ambulation have been associated with a poorer prognosis [11].
- Reversal of neurologic consequences of spinal stenosis seems to be a relative indication for surgery unless the symptoms are acute [11].
- Correlation of imaging with symptoms seems to be the best guarantee of improvement after surgery [11].
- Localized lesions on radiograph without general involvement respond best [11].
- Ganz reported a 96% success rate in patients whose preoperative symptoms were relieved by postural change [11].
- A patient's inability to tolerate the restricted lifestyle necessitated by the disease and the failure of a good conservative treatment regimen should be the primary determining factors for surgery [11].
- The patient should understand the potential for the operation to fail to relieve pain or to worsen it, especially in regard to the axial component of the symptoms [11].
- Lumbar spinal stenosis does not result in paralysis, only decreased ambulatory capacity [11].

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