CQ HAND + UPPER LIMB
SPECIALIST ORTHOPAEDIC SURGEON

EVIDENCE SUMMARY

Lumbar discectomy

Anatomy & Pathophysiology

DISC STRUCTURE AND COMPOSITION

- The intervertebral disc consists of a central gelatinous nucleus pulposus (NP) surrounded by a fibrous annulus fibrosus (AF) [29].
- The nucleus pulposus is composed mainly of high concentrations of proteoglycans and water, surrounded by a loose type II collagen network with random fibril orientation [29].
- The annulus fibrosus has low proteoglycan and water content but high concentrations of type I and small amounts of type II collagen organized into 20 to 25 concentric lamellae [29].
- In the annulus fibrosus, collagen fibrils in adjacent lamellae are oriented in opposite directions to resist tensile forces during bending and twisting [29].
- Water and proteoglycan content increase from the annulus fibrosus to the nucleus pulposus, while collagen content decreases from the outer annulus to the nucleus [29].
- With increasing age, the proteoglycan and water content of the nucleus pulposus decrease [29].
- The cartilage end plates are a thin layer of hyaline cartilage tissue that separates the intervertebral disc from the adjacent vertebral bodies [29].

LUMBAR SPINE BONY ANATOMY

- Lumbar vertebral bodies have a transverse diameter greater than the anterior-posterior diameter [26].
- Lumbar pedicles arise from the superior aspect of the vertebral bodies and project more horizontally than thoracic pedicles [26].
- Pedicle orientation becomes more medial as one progresses down the lumbar spine, particularly at L5 [26].
- The superior articular facet arises at the junction of the pedicle and lamina and is oriented such that the articular surface faces dorsomedially [26].
- The sagittal orientation of lumbar facet joints allows flexion and extension while providing resistance to axial rotation and translation [26].
- In a study of 2905 pedicle measurements from T1 to L5, pedicles were widest at L5 and narrowest at T5 in the horizontal plane [25].

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- The widest pedicles in the sagittal plane were found at T11, and the narrowest at T1 [25].
- In the sagittal plane, lumbar pedicles angle caudal at L5 and cephalad at L3-T1 [25].

NEURAL ELEMENTS AND INNERVATION

- In the lumbar spine, the named nerve root exits below the named pedicle [23].
- Intervertebral discs are formally named for the vertebral bodies between which they lie, such as the L4-5 disc lying between the L4 and L5 vertebral bodies [23].
- Lateral recess pathology, such as posterolateral disc herniation, typically involves the nerve root exiting caudal to that disc; for example, an L4-5 posterolateral herniation causes L5 nerve root symptoms [23].
- The dorsal root ganglion (DRG) lies within the outer confines of the intervertebral foramen [23].
- The sinuvertebral nerve is a recurrent branch of the ventral ramus that innervates the posterior aspect of the disc, vertebral bodies, and posterior longitudinal ligament [23].
- Disc innervation occurs through afferent axons with cell bodies within the DRG, with signals transmitted via the sinuvertebral nerve and paravertebral sympathetic trunk [23].
- Animal studies indicate the lateral annulus is innervated by fibers from the index level and two additional superior levels via sinuvertebral nerves, and by DRG from three levels even more superior via the sympathetic trunk [23].
- The basivertebral nerve enters the vertebral margin with vessels to innervate the vertebral endplate, with a density of innervation similar to that of the outer annulus [23].
- The medial branch of the dorsal ramus provides primary innervation to the facet joints at that level and adjacent levels above and below [23].

STENOSIS ANATOMY

- The central spinal canal is defined as the space posterior to the posterior longitudinal ligament, anterior to the ligamentum flavum and laminae, and bordered laterally by the medial border of the superior articular process [13].
- The lateral recess is defined by the superior articular facet posteriorly, the thecal sac medially, the pedicle laterally, and the posterolateral vertebral body anteriorly [13].
- The intervertebral foramen is bordered superiorly and inferiorly by adjacent level pedicles, posteriorly by the facet joint and lateral extensions of the ligamentum flavum, and anteriorly by adjacent vertebral bodies and disc [13].
- Normal foraminal height is 20 to 30 mm, and superior width is 8 to 10 mm [13].
- The lateral recess, also known as “Lee’s entrance zone,” begins at the medial border of the superior articular process and extends to the medial border of the pedicle [22].
- The foraminal region, or “Lee’s midzone,” lies ventral to the pars and contains the dorsal root ganglion and ventral motor root, which occupy 30% of this space [22].
- The exit zone is identified as the area lateral to the facet joint where the nerve root can be compressed by a far lateral disc, spondylolisthesis, or facet arthritis [22].

PATHOPHYSIOLOGY OF DEGENERATION

- Disc degeneration is a 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 nucleus pulposus cells [24].
- Genetic factors are considered more important than mechanical stresses in the development of disc herniation [15].
- The degenerative process is divided into three stages: dysfunction (ages 15-45), instability (ages 35-70), and stabilization (age >60) [18].
- The dysfunction stage is characterized by circumferential and radial tears in the disc annulus and localized synovitis of the facet joints [18].
- The instability stage is characterized by internal disruption of the disc, progressive disc resorption, degeneration of facet joints with capsular laxity, subluxation, and joint erosion [18].
- The stabilization stage is characterized by progressive development of hypertrophic bone around the disc and facet joints leading to segmental stiffening or frank ankylosis [18].
- Disc herniation is considered a complication of disc degeneration occurring in the dysfunction and instability stages [18].
- Spinal stenosis from degenerative arthritis is a complication of bony overgrowth compromising neural tissue in the late instability and early stabilization stages [18].
- As disc height decreases, the loading characteristics of the facet joints are altered, leading to capsular incompetence and subsequent hypertrophy of the capsule, ligamentum flavum, and facets [13].
- The ligamentum flavum becomes less pliable with age [13].
- In spinal extension, the spinal canal diameter diminishes resulting in buckling of the shortened, hypertrophied ligamentum flavum; in flexion, there is a relative increase in canal diameter [13].
- TNF-α, interleukin-1β (IL-1β), and interleukin-6 (IL-6) are found in facet joint tissues in degenerative lumbar disorders [39].
- IL-1β is present in higher concentrations with lumbar spinal stenosis and degenerative changes compared with lumbar herniated discs [39].
- IL-1β stimulates the production of matrix metalloproteinases (MMPs) through activation signaling pathways [39].
- Adiponectin has been identified in the process of facet joint osteoarthritis and shown to have greater expression than IL-1β and TNF-α in this context [39].
- High-molecular-weight adiponectin has a proinflammatory response, whereas the low-molecular-weight isoform has an anti-inflammatory function [39].

NATURAL HISTORY

- The natural history of disc disease is one of recurrent episodes of pain followed by periods of symptomatic or complete relief [18].

- The natural history of spinal stenosis is not well understood, but it is typically favorable, with approximately 15% of patients deteriorating clinically [13].
- Improvement occurs in 30% to 50% of patients with spinal stenosis [13].
- More than half of patients who seek treatment for low back pain recover in 1 week, and 90% recover within 1 to 3 months [8].
- Abnormal magnetic resonance imaging findings are present in 76% of asymptomatic matched controls [41].

Clinical Presentation

GENERAL PRESENTATION AND EPIDEMIOLOGY

- Lumbar disc herniation (LDH) peak incidence occurs 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].
- Caudal segments are affected more commonly, with L5-S1 more commonly affected than L4-L5 [51].
- LDH may or may not be associated with an inciting event such as load bearing [51].
- The patient typically presents with varying degrees of back and leg pain [51].
- Leg pain usually follows the dermatomal path of the affected root(s) [51].
- Radicular pain may be accompanied by motor, sensory, and/or reflex disturbances [51].
- The presence of sciatica is the most sensitive and specific finding for lumbar disc herniation [51].
- Cauda equina syndrome secondary to large central lumbar disc herniations is rare [51].
- Discogenic back pain is secondary to intervertebral disc degeneration without other pathologic entities such as spinal instability, fractures, dislocations, and neural compression [8, 9].
- Discogenic back pain is characterized by a paucity of physical findings [8, 9].
- In discogenic back pain, back pain is greater than leg pain [8, 9].
- Discogenic back pain presents with no radiculopathy and an absence of tension signs [8, 9].
- Diskogenic pain related to disk degeneration or disk herniation may be worse in flexion, while sitting, or with prolonged axial loading [52].
- Diskogenic pain is often described in a diffuse, bandlike distribution [52].
- Facet-mediated pain related to facet arthrosis or spondylolysis may be worse in extension and is often activity related and well localized [52].

PHYSICAL EXAMINATION

- 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 [52].
- The straight leg raise must produce radicular symptoms in the distribution of the provoked root; for the sciatic nerve, this means pain distal to the knee [51].
- The Lasegue sign is defined as SLR radiculopathy aggravated by ankle dorsiflexion [51].
- The contralateral SLR (well-leg SLR) puts tension on the involved root from the opposite direction [51].
- The Kernig test involves flexing the neck chin to chest, flexing the hip to 90°, and then extending the leg similar to SLR to reproduce radiculopathy [51].
- The Bowstring sign is defined as SLR radiculopathy aggravated by applying pressure over the popliteus fossa [51].
- The femoral stretch test is performed with the patient prone to stretch the femoral nerve roots and test L2 to L4 irritation [51].
- The Naffziger test involves compression of neck veins for 10 seconds with the patient lying supine, followed by coughing to reproduce radiculopathy [51].
- The Milgram test involves the patient raising both legs 3 inches off the examining table and holding this position for 30 seconds, which may reproduce radiculopathy [51].
- L1 nerve root involvement presents with no motor deficit, sensory changes in the inguinal crease, and no reflex changes [52].
- L2 nerve root involvement presents with hip flexion weakness, sensory changes in the anterior upper/inner thigh, and no reflex changes [52].
- L3 nerve root involvement presents with hip flexion/adduction weakness, sensory changes in the anterior/inner thigh, and no reflex changes [52].
- L4 nerve root involvement presents with knee extension weakness, sensory changes in the lateral thigh, anterior knee, and medial leg, and patellar reflex changes [52].
- L5 nerve root involvement presents with ankle/toe dorsiflexion and hip abduction weakness, sensory changes in the lateral leg and dorsum of foot, and no reflex changes [52].
- S1 nerve root involvement presents with ankle plantar flexion and foot eversion weakness, sensory changes in the posterior leg and lateral foot, and Achilles reflex changes [52].
- S2 nerve root involvement presents with toe plantar flexion weakness, sensory changes in the plantar foot, and no reflex changes [52].
- S3-S4 nerve root involvement presents with bowel/bladder dysfunction, perianal sensory changes, and cremasteric reflex changes [52].
- The five categories of nonorganic or psychologic pain signs are tenderness, simulation, distraction, regional disturbances, and overreaction [52].

- The presence of three or more Waddell signs should prompt evaluation for other etiologies such as depression, hypochondriasis, or secondary gain issues [52].
- The presence of three or more Waddell signs does not discount the possibility of a spine problem but is associated with higher pain scores and poorer treatment outcomes overall [52].

RECURRENT DISC HERNIATION

- 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 happen in the relatively early postoperative period, primarily the first 6 months after surgery [6].
- For patients with a history of no or minimal improvement after disc excision, diagnostic difficulties are greater due to the need to consider incorrect original diagnosis, incorrect level, root anomaly, root injury, CSF leak, and infection in addition to recurrent disc herniation [6].
- The best results from repeat surgery for disc problems occur in patients who have experienced 6 months or more of complete pain relief after the first procedure [44].
- The best results from repeat surgery for disc problems occur when leg pain exceeds back pain [44].
- The best results from repeat surgery for disc problems occur when a definite recurrent disc can be identified [44].
- Adverse factors for repeat spine surgery include scarring, previous infection, repair of pseudarthrosis, and adverse psychologic factors [44].
- Satisfactory results from reoperation for failed spine surgery have been reported to be 31% to 80% [44].
- Complications of repeat spine surgery have been reported to be three to five times higher than for primary surgeries [44].
- Patients should expect improvement in the severity of symptoms rather than complete relief of pain after repeat spine surgery [44].
- As the frequency of repeat back surgeries increases, the chance of a satisfactory result decreases precipitously [44].

RED FLAGS AND DIFFERENTIAL DIAGNOSIS

- A history of fevers, chills, weight loss, a history of cancer, immunosuppression, and/or intravenous drug abuse should prompt the clinician to consider infection or malignancy as a possible etiology for low back or leg pain [52].
- Reports of clumsiness, gait instability, bowel, bladder, or sexual dysfunction should prompt the clinician to carefully assess for causes of spinal cord dysfunction such as cervical or thoracic myelopathy [52].

Investigations

IMAGING MODALITIES

- 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 [32].
- MRI is superior to CT for directly imaging neural structures and the intervertebral disc [32].
- MRI allows imaging of the nerve root within the foramen, which is difficult with postmyelography CT because contrast does not fully extend through the foramen [32].
- 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 [32].
- MRI findings must be correlated with clinical impression because abnormal anatomy may be asymptomatic [32].
- Meaningful clinical information from MRI is obtained by posing specific questions derived from history and physical examination regarding neural compression, instability, and deformity [32].
- CT is the diagnostic imaging modality of choice for injuries involving the thoracic, lumbar, or sacral regions of the spine [37].
- The use of MRI in thoracic and lumbar trauma remains controversial and has a limited role, as it added very little to management in patients with CT-proven injuries [34].
- CT findings can be well correlated with MRI findings, negating the need for MRI in most thoracolumbar injuries [34].
- Myelography is indicated when MRI cannot be obtained, when there is suspicion of an intraspinal lesion, in patients with spinal instrumentation causing artifact, or when diagnosis is questionable due to conflicting findings [38].
- Myelography is valuable in previously operated spines and in patients with marked bony degenerative change that may be underestimated on MRI [38].
- Postmyelography CT improves the value of myelography in evaluating spinal stenosis and in previously operated spines [38].
- Plain radiographs, including flexion and extension views, can reveal instability, subluxation, congenital narrowing, or fracture [38].
- Oblique radiographic views show the spinal foramen [38].
- Abnormal magnetic resonance scans of the lumbar spine are common in asymptomatic subjects [14].

DIAGNOSTIC PROCEDURES AND INJECTIONS

- MRI with intravascular contrast material is helpful in identifying recurrent disc herniations [6].
- It is difficult to distinguish a peridural scar from a small recurrent herniation on MRI [6].
- Intravenous contrast-enhanced CT of the postoperative lumbar spine improves the identification of recurrent disk herniation, scar, arachnoiditis, and diskitis [14].

- Provocation discography has been used as a guide to planning operations on the spine [14].
- There is no consensus of diagnostic criteria for internal disc derangement (IDD) regarding symptom type, severity, physical examination, or diagnostic imaging [15].
- The diagnosis of IDD requires a compilation of findings consistent with the condition and the elimination of other diagnostic possibilities [15].
- Imaging studies for IDD should include a lumbar spine series and dynamic films to assess deformities, measurable instability, or destructive lesions [15].
- Epidural steroid injections are used in the management of chronic pain associated with lumbar disc herniation or radiculitis [1].
- Transforaminal injection of corticosteroids for lumbar radiculopathy has been evaluated in systematic reviews and meta-analyses [1].
- Facet joint injections have been evaluated for their diagnostic value in low back pain [1].
- A positive lumbar extension test is highly predictive of lumbar spinal stenosis [13].
- EMG may be helpful to distinguish peripheral neuropathy from lumbar spinal stenosis [13].
- Needle EMG has a lower false positive rate than MRI in asymptomatic older adults being evaluated for lumbar spinal stenosis [3].

CLINICAL EVALUATION AND HISTORY

- Most recurrences of disc herniation occur in the first 6 months after surgery [6].
- For patients with a history of no or minimal improvement after disc excision, diagnostic difficulties are greater and must consider incorrect original diagnosis, incorrect level, root anomaly, root injury, CSF leak, and infection [6].
- Patients with lumbar spinal stenosis typically present with pain, paresthesias, subjective weakness, or heaviness in the back, buttocks, and lower extremities that occurs with walking or prolonged standing [13].
- Symptoms of lumbar spinal stenosis usually start proximally and progress distally, whereas vascular disease symptoms progress in the opposite direction [13].
- Patients with lumbar spinal stenosis usually gain relief by sitting down, unlike vascular insufficiency where stopping walking alleviates symptoms [13].
- Common symptoms of lumbar spinal stenosis include pseudoclaudication and standing discomfort (94%), numbness (63%), and subjective weakness (43%) [13].
- The physical examination in most patients with lumbar spinal stenosis is normal, but weakness, numbness, and reflex abnormalities can occur [13].
- A vascular examination must be performed in all patients with suspected lumbar spinal stenosis [13].
- Patients with internal disc derangement are usually relatively young, in the third to sixth decades of life [15].
- Pain from internal disc derangement is primarily axial, often with buttock and posterior thigh pain, and is exacerbated by sitting or flexion [15].

- Recumbency, especially in the fetal position, often decreases pain associated with internal disc derangement [15].
- Examination for internal disc derangement reveals no weakness or reflex changes if IDD is the only diagnosis [15].
- Straight-leg raising in internal disc derangement typically causes back and buttock pain but no pain distal to the knee [15].
- If three or more Waddell signs are present, an alternative diagnosis to internal disc derangement is more likely [15].

Treatment

NONOPERATIVE MANAGEMENT

- Nonoperative treatment for lumbar disc herniation is usually effective [40].
- Principles of nonoperative management include short-term rest, pain relief, antiinflammatory agents, and progressive directed activity restoration [40].
- Nonoperative measures for lumbar disc herniation should generally be continued for at least 6 to 12 weeks if feasible [40].
- More than half of patients who seek treatment for low back pain recover in 1 week [8].
- 90% of patients who seek treatment for low back pain recover within 1 to 3 months [8].
- Conservative management for discogenic back pain includes NSAIDs, physical therapy, and conditioning [8].
- Patient education regarding the self-limiting nature of discogenic back pain is important [8].
- A randomized, double-blind, controlled trial evaluated the effectiveness of lumbar disc herniation epidural injections in managing chronic pain of lumbar disc herniation or radiculitis [1].
- A systematic review evaluated whether epidural injections provide short- and long-term relief for lumbar disc herniation [55].
- A prospective, randomized, controlled trial compared plasma disc decompression with fluoroscopy-guided transforaminal epidural steroid injections for symptomatic contained lumbar disc herniation [55].
- A multicentre, blinded, randomised controlled trial evaluated the effect of caudal epidural steroid or saline injection in chronic lumbar radiculopathy [55].
- A prospective randomized control study evaluated the utility of diagnostic transforaminal epidural injection in selective percutaneous endoscopic lumbar discectomy for multilevel disc herniation with monoradicular system [55].

INDICATIONS FOR SURGERY

- Surgery is recommended if neurologic deficits progress or manifest as myelopathy [40].
- Surgery is recommended if pain remains at an intolerable level [40].

- For discogenic back pain, surgery should be avoided whenever possible and conservative measures should be exhausted before consideration of surgical intervention [8].
- Currently, there is no good surgical option available that reliably reduces symptoms of discogenic back pain [8].

OPERATIVE TECHNIQUES: LUMBAR

- The initial procedure recommended for thoracic disc herniation was posterior thoracic laminectomy and disc excision [40].
- At least half of thoracic disc herniations have been identified as central, making excision from a posterior approach extremely difficult [40].
- Most series reported fewer than half of patients improving after posterior laminectomy and discectomy for thoracic disc herniation, with some becoming worse [40].
- Lateral rachiotomy (modified costotransversectomy) or an anterior transthoracic approach for thoracic discectomy produces considerably better results than posterior approaches with no evidence of worsening [40].
- Video-assisted thoracic surgery (VATS) has been used to remove central thoracic disc herniations successfully without the need for a thoracotomy or fusion [40].
- Awake transforaminal endoscopic discectomy is the most promising and least invasive technique for surgical treatment of thoracic disc herniation [40].
- The awake transforaminal endoscopic approach to the thoracic spine allows resection of disc material that can begin midline and be extended laterally to either side [46].
- The transforaminal endoscopic approach typically can reach herniations from T4 to L4 in most people [46].
- The transforaminal endoscopic approach does not require violation of the chest cavity, usually does not require fusion, and does not require general anesthesia [46].
- A diagnostic transforaminal epidural injection at the site of a thoracic herniation can confirm the diagnosis and ensure enough space between the rib, transverse process, and facet joint for the endoscopic approach [46].
- Profound relief from a transforaminal epidural injection is a good predictor of surgical outcome for thoracic disc herniation [46].
- Decompression in transforaminal endoscopic thoracic discectomy is complete when the undersurface of the thoracic dura is seen pulsating to heartbeat and the patient notes resolution of typical thoracic radicular pain [46].
- Patients undergoing transforaminal endoscopic thoracic discectomy are limited in bending, lifting, and twisting but may shower the day of the procedure [46].
- Patients undergoing transforaminal endoscopic thoracic discectomy are typically discharged from the surgery center as soon as they can ambulate independently and void [46].

- Driving after transforaminal endoscopic thoracic discectomy is delayed until postoperative day 2 or until narcotics are discontinued [46].
- Trunk stabilization therapy can begin 2 weeks after transforaminal endoscopic thoracic discectomy and advance as tolerated [46].
- Thoracoscopic thoracic discectomy involves placing the patient in the left lateral decubitus position to allow a right-sided approach and displacement of the aorta and heart to the left [49].
- In thoracoscopic thoracic discectomy, four trocars are inserted in a triangular fashion along the middle axillary line converging on the disc space [49].
- In thoracoscopic thoracic discectomy, the lung is deflated using a Carlen tube or similar method [49].
- In thoracoscopic thoracic discectomy, the parietal pleura is split starting at the medial part of the intervertebral space and extending up to the costovertebral process [49].
- In thoracoscopic thoracic discectomy, segmental arteries and sympathetic nerve are preserved and mobilized out of the operating field [49].
- In thoracoscopic thoracic discectomy, the rib head and lateral portion of the pedicle are drilled away, and the remaining pedicle is removed with Kerrison rongeurs to improve exposure to the spinal canal [49].
- In thoracoscopic thoracic discectomy, disc and posterior longitudinal ligament removal is restricted to the posterior third of the intervertebral space and costovertebral area to maintain stability [49].
- Chest tubes are inserted in the standard fashion and set to water suction after thoracoscopic thoracic discectomy [49].
- Patients undergoing thoracoscopic thoracic discectomy are rapidly mobilized as tolerated by the chest tubes [49].
- Discharge after thoracoscopic thoracic discectomy is possible after chest tubes have been removed and the patient is ambulating well [49].
- Minimally invasive thoracic discectomy involves placing the patient in the lateral decubitus position with the affected side up [49].
- In minimally invasive thoracic discectomy, a 5-cm portion of rib can be resected if it is overlying the disc, or the approach can sometimes be performed without rib resection [49].
- In minimally invasive thoracic discectomy, a retropleural approach is made down to the spine and a minimally invasive retractor system is docked on the disc space and rib head of interest [49].
- In minimally invasive thoracic discectomy, there is no need for a chest tube if the pleura is not violated [49].
- The approach for minimally invasive thoracic discectomy can be extended down to L1-2 by mobilizing the diaphragm off the rib and transverse process attachments [49].
- Patients undergoing minimally invasive thoracic discectomy are mobilized the day of surgery and are discharged when ambulating well [49].
- Microsurgical and endoscopic operative techniques for thoracic disc excision should be performed by a surgeon proficient in the technique and use of thoracoscopic equipment, with the assistance of an experienced thoracic surgeon [49].
- Ideally, thoracoscopic disc excision procedures should first be done on cadavers or live animals [49].

- For recurrent lumbar disc herniation, the principles of identifying and protecting the nerve root and then removing the herniation are the same as for a primary discectomy [6].
- The area of exposure for recurrent lumbar disc herniation surgery generally should be larger than for primary discectomy [6].
- Surgery for recurrent lumbar disc herniation usually can be done on an outpatient basis [6].
- Treatment of recurrent disc herniation is one of the advantages of the transforaminal endoscopic approach [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].
- In repeat lumbar disc excision, 25 mL of 0.25% bupivacaine with epinephrine is injected into the paraspinal muscles on the involved side [6].
- In repeat lumbar disc excision, a midline incision 4 cm long is made centered over the interspace where the disc is located [6].
- In repeat lumbar disc excision, the supraspinous ligament is incised and muscles are stripped from the spinous processes and laminae on the side of the lesion by subperiosteal dissection [6].
- In repeat lumbar disc excision, the location is verified with a radiograph to ensure no mistake is made regarding the interspaces explored [6].
- In repeat lumbar disc excision, scar is removed from the edges of the laminae using a curet to expose normal dura [6].
- In repeat lumbar disc excision, pedicles are identified superiorly and inferiorly if there is any question of position and status of the root [6].
- In repeat lumbar disc excision, the dissection is carried from the pedicles to identify each root, which may allow the development of a normal plane between the dura and scar [6].
- In repeat lumbar disc excision, the root and epidural scar are mobilized as a single mass off the floor of the canal using a curet, which may uncover the underlying disc herniation [6].
- In repeat lumbar disc excision, the axilla of the root and the subligamentous space are explored for retained fragments [6].
- In repeat lumbar disc excision, it is ensured that the nerve root is well decompressed in the lateral recess [6].
- Spinal fusion is not done 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].
- If the initial procedure was done using the tubular retractor technique, a tubular retractor is used for recurrent disc herniations [6].
- Postoperative care after repeat lumbar disc excision is the same as after primary disc excision [6].
- Additional exposure for lumbar disc herniation includes hemilaminectomy, total laminectomy, and facetectomy [54].

- Hemilaminectomy is usually required when identifying the root as a problem, such as with a conjoined root [54].
- Total laminectomy is usually reserved for patients with central spinal stenoses, which occur typically in cauda equina syndrome [54].
- Facetectomy is usually reserved for foraminal stenosis or severe lateral recess stenosis [54].
- If more than one facet is removed, a fusion should be considered in addition [54].
- Fusion is especially indicated when facets and the disc are removed at the same interspace in a young, active individual with a normal disc herniation at that level [54].
- Excision of an intradural disc may require a transdural approach, which increases the risk of complications from CSF leak and intradural scarring [54].
- A far lateral disc herniation may require exposure outside the spinal canal by removing the intertransverse ligament between the superior and inferior transverse processes lateral to the spinal canal [54].
- In far lateral disc herniation, the disc hernia is usually anterior to the nerve root, which is found in a mass of fat below the intertransverse ligament [54].
- A microsurgical approach is a good method for dealing with far lateral disc herniation [54].
- A long tubular retractor is especially useful for the far lateral approach if the tube is inserted at the proper trajectory to treat pathology in or lateral to the foramen [54].
- If the facet is not hypertrophic and the plane between the facet joint capsule and intertransverse ligament can be identified, foraminal and far lateral disc herniation can sometimes be removed without bony resection above the L5 level [54].
- The least invasive approach to a far lateral lumbar disc herniation is a transforaminal endoscopic approach with a slightly steeper angle than would be used for pathology inside the spinal canal [54].
- The transforaminal endoscopic approach for far lateral herniation minimizes bleeding and eliminates the need for bony resection but is a more advanced endoscopic technique because of the lack of bony anatomy in the extraforaminal zone [54].
- In percutaneous anterior lumbar arthrodesis via lateral approach, the anterior annulotomy window is centered in the anterior half of the disc [48].
- In percutaneous anterior lumbar arthrodesis via lateral approach, the disc is removed with standard instruments and the posterior annulus is left intact [48].
- In percutaneous anterior lumbar arthrodesis via lateral approach, the contralateral annulus is released using a Cobb dissector to allow distraction of the disc space to insert the implant [48].
- In percutaneous anterior lumbar arthrodesis via lateral approach, an implant is inserted that will rest on both lateral margins of the epiphyseal ring [48].
- Supplementary posterior instrumentation must be used to maintain stability after percutaneous anterior lumbar arthrodesis via lateral approach [48].
- Complications, primarily related to nerve root injury or irritation, have been reported in 22% of patients after a minimally invasive direct lateral anterior lumbar fusion and extreme lateral interbody fusion [48].

- Knowledge of "safe zones" for the minimally invasive direct lateral approach and familiarity with the dilating retractor systems are essential for avoiding complications [48].
- In transforaminal lumbar interbody fusion, a spinal needle is inserted into the paraspinal musculature at the interspace of interest, 40 to 60 mm lateral to the midline depending on patient depth [47].
- In transforaminal lumbar interbody fusion, the trajectory should approach the anterior and middle third of the disc space [47].
- In transforaminal lumbar interbody fusion, a 20-mm vertical incision is made at the puncture site [47].
- In transforaminal lumbar interbody fusion, the guidewire is advanced only through the lumbodorsal fascia, taking care not to penetrate the ligamentum flavum and to avoid inadvertent dural puncture [47].
- In transforaminal lumbar interbody fusion, progressively larger dilators are used to create a muscle-sparing surgical corridor down to the appropriate interlaminar space while remaining orthogonal to the disc [47].
- In transforaminal lumbar interbody fusion, a 16- or 18-mm tubular retractor is docked on the facet joint complex and interlaminar space [47].
- In transforaminal lumbar interbody fusion, a total facetectomy is carried out with a high-speed drill or osteotomes [47].
- In transforaminal lumbar interbody fusion, the osteotomy is L-shaped and should connect the interlaminar space at the base of the spinous process with the pars interarticularis just above the disc space but below the pedicle [47].
- In transforaminal lumbar interbody fusion, removed bone is denuded of soft tissue and morcellized for later use as interbody graft material [47].
- In transforaminal lumbar interbody fusion, a conventional discectomy is performed by incising the annulus with a no. 15 scalpel blade lateral to the dural sac while retracting the traversing nerve root [47].
- In transforaminal lumbar interbody fusion, there is no need to retract the exiting root [47].
- In transforaminal lumbar interbody fusion, all cartilage should be removed from the disc space up to the outer annulus [47].
- In transforaminal lumbar interbody fusion, the disc space is sequentially distracted until the original disc space height is obtained and the normal foraminal opening is restored [47].
- In transforaminal lumbar interbody fusion, soft tissue and the cartilaginous endplate covering are removed with scraping or curettage [47].
- In transforaminal lumbar interbody fusion, the graft is countersunk until it is 4 to 5 mm below the posterior margin of the disc space [47].
- In transforaminal lumbar interbody fusion, the extradural space and foramina are probed to ensure adequate decompression of the neural elements [47].
- In transforaminal lumbar interbody fusion, bilateral percutaneous pedicle screws are placed to allow a stable environment for fusion across the disc space if positioning is adequate with restoration of disc height and lordosis [47].
- In transforaminal lumbar interbody fusion, incisions are closed subcutaneously with 2-0 Vicryl and skin glue is used for final skin closure [47].

- When a 20-mm or smaller tube is used in transforaminal lumbar interbody fusion, there is no need for fascial closure [47].
- Patients are encouraged to walk as much as possible immediately after transforaminal lumbar interbody fusion surgery [47].
- Bending, lifting, and twisting are restricted for a period of 3 months after transforaminal lumbar interbody fusion [47].
- All restrictions are lifted at 3 months after transforaminal lumbar interbody fusion if radiographs show appropriate progression of fusion [

Complications

- Smoking is associated with increased blood loss and transfusion use after lumbar spinal surgery [4].
- The extent of decompression influences the incidence of postoperative epidural hematoma among different techniques of spinal decompression in degenerative lumbar spinal stenosis [4].
- Hospital and surgeon volume affect postoperative complications after lumbar spine surgery [4].
- Perioperative surgical complications occur in transforaminal lumbar interbody fusion [4].
- Complications are associated with anterior lumbar surgery [4].
- Failed anterior lumbar interbody fusion can result from incomplete foraminal decompression [4].
- Pseudarthrosis is a complication following lumbar pedicle subtraction osteotomy in adult spinal deformity [4].
- Pseudarthrosis is a complication following posterior lumbar fusion surgery [4].
- Revision surgery is performed for lumbar pseudarthrosis [4].
- Anterior lumbar interbody fusion is used as a salvage technique for pseudarthrosis following posterior lumbar fusion surgery [4].
- Recurrent lumbar disc herniation is a complication treated with microendoscopic discectomy [4].
- Recurrent lumbar disc herniation is a complication treated with anterior discectomy and total disc replacement [4].
- Failed back surgery syndrome is a recognized outcome following failed discectomy [4].
- Epidural fibrosis is associated with failed back syndrome [4].
- Pain radiography is important in the evaluation of radiculopathy after failed discectomy [4].
- Reoperation rates are associated with surgery for spinal stenosis [4].
- Revision surgery occurs after stand-alone lateral lumbar interbody fusion for lumbar spinal stenosis [4].

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