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CHAPTER 13

Posterior Lumbar Microscopic Discectomy and Rehabilitation

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Lumbar herniated nucleus pulposus (HNP) falls within the spectrum of degenerative spinal conditions and can occur with little or no trauma. Lumbar disc abnormalities increase with age.[5,130] The actual incidence of lumbar disc herniations is unknown, because many people with herniations are asymptomatic.[5,7,41] Approximately 90% of lumbar herniations occur at the L4-L5 and L5-S1 levels.[5,17,31] More than 200,000 discectomies are performed in the United States each year, and this number is likely increasing.[14] The success of this procedure, as with all surgical procedures, depends vastly on proper patient selection and to a lesser extent on surgical technique. However, it is incumbent on the spinal surgeon to be absolutely meticulous with intraoperative technique once the decision for surgery is made. To this end, the use of a microscope is recommended for lumbar discectomy. Once the learning curve has been mastered, the microscope not only offers advantages over loupes but also forces one to think at a much higher level of clarity about what and where root encroachment pathology is present.[18] More importantly, the patient has less morbidity and an earlier hospital discharge compared with standard or limited discectomy.*

SURGICAL INDICATIONS AND CONSIDERATIONS

Pathophysiology

Intervertebral discs cushion and tether the vertebrae, providing both flexibility and stability. The normally gelatinous nucleus pulposus is surrounded by the ligamentous annulus fibrosis. In the young and healthy disc, the nucleus and annulus blend. Degenerative or pathologic changes can cause separations of the two entities, as well as compromise the integrity of the annulus, such that a sufficient load can cause nuclear fragments to migrate and impinge on neural elements.[131] Lumbar disc herniations may occur with little or no trauma, although patients frequently report a bending or twisting motion as the inciting event, causing the onset of symptoms. Common causes of lumbar herniations include falls, car accidents, repetitive heavy lifting, and sports injuries of all types.

Diagnosis

The radiographic diagnosis of lumbar disc herniation has been made rather simple with magnetic resonance imaging (MRI). The clinical diagnosis is frequently straightforward as well. A patient with a lumbar herniation generally has some element of low back pain with radiation into the buttocks, thigh, leg, and foot. The leg radiation almost always follows a dermatomal distribution. Patients frequently complain of numbness, tingling, or weakness in the affected dermatome. Lying down may relieve the symptoms. Whereas sitting, walking, and standing may exacerbate them. Complaints of bowel and bladder dysfunction may signal a cauda equina syndrome, and may necessitate emergent workup and treatment.

Physical Examination

Visual inspection may reveal lumbar muscle spasm, fasciculations, and postural changes, including listing to

*References 11, 17, 59, 101, 103, 110, 111.

the side and a forward flexed position. Gait observation can reveal a listing antalgic walk. Weakness can give a dropped foot type gait (anterior tibialis) or buckling of the leg (quadriceps). Range of motion (ROM) testing may be limited secondary to pain. Neurologic testing is extremely important and should include motor, sensory, and reflex testing. Lumbar herniations may cause varying degrees of dermatomal weakness, sensory deficits, and reflex changes. Straight leg raises (SLRs) are a good indicator of nerve root impingement in lower lumbar herniations, and a positive femoral stretch can indicate an upper lumbar herniation.

Imaging and Other Tests

MRI is clearly the imaging study of choice to diagnose a lumbar disc herniation (Fig. 13-1, A and B). Plain radiographs should always be obtained to evaluate overall alignment, bony integrity, and stability. Patients who cannot obtain an MRI can be diagnosed using computed tomography (CT), CT myelogram, or CT discogram. These imaging tests are so sensitive that discectomy is not indicated if a disc is not found to be herniated by one of these techniques. Other tests can include an electromyogram (EMG) or nerve conduction study (NCS).

Management

It is important to understand that most patients with symptomatic herniated lumbar discs will get better over time, regardless of the type of treatment. Weber's classic study[120] reported that sciatica from HNP would improve 60% of the time with nonsurgical methods, and 92% of the time with surgery at 1 year. By 4 years out, no statistical difference was found between the two groups, and no difference at 10-year follow-up. In the absence of cauda equina syndrome, progressive or significant neurologic deficits, most practitioners attempt at least 4 to 8 weeks of conservative care before suggesting surgical intervention.

Nonoperative Treatment

Nonoperative treatment may include:

1. Modified activity
2. Modified bed rest for 2 to 3 days (prolonged bed rest should be avoided)[20,46,115]
3. Analgesic, anti-inflammatory medication (e.g., nonsteroidal anti-inflammatory drugs [NSAIDs], steroids), or both
4. Physical therapy (as tolerated) or external support (e.g., corset, brace)
5. Epidural steroid injections (the authors recommend up to three)

Indications for Surgery

Surgical indications, as currently recommended by the North American Spine Society (NASS), include a definite diagnosis of ruptured lumbar intervertebral disc and the following:[9,21]

A

B

Fig. 13-1 A, Sagittal magnetic resonance imaging (MRI) showing herniated discs at the bottom two lumbar discs, at L4-5 and L5-S1. B, An axial cut of a lumbar spine MRI revealing a left-sided broad-based paracentral disc herniation effacing the thecal sac, causing left-sided lateral recess, foraminal stenosis, and neural compression.

1. Failure of conservative treatment
2. Unbearable or recurrent episodes of radicular pain (or both)
3. Significant neurologic deficit
4. Increasing neurologic deficit (absolute indication)
5. Cauda equina syndrome (absolute indication)

Conservative treatment consists of nonoperative management and careful observation for at least 4 to 8 weeks. Some may benefit from a short trial of nonoperative treatment even after 8 weeks if no prior care was given. Failed conservative treatment is the most common indication for lumbar discectomy. Those who have not improved sufficiently and are not experiencing continued improvement might then be offered treatment by surgical excision of the disc. Such patients should be advised that this is an elective operation but that delay for longer than 3 to 6 months in the face of persistent and severe symptoms may compromise the best ultimate result.[21,62]

The other indications (2 to 5) are exceptions to the 4- to 8-week rule. Excruciating pain may not be relieved by nonoperative means and may require earlier surgical decompression. Recurrent sciatica should also receive consideration for surgery: the chance of recurrent sciatica after the second episode is 50% and after the third episode is almost 100%.[62] An example of a significant neurologic deficit may be a foot drop or weakness that prevents normal posture, gait, or affects the patient's profession or a particular skill. Any definite progression of neurologic deficit is an absolute indication for surgery. Cauda equina syndrome is relatively rare, being reported in 1% to 3% of patients with confirmed disc herniations,[45,99] which is an orthopedic or neurosurgical emergency. Features include rapid progression of neurologic signs and symptoms, bilateral leg pain, caudal sensory deficit, bladder overflow incontinence or retention, and loss of rectal sphincter tone with or without fecal incontinence.

Contraindications for Discectomy

NASS and the American Academy of Orthopaedic Surgeons (AAOS) have identified the following factors as absolute or relative contraindications for discectomy[21,30]:

1. Lack of clear clinical diagnosis, anatomic level of lesion, and radiographic evidence of HNP
2. Lack of trial of nonoperative treatment (with the exceptions mentioned previously)
3. Disabilities with major nonorganic components (i.e., multifocal, nonanatomic, or disproportionate signs and symptoms)
4. Systemic disease processes that can negatively influence outcome of surgery (e.g., diabetic neuropathy)
5. Medical contraindications to surgery (e.g., major co-morbidities, unfavorable survival)
6. Disc herniation at a level of instability (may need additional stabilization)

SURGICAL PROCEDURES

One only has to review the natural history of lumbar disc disease to realize that spinal surgeons play a palliative role in the management of HNP.* Surgical procedures as treatment for lumbar HNP include the following:

1. Lumbar discectomy (microscopic or standard open technique)
   a. Hemilaminotomy and discectomy
   b. Laminectomy and discectomy
2. Minimally invasive percutaneous techniques
   a. Chemonucleolysis
   b. Percutaneous discectomy (suction, shaver, laser, endoscopic tools)

Use of an Operating Microscope

The attempt to improve visualization and illumination has led many spine surgeons to use loupes and a headlight. The authors believe the magnification and illumination built into the microscope offer many surgical advantages, the most important of which is reduced wound size and decreased tissue manipulation. The surgeon can limit the amount of tissue dissection by working through a small exposure directly over the pathology to be removed. Microsurgical techniques can also be used to preserve the ligamentum flavum and epidural fat to minimize postoperative epidural fibrosis and improve clinical results by preserving natural tissue planes.[15,18] With this approach, the disc herniation can be easily removed, lateral recess stenosis can be decompressed, and nerve root manipulation is kept to a minimum. The senior author has used this technique since 1986 for most lumbar disc herniations and has found the approach to be safe, with fewer dural tears and nerve root injuries and less postoperative epidural fibrosis than with standard discectomy.[17,18,59,63]

However, the microscope is not without its disadvantages. Peripheral vision is lost, with the field of vision limited to approximately 4 to 5 cm. Because of this, the surgeon needs to know detailed anatomy of the spine. The line of vision is fixed through the microscope. To look over structures (to overcome tissue overhang), the patient or microscope has to be adjusted during the surgery. This can be avoided by proper retraction or dissection of tissue away from the line of vision. Researchers reported increased disc space infection after microsurgery.[126,127] This was most likely caused by contamination from unsterile parts of the microscope during surgery; although no one has looked at the potential for an increased infection rate when two surgeons with loupes and headlights bump heads over the wound! Recent reports by those who have experience with the microscope do not show any increased infection rates.[17,59,94,111]

*References 22, 23, 29, 57, 121.

Lumbar Microdiscectomy

Microscopic discectomy (microdiscectomy) has become the *gold standard* for operative treatment of lumbar disc herniations, and the latest minimally invasive percutaneous techniques have not been shown to be more effective.[16,18,55] Although no statistical differences can be shown in the ultimate long-term outcomes of microscopic versus standard open discectomies,* the microscope provides improved illumination and magnification, and patients have less morbidity and earlier hospital discharge when compared with standard discectomies (Fig. 13-2).†

Operative Setup

General anesthesia is preferable because of patient comfort, as well as airway and sedation control. Another advantage is the option of hypotensive anesthesia. The procedure can also be done under epidural or local anesthesia with sedation, although this is not the authors' preference. The patient's position is always prone with the abdomen free, thus relieving pressure on the abdominal venous system and, in turn, decreasing venous backflow through Batson's venous plexus into the spinal canal. This has the effect of decreasing bleeding from the epidural veins intraoperatively. Several frames are available for this, but the authors prefer a Wilson frame on a regular operating table because of the ease of setup.

Identification of Level and Side

A preincision lateral radiograph or fluoroscopy image, with a radio-opaque skin marker placed according to preoperative radiographs and anatomic landmarks, will identify the appropriate incision location for the disc space to be exposed. This is best done by placing a spinal needle as straight vertically as possible, approximately 2 cm from midline contralateral to the side of surgery. The side of surgery is usually the more symptomatic side, although occasionally a midline HNP can be approached from either side.

Fig. 13-2 A surgeon and an assistant surgeon using the operative microscope with a high-intensity light source and microscopic magnification. The two surgeons can work hand-in-hand with unobstructed view of the operative field.

Skin Incision and Interlaminar Space Exposure

A 2- to 3-cm incision is made midline or up to 1 cm lateral to the spinous process on the symptomatic side, at a level directly over the disc space based on the localizing lateral radiograph. At L5-S1 this incision tends to be directly over the interlaminar space, but as one moves up the lumbar spine, this incision will be progressively over the cephalad lamina. The dissection is carried down to the lumbodorsal fascia, which is sharply incised. The fascial incision is placed carefully, just lateral to the spinous processes to avoid damage to the supraspinous and interspinous ligament complex. The subperiosteal muscle dissection and elevation are confined to the interlaminar space and approximately half of the cephalad and caudad lamina. The facet capsules are carefully preserved. A Cobb elevator and Bovie cautery are used. A framed retractor is then placed. The surgeon should expose the lateral border of the pars as a landmark for preserving enough of the pars during laminotomy to prevent fracture.

At this time another localizing lateral radiograph should be obtained to confirm the proper level. A forward-angled curette can be placed underneath the cephalad lamina of the interspace. With this intraoperative radiographic verification, wrong-level surgery is impossible. The radiograph will also indicate how much of the cephalad lamina needs to be removed to expose the disc space. The microscope is then brought into position.

Spinal Canal Entry

After exposure of the interlaminar space and placement of the retractor, a high-speed burr is used to remove several millimeters of the cephalad lamina and 2 to 3 mm of the medial aspect of the inferior facet (Fig. 13-3). Once the cephalad lamina and medial aspect of the inferior facet have been removed, the ligamentum flavum is easily seen as its bony attachments are exposed. The ligamentum attaches at the very cephalad edge of the lower lamina, but approximately halfway up the upper lamina, and it attaches to the medial aspect of the superior facet. Thus the high-speed burr can be used relatively safely on top of the bottom half of the superior lamina, as well as the medial aspect of the inferior facet.

Free Ligamentum Flavum

The ligamentum flavum is then released from the medial edge of the superior facet with a forward-angled curette. It can also be released from the undersurface of the upper and lower lamina (Fig. 13-4). It is safest to start the curette

*References 1, 4, 57, 101, 106, 110, 111.
†References 17, 11, 59, 101, 103, 110, 111.

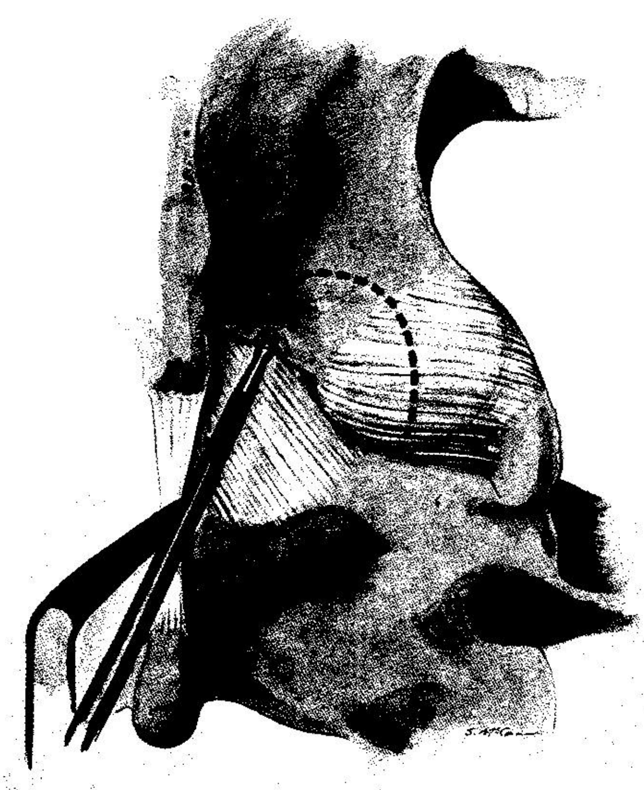

Fig. 13-3 After skin exposure and subsequent subperiosteal elevation, the retractor in position reveals the interlaminar interval, with exposure of the upper and lower laminae. Several millimeters of the cephalad lamina and 2 to 3 mm of the medial edge of the inferior facet are removed with the high-speed burr. This bone can be safely removed because the undersurface is protected by the ligamentum flavum.

Fig. 13-4 A small, forward-angled curette frees the ligamentum flavum from its attachment to the medial edge of the superior facet. The ligamentum flavum also can be freed from the undersurface of the upper and lower laminae.

inferolaterally toward the superior aspect of the pedicle (caudal aspect of the foramen).

A ligamentum- and epidural fat-sparing approach, by creating a flap of the ligamentum as described previously, decreases postoperative epidural fibrosis and can improve results.[15,18] However, this can make it more difficult to get a good view of the nerve root. Certainly this is easier with a microscope than without one. The less-experienced surgeon may perform partial removal of these tissues. The ligamentum flap is also not recommended for large midline disc herniations (with or without cauda equina syndrome) and severely stenotic canals, because the ligamentum itself occupies more room in the already severely compromised spinal canal and would also interfere with direct visualization for the delicate manipulation of the thecal sac.

Lateral Recess Exposure

After release of the ligamentum flavum, the medial edge of the superior facet is resected with 2- to 4-mm Kerrison rongeurs. This resection goes from the lower pedicle to the tip of the superior facet (Fig. 13-5). This medial facet resection decompresses any lateral recess stenosis at the level of the pedicle and up into the foramen, and it allows easy access to the lateral disc space. If needed, some of the lateral ligamentum flavum, particularly into the foramen, can be removed with the Kerrison rongeurs.

Nerve Root and Ligamentum Retraction

Bipolar cautery can be used at this time to cauterize any epidural bleeding over the lateral disc space, directly cephalad to the pedicle. The authors recommend finding the pedicle and then using it as a guide to release the epidural non-neural tissues above the disc space. At this point a nerve root retractor can be placed on the disc space, and the ligamentum flavum, epidural fat, and nerve root are retracted toward the midline, generally exposing the herniation (Fig. 13-6). Again, the bipolar can be used to cauterize any epidural veins over the disc herniation. Any free large fragments of disk can now be removed (Fig. 13-7). If needed, a forward-angled curette can be used to scrape the inferior and posterior bony margins of the foramen, using a unidirectional pulling motion. Using the bony pedicle as a starting point ensures that the end

Fig. 13-5 A 3-mm or 4-mm Kerrison rongeur is used to remove the lateral recess (subarticular) stenosis (i.e., the medial edge of the superior facet) back to the pedicle of the lower vertebra and cephalad to the top of the superior facet. This bony resection removes the lateral recess (subarticular) stenosis and allows exposure of the lateral disc space.

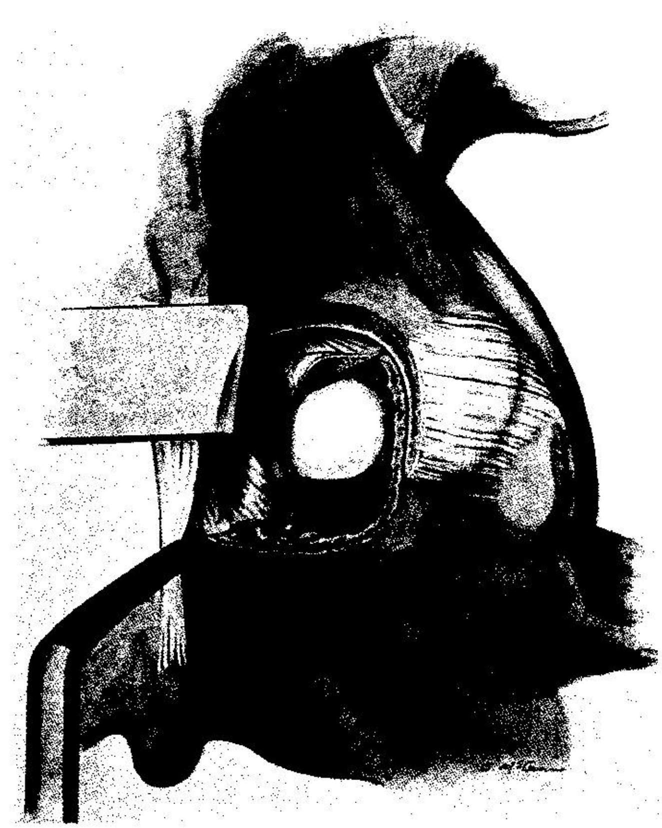

Fig. 13-6 A nerve root retractor is used to retract the ligamentum flavum, nerve root sleeve, and epidural fat toward midline over the herniated disc. Bipolar cautery can be used to cauterize the epidural plexus over the disc herniation.

of the curette does not include any neural tissue before scraping.

Discectomy

Frequently the annular defect of the disc herniation is all that is necessary to allow cleaning out of any loose nucleus pulposus inside the disc space, although the annulotomy can be enlarged with a No. 11 blade. The herniated nuclear material is then cleaned out with straight or angled pituitary rongeurs and small back-angled curettes. Care should be taken not to damage or curette the endplates. The annulotomy can be performed in various shapes, which are not discussed in detail here.[84,126]

One unresolved issue is how much disc to remove from the discal cavity. Removal of as much disc as possible implies curettage of the interspace, including possible removal of the cartilaginous endplates. Critics of this approach point out that no matter how long the surgeon works, it is impossible to remove all disc material in this fashion. They also argue that this method increases risk of damage to anterior visceral structures and increases risk of chronic back pain induced by conditions such as sterile disciitis and instability. Although some surgeons believe that extensive intradiscal débridement decreases the rate of recurrent HNP, others refute that position.* In the end, the only reasonable prospective controlled study is Spengler's,[104] which suggests that limited disc excision is all that is necessary. The advantages of limited disc excision are less trauma to endplates and less dissection, less nerve root manipulation, a lower prevalence of infection, reduced risk of damage to structures anterior to disc space, and less disc space settling postoperatively (theoretically reducing the incidence of chronic back pain).

Disc Space Irrigation

After the HNP and any remaining loose material is removed, the disc space is irrigated under some pressure with a long angiocatheter; then the pituitary rongeur is again used to remove any loose fragments. The spinal canal is then palpated underneath the nerve root and across the vertebral bodies above and below for any residual fragments. In doing the limited disc excision, one must also be sure to probe under the posterior annulus (both

*References 78, 92, 125, 126.

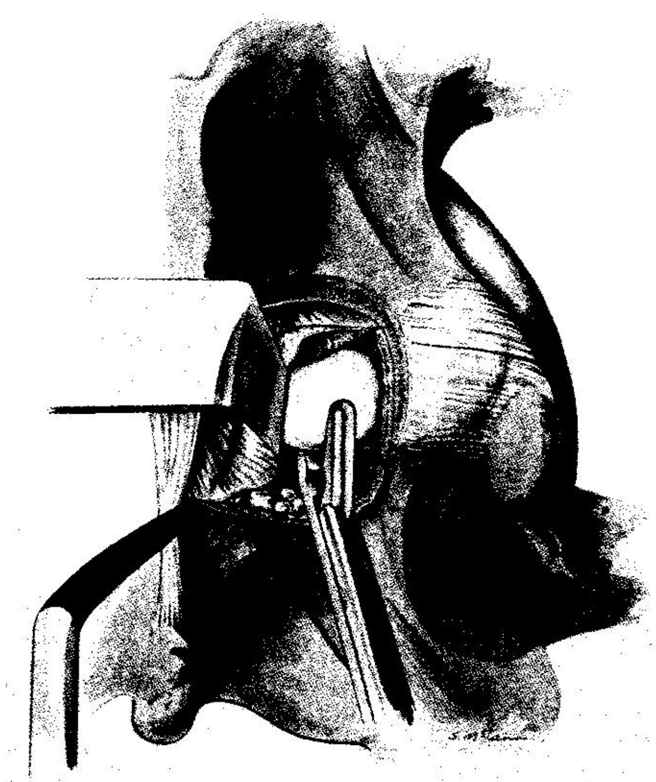

Fig. 13-7 After exposure of the disc herniation, large free fragments can be removed with a pituitary rongeur, the natural annulotomy from the disc herniation can be enlarged with a No. 11 blade, or both can be done.

medially and laterally) for loose fragments. This is an important step to ensure that no displaced or sequestered fragments are missed. Residual disc material will feel rough, whereas the native dural surface is quite smooth. In the end the patient must be left with a freely mobile nerve root. The preoperative MRI should be carefully studied for displaced fragments, but it is important to keep in mind that fragments may have moved since the MRI was taken.

Closure

Once the decompression is complete, the entire surgical wound is thoroughly irrigated with antibiotic-containing irrigant. Any final bleeding is controlled with bipolar cautery, thrombin-soaked gel foam, or FloSeal hemostatic gel. After complete hemostasis and removal of all gel foam, the closure is performed in layers. Many attempts have been made to design substances to seal the laminotomy defect and prevent scar formation, including fat grafts, hydrogel, silicone, Dacron, and steroids.[64] The authors simply prefer the ligamentum flap (Fig. 13-8).[17,18,62] The dorsal lumbar fascia is closed with No. 1-0 sutures, the subcutaneous layer with 2-0 sutures, and the skin with 3-0 subcuticular sutures. Using this ligamentum flavum–sparing approach, blood loss should be no more than 10 to 20 cc. With good hemostasis, drainage of the surgical wound is not necessary.

Postoperative Course

Many microdiscectomy procedures can be done on an outpatient basis.[6,73,103,133] Most patients are encouraged to walk as tolerated. Sitting is also tolerated, but may be more limited. Many return to work within 5 to 10 days, especially those with desk type of work. All patients are required to participate in lumbar physical therapy, primary stabilization, and mobilization beginning at around 4 weeks after surgery. Most athletes return to their normal athletic activities within 8 weeks after surgery. However, the postoperative course is variable, and return to normal activities depends on the patient's overall medical condition, as well as neurologic and overall recovery.[10,118,120]

Unusual Disc Herniations

Herniated Nucleus Pulposus at High Lumbar Levels (L1-L2, L2-L3, L3-L4)

High lumbar HNPs are uncommon (5%). When they occur they are likely to be foraminal or extraforaminal.[61,62] Important skeletal anatomy in the higher lumbar spine for the spinal surgeon to be aware of includes the following: (1) the pars are narrower, and facet integrity is easily lost with excessive laminotomy; (2) the laminae are broader; (3) the interlaminar window is narrower; (4) the inferior border of the lamina overhangs more of the disc space; (5) at L1-L2, the conus cannot be retracted like the cauda equina at lower levels; (6) the nerve roots exit more horizontally and are less mobile; and (7) epidural veins may be more prevalent. At these levels, because of limited size of the interlaminar space, ligamentum excision rather than sparing is recommended.

Recurrent Disc Rupture

The incidence of recurrent HNP is 2% to 5%.[17,52,81] The microscope is especially valuable in this scenario, because of the scar between tissue planes, including neural elements. Adequate time must be spent carefully teasing the tissues apart with a blunt instrument (e.g., bipolar, curette, Penfield) before forcefully mobilizing the nerve root. The incidence of complications is understandably higher in revision discectomies.

Cauda Equina Syndrome

The classic teaching in cauda equina syndrome is that (1) it is an orthopedic emergency, and (2) a wide decompression through a bilateral approach is necessary. The authors agree with the first point, but not the second. Few disc herniations are too big to be addressed microsurgically. A wider hemilaminectomy may be needed. The microscope is invaluable when working in the severely stenotic canal.

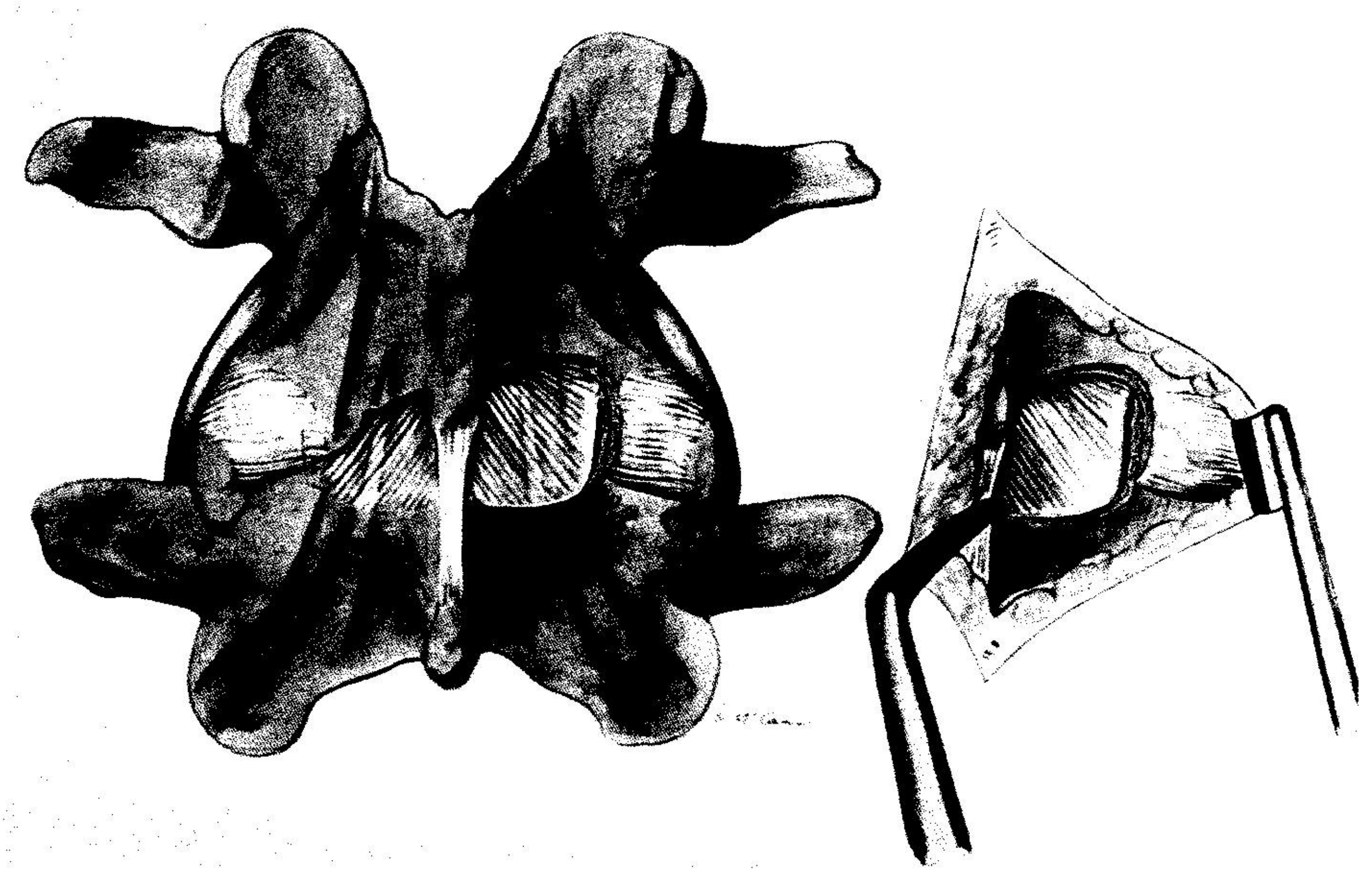

Fig. 13-8 After thorough irrigation, the nerve root retractor is released, allowing the ligamentum flavum and nerve root sleeve to return to their normal anatomic positions.

If the disc cannot be easily or totally excised unilaterally, then bilateral hemilaminotomies may be done.[45,99]

Herniated Nucleus Pulposus in the Adolescent Patient

The risk for recurrence of HNP after surgical excision is higher in adolescents than in adults. Because of the high proteoglycan content in adolescent discs and the prevalence of disc protrusions rather than disc extrusions, some have recommended percutaneous chemonucleolysis rather than surgical intervention in this age group.[25,51,62] Studies have been published with controversial results for surgical discectomy in this patient population.[19,83,102] Chemonucleolysis may have merit in the treatment of symptomatic disc protrusions, but discectomy is necessary in the setting of an extruded or sequestered disc causing significant or progressive neurologic deficit or pain. These extruded or sequestered fragments are frequently heavily collagenized.[21,75]

Complications

Complications for the discectomy procedures include dural tears, neural injury, visceral injuries, postoperative infection, recurrence of herniation, inadequate decompression, and iatrogenic instability.

Dural tears occur in 1.0% to 6.7% of cases, although the incidence decreases with experience.* If possible, then repair should be done by direct suture (5-0 to 7-0 silk, nylon, or polypropylene) with or without a dural patch.[60] The patient should be kept flat for a few days after surgery to lower the hydrostatic pressure in the lumbar thecal sac while the repair seals.

Neural injuries are rare, although the risk is greater with unusual disc herniations as described previously. Visceral injuries occur when an instrument penetrates the anterior annulus. Among these, vascular injuries are the most common.[60,91] If these are recognized, then immediate laparotomy for surgical repair is indicated.

Postoperative disciitis occurs in 1% of cases or less in experienced hands, although clearly a learning curve exists in developing facility with the microscope. Higher infection rates (up to 7%) have been reported with the use of a microscope during surgery, although in experienced hands

*References 17, 60, 94, 98, 107, 120.

this has been shown not to be true.[60] An MRI is the best diagnostic imaging tool. An image-guided needle biopsy may be performed to assist in appropriate antibiotic selection. Reoperation may not be necessary unless the patient develops root compression, cauda equina syndrome, or an epidural abscess.

The literature reports recurrent HNP occurring anywhere from 2% to 5% after lumbar discectomy.[62,122] When reoperating for a recurrent HNP, it is important to get adequate exposure of the dural sac above and below the disc space. Then using a combination of blunt (nerve hook, Penfield, bipolar) and sharp (Kerrison) dissection, the dural sac and nerve root are exposed and mobilized above the HNP.

Iatrogenic mechanical instability is fortunately a rare occurrence after discectomy, even if a decompressive laminectomy was required for a stenotic canal or to excise a large disc.[31] Symptomatic mechanical treatment may require surgical stabilization. Suboptimal results after discectomy surgery can be the result of several other problems that, unfortunately, do not have a straightforward medical or surgical treatment. Although very rare, these can include epidural fibrosis, arachnoiditis, and complex regional pain syndrome.[60]

Discussion

Most modern studies using microscopic techniques for treatment of herniated lumbar discs report 90% to 95% success rates.* A multicenter, prospective trial has proved what cannot be repeated often enough: If the therapist selects patients with dominant radicular pain (compared with back pain), with neurological changes and painful SLRs, and with a study confirming a disc rupture, then he or she can anticipate a high level of success for discectomy, with or without a microscope.[1] The rate of successful outcome drops significantly as more of these inclusion criteria are not met. Persistent back pain occurs in up to 25% of patients who undergo microdiscectomy.[98,107] This has led to the opinion that it is important to save the supraspinous and intraspinous ligament complex, remove as little lamina as possible, save the ligamentum flavum as a flap, and do a limited discectomy. These steps theoretically reduce iatrogenic instability, epidural fibrosis, sterile disciitis, and loss of disc height. All of these steps are facilitated by the use of a microscope, but no proof exists that these steps reduce the incidence of back pain.

The most frequent cause of poor result from lumbar disc surgery is faulty patient selection because of erroneous or incomplete diagnosis. Technical errors such as wrong-level surgery, incomplete decompression, and intraoperative complications explain a small percentage of failures. A 1981 study assigned the following frequency of missed diagnoses as sources of failure: lateral spinal stenosis 59%, recurrent or persistent herniation 14%, adhesive arachnoiditis 11%, central canal stenosis 11%, and epidural fibrosis 7%. Finally, the results of repeat surgery are not as good as primary surgery, regardless of the reason or whether a microscope was used, because of scar tissue, higher incidence of complications, or larger dissections.

In the past decade, a substantial increase in interest in minimally invasive procedures has occurred in all areas of medicine, particularly for spinal disorders. Several methods to remove HNP have been proposed as alternatives to standard open discectomy. Injected chymopapain can dissolve much of the central nucleus, but is not likely to act on extruded or sequestered fragments, which are often heavily collagenized.[21,25,75] Likewise, percutaneous suction discectomies and removal of nucleus (either mechanically or by laser from the center of the disc) may reduce intradiscal pressure but are unlikely to influence the effects of extruded or sequestered disc material. Therefore although alternative minimally invasive techniques hold considerable promise, lumbar microdiscectomy is still the gold standard for surgical treatment of lumbar HNP with radiculopathy. However, the skills and technology to remove herniated discs by such alternatives are evolving.*

THERAPY GUIDELINES FOR REHABILITATION

Postoperative spine rehabilitation allows for a safer and faster return to functional activities. The early return to *appropriate* activities has been encouraged after surgeries of the extremities for many years. The same approach should be applied to the spine. Careful instruction and frequent re-evaluation enable a therapist to progress the patient's functional activities to premorbid levels safely. The therapist should apply a functionally appropriate and suitably aggressive postoperative protocol to the patient recovering from lumbar microdiscectomy.

Lumbar disc herniations can do more than compromise the nerve root. Compensatory movement patterns, altered mechanics of the motion segment, and muscle splinting may result in misleading referred pain patterns (e.g., myofascial trigger points). Furthermore, the literature suggests that abnormal changes in paraspinal muscle activity occur after a HNP.[28,68] Triano and Schultz[108] found a high correlation between the absence of the flexion-relaxation phenomenon (i.e., the relaxation of the lumbar paraspinal muscles at terminal flexion in standing) and poor results on the Oswestry Pain Disability Scale (Box 13-1).

*References 4, 11, 15, 17, 18, 22, 52, 94, 98, 101, 103, 106, 110, 111, 122, 127, 128.

*References 16, 21, 24, 55, 76, 77.

Box 13-1 Oswestry Low Back Pain Disability Questionnaire

This questionnaire has been designed to give your physical therapist (PT) information as to how your back pain has affected your ability to manage in everyday life. Please answer every question by marking the *one* box that applies. We realize you may consider that two of the statements in any one section relate to you, but please just mark the box that most closely describes your problem.

Name: ________________________________

Date: ____________ Initial Interim/Discharge

1. Pain intensity
   - ☐ I can tolerate the pain I have without having to use painkillers.
   - ☐ My pain is bad, but I manage without taking painkillers.
   - ☐ Painkillers give me complete relief from my pain.
   - ☐ Painkillers give me moderate relief from my pain.
   - ☐ Painkillers give me very little relief from my pain.
   - ☐ Painkillers have no effect on my pain, and I do not use them.
2. Personal care
   - ☐ I can look after myself normally without causing extra pain.
   - ☐ I can look after myself normally, but it causes extra pain.
   - ☐ It is painful to look after myself, and I am slow and careful.
   - ☐ I need some help, but I manage most of my personal care.
   - ☐ I need help every day in most aspects of self-care.
   - ☐ I do not get dressed, wash with difficulty, and stay in bed.
3. Lifting
   - ☐ I can lift heavy objects without causing extra pain.
   - ☐ I can lift heavy objects, but it gives me extra pain.
   - ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage light to medium objects if they are conveniently positioned.
   - ☐ I can lift only very light objects.
   - ☐ I cannot lift anything at all.
4. Walking
   - ☐ Pain does not prevent me from walking any distance.
   - ☐ Pain prevents me from walking more than 1 mile.
   - ☐ Pain prevents me from walking more than $\frac{1}{2}$ mile.
   - ☐ Pain prevents me from walking more than $\frac{1}{4}$ mile.
   - ☐ I can only walk using a cane or crutches.
   - ☐ I am in bed most of the time and have to crawl to the toilet.
5. Sitting
   - ☐ I can sit in any chair as long as I like.
   - ☐ I can sit only in my favorite chair as long as I like.
   - ☐ Pain prevents me from sitting more than 1 hour.
   - ☐ Pain prevents me from sitting more than $\frac{1}{2}$ hour.
   - ☐ Pain prevents me from sitting more than 10 minutes.
   - ☐ Pain prevents me from sitting at all.
6. Standing
   - ☐ I can stand as long as I want without extra pain.
   - ☐ I call stand as long as I want, but it gives me extra pain.
   - ☐ Pain prevents me from standing more than 1 hour.
   - ☐ Pain prevents me from standing more than $\frac{1}{2}$ hour.
   - ☐ Pain prevents me from standing more than 10 minutes.
   - ☐ Pain prevents me from standing at all.
7. Sleeping
   - ☐ Pain does not prevent me from sleeping well.
   - ☐ I can sleep well only by taking medication for sleep.
   - ☐ Even when I take medication, I have less than 6 hours' sleep.
   - ☐ Even when I take medication, I have less than 4 hours' sleep.
   - ☐ Even when I take medication, I have less than 2 hours' sleep.
   - ☐ Pain prevents me from sleeping at all.
8. Sex life
   - ☐ My sex life is normal and gives me no extra pain.
   - ☐ My sex life is normal but causes some extra pain.
   - ☐ My sex life is nearly normal but is very painful.
   - ☐ My sex life is severely restricted by pain.
   - ☐ My sex life is nearly absent because of pain.
   - ☐ Pain prevents any sex life at all.
9. Social life
   - ☐ My social life is normal and gives me no extra pain.
   - ☐ My social life is normal but increases the degree of pain.
   - ☐ Pain has no significant effect on my social life apart from limiting my more energetic interests, such as dancing.
   - ☐ Pain has restricted my social life, and I do not go out as often.
   - ☐ Pain has restricted my social life to my home.
   - ☐ I have no social life because of pain.
10. Traveling
    - ☐ I can travel anywhere without extra pain.
    - ☐ I can travel anywhere, but it gives me extra pain.
    - ☐ Pain is bad, but I manage journeys over 2 hours.
    - ☐ Pain restricts me to journeys of less than 1 hour.
    - ☐ Pain restricts me to short, necessary journeys of less than $\frac{1}{2}$ hour.
    - ☐ Pain prevents me from traveling except to the doctor or hospital.