Evaluation of varied surgical approaches used in the management of 170 far-lateral lumbar disc herniations: indications and results

NANCY E. EPSTEIN, M.D.

Department of Surgery (Neurosurgery), North Shore University Hospital, Manhasset, New York; and the Cornell University Medical College, New York, New York

This study was undertaken to determine and compare indications and relative benefits of various surgical approaches in 170 patients (average age 55 years) with far-lateral herniated lumbar discs, identified by magnetic resonance (MR) imaging and computerized tomography (CT) and operated on between 1984 and 1994. Essentially three surgical procedures were performed: complete facetectomy in 73 patients, laminotomy with medial facetectomy in 39 patients, and intertransverse discectomy (also known as ITT) in 58 patients. Follow-up periods averaged 5 years (range 0.5–10 years). Outcomes were scored as excellent (no deficit), good (mild radiculopathy), fair (moderate radiculopathy), and poor (unchanged or worse).

Overall, excellent and good results were achieved in 73 and 51 patients, respectively, and fair and poor results in 26 and 20, respectively. There was little difference among the results encountered for the three major surgical groups: 79% of the intertransverse (ITT) group had good-to-excellent outcomes, as compared with 70% of the facetectomy group, and 68% of the group who underwent at minimum laminotomy, and additional hemilaminectomy or laminectomy with medial facetectomy. Results were the same for the 121 patients followed for more than 2 years and for the 49 patients studied for under 2 years.

In the management of far-lateral discs, total facetectomy provides the best exposure, but increases the risk of instability. Laminitomy and medial facetectomy uncover the lateral and subarticular recess and preserve stability, but visualization of the far-lateral compartment is often inadequate. The intertransverse approach offers extensive far-lateral but not medial intraforaminal exposure, while also preserving stability.

Full facetectomy, laminotomy with medial facetectomy, and the intertransverse approaches yielded nearly comparable outcomes in far-lateral disc surgery. Only the full facetectomy exposes the entire course of the nerve root both medially and laterally, whereas the intertransverse procedure provides direct exposure of the far-lateral compartment alone.

It is important to select the correct approach or combination of approaches to address attendant complicating factors such as spinal stenosis, spondyloarthrosis, and degenerative spondylolisthesis identified on CT and MR studies.

KEY WORDS • far-lateral disc herniation • sequestered disc • surgical approach

The management of far-lateral disc herniation by means of laminotomy with medial facetectomy and full facetectomy has resulted in 70% to 85% excellent-to-good results, with minimal requirements for fusion. The recently popularized intertransverse approach, although assuring adequate removal of isolated extraforaminal lesions, provides less exposure of intraforaminal subarticular pathology.

In this article postoperative results are reported in 170 patients with far-lateral disc herniations located primarily beyond the pedicle, although some presented with additional lesser elements in the foramen and spinal canal. The location of all far-lateral disc herniations was confirmed by preoperative magnetic resonance (MR) imaging and computerized tomography (CT) examinations, which also identified associated structural abnormalities contributing to stenosis of varying degrees and characteristics.

Three surgical techniques were used: laminotomy with medial facetectomy, full facetectomy, and the intertransverse approach. Based on the preoperative studies, it was important to determine which procedure provided the best results with the least morbidity.

Clinical Material and Methods

Far-Lateral Disc Herniation

Far-lateral disc herniations are found lateral to the pedicle, but often are accompanied by foraminal and even intracanalicular fragments. Others may be complicated by central, lateral recess, and far-lateral stenosis, associated with spondyloarthrosis, degenerative spondylolisthesis, spondylolisthesis with lysis, degenerative scoliosis, and far-lateral calcified limbus fractures. For the purposes of
this article, the term “stenosis” is used for all elements that comprise the spinal canal.

Patient Population

Between 1984 and 1994, 170 patients were operated on for far-lateral disc herniations documented by MR and CT examinations. One hundred twenty-one of these cases were followed for more than 2 years, 49 for less than 2 years, with an average follow-up interval of 5 years. Seventy-seven of the patients were treated prior to 1990, whereas 93 were operated on from 1990 to 1994, reflecting an increased awareness of this disorder. The patients averaged 55 years of age with a range of 24 to 84 years (Table 1); there were 112 men and 58 women. Although the patients presented with chronic symptoms averaging 29 months in duration, subacute deterioration over 6-month intervals was the rule. On occasion, the sudden onset of acute symptoms of unusual severity prompted emergency surgery to remove sequestered disc fragments.

Preoperative evaluations included MR images and non-contrast CT scans using 2-mm sections. In selected patients, myelographic CT or three-dimensional CT evaluations were also performed. All 170 patients had documented far-lateral disc herniations on these tests, lesions that were frequently accompanied by structural changes and by additional disc material in the neural foramen or spinal canal. The lesions operated on also included single or multilevel primary or recurrent herniations. With these studies, 68 patients had far-lateral lesions located at L4–5, 63 at L3–4, and 33 at L5–S1, whereas another four had lesions at L2–3, and only two at L1–2. Five patients had two simultaneous far-lateral disc herniations (Table 1). Stenosis of the far-lateral compartment, defined by arthrotic changes with enlarged facet joints, and spondylotic degeneration, involving the vertebral margins, were noted in 30 patients, most occurring at L4–5, followed by L5–S1, and last by L3–4 (Table 2). Far-lateral disc herniations were also associated with degenerative spondylolisthesis in 23 patients, the levels ofolisthesis and far-lateral disc herniations coinciding in 15 patients at the L4–5 level, whereas levels were dissimilar in eight (Table 2).

Surgical Procedure

Although direct comparison was complicated by the varied pathologies at hand, surgical outcomes of the three techniques were assessed (Figs. 1–3). In this regard, complete laminectomies were required for correction of attendant multilevel stenosis, whereas unilateral laminotomies were required for isolated far-lateral discs with moderate lateral recess stenosis and hemilaminectomies were required to decompress patients with more severe stenotic findings.

Laminectomy. Laminectomy, performed in 36 patients from the L-1 through S-1 levels, addressed far-lateral discs and stenosis due to degenerative spondylolisthesis, spondylolisthesis with lysis, degenerative scoliosis, and limbus fractures (Table 3). This was followed by full facet (58%), medial facet (17%), and intertransverse (25%) resection.
Laminotomy and Hemilaminectomy. Laminotomies or hemilaminectomies were performed in 134 patients from the L-1 through S-1 levels (Tables 1 and 3). The types of accompanying facet resections included the full facetectomy technique in 38% of patients and medial facetectomy in 24%. Laminar resections were combined with the intertransverse technique in 37% of cases. Only one individual had a far-lateral disc removed using a trans pars approach, that technique having limited value.

Spinal Fusions. Six of the seven patients with evidence of spinal instability underwent fusion (4%); one refused consent for a secondary fusion (Table 4). The three women and four men averaged 51 years of age and required an average of 2.6 operations. The procedures addressed an isolated far-lateral disc (one patient), a far-lateral disc with an L5–S1 spondylolisthesis with lysis (one patient), a routine disc (one patient), and spinal stenosis (one patient). Degenerative spondylolisthesis was present prior to the first procedure in three patients and was newly evolved in two of the four already mentioned. The level of the spondylolisthesis and the discal herniations coincided. The three patients who underwent fusion before 1990 received Hibbs fusion, whereas those who underwent fusion after that time received Texas Scottish Rite Hospital (TSRH) instrumented fusions.

Secondary Operations for Recurrent Far-Lateral Disc Herniations or Stenosis. Additional surgery was performed in 31 patients. Twenty-five required two operations, and six needed three procedures (Table 2). Initial surgeries, which had preceded the secondary operations by an average of 49 months, had addressed spinal stenosis, a neurofibroma, and prior disc herniations. Of 15 cases of previous disc disease, six operations originally had been

<table>
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<th>TABLE 2</th>
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<td>Additional pathology associated with far-lateral disc herniations</td>
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<tr>
<td></td>
</tr>
<tr>
<td>pathology</td>
</tr>
<tr>
<td>far-lateral disc herniation/stenosis (30 patients)</td>
</tr>
<tr>
<td>degenerative spondylolisthesis (23 patients)</td>
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<tr>
<td>far-lateral disc herniation + degenerative spondylolisthesis</td>
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Fig. 1. Schematic drawings depicting medial facetectomy with laminotomy and focal resection of the pars interarticularis for far-lateral disc excision. The L-5 nerve root underlying the superior articular facet of L-5 (large arrow) courses around the L-5 pedicle as it extends into the L5–S1 neural foramen (small arrows) on its way to the far-lateral compartment (upper). Sequestered elements of the far-lateral disc herniation extending to and through the L5–S1 neural foramen are adequately decompressed through medial facetectomy and foraminotomy (lower, A). Focal resection of the L-5 pars interarticularis with extraspinal exposure (lower, B) is initiated through a superior L4–5 laminotomy that directly visualizes the L-5 nerve root (double arrows) as it leaves the spinal canal (lower, A) and enters the L4–5 neural foramen (lower) a. = left lateral recess; P. = pars interarticularis.

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performed for far-lateral disc, whereas nine had been for simple herniations medial to the pedicles. True recurrent far-lateral disc herniations were observed in only six (4%) of the 170 patients, accounting for six (19%) of the 31 operations performed.

**Intraoperative X-ray Confirmation of the Surgical Level.** Although many patients with far-lateral disc herniations, particularly above the L4–5 level, undergo preoperative fluoroscopic interspinous ligament marking, additional intraoperative x-ray confirmation of the level is essential.

**Results**

Patients were physically reexamined on a routine basis approximately 1 week, 1 month, 3 months, 6 months, and then yearly after surgery, with additional evaluations being included if required. Magnetic resonance images and CT scans were obtained as indicated postoperatively for assessment of specific complaints, but were not routinely used to confirm the extent of laminar and/or facet joint resection that had been directly determined intraoperatively. An outcome study, using the Short Form 36 as a tool, is pending. Using purely clinical parameters, radiculopathy decreased from 94% to 57% postoperatively. Motor deficits similarly declined from an incidence of 74% to 27%, reflex abnormalities from 98% to 60%, and sensory deficits from 79% to 57% (Table 1). Excellent outcomes were achieved in 73 patients, good outcomes in 51 patients, fair results in 26 patients, and poor results in 20 patients (Table 1). The results of all three approaches (intertransverse discectomy, 79%; full facetectomy, 70%; and laminotomy with medial facetectomy, 68%) were comparable (Tables 1 and 5). However, comparison was difficult because of the variety of associated abnormalities that accompanied the far-lateral disc herniations in most of these patients. This included the presence of foraminal and intracanalicular fragments of disc with attendant narrowing, caused by previously indicated structural changes.

**Illustrative Cases**

**Case 1**

This obese man, weighing 280 lbs, with a 6-week history of right lower-extremity pain, weakness and numbness, presented with a partial foot drop and L-5 radiculopathy. The noncontrast CT and MR studies showed a far-lateral right-sided L5–S1 disc herniation, which was removed through a superior laminotomy plus a trans pars and extraforaminal resection (Fig. 4). The interspace was not decompressed. Postoperatively, the patient progressed well for 6 weeks, following which his symptoms returned acutely with a complete foot drop. When the postoperative MR image, enhanced with gadolinium–diethylene-triamine pentaacetic acid (Gd-DTPA) revealed a recurrent discal extrusion, a second operation, using a complete facetectomy and a medial plus far-lateral discectomy was undertaken. Postoperatively, although the patient’s pain disappeared, his foot drop only partially resolved over the following 12 months to the 4/5 level. His spine remained stable with no indication for fusion.

![Fig. 3. Drawings illustrating hemilaminectomy and full facetectomy for excision of type III calcified far-lateral limbus vertebral fracture. A right-sided hemilaminectomy and full L5–S1 facetectomy provides completed exposure of the right L-5 root and calcified type III limbus vertebral fracture from within the canal through the foramen and into the far-lateral compartment (A). The lateral view (B) reveals fracture arising from the inferior end plate of the L-5 vertebral body intruding into the L5–S1 foramen. The transaxial view (C) illustrates the predominant foraminal location of the limbus fracture. Intraforaminal and extraforaminal lesions require a complete facetectomy.](image-url)
Case 2

This 35-year-old man developed an acute right-sided L-4 root entrapment syndrome consisting of extreme unremitting pain, numbness, and weakness (3/5) after lifting a television set. Following removal of a sequestered far-lateral L4–5 disc fragment demonstrated on the preoperative MR and CT studies using an intertransverse technique, the patient fully recovered and, after two years, was neurologically intact (Fig. 5 left).

Case 3

This 32-year-old man, a construction worker, with a 2-year history of left-leg pain and weakness, presented with a profound L-5 root syndrome characterized by a partial foot drop, loss of the Achilles response, and decreased pin appreciation over the L-5 dermatome. On the MR and myelographic CT studies he demonstrated a left L5–S1 foraminal and far-lateral disc extrusion plus a calcified type III limbus vertebral fracture (Fig. 5 center). After an L-5 hemilaminectomy with complete facetectomy and excision of the sequestrated disc and limbus fracture, the patient’s foot drop resolved and he has maintained a normal status for the past 2 years. Fusion was not required.

Case 4

This 42-year-old man with a complete foot drop lasting 6 weeks had, as shown on the myelographic CT scan, a massive right-sided L5–S1 far-lateral sequestered disc accompanied by a calcified limbus fracture (Fig. 5 right). Surgery, consisting of a complete right L-5 hemilaminectomy and full L5–S1 facetectomy, facilitated removal of a massive soft disc and a calcified limbus fracture, resulting in a good progressive recovery of function after 3 postoperative months. Two and one-half years later, the patient remains neurologically intact.

Discussion

Frequency and Location

Far-lateral disc herniations, located beyond the neural foramen and lateral to the pedicles, constitute from 7% to 12% of all herniated lumbar discs.1,4,6,9,14,15,18 Originating at the disc space, sequestered fragments or often a large single sequestrum migrate superolaterally into and beyond the neural foramen into the far-lateral compartment in which the superiorly exiting nerve root and ganglion are compressed.45 Far-lateral disc herniations involve higher lumbar segments compared to routine discs. The L4–5 level is most commonly involved, followed in descending order by L3–4 and L5–S1 herniations, and last by L2–3 and L1–2 herniations.1,3,9,12 However, unlike Siebner and

TABLE 3

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<tr>
<th>Surgical Procedure (No. of Cases)</th>
<th>Breakdown (No. of Cases)</th>
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<tbody>
<tr>
<td>laminectomy (36)</td>
<td></td>
</tr>
<tr>
<td>facet resection</td>
<td>L1–4 (4) full facetectomy (21), 58%</td>
</tr>
<tr>
<td>reoperation (15)</td>
<td>fusion + stenosis (4) recurrent far-lateral disc herniation (11) mean interval 40 mos</td>
</tr>
<tr>
<td>laminotomy/hemilaminectomy (134)</td>
<td></td>
</tr>
<tr>
<td>laminotomy</td>
<td>L1–2 (0) full facetectomy (51), 38%</td>
</tr>
<tr>
<td>reoperation (16)</td>
<td>recurrent far-lateral disc herniation + stenosis (3) mean interval 7.5 years</td>
</tr>
<tr>
<td>total reoperations (31)</td>
<td>1st operation (25) 2nd operation (6)</td>
</tr>
<tr>
<td>first operation</td>
<td>15 discs 15 stenosis</td>
</tr>
<tr>
<td>reoperations</td>
<td>24 discs 7 stenosis/disc</td>
</tr>
</tbody>
</table>

Fig. 4. Magnetic resonance (MR) images obtained in Case 1. Left: On this parasagittal T1-weighted MR image of intra- and extraradicular far-lateral disc, the foraminal portion of a large, sequestered L5–S1 far-lateral disc herniation is well visualized (large arrow). Right: This transaxial T1-weighted MR image of the L5–S1 level shows a large, sequestered right-sided foraminal and far-lateral disc (small arrows).
Faulhauer’s series, in which 4% of 694 discs were truly extraforaminal and another 3% were both intra- and extraforaminal, all of the present patients exhibited major far-lateral disc herniations on preoperative MR imaging and/or CT evaluations.

**Neurodiagnostic Studies**

The high-resolution noncontrast CT study with fine 2-mm sections and the CT discogram have been used accurately to establish the diagnosis of far-lateral disc herniations. The combined use of noncontrast CT scans and MR images helps differentiate true far-lateral disc herniations from changes attributed to bone abnormalities, other paravertebral lesions, and volume averaging. Although myelograms and myelographic CT examinations failed to identify far-lateral disc herniations (especially in the case of the former), such studies provide useful information regarding attendant intraspinal pathology, particularly in older patients.

Future increases in the quality and resolution of MR images may supplant the need for CT examinations. Studies enhanced with Gd–DPTA help differentiate between new or recurrent far-lateral disc herniation and postoperative scar. For those who have had recent surgery, both the MR imaging with Gd–DTPA and CT studies may be helpful, but more often they are unreliable.

**Neurological Symptomatology**

Far-lateral disc herniations occur in older patients, averaging 55 years of age in the present series and 56 to 65 years of age in other studies. Back pain is a secondary complaint and may be absent. Because these lesions impinge on the nerve roots exiting at the same level as the herniation (for example, the L-4 root at the L-4 deg sp level), more cephalad nerve root syndromes are observed, as compared to the commonly found lateral disc herniations that compress the inferior root (for example, the L-5 root at the L4–5 interspace). Mechanical findings, including fixed-knee contractures and signs of neural entrapment, are conspicuous and are accompanied by significant neural deficits clearly defining the root involved. In the present series, positive Lasègue (94%) or reverse Lasègue (femoral stretch test, 84%) maneuvers, plus ipsilateral knee contractures (84%) were accompanied by significant motor (74%), reflex (98%), and sensory (79%) dysfunction. Sphincteric difficulties were rare (4%).

**TABLE 4**

**Fusion requirements for seven of 170 patients with far-lateral disc herniation and spinal instability**

<table>
<thead>
<tr>
<th>Case No. (No. of Operations)</th>
<th>Age at Last Operation (yrs), Sex</th>
<th>Fusion Type (No. of Operations)</th>
<th>1st Operation (Date)</th>
<th>2nd Operation (Date)</th>
<th>3rd Operation (Date)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (3)</td>
<td>61, F</td>
<td>TSRH (2)</td>
<td>CHL L4–5 deg sp L4–5, Grade I (10/90)</td>
<td>TSRH fusion L4–5 deg sp L4–5, Grade I (8/91)</td>
<td>redo TSRH L4–S1 deg sp L4–5, Grade I (10/90)</td>
<td>fair, residual pain, stable on x-ray film</td>
</tr>
<tr>
<td>2 (3)</td>
<td>67, F</td>
<td>TSRH (3)</td>
<td>LAM L4–S1, stenosis L4–S1 (8/91)</td>
<td>redo LAM L4–S1 deg sp L4–5, Grade I (2/92)</td>
<td>TSFH L4–S1 FLD L4–5 deg sp, Grade II (7/89)</td>
<td>good/excellent</td>
</tr>
<tr>
<td>3 (2)</td>
<td>67, M</td>
<td>TSRH (2)</td>
<td>CHL L4–5 deg sp L4–5, Grade I (3/88)</td>
<td>LAM + TSRH L3–S1 deg sp L3–4, L4–5, Grade I + FLD L3–4 (12/93)</td>
<td>NA</td>
<td>good/excellent</td>
</tr>
<tr>
<td>4 (3)</td>
<td>51, F</td>
<td>Hibbs (2)</td>
<td>reg disc ILL L4–5 (1/76)</td>
<td>LAM L4–5 Hibbs fusion L4–5 deg sp L4–5, Grade I (7/77)</td>
<td>FLD L4–5 LAM/disc excision L4–5, Grade I no refusion (10/91)</td>
<td>good</td>
</tr>
<tr>
<td>5 (1)</td>
<td>58, M</td>
<td>none, no fusion (2)</td>
<td>FLD L4–5 deg sp L4–5, Grade I HL fusion L4–5 (1/90)</td>
<td>FLD L4–5, Grade II slip no fusion (none)</td>
<td>NA</td>
<td>poor, refused 2nd operation; fusion needed but declined excellent</td>
</tr>
<tr>
<td>6 (1)</td>
<td>40, M</td>
<td>Hibbs (1)</td>
<td>FLD L5–S1, Grade I lysis + lysis L5–S1 GILL fusion (8/87)</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>7 (3)</td>
<td>42, M</td>
<td>Hibbs (2)</td>
<td>FLD L4–5 deg sp L4–5, Grade I (10/90)</td>
<td>Hibbs fusion L4–5 + FLD L4–5 (4/88)</td>
<td>pseudarthrosis L4–5 reop post/ant fusion (4/89)</td>
<td>fair/good</td>
</tr>
</tbody>
</table>

* Abbreviations: TSRH = Texas Scottish Rite Hospital; CHL = coronal hemilaminectomy; deg sp = degenerative spondylolisthesis; FLD = far-lateral disc herniation; LAM = laminectomy; reg disc = regular disc herniation; ILL = laminotomy; HL = hemilaminectomy; full fac = full facetectomy; GILL = Gill procedure; ant = anterior; post = posterior.

**TABLE 5**

**Summary of outcomes reported in other far-lateral disc herniation series**

<table>
<thead>
<tr>
<th>Author &amp; Year</th>
<th>No. of Cases</th>
<th>Facet Operation</th>
<th>Outcome of Good/Excellent</th>
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</thead>
<tbody>
<tr>
<td>Sibbner &amp; Faulhauer, 1990</td>
<td>40</td>
<td>extraforaminal</td>
<td>85%</td>
</tr>
<tr>
<td>Kunogi &amp; Hasue, 1991</td>
<td>8</td>
<td>intertransverse</td>
<td>100%</td>
</tr>
<tr>
<td>Deckler, et al., 1992</td>
<td>10</td>
<td>extraforaminal</td>
<td>70%</td>
</tr>
<tr>
<td>Garrido &amp; Connaughton, 1992</td>
<td>41</td>
<td>full facetectomy</td>
<td>85%</td>
</tr>
<tr>
<td>Donaldson, et al., 1993</td>
<td>29</td>
<td>medial facetectomy</td>
<td>72%</td>
</tr>
<tr>
<td>Epstein, 1995</td>
<td>73</td>
<td>full facetectomy</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>intertransverse</td>
<td>79%</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>medial facetectomy</td>
<td>68%</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>trans pars</td>
<td>0%</td>
</tr>
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Conservative Management

Far-lateral disc herniations may be treated conservatively for the first 6 weeks if acute pain can be controlled unless a significant sensory or motor deficit is present. Treatment consists of high-dose steroid or nonsteroid anti-inflammatory agents combined with bed rest and physiotherapy. In my present experience, I believe approximately 10% of patients with far-lateral disc herniations can be successfully managed with conservative modalities, often showing resorption of a sequestered fragment on consecutive MR imaging studies.

Success of Surgical Management. Excellent-to-good outcomes were achieved in 79%, 70%, and 68% of patients treated with the intertransverse discectomy, full facetectomy, and laminotomy–medial facetectomy techniques, respectively. The differing techniques, of necessity, were tailored to each patient’s unique pathology. Nevertheless, the success rates for these three techniques proved to be comparable to the quality of outcome cited in other series (Table 5).

Fusion Requirements

Each of the techniques that require facet removal poses a risk of instability. However, large series employing combinations of partial and/or full facetectomy, cite a remarkably low 1/60 and 1/41 frequency of instability requiring fusion. Alternatively, Kunogi and Hasue advocated automatically fusing all patients with far-lateral discs managed with full facetectomies.

In this series, only 4% of patients developed spinal instability requiring fusions, which included three Hibbs (prior to 1990) and three TSRH (after 1990) approaches. Based on my experience and despite the low incidence in this series, I believe that primary fusions should now be considered in patients with far-lateral disc herniation at the same level as degenerative spondylolisthesis, particularly in cases in which a full facetectomy has already been performed. Of the 15 patients in this study with far-lateral disc herniation and spondylolisthesis at the same level, five who had unilateral full facetectomies later required fusions as a secondary procedure (Table 4). The other ten patients had either intertransverse discectomy or partial facetectomy. Even in cases in which fusions had previously been performed to stabilize degenerative spondylolisthesis, two patients developed new far-lateral disc herniations at the same level. In one of these patients, the far-lateral disc alone was excised and the contralateral fusion was left in place, whereas in the second patient, TSRH instrumentation was both redone and extended.

Lumbar Anatomy

With caudal progression in the lumbar spine, the disc space migrates farther laterally as the pedicles diverge. At lower levels, the facet joint covers more of the lateral portion of the disc, increasing the necessity for partial or complete facetectomy to remove extreme far-lateral lesions. Nevertheless, after disruption of a unilateral facet joint, instability is infrequent, especially at the L-5 vertebral level and more so if L-5 is below the intercrestal line, where it is strongly supported by the iliotransverse ligaments.

Pros and Cons of Different Surgical Techniques

Medial Facetectomy. A select group of far-lateral disc herniations may be removed through an extended laminotomy or, preferably, a hemilaminectomy with medial facetectomy and foraminotomy in cases in which the lateral recesses are narrow with attendant spondyloarthrotic pathology (Fig. 1A). The hemilaminectomy and foraminotomies are performed at the level of the involved nerve root (for example, the L-4 for an L4–5 lesion), and provide access to medial and intracanalicular sequestered fragments, often with a “tail” facilitating removal of extra-foraminal lesions. Operating across the table opposite to the disc herniation improves visualization as does tilting the table down toward the surgeon. However, no direct access is provided to the far-lateral compartments.
Therefore, if a tail is not available, one of the other techniques to excise fragments not accessible with this exposure should be added. Although occasionally blind lateral epidural or intradiscal dissection with angulated down-biting curettes or the Woodson dissector may access retained far-lateral fragments, the unseen nerve root may be injured, and additional portions of disc missed. As stenosis is minimal at the L5–S1 level, this approach is best suited for L5–S1 lesions in which the pedicles are farther apart and most of the disc is accessible.

**Full Facetectomy.** In cases in which severe spondylostenosis is present, the complete facetectomy offers the best visualization of the entire nerve root and ganglion throughout their course. Adequate decompression of stenosis may be accomplished with minimal manipulation being assured. This procedure is usually combined with an extended laminotomy or hemilaminectomy (Fig. 3). It is also the procedure of last resort if difficulty in exposure occurs. Furthermore, the risk of spinal instability with this full facetectomy does not appear to be as high as anticipated, especially at L5–S1, with under 2% of cases requiring fusion. With these data, it is difficult to justify automatic fusion, regardless of age, as promoted by Kunogi and Hasue.11

**Trans Pars Technique Plus Extraforaminal Exposure.** Far-lateral disc excision using the trans pars technique is accomplished through a superior laminotomy, with partial resection of the pars interarticularis overlaying the foraminar nerve root, preserving the facet. This is supplemented with further extraforaminal exposure (Fig. 1B). This technique visualizes both the medial and far-lateral segments of the nerve root and ganglion, allowing for removal of the sequestered portion of the disc. However, there is no provision for access medially for intervertebral disc excision or bone decompression for attendant stenosis or spondylarthrosis. Although the facet is preserved, supported by the lamina, exposure is limited and can only be extended by further laminar and facet excision.

Unfortunately, this technique fails to address pathology in the lateral recesses, increasing the probability of retained disc fragments and complications associated with overlooked medial stenosis. Nevertheless, when Donaldson and associates' studied 29 patients undergoing far-lateral disc excision using trans pars and extraforaminal techniques combined, 72% exhibited good-to-excellent outcomes (Table 5). Unfortunately, in the current study the patient in Case 1, an obese man with a right-sided L5–S1 lesion that was excised using this approach, suffered a near-immediate disc recurrence. At the first surgery, only the far-lateral disc had been excised, not the medial portion, whereas during the second procedure both medial and lateral discectomy were accomplished.

**Combined Intertransverse Technique.** Far-lateral disc resection is best accomplished through an extended interlaminar laminotomy or a hemilaminectomy combined with a far-lateral extraforaminal exposure, particularly in the presence of significant attendant stenosis and associated abnormalities common in older patients (Fig. 2).9,10,21 Visualization of the nerve root and ganglion is accomplished via their exposure underneath the intertransverse ligament and fascia. This allows for resection of all sequestered disc fragments that usually migrate superolaterally, where they displace and compress the nerve root and ganglion against the pedicle or underneath the inferior facet. The interspace can also be entered and directly decompressed. Down-biting curettes may also be used both medially and laterally to explore underneath the pars and the poorly visualized intraforaminal segment of the nerve root. The intertransverse exposure preserves stability because the minimum superolateral facet resection leaves the major weight-bearing portion of the facet joint intact, preserving the pars interarticularis. If the pedicle is short, undercutting the facet is indicated.

Advantages of this technique include more complete subarticular and far-lateral disc excision under direct vision. All eight of Kunogi and Hasue’s patients treated with the intertransverse procedure for intraforaminal and extraforaminal disc herniations did well, none requiring a fusion. Oeckler’s patients, who were managed with the intertransverse approach, experienced no discal recurrences, compared with a 30% discal recurrence rate in those treated with isolated extraforaminal exposures.

However, the intertransverse procedure also has several drawbacks such as the failure to adequately visualize the nerve root along its complete foraminal course. This may lead to attempts at blind manipulation to remove residual disc fragments that traumatize the nerve root in the subarticular recesses. This risk is further magnified if the foramen is narrowed dorsally because of shortened pedicles. If combined with extensive facet resection, fracture of the pars may occur. In the extremely stenotic and arthritic individual, the far-lateral exposure may prove too limited to adequately decompress the nerve root, making conversion to a full facetectomy an important option to avoid inadvertent neural injury.

**Extraforaminal (Extreme-Lateral) Approach.** The extraforaminal approach is best used for the pure extraforaminal lesion in the absence of spinal stenosis or spondylarthrosis. Entry to the far-lateral compartment is initiated through either a midline or paramedian muscle-splitting incision. After dissecting downward between the longissimus and multifidus muscles, the intertransverse ligament and fascia are exposed and excised, medially defining the lateral aspect of the facet joint, the pars interarticularis, the pedicle, and the transverse process, and exposing the lesions and involved nerve root.2,8,12,18

The isolated extraforaminal exposure allows for excision of sequestered, often single-fragment, far-lateral discal extrusions without providing access to the spinal canal.1,6,13,18 Comprising the far-lateral half of the intertransverse approach, the extraforaminal procedure is performed through a midline or paramedian muscle-splitting incision with dissection through the intertransverse ligament and fascia overlaying the far-lateral nerve root and ganglion. This procedure provides no access to the medial portions of the spinal canal, foramen, or disc. In 225 patients reported by Monteiro, et al., 40% of those who were treated with the extraforaminal approach through the midline were “cured,” whereas 85% of Siebner and Faulhauer’s 40 patients who were treated with midline (38 patients) and paramedian (two patients) approaches did well (Table 5). Others similarly successfully employed the paramedian extraforaminal approach to far-lateral discs while limiting instability, with medial scar being avoided in patients who previously had received surgery.5,6,12,14,19
Percutaneous Techniques. Bonafe, et al., evaluated 40 cases of foraminal (28 patients) and extraforaminal (12 patients) lesions removed with a nucleolysis or percutaneous automated nucleolotomy technique. Over a mean interval of 12 months, these combined procedures were successful 67.5% of the time. Privat, however, has emphasized that few patients were candidates for any of the percutaneous procedures, indicating that direct microsurgery is still the technique of choice for patients over 45 years of age with free or extruded fragments, accompanying spinal stenosis, or histories of previous surgery.

Anterolateral Retroperitoneal Approach. Strum and colleagues advocated the anterolateral retroperitoneal approach for the resection of far-lateral discs. Anterolateral entry into the disc space facilitated discitomy, whereas fusion could either be accomplished using a tricortical iliac crest bone graft or by packing the interspace with bank bone. Advantages included less scar formation around the thecal sac or nerve roots and preservation of the posterior elements.

Disadvantages, however, included the greater morbidity of the transabdominal, retroperitoneal approach in which the nerve root is poorly visualized, increasing the risk of both root injury and retained disc. In addition, stenosis could not be addressed. Finally, the anterior operation mandates a simultaneous fusion, less frequently required for posterior approaches.

Conclusions

Neither the full facetectomy, medial facetectomy, or intertransverse approaches should be automatically adopted as isolated techniques to resect all far-lateral discs. Rather, each procedure must be tailored to the individual patient. For the younger patient with an isolated far-lateral fragment and no accompanying stenosis, the intertransverse technique is ideal. Stability is preserved, lateral disc excision is facilitated, and sequestered fragments are removed with ease; the only shortcoming is a lack of visualization medially into the subarticular neural foramen. For the older individual with accompanying intraforaminal and intraspinal pathology, complete facetectomy with laminar decompression provides direct visualization of the nerve root from its origin in the spinal canal through the foramen and into the far-lateral compartment. This guarantees the fullest degree of root decompression from disc pathology and stenosis, with the least risk of root injury. Fusion may be performed if indicated. Finally, the laminotomy with medial facetectomy procedure, particularly at the L5–S1 level, may be used in cases in which a “tail” of sequestered disc can be visualized from inside a wide spinal canal, facilitating removal of the major fragment. A disadvantage of this approach is the failure to visualize the far-lateral compartment adequately, increasing the risk of retained fragments.

Acknowledgment

The author would like to thank Dr. Joseph Epstein for his editorial comments, illustrations, and unlimited patience.

References
