Unsuccessful Percutaneous Endoscopic Lumbar Discectomy: A Single-Center Experience of 10 228 Cases

**BACKGROUND:** Percutaneous endoscopic lumbar discectomy (PELD) has remarkably evolved with successful results. Although PELD has gained popularity for the treatment of herniated disc (HD), the risk of surgical failure may be a major obstacle to performing PELD. We analyzed unsuccessful cases requiring reoperation.

**OBJECTIVE:** To find common causes of surgical failure and elucidate the limitations of the conventional PELD technique.

**METHODS:** A retrospective review was performed on all patients who had undergone PELD between January 2001 and December 2012. Unsuccessful PELD was defined as a case requiring reoperation within 6 weeks after primary surgery. Chart review was done, and preoperative, intraoperative, and postoperative radiographic reviews were performed. All unsuccessful PELD cases were classified according to the type of HD, location of herniation, extruded disc migration, working channel position, and intraoperative and postoperative findings.

**RESULTS:** In 12 years, 10 228 patients had undergone PELD; 436 (4.3%) cases were unsuccessful. The causes were incomplete removal of HDs in 283 patients (2.8%), recurrence in 78 (0.8%), persistent pain even after complete HD removal in 41 (0.4%), and approach-related pain in 21 (0.2%). Incomplete removal of the HD was caused by inappropriate positioning (95 cases; 33.6%) of the working channel and occurred in central HDs (91 cases; 32.2%), migrated HDs (70 cases; 24.7%), and axillary type HDs (63 cases; 22.3%).

**CONCLUSION:** Proper surgical indications and good working channel position are important for successful PELD. PELD techniques should be specifically designed to remove the disc fragments in various types of HD.

**KEY WORDS:** Incomplete removal, Percutaneous endoscopic lumbar discectomy, Recurrence, Reoperation

**ABBREVIATIONS:** HD, herniated disc; PELD, percutaneous endoscopic lumbar discectomy

Percutaneous endoscopic lumbar discectomy (PELD) is a minimally invasive spinal technique that has several advantages over open discectomy, including less paravertebral muscle injury, preservation of bony structure, and rapid recovery. PELD has gained popularity for removal of herniated disc (HD) material over the past few years since Kambin introduced the percutaneous posterolateral approach in 1983. Despite the remarkable evolution of endoscopic techniques and instrumentation leading to successful outcomes comparable to conventional open surgery, surgeons still have some difficulty in PELD. Most concerns are about the incomplete removal of disc fragments, a steep learning curve, recurrence, and radiation exposure. The risk of surgical failure may be a major obstacle to performing PELD. We analyzed unsuccessful cases requiring reoperation. The purpose of this study was to find the common causes of surgical failure and to elucidate the limitations of the conventional PELD technique. We also discuss techniques to address these limitations.
METHODS

This study was approved by our institutional review board. A retrospective review was performed on all patients who had undergone PELD between January 2001 and December 2012. This study included patients (1) with lumbar disc herniation at L1-2, L2-3, L3-4, L4-5, and L5-S1; (2) with intracanal and extracanal (foraminal/extraforaminal) disc herniations; (3) undergoing transforaminal PELD alone; and (4) having preoperative and postoperative magnetic resonance image (MRI), computed tomography (CT) scan, and intraoperative radiography before discharge, with postoperative checkup 6 weeks later at an outpatient clinic. Exclusion criteria were as follows: (1) interlaminar PELD, (2) segmental instability, and (3) infection. Clinical outcomes were assessed by the Modified MacNab criteria (Excellent: no pain, no restriction of mobility, return to normal work and level of activity; Good: occasional nonradicular pain, relief of presenting symptoms, able to return to modified work; Fair: some improved functional capacity, still handicapped and/or unemployed; Poor: continued objective symptoms of root involvement, additional operative intervention needed at index level irrespective of length of postoperative follow-up).

Unsuccessful PELD was defined as a case requiring reoperation (open surgery or another PELD attempt) on the same side in the same level within 6 weeks after primary surgery. Recurrence was defined as a reherniation at the same level and side under radiological diagnosis despite a transient symptom-free period of at least 2 weeks, with an immediate postoperative MRI confirming the complete removal of herniated disc fragments. Postoperative analysis was done with a chart review and the evaluation of preoperative and postoperative MRIs and intraoperative radiography. Independent observers (K.-C.C. and L.A.S.) analyzed all unsuccessful cases according to the type of disc herniation; the location of the herniated disc on the axial view (central or paramedian), coronal view (shoulder or axillary), and sagittal view (high-grade or low-grade migration) on MRI; the position of the endoscopic working channel; and intraoperative and postoperative findings.

An inappropriate position of the endoscopic working channel was described as having the bevel-ended opening of the cannula verified below the posterior vertebral line (within the disc space) on lateral intraoperative fluoroscopic radiographs. On confirmation with anteroposterior intraoperative radiographs, it reveals the bevel-ended cannula position to be immediately below the main herniated disc mass (Figure 1). In this situation, removal of the extruded disc was almost impossible.

The location of herniation in relation to the pedicle and spinal canal was described either as central or paramedian. A higher herniation midline split ratio exceeding 60:40 placed the herniation in the paramedian group. In paramedian HD, the herniated disc was classified as a shoulder or axillary type. An axillary type describes the herniated disc fragment location between the traversing nerve root and the thecal sac or nerve root.9 A shoulder type describes the herniated disc fragment as located
lateral to traversing nerve root or underneath the medial to lateral part of a nerve root with a broad base. Herniated disc migration was described as a high-grade migration if the extent of migration was larger than the measured height of the posterior marginal disc space. On the other hand, migration of less than the measured height of the posterior marginal disc space was described as a low-grade migration.10,11 Lateral recess stenosis was defined as lateral recess measurement of less than 3 mm on CT scan.12 The Pfirrmann grading system of nerve root compromise due to disc herniation was used: grade 0 (normal), no compromise of the nerve root; grade 1 (contact), visible contact of disc with the nerve root; grade 2 (deviation), dorsal displacement of the nerve root by disc material; grade 3 (compression), compress nerve root by disc.13 An incomplete removal of HD was defined as the deviation or compression of the nerve root after the initial PELD. We compared all PELD cases with the cases of 3 surgeons (K.-C.C., M.-J.K., and J.-S.K.) having experienced more than 250 cases with teaching PELD in Korea Minimal Invasive Surgery Society. We performed statistical analyses using SPSS for Windows (version 12.0; SPSS, Inc, Chicago, IL). We used the χ2 test for comparing the data of the 2 groups. The result was considered statistically significant if the P value was less than .05.

Surgical Techniques

In all of the patients, the PELD procedure was performed under local anesthesia in the prone position. The patients communicated with the surgeon during the entire procedure. Skin entry point was usually about 8 to 13 cm from the midline. The point depends on the patient’s body size, location of the herniated disc, and foraminal dimension. After infiltration of the entry point with local anesthetics, an 18-gauge spinal needle was introduced under fluoroscopic guidance. The needle tip was positioned at 1 point of the medial-to-lateral pedicular line on the anteroposterior fluoroscopic projection and at the posterior vertebral line on the lateral projection. Next, an epidurogram was performed by using contrast media to confirm the location of the exiting root and the traversing root. After inserting the spinal needle into the disc, the nucleus pulposus was stained blue with a 1-mL mixture of contrast media and indigo carmine for discography. Then the following steps were performed: (1) a guide wire was inserted through the spinal needle, (2) the spinal needle was removed, (3) a small incision was made in the skin at the entry site, (4) a tapered cannulated obturator was inserted along the guide wire, (5) after touching the annulus, the obturator was inserted into the disc by hammering, and, last (6), a bevel-ended, oval-shaped working cannula was inserted into the disc along the obturator after which the obturator was removed. Next, an endoscope was inserted through the cannula. The pathological nucleus was stained for easy discrimination. The blue-stained disc was removed using endoscopic forceps and a side firing, holmium:yttrium-aluminum-garnet laser using the “in and out” technique by working from the central portion to the lateral portion of the disc space on the anteroposterior image. The inflamed nucleus was observed as being anchored by the annular fissure. The herniated disc and fibrotic scar tissues were released and removed by the use of endoscopic forceps and a side-firing the holmium:yttrium-aluminum-garnet laser. After the herniated fragment was completely removed, the endoscope was removed (See Video, Supplemental Digital Content, http://links.lww.com/NEU/A707).

RESULTS

In the span of 12 years, 11,118 patients had undergone PELD. This study included 10,228 patients who had undergone transforaminal PELD. The remaining 890 patients excluded from this study were 733 patients who had undergone interlaminar PELD and 157 patients who were not checked up postoperatively or whose postoperative MRI was not verified or available. According to their levels, there were 31 cases at L1-2, 171 cases at L2-3, 602 cases at L3-4, 7499 cases at L4-5, and 1925 cases at L5-S1. There were 6451 men and 3777 women with a mean age of 39.9 years (range, 20-59). The mean operation was 50 minutes, ranging from 30 minutes to 90 minutes. The mean hospital stay was within 1 day. Forty-two different endoscopic surgeons treated the patients. Based on modified MacNab criteria, the outcomes were rated as excellent 48% (4910), good 42% (4295), fair 5.2% (532), and poor 4.8% (491). Four hundred thirty-six patients (4.3%)

<table>
<thead>
<tr>
<th>Causes of Incomplete Disc Removal</th>
<th>No. of Patients</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Incomplete disc removal</td>
<td>283</td>
<td>33.6</td>
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<tr>
<td>Inappropriate working channel</td>
<td>95</td>
<td>11.4</td>
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<tr>
<td>Central HD</td>
<td>91</td>
<td>32.2</td>
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<tr>
<td>Migrated HD</td>
<td>70</td>
<td>24.7</td>
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<tr>
<td>Low-grade cranial</td>
<td>56</td>
<td>19.8</td>
</tr>
<tr>
<td>High-grade cranial</td>
<td>4</td>
<td>1.4</td>
</tr>
<tr>
<td>Low-grade caudal</td>
<td>7</td>
<td>2.5</td>
</tr>
<tr>
<td>High-grade caudal</td>
<td>63</td>
<td>22.3</td>
</tr>
<tr>
<td>Axillary type HD</td>
<td>18</td>
<td>6.4</td>
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<tr>
<td>Shoulder type HD</td>
<td>12</td>
<td>4.2</td>
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</table>

*HD, herniated disc.*
underwent reoperation within 6 weeks after surgery. After initial PELD for lumbar disc herniation, the patients required revision surgery for the following reasons: persistent preoperative symptoms, aggravated pain, or development of neurological deficit. Open discectomy was done in 326 (74.8%) patients, fusion in 2 (0.5%) patients, and repeat PELD in 108 (24.8%) patients. According to the revised levels, there were 5 patients at L1-2, 10 patients at L2-3, 34 patients at L3-4, 313 patients at L4-5, and 74 patients at L5-S1. The mean period of revision was 9.3 days (range, 0-42 days). There were 283 (2.8%) cases with incomplete removal of herniated disc material, 78 (0.8%) with recurrence, 41 (0.4%) with persistent pain regardless of the complete removal of HD, 21 (0.2%) with conversion to open surgery because of approach-related pain, 6 (0.1%) with postoperative epidural hematoma, and 3 with neural injuries (Table 1). Of the patients with persistent pain, 26 (63.4%) had radiographically verified complete herniated disc removal with concomitant lateral recess stenosis. Among the 283 cases with incomplete removal of HD, technically inappropriate positioning of the working channel was the main reason (95 cases; 33.6%) for the incomplete removal. The herniated disc materials in these cases were classified as central disc herniations (91 cases, 32.2%), migrated discs (70 cases, 24.7%), axillary type HDs (63 cases, 22.3%), shoulder type HDs (18 cases, 6.4%), and foraminal/extraforaminal HDs (12 cases, 4.2%). The migrated discs include low-grade cranially migrated (3 cases, 1.1%), low-grade caudally migrated (56 cases, 19.8%), high-grade cranially migrated (4 cases, 1.4%), and high-grade caudally migrated (7 cases, 2.5%; Table 2).

Comparing all cases with the 3 teaching surgeons, the rates of early revision surgery and incomplete removal of HD were lower in the 3 teaching surgeons ($P = .04$, Table 3).

**DISCUSSION**

Reoperation rates of PELD have been reported from 2.3% to 15%. According to a nationwide cohort study, there is no significant difference in the reoperation rates between open discectomy (13.7%) and endoscopic discectomy (12.4%). The authors have also reported that early reoperation rates (<3 months) were similar between the 2 groups. However, some authors reported that endoscopic discectomy has a shorter reoperation interval than open discectomy.

Our experience of 10,228 cases done in a single center shows that the unsuccessful surgical rate of PELD was 4.3%. The common causes were incomplete removal of herniated disc material (2.8%) and early recurrence (0.8%). Inappropriate positioning of the working channel, herniated disc type, and migration characteristics of herniated discs influenced surgical outcomes.

The key step of PELD is to position the working channel near the herniated mass. If the working cannula is located inside the nucleus pulposus with a steep trajectory angle, the ruptured disc in the epidural space is not accessible and cannot be removed (Figure 1). This problem happens frequently to the neophyte practitioners of PELD and can be reduced with acquiring experience. In the case of foraminal narrowing due to facet hypertrophy and L5-S1 intracanal disc herniation, there is a high possibility of the occurrence. The location of the fixed working cannula, which is far from hernia mass, due to the narrow foramen and disc space, and overlying iliac bone, makes it difficult to remove the herniated disc material. In intracanal disc herniation, during the needling step, the final target point of the spinal needle is the medial pedicular line on the anteroposterior image and the posterior vertebral line on the lateral image. However, if the

### Table 3. Comparison of Revisional Operation in All Cases and 3 Teaching Surgeons

<table>
<thead>
<tr>
<th></th>
<th>42 Surgeons</th>
<th>3 Teaching Surgeons</th>
<th>$P$ Value</th>
</tr>
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<tbody>
<tr>
<td>No. of operations</td>
<td>10,228</td>
<td>1,009</td>
<td></td>
</tr>
<tr>
<td>Revision</td>
<td>436 (4.3%)</td>
<td>29 (2.9)</td>
<td>.04</td>
</tr>
<tr>
<td>Incomplete removal of HD</td>
<td>283 (2.8%)</td>
<td>17 (1.9)</td>
<td>.04</td>
</tr>
<tr>
<td>Recurrence</td>
<td>78 (0.8%)</td>
<td>9 (0.9)</td>
<td>.66</td>
</tr>
<tr>
<td>Persistent pain regardless of complete removal of HD</td>
<td>41 (0.4%)</td>
<td>2 (0.2)</td>
<td>.43</td>
</tr>
<tr>
<td>Approach-related pain</td>
<td>21 (0.2%)</td>
<td>1 (0.1)</td>
<td>.72</td>
</tr>
<tr>
<td>Cause of incomplete removal of HD</td>
<td>283</td>
<td>17</td>
<td>.17</td>
</tr>
<tr>
<td>Inappropriate working channel location</td>
<td>95 (33.6%)</td>
<td>3 (17.6)</td>
<td>.17</td>
</tr>
<tr>
<td>Central disc herniation</td>
<td>91 (32.2%)</td>
<td>4 (23.5)</td>
<td>.46</td>
</tr>
<tr>
<td>Migrated HD</td>
<td>70 (24.7%)</td>
<td>7 (41.2)</td>
<td>.15</td>
</tr>
<tr>
<td>Axillary type HD</td>
<td>63 (22.3%)</td>
<td>2 (11.8)</td>
<td>.54</td>
</tr>
<tr>
<td>Shoulder type HD</td>
<td>18 (6.4%)</td>
<td>2 (11.8)</td>
<td>.32</td>
</tr>
<tr>
<td>Foraminal/extraforaminal HD</td>
<td>12 (4.2%)</td>
<td>1 (5.9)</td>
<td>.54</td>
</tr>
<tr>
<td>Recurrent HD</td>
<td>11 (3.9%)</td>
<td>1 (5.9)</td>
<td>.51</td>
</tr>
</tbody>
</table>

$^a$HD, herniated disc.

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**TABLE 3. Comparison of Revisional Operation in All Cases and 3 Teaching Surgeons**
spinal needle is on the medial pedicular line on anteroposterior view and the needle tip is located within disc space on lateral view, foraminal widening technique may be needed if blocked by the iliac crest or by hypertrophy of the facet joints. The superior facet is undercut a little by a bone reamer or bone cutter. Choi et al reported that 40% of transforaminal PELD at the L5-S1 level required a foraminoplasty to gain access in the level of the disc herniation.

A conventional “inside-out technique” has more than 25° approach angle. The technique involves an intradiscal working channel that utilizes a cavity through annulotomy opening with the use of biting forceps, but this technique has a limited removal of the epidural disc fragment in the central portion of the herniated disc (Figure 2). In cases of centrally located disc herniations, the bevel-ended cannula should be located in the midline on anteroposterior view as well as in between the epidural space and intra-annular portion on the lateral view in intra-operative fluoroscopic guidance resulting in a relatively shallow angle. This approach provides direct access to the annular defect site where the pathological disc fragment can be readily found.

An axillary type of disc herniation is a common cause of incomplete removal of herniated disc material. Although axillary type disc herniations may seem to be removed easily by conventional PELD, there are actually remaining herniated disc fragments located in the epidural space compressing the traversing nerve root in our cases. What is usually removed are the subannular disc protrusions within the disc space (Figure 3). There are 3 important points to remember. First, it is necessary to do adequate release of the entire disc fragment from the annulus

![FIGURE 2. Central disc herniation. Central disc herniation compressing the thecal sac and nerve root (A), bevel opening is located between medial pedicle and midline (B), as well as between epidural space and disc space (C), and the epidural extruded disc still remained with removal of the subannular disc (D).](image-url)
before grasping the tail or tip of the herniated disc and pulling it out. If this is not done, an epidural disc fragment remnant will remain when the intradiscal portion of the herniation is pulled out. Second, the herniated disc removal is to be done at the level of the bevel cannula opening. For example, in the case of an axillary-located disc with a downward migrated fragment, the fragment can be covered by the working cannula bevel. When the working cannula bevel is rotated and opens caudally, we should carefully search for the herniated disc fragment in the epidural space. Third, it is not uncommon to have multiple disc fragments in a disc herniation. It may be possible to have some retained fragments while some have been removed.

In cases of a high-grade migrated HD, the use of the conventional PELD technique may result in the difficulty of the removal of a migrated HD (Figure 4). Migrated discs are considered inaccessible by conventional PELD techniques because of rigid instrumentation, poor visualization, and the inability to reach and grasp herniated fragments. Occasionally, it is possible for conventional PELD to remove the whole migrated disc by grasping the tip of the disc fragment. However, this technique does not guarantee complete removal in high-grade disc migration. In caudally migrated discs, foraminal widening through removal of the superior part of facet is needed to expose the anterior epidural space. For cranially migrated discs, the working channel can directly access the target lesion in the epidural space without annulus penetration. Choi et al described a procedure in which the cannula was initially positioned at the lower part of the disc and gradually shifted upward. Percutaneous endoscopic technique for migrated disc is technically demanding and can be affected by the surgeon’s experience. Yeung and Tsou suggested that 70° wide angle endoscope makes it possible to find hidden epidural migrated disc fragments. Choi et al introduced the MRI-equipped operative suite-assisted PELD for concerns about surgical failure, especially highly migrated disc. They could confirm complete decompression in the operating room immediately after PELD.

Concomitant persistent pain was commonly caused by surgically unappreciated disc fragments, concurrent lateral recess stenosis, nerve root injury, epidural hematoma, and nerve root edema regardless of the complete removal of the herniated disc in the postoperative MR. Concurrent lateral recess stenosis is associated with poor prognosis. Lateral recess bony stenosis
can be addressed with a separate decompression procedure. These problems can be solved by open surgery. In our study, 63.4% of patients with persistent pain were associated with lateral recess stenosis.

PELD under local anesthesia potentially limits neural injury, although some authors perform PELD safely under general anesthesia. Sometimes PELD can be converted to open surgery owing to approach-related pain. Irritation of the exiting nerve root and dorsal root ganglion can cause severe leg pain. In this situation, if the irritation symptom occurs, the surgeons try to adjust the entry point and trajectory, and then stop the procedure if the pain persists. Postoperative dysesthesia is one of the significant sequelae and affects the patient’s daily life negatively. Some authors suggest that the technique of not penetrating the annulus can minimize the exiting nerve irritation. Measurement of the preoperative distance from exiting nerve root to facet at the lower disc level helps to avoid exiting nerve root injury. In performing the discogram or the working cannula insertion, when the needle touches or penetrates into the annulus, severe pain may occur. If there is poor patient pain tolerance, the procedure should be discontinued, otherwise the use of serial dilation or a preemptive epidural block to diminish the pain can be done.

The early recurrence rate was 0.8% in our study (Figure 5). PELD recurrence rates are reported to range from 0% to 7.4%. Recurrence rates after open discectomy have been reported to range from 1% to 21%. Several studies showed no difference in recurrence rates between PELD and open discectomy. Some authors reported that real recurrent herniation requiring reoperation is higher after PELD than after open discectomy. In 1 study, the early recurrence (<6 months) rates have been shown to be more than 50% in PELD. Surgically

FIGURE 4. Migrated disc herniation. Ruptured disc migrating downward (A, B, C), intraoperative endoscopic view (D) showing removal of the subannular disc and decompression of neural tissue, removed disc fragment (E) during the PELD, postoperative MR (F) showing migrated disc still remaining, and remnant disc was removed by revision open surgery (G). PELD, percutaneous endoscopic lumbar discectomy.
unappreciated disc fragment remnants and incomplete decompression by piecemeal removal may lead to a higher early recurrence. To reduce recurrence rates, complete removal of herniated mass is required including the basal and extruded parts.34

PELD technique and experience can affect success of PELD. During the steep learning curve phase, longer operation times are required and the incidence of complication may be higher than those by experienced surgeons.35,36 Experienced surgeons can also expand the indications of PELD for applications in various strategic indications.20-24

Ahn et al7 reported that radiation exposure time was 2.5 minutes during the PELD in the author’s institute. They suggested that 5000 PELD cases can be performed per year using radiation shielding clothes and 291 PELD cases can be performed without shielding clothes.

Limitations

This study has some limitations. First, it was a retrospective review. Second, there was no control group. If this study had a control group, a comparative study would have provided a clearer elucidation of the answers.

CONCLUSION

Although the PELD technique has evolved remarkably, successful PELD requires techniques tailor-made to remove the herniated disc fragments in various types of disc herniations such as central, axillary, or migrated disc herniations. Accurate positioning of the working channel should be considered depending on the location of the disc and its fragments. Experienced surgeons have fewer revisions.

Disclosures

This study was supported by a grant from the Wooridul Spine Foundation. The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES

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**Supplemental digital content** is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal’s Web site (www.neurosurgery-online.com).

**COMMENTS**

This is a very large retrospective study of over 10,000 patients who underwent percutaneous endoscopic lumbar discectomy (PELD) for symptomatic lumbar disc herniation. The primary purpose of the investigation was to determine causes for failure and discuss limitations of the PELD approach with a subsequent discussion on techniques to mitigate the common reasons for failure. Overall rate of failure was 4.3%; however, this was based on their specific criteria encompassing the need for re-operation within 6 weeks of the index surgery. An anticipated and unsurprising finding was that experienced surgeons had significantly less failures mostly due to more complete disc removals. The authors’ recommendations on methods to minimize incomplete disc resections based on location of the disc herniation are insightful and reflective of their extensive experience.

Paul Park
*Ann Arbor, Michigan*

The authors analyze the outcome after PELD surgery in 10,228 patients at a single institution over 12 years. They review the results of 4,242 surgeons performing the technique. In their study, they observe a 4.3% reoperation rate which was defined as the need for revision surgery within 6 weeks after the initial surgery. The main indications for revision surgery were incomplete removal of the herniated disk and technique related issues. Reoperated disks were treated with repeat PELD in about 3/4 of the cases, with an additional 1/4 revised as an open discectomy. They spend a considerable
time identifying the anatomy and location of disk herniations and the optimal techniques using PELD to achieve success. Their study demonstrates that PELD can be performed successfully but that experience matters.

Daniel Refai
Atlanta, Georgia

This is a very large and comprehensive study of 10,228 patients from a single institution that underwent percutaneous endoscopic lumbar discectomy (PELD) over a 12 year period. The authors review the relevant anatomy of the procedure and add in insights from their vast experience. They define failure of the primary procedure (4.3%) if repeat surgery was necessary within 6 weeks of the first operation. They indicate that such patients could still undergo successful repeat PELD (75%) and conversion to open surgery (25%). It is evident from their discussion and personal experience that appreciation for anatomic variations and the completeness of disc removal in the primary operation are important to prevent recurrences. The experience of the operating surgeon is paramount in this regard. Their insights to the reader in techniques to reduce recurrences are thoughtful and practical. They are to be commended on their excellent work.

Shekar N. Kurpad
Milwaukee, Wisconsin

CME QUESTIONS:

1. What factor is associated with increased re-operation rates after percutaneous endoscopic lumbar discectomy (PELD)?
   A. Performing surgery using only local anesthesia
   B. Decompressing the annulus prior to the herniated mass.
   C. High-grade whole migrated discs
   D. Positioning the working channel near the herniated mass.
   E. Central disc herniation

2. Following percutaneous endoscopic lumbar discectomy procedure (PLED), what factor is correlated with approach-related nerve injury and pain?
   A. Completely penetrating the annulus with the working channel
   B. Central disc herniation
   C. Lateral recess stenosis
   D. Partially penetrating the annulus with the working channel
   E. Multiple disc fragments

3. During a percutaneous lumbar discectomy procedure (PLED) under local anesthesia, a patient experiences a persistent severe leg pain. What is the most appropriate next action?
   A. Abort the procedure
   B. Convert PLED to open discectomy
   C. Administer more analgesics
   D. Adjust the entry point and trajectory
   E. Convert to general anesthesia

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