

Operative Failure of Percutaneous Endoscopic Lumbar Discectomy: A Radiologic Analysis of 55 Cases

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Study Design. A retrospective study.

Objective. To determine the range of lumbar disc herniation that can be addressed effectively using current endoscopic techniques.

Summary of Background Data. The current technical limitation of the procedure in terms of the location and size of the herniation has not been fully documented in previous studies.

Methods. The inclusion was an intracanal lower lumbar disc herniation in which subsequent surgery was performed because of the presence of remnant fragments. All 1586 cases, including 55 failed cases, were classified according to the size, location, and extent of migration.

Results. In the nonmigrated herniations, the central located high-canal compromised (>50%) herniations showed the highest rate of failure (15%), and the rate was significantly different from the low and high-canal compromise group (1.9% and 11.1%, respectively, $P < 0.001$). There was no significant difference in the failure rate between the nonmigrated herniations and low-grade migration group (2.7% and 3.7%, respectively). However, the high-grade migration group (beyond the measured height of the posterior marginal disc space) showed a significantly high-incidence of failure (15.7%, $P < 0.001$).

Conclusions. Based on these results, open surgery may be considered for herniations with high-canal compromise and high-grade migration. On the other hand, percutaneous endoscopic lumbar discectomy can be considered to be a surgical option in the remaining intracanal disc herniations.

Key words: posterolateral, endoscopic discectomy, operative failure, size of herniation, migration. **Spine** 2006;31:E285–E290

the procedure has evolved into the direct removal of protruded or extruded fragments.^{8,10,13,14} Despite the good surgical outcomes reported for the endoscopic procedure for various lumbar spinal pathologies as well as a lumbar disc herniation,^{12–21} this procedure still appears to be very complicated for most surgeons.

Apart from the technical aspect of the procedure, the appropriate patient selection is not easy for surgeons because the range of lumbar disc herniations that can be addressed effectively using the current techniques has not been statistically analyzed. Several investigators have reported good results from this technique for treating LDH such as massive extrusions, epidural located herniations, including some migrated fragments,^{10,12–14} and it is believed that an experienced endoscopic surgeon can overcome some of the concerns with such herniations. However, it is still necessary to verify whether or not this technique is indeed effective in all extrusions, regardless of the location and size of the herniation, and whether or not this technique can address an extrusion with some migration.

At our institute, there have been cases in which the PELD failed because of the incomplete removal of disc fragments, resulting in the need for subsequent open surgery. The authors examined these failed cases to answer those questions raised by previous studies, and to clarify the common causes and/or types of disc herniation resulting in operative failure. Therefore, the aim of this study was to elucidate the range of intracanal lumbar disc herniation that could be treated using the current posterolateral endoscopic techniques.

■ Materials and Methods

Patient Population. A retrospective review was performed on 55 patients who had undergone a subsequent open discectomy after a failed posterolateral endoscopic discectomy. Operative failure was defined as: (1) intracanal lower lumbar (L3–L4, L4–L5, and L5–S1) disc herniation that required subsequent surgery because of persistent symptoms within the 2 weeks after surgery; (2) no pain-free interval from the first operation to the subsequent procedure; and (3) verification of remnant fragments by radiologic studies. The exclusion criteria are: (1) subsequent surgery because of recurrent symptoms at least after 2 weeks of pain-free period following the PELD; (2) upper lumbar and extracanal (foraminal, extraforaminal) herniation; and (3) recurrent herniation after prior open lumbar surgery at the index level. Statistical analysis was performed using a χ^2 test, and a P value <0.05 was considered significant.

After the introduction of the posterolateral percutaneous lumbar disc decompression by Kambin and Gellman,¹ many investigators have stated concerns about the technique as well as the clinical outcome of the endoscopic discectomy, including percutaneous endoscopic lumbar discectomy (PELD) by Schreiber *et al.*^{2–14} With the development of endoscopic instruments and techniques, since the late 1980s, indirect central decompression of

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Radiologic Classification. The analysis was performed using the preoperative and postoperative magnetic resonance imaging and computerized tomography images, as well as the intraoperative C-arm images obtained during the endoscopic procedure. An independent radiologist who was blinded to the surgical results classified all cases examined, including the 55 failed cases, according to size and the location of the herniation. A herniated disc without migration was divided according to the canal cross-sectional area compromise as either low or high-grade.²² Herniation exceeding 50% of the canal cross-sectional area compromise was described as a high-grade canal compromise (Figure 1). 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.¹³

A migrated disc herniation was defined as a herniation, which was displaced away from the extrusion site, either above

the endplate of the upper body, or below the endplate of the lower body.²³ The herniation was described as a high-grade migration if the extent of migration was larger than the measured height of the posterior marginal disc space at the T2-weighted sagittal magnetic resonance image. On the other hand, migration being smaller than the measured height of the posterior marginal disc space was described as a low-grade migration.

Surgical Technique. We used the Yeung Endoscopic Spine System (Richard Wolf Surgical Instrument Co., Vernon Hills, IL) and modified the Selective Endoscopic Discectomy™ (SED™) (SpineUniverse System, Wheaton, IL), which was reported by Yeung *et al*,¹³ and used it as a standard approach to the lumbar disc herniation. The patient is placed in the prone position on a radiolucent table under local anesthesia. A line is marked from the foraminal window to the disc fragment, according to the preoperative imaging studies and intraoperative C-arm images. A 6-inch long 18-gauge needle is inserted into the line, with the determined trajectory under a fluoroscopic guide. After insertion of the needle into the midline, an intraoperative diskography is performed to determine the pathology. Before the needle is withdrawn, a guidewire is inserted to introduce the serial dilators and obturator.

A beveled working cannula is then introduced gently over the obturator. Some widening of the working canal is then performed using an annular cutter. Through this canal, a manual discectomy is performed in the subannular region to secure adequate room to handle the working cannula under fluoroscopic guidance. An endoscope with a working channel and 2 irrigation channels is introduced. At this time, the blue-stained annular surface and part of the disc material could be observed under endoscopic visualization. To gain access to the herniated fragment, widening of sidewalls of the annular fissure is performed using a side-firing Holmium yttrium-aluminum-garnet laser and a bipolar radiofrequency coagulator (Ellman®; Ellman International, Hewlett, NY). After a sufficient annulectomy, the blue-stained herniated fragments could be observed. Meticulous removal of the herniated disc material, including migrated fragments, could then be performed using endoscopic forceps with fluoroscopic guidance.

The patients are generally discharged within 24 hours after surgery. If the patient has persistent symptoms after the procedure, a reexamination, including a neurologic and radiologic examination, is performed to identify the cause of the persistent symptoms. In cases in which the remnant fragments are confirmed by the radiology studies, an open microdiscectomy is performed on the patient under general anesthesia in the standard manner. Patients are allowed to ambulate on the first postoperative day and are discharged as soon as they are independently able to walk.

■ Results

From January 2003 to December 2003, 16 spinal surgeons at our institute surgically treated 1586 patients with an intracanal lower lumbar disc herniation using a posterolateral endoscopic technique. There were 96 cases with L3–L4, 1273 with L4–L5, and 217 with L5–S1 herniation. A total of 82 patients underwent subsequent open surgery at the index level, of whom, 55 met the inclusion criteria and were enrolled in the study. There were 39 males and 16 females, with a mean age of

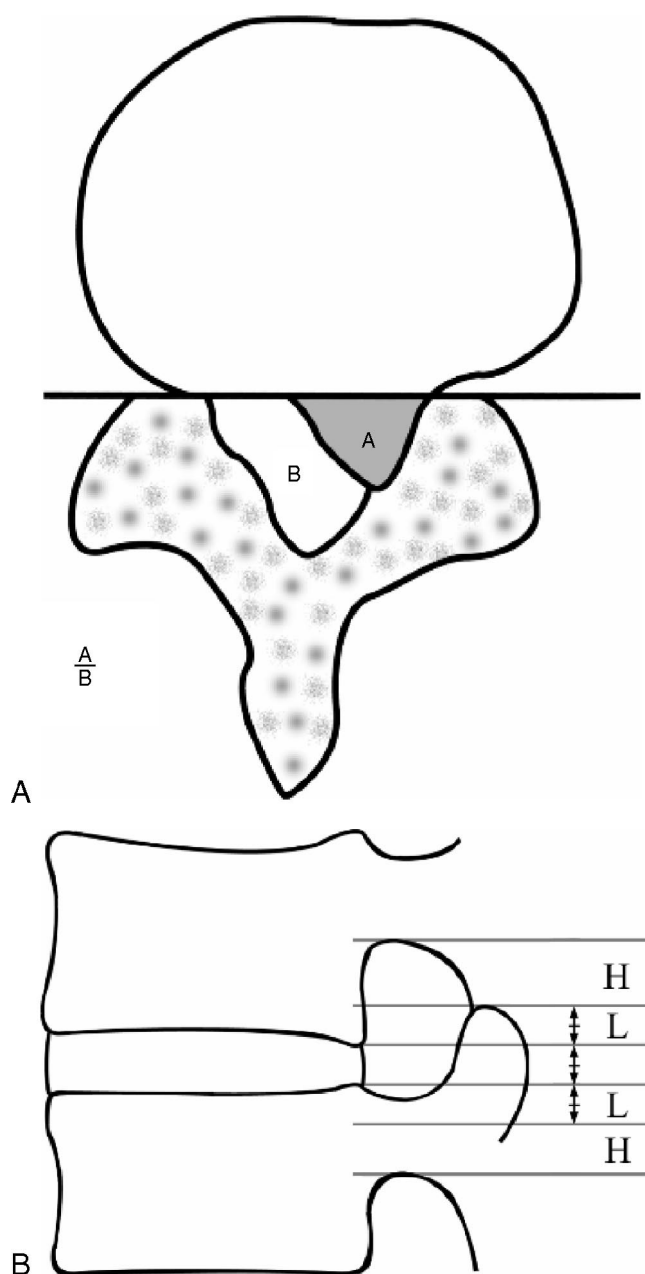


Figure 1. **A**, size of herniated disc; **B**, size of the spinal canal.

Table 1. Operative Failure of the Nonmigrated Herniations

	Total No.	Failure No. (%)	P
Low-grade canal compromise	1091	21 (1.9)	<0.001
High-grade canal compromise	99	11 (11.1)	
Central, low-grade compromise	328	8 (2.4)	
Paramedian, low-grade compromise	760	13 (1.7)	NS
Central, high-grade compromise	60	9 (15)	NS
Paramedian, high-grade compromise	39	2 (5.1)	

NS indicates nonsignificant.

42.9 years (range 20–78). Of the remaining 27 patients, 7 underwent subsequent surgery between 2 and 6 weeks following the endoscopic procedure, and 20 patients after 6 weeks. All patients who had recurrence of symptoms after a definite pain-free period following PELD were excluded from this study. The level responsible was L3–L4, L4–L5, and L5–S1 in 6, 43, and 6 patients, respectively, and the overall incidence of surgical failure was 3.5%. Sixteen spinal surgeons who performed the procedure had some cases of failure. Mean duration from the endoscopic discectomy to the subsequent surgery was 3 days.

Operative Failure According to Location and Size of Herniation

In the herniations without migration, the high-grade canal compromise group showed a significantly high-rate of operative failure compared with the low-grade canal compromise group (11.1% and 1.9%, respectively, $P < 0.001$) (Table 1). In relation to the location of herniation, central herniation with high-grade canal compromise showed the highest rate of operative failure (15%). The direction of migration (upward and downward) did not have a significant effect on the incidence of operative failure in the migrated herniation group, whereas the extent of migration was strongly related to the failure of the procedure (Table 2). The incidence of failure was significantly higher in those with high-grade migrations (15.7%, $P < 0.001$). However, there was no significant difference in the rate of failure between the low-grade migrations and nonmigrated herniations (3.7% and 2.7%, respectively) (Table 3).

Overall, 82 patients, including the 55, underwent subsequent open surgery such as an open discectomy and a soft or rigid fixation at the index level from the time of the first procedure to January 2005. Therefore, the rate

Table 2. Operative Failure of the Migrated Herniations

	Total No.	Failure No. (%)	P
Low-grade migration	326	12 (3.7)	<0.001
High-grade migration	70	11 (15.7)	
Upward migration	72	4 (5.6)	NS
Downward migration	324	19 (5.9)	

NS indicates nonsignificant.

Table 3. Comparison of Operative Failure Between Nonmigrated Herniations and Migrated Herniations

	Total No.	Failure No. (%)	P
Nonmigrated, overall	1190	32 (2.7)	NS
Low-grade migration	326	12 (3.7)	NS
Nonmigrated, low-grade compromise	1091	21 (1.9)	
Low-grade migration	326	12 (3.7)	<0.001
Nonmigrated, overall	1190	32 (2.7)	
High-grade, migration	70	11 (15.7)	<0.001
Nonmigrated, low-grade compromise	1091	21 (1.9)	
High-grade migration	70	11 (15.7)	

NS indicates nonsignificant.

of additional surgery resulting from operative failure and other causes such as a recurrent herniation or segmental instability after the posterolateral endoscopic discectomy was 5.2%.

Discussion

The rate of operative failure differed significantly according to the size and location of the herniation. The disc herniation with high-grade canal compromise and high-grade migration showed a significantly high incidence of operative failure. Although several investigators have reported the outcomes of PELD, there are few reports on the failure of the procedure. Schaffer and Kambin²⁴ analyzed 11 patients who underwent reoperation out of 100 patients treated with PELD in 1991. Of these 11 patients, 5 had persistent symptoms after endoscopic surgery. The most common causes for subsequent surgery for the 11 patients were a lateral recess stenosis, sequestered herniation, and an improper placement of the working instruments. However, the study did not refer to the location or size of the herniation resulting in operative failure. Based on the results of this study, surgical results of the PELD can be also affected by location and size of the herniation.

A Disc Herniation Without Migration

The low-rate operative failure in the nonmigrated herniations (2.7%) is notable. This result shows that those herniations can be effectively addressed using the percutaneous endoscopic technique. However, the failure rate in the nonmigrated herniations showed a difference according to the size of the herniation. Operative failure occurred in 11.1% of patients in high-grade canal compromised herniations, whereas the rate was only 1.9% in low-grade canal compromised herniations.

When the postoperative imaging studies were reviewed, most (14 of 21 cases; 67%) of the failed low-grade canal compromised herniations had an evacuation of the deep central disc space as a result of the improper placement of the working instruments. There were few cases with a concurrent osseous lateral recess stenosis or overtly calcified fragments that were generally being regarded as a current technical limitation.¹⁴ These reports indicate that an improper trajectory to the pathology

was an important cause for the failure of the procedure in the low-grade canal compromised herniations.

As reported elsewhere,^{13,15,23} a herniated fragment is accessible only when the surgical instrument is placed in the optimal trajectory. If the endoscope is placed too centrally in the disc space, the pathologic lesion will not be included in the accessible boundary of the mechanical instruments. Subsequently, the surgeon should remove much of the irrelevant nucleus and anulus to eliminate the herniated fragments, and sometimes it is even impossible to reach the pathologic lesion. The importance of appropriate working instrument placement and the techniques for overcoming obstacles in placing the working instruments have been reported in previous literatures.^{7,13-15,23}

On the other hand, when treating patients with high-grade canal compromised herniations using the posterolateral endoscopic technique, the range of working space that mechanical instruments should access becomes too wide, even in cases in which the operating instruments are placed in the optimal trajectory. Consequently, a surgeon should perform a wide resection of the anulus and nucleus, along the margin of the herniation across the midline. A biportal approach is essential on occasion.^{13,15} Besides, the patient's symptoms can be sustained sometimes after removing the fragments in such cases, with a persistent broad-based capsule of the anulus and PLL. With the failed cases, the average canal cross-sectional area compromise was 58%, and the herniation midline split ratio was 55:45. Most of the failed cases had a relatively broad base extending to the medial edges of each facet. Postoperative imaging studies showed the insufficient removal of the huge herniated fragments, despite the optimal trajectory to the pathology.

In previous studies, several investigators have referred to the successful retrieval of a large or massive herniation using the percutaneous endoscopic technique.^{13,15} However, there are too few results to make a conclusive recommendation of percutaneous endoscopic discectomy for those herniations. The incidence of failure in the present study was much higher in the high-grade canal compromised herniations. This result indicates that the adequate removal of a large herniation *via* the percutaneous endoscopic technique is technically demanding and can be affected by the surgeon's experience. As mentioned previously, an experienced endoscopic surgeon may overcome some of the concerns regarding the herniations with high failure rates. However, in the authors' opinion, the percutaneous endoscopic technique should be chosen carefully for a large lower lumbar herniation exceeding 50% of canal compromise. An open microdiscectomy appears to be a better treatment option compared with percutaneous endoscopic techniques for those herniations.

A Disc Herniation With Migration

Although Yeung *et al*¹³ reported that the current 70° wide-angle surgical endoscope makes it possible to visualize even hidden, epidural located migrated fragments

and that migrated fragments can be extracted if the trajectory can reach the tail of the fragment, published reports concerning removal of the migrated fragments are rare.^{10,12} Indeed, migrated herniations are considered by most surgeons to be inaccessible by the percutaneous endoscopic techniques. In dealing with migrated herniations, some problems make surgeons consider the percutaneous endoscopic technique demanding. First, access through a narrow channel might be ineffective and might cause an injury to the neural structure during extraction of the migrated fragments using endoscopic forceps. Second, the mechanical ability to reach and grasp the herniated fragments is far behind the endoscope's optical capabilities.¹³ However, the results of this study show that the migrated fragments were accessible in most cases when the fragments were not too far away from the disc space.

The surgical techniques for dealing with a migrated herniation can be considered an extension of those used for epidural located herniation. To gain access to the epidural located fragments, a widening of the intradiscal working canal and a sufficient extension of the anular tear are always necessary. When adequate widening of the intradiscal working cavity is achieved, the angle of the endoscope becomes more horizontal and pivots on the foramen. Thus, a surgeon can examine the full undersurface of the anulus and identify the blue-stained, epidural located disc fragments.¹⁴ The risk for any inadvertent physical trauma to the nervous structure can be prevented by monitoring those patients while they are continuously conscious.^{13,14}

As in the case with epidural located fragments, the surgeon could visualize the blue-stained, sometimes hidden, tip of the migrated disc fragments only after sufficient extension of the anular tear that traps the fragments (Figure 2). A side-firing laser or bipolar radiofrequency coagulator is always essential for cutting the thick anulus fibrosus attachments or coagulate bleeders in difficult to reach places.^{12,13,25} The meticulous removal of fragments can then be performed under fluoroscopic guidance, by monitoring the response of the patient carefully, in cases in which migrated fragments are in the accessible boundary of the mechanical instruments.

There was no significant difference in the rate of failure between the nonmigrated herniations and low-grade migrations, which indicates that most of the fragments were accessible in the low-grade migration group. On the other hand, the significantly high failure rate in the high-grade migration group (15.7%) shows that access to the fragments was technically demanding and required a more cumbersome processes. There is no consensus as to the degree of migration that can be removed using current endoscopic instruments. At our institute, the accessible boundary has been accepted as the mid-pedicle level of the lower body in downward migration (Figure 3). In this study, most of the migrated herniation had a downward direction, but the direction of migration (upward and downward) did not have a significant influence on the failure rate. This finding indicates that the migrated

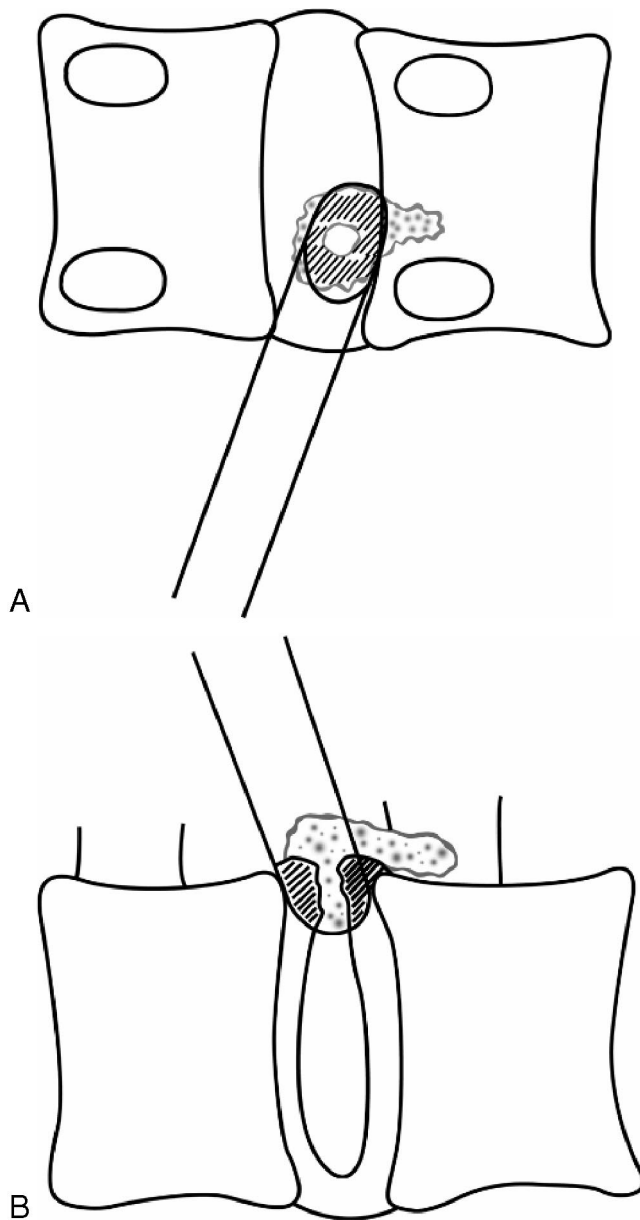


Figure 2. Annular tear that traps the herniated fragment in the anteroposterior (A) and lateral views (B). Only after a sufficient annulectomy around the tear (oblique lines) endoscopic forceps can be used to approach and remove the epidural herniated disc fragment.

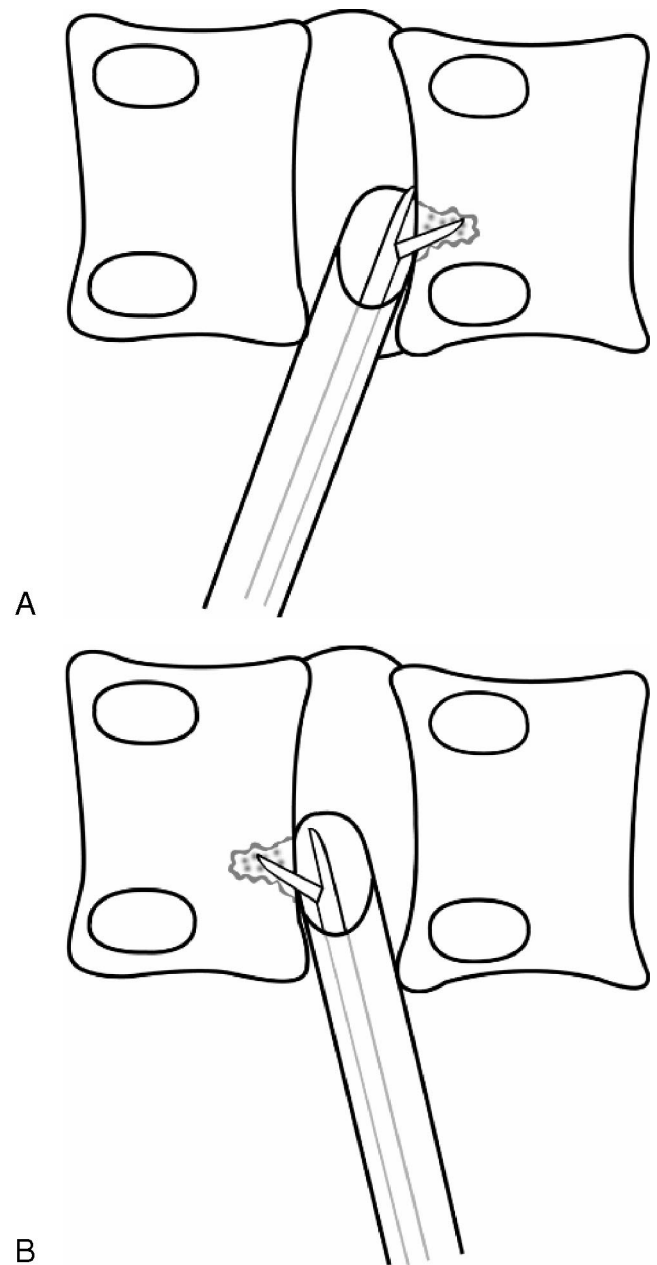


Figure 3. The accessible boundary of the mechanical instruments in the downward migration (A) and upward migration (B). The endoscopic forceps can generally access the fragments that migrated into the mid-pedicle level (A) with the appropriate placement of the working cannula.

fragments were accessible, regardless of the direction of migration. The posterolateral endoscopic technique for an upward herniation has not been attempted at L5–S1 because the iliac crest generally prevents the introduction of a working cannula in the direction of migration.

There was a troublesome type of disc herniation in the failed cases with low-grade migration. The migration occurred in a downward direction, with a relative small size, and the migrated portion was very close to the pedicle in the lateral recess. In that case, surgeons could not remove the fragments easily because the migrated portion was seldom included in the accessible boundary of the mechanical instruments. For this case, an open mi-

crodiscectomy appears to be more desirable than an endoscopic procedure.

Most types of herniation, excluding the herniation with high-grade migration and a large central herniation, had a relative low-failure rate in this study. However, the low rate of operative failure should not be the same as a good indication for this procedure. The outcome of this procedure can be highly affected by the surgeon's experience, and the surgical outcome of these patients can vary, even after a successful PELD. For this reason, the aim of the study was to identify the common causes for operative failure and clarify the range of lumbar disc

herniation that could be addressed effectively with the current posterolateral endoscopic technique.

With the current surgical techniques and instruments, the authors do not accept that all disc herniations can be treated using this procedure. It is believed that open surgery is more appropriate than posterolateral endoscopic discectomy in a lower lumbar disc herniation with high-grade migration and large herniation exceeding 50% of the canal compromise, particularly with a central location. On the other hand, this technique can be considered a surgical option in the remaining intracanal disc herniation as an alternative to a conventional microdiscectomy.

The cases of upper lumbar and extracanal disc herniation were excluded from this study. This exclusion is not because such herniations are inappropriate for PELD, but because statistical analysis was too complicated to document all the results in 1 article. According to the reported literature, those herniations have been accepted as a good indication for the endoscopic procedure.^{13,14} We have a plan to report our results with those disc herniations in the near future. Overall, it is expected that these results will help in the selection of appropriate patients for PELD.

■ Key Points

- The rate of operative failure following PELD differed significantly according to the size and location of the herniation.
- In the nonmigrated herniations, central herniation with high-grade canal compromise showed the highest rate of operative failure, and the rate was significantly different between low and high-grade canal compromise group.
- The incidence of failure was significantly higher in the high-grade migration. However, there was no significant difference in the failure rate between the low-grade migrations and nonmigrated herniations.

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