Retrospective Assessment

Percutaneous Endoscopic Lumbar Discectomy as an Alternative to Open Lumbar Microdiscectomy for Large Lumbar Disc Herniation

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Background: Remarkable advancements in endoscopic spinal surgery have led to successful outcomes comparable to those of conventional open surgery. Large lumbar disc herniation (LLDH) is a serious condition, resulting in higher surgical failure when accessing the herniated disc.

Objectives: This study compared the outcomes of LLDH treated with percutaneous endoscopic lumbar discectomy (PELD) and open lumbar microdiscectomy (OLM).

Study Design: Retrospective assessment.

Methods: This retrospective observational study was conducted from January 2011 to June 2012. Forty-four consecutive patients diagnosed with LLDH without cauda equina syndrome who were scheduled to undergo spinal surgery were included. LLDH was defined as herniated disc fragment occupying > 50% of the spinal canal. Clinical outcomes were evaluated using a visual analogue scale (VAS, 0 – 10), functional status was assessed using the Oswestry Disability Index (ODI, 0 – 100%) at 1, 6, and 24 months postoperatively and surgical satisfaction rate (0 – 100%) at final follow up. Radiological variables were assessed by plain radiography.

Results: Forty-three patients were included; 20 and 23 patients underwent PELD and OLM, respectively. Both groups exhibited significant improvements in leg and back pain postoperatively ($P < 0.001$). Although there was no significant difference in leg pain improvement between the groups, improvement in back pain was significantly higher in the PELD group than in the OLM group (4.9 ± 1.5 vs. 2.5 ± 1.0, $P < 0.001$). The surgical satisfaction rate of the PELD group was significantly higher than that of the OLM group (91.3% ± 6.5 vs. 84.3% ± 5.2, $P < 0.001$). Mean operating time, hospital stay, and time until return to work were significantly shorter in the PELD group than in the OLM group (67.8 vs. 136.7 minutes, 1.5 vs. 7.2 days, and 4.2 vs. 8.6 weeks; $P < 0.001$). Disc height (%) decreased significantly from 23.7 ± 3.3 to 19.1 ± 3.7 after OLM ($P < 0.001$), but did not change significantly after PELD (23.6 ± 3.2 to 23.4 ± 4.2; $P = 0.703$). The segmental angle of the operated level increased from 10.3° to 15.4° in the PELD group, which was significantly higher than that in the OLM group (9.6° to 11.6°; $P = 0.038$). In the OLM group, there was one case of fusion due to instability. In the PELD group, one case required revision surgery and another case experienced recurrence. There were no perioperative complications in either group.

Limitation: The study was retrospective with a small sample size and short follow-up period.

Conclusion: PELD can be an effective treatment for LLDH, and it is associated with potential advantages, including a rapid recovery, improvements in back pain, and disc height preservation.

Key words: Large lumbar disc herniation, percutaneous endoscopic lumbar discectomy, microdiscectomy, back pain, disc height

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A disc herniation that occludes > 50% of the spinal canal and impinges on neural structures is defined as a large, massive, or giant disc herniation (1,2). The most common presenting symptom of large lumbar disc herniation (LLDH) is radicular pain without neurologic deficit. However, there are reports of association with cauda equina syndrome (1,3,4). Although a few cases of large disc herniation are naturally absorbed (5,6), LLDH requires surgery when severe and disabling leg or back pain become refractory to conservative treatments or when neurologic deficits, including motor weakness or sensory loss, develop. The current gold standard of surgical management for lumbar disc herniation is open discectomy with partial laminectomy. However, the massive loss of the nucleus pulposus and large defect in the annulus fibrosis caused by LLDH may negatively affect long-term prognosis; this results in increased risks of postoperative spinal instability and chronic back pain after open lumbar discectomy (7).

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 structures, and rapid recovery (8-11). Since Kambin and Sampson (12) introduced the percutaneous posterolateral approach in 1986, PELD has become popular over the past few years for the removal of herniated disc material. The remarkable advancements of endoscopic techniques and instrumentation have led to successful outcomes comparable to those of conventional open surgery (9,10,13).

The existing inside-out PELD techniques for large disc herniation poses a difficult scenario for LLDH because of the need of a larger working space, unavoidable injuries to non-pathological disc tissues, and its higher rate of surgical failure to access the herniated disc (14). We recently reported a new inside-out PELD technique that removes only the pathologic herniated disc in LLDH (15). Although a few studies have compared minimally invasive microendoscopic discectomy with open discectomy for LLDH (16,17), no study has compared PELD with open lumbar microdiscectomy (OLM) for LLDH. Therefore, this study compared the outcomes of LLDH between PELD and OLM.

Methods

This retrospective cohort study was approved by our institutional review board (2015-W02), and written informed consent was obtained from all participants. We enrolled 44 patients who underwent surgery between July 2011 and June 2012 for the treatment of LLDH: 20 consecutive patients were treated with PELD by one surgeon (Surgeon A), while 24 consecutive patients were treated with OLM by another surgeon (Surgeon B). Both surgeons have performed > 1,000 OLM cases. Surgeon A has performed > 200 PELD procedures, while surgeon B performs 400 cases of OLM annually. Data were collected from the preoperative period until 2 years postoperatively. Questionnaires with outcome measurements evaluating pain intensity and functional disability were completed preoperatively and at the first, sixth, and twenty-fourth month postoperative follow-up visits. The inclusion criteria were (1) intracanal disc herniation that occupied > 50% of the spinal canal, (2) leg or back pain associated with LLDH, and (3) failure of conservative treatments over 6 weeks. The exclusion criteria were as follows: (1) disc herniation with calcified disc, (2) sequestrated disc herniation (i.e., displaced disc material that has completely lost any continuity with the parent disc), (3) foraminal or extraforaminal disc herniation, (4) recurrent disc herniation, (5) cauda equina syndrome, (6) motor weakness of less than a manual motor test grade IV, and (7) instability.

Clinical and functional outcomes were assessed by using a visual analogue scale (VAS, 0 – 10) and the Oswestry Disability Index (ODI, 0 – 100%), respectively. Subjective surgical satisfaction rate (%) was assessed by asking the patient, "How satisfied were you with this operation?" Pre- and postoperative data were assessed by clinical charts and operation records. Radiographs were assessed preoperatively, postoperatively, and at the final follow-up. Radiographs were assessed preoperatively and at the 2-year follow-up. On flexion–extension lateral radiographs of the lumbar spine, anterior translation of the index segment > 4.5 mm in the sagittal plane or sagittal plane motion > 15° from L1-2 to L3-4, > 20° at L4-5, and > 25° at L5-S1 from extension to flexion were considered spinal instability (18). Disc height was calculated as the mean of the anterior, middle, and posterior disc heights on plain standing lateral radiography as described previously by Inoue et al (19). Disc height (%) was calculated by the following equation: (disc height/vertebral height) × 100 (9). The segmental angle was measured between the upper endplate of the cranial vertebral body and the lower endplate of the lower vertebral body for the operated level.

Occupational activities were divided into the following 3 categories: light work (i.e., office jobs), me-

dium strenuous work (including household tasks), and heavy work (e.g., construction workers, farming, etc. [20]).

Surgical Techniques

Percutaneous Endoscopic Lumbar Discectomy (PELD)

PELD was performed under local anesthesia, with the patient in the prone position on a C-arm fluoroscopic table. Conscious sedation with neuroleptic analgesia allowed continuous feedback from the patient throughout the procedure, which enabled the surgeon to estimate real-time improvement and avoid injuring the neural structures.

The distance from the midline to the skin entry point was confirmed using axial magnetic resonance or computed tomography images preoperatively in order to advance the working cannula through the optimal route. The approach angle was approximately 15° from the horizontal plane on the axial section, which is much lower than that of the existing posterolateral transforaminal approach (11). After administering local anesthetic, an 18-gauge needle was inserted into the skin entry point passing just under the surface of the superior facet. When approaching the medial pedicular line on the anteroposterior view of fluoroscopy, the needle tip lay at the posterior annulus on the lateral view. While the needle tip advanced to the midline on the anteroposterior view, it was still aligned with the posterior border of the vertebral body line on the lateral view. After inserting the needle, discography was performed using indigo carmine, which selectively stains the degenerated nucleus blue, in order to identify the pathological fragment. The needle was then replaced with a 0.8-mm guidewire. A tapered cannulated obturator was then passed over the guidewire until its tip reached the midline as observed in the anteroposterior view. An 8-mm working cannula was subsequently passed over the obturator. After the obturator and guidewire were removed, an endoscope (YESS II system; Richard Wolf, Knittlingen, Germany) was positioned at the annular defect site, usually in the midline of the disc, where the disc fragment was trapped.

To remove the firmly interposed disc fragment, the annular anchorage of the herniated fragment was released using a side-firing holmium: YAG laser (Lumenis Inc., Yokneam, Israel; Fig. 1A). It was subsequently possible to perform a manual herniotomy in

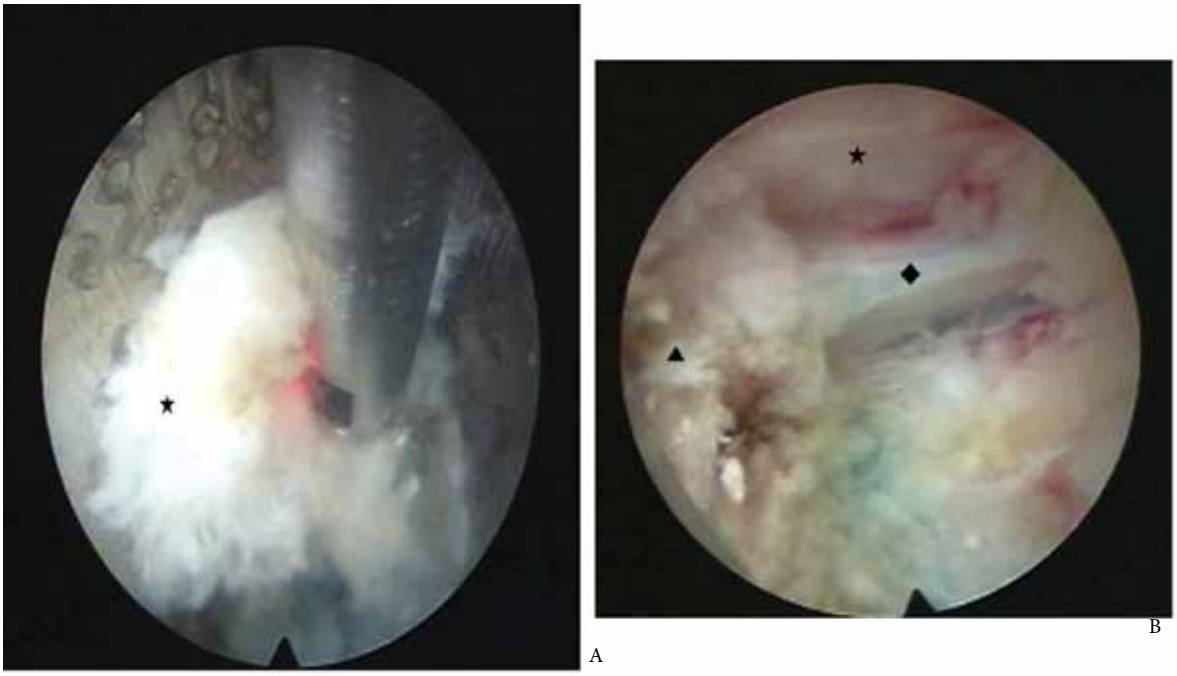

Fig. 1. *Intraoperative photographs during percutaneous endoscopic lumbar discectomy. A: The herniated disc (★) is filled with the working cannula for removal using a side-firing laser. B: After removing the herniated disc, the thecal sac (★) is decompressed, and the posterior longitudinal ligament (◆) and annulus fibrosus (▲) are torn.*

the subannular region, with the working channel being level with the posterior outer layer of the annulus. Only the pathologic fragment was vaporized by the laser or bipolar radiofrequency coagulator (Ellman International, Hicksville, NY, USA) and/or removed with cutting forceps. After widening the posterior longitudinal ligament tear, the cannula was levered to tilt it more downward, allowing it to advance into the spinal canal space and providing direct visualization of the extruded fragment. The herniated mass residing in the canal area was removed by pulling the tip of the fragment through the intra-annular working tunnel. The granulation tissue and annular fissure were subsequently thermo-coagulated or ablated using a laser or bipolar radiofrequency coagulator. The epidural space and annular fissure were adequately decompressed (Fig. 1B).

Open Lumbar Microdiscectomy (OLM)

OLM was performed under general anesthesia. With the patient in the prone position, a 4-cm skin midline incision was made, and the paravertebral muscles were dissected. Under microscopic visualization, partial laminectomy and medial facetectomy less than one-third of the total facet joint were performed, and the ligamentum flavum was removed on one side; the same procedure was subsequently performed on the other side. The ruptured disc fragment was exposed by gentle retraction of the thecal sac and traversing nerve root. Discectomy was performed on one side and usually on the other side as well. The extruded disc fragment, intra-annular disc fragment, and partial nucleus pulposus were removed, preserving the endplate (Fig. 2). After adequate decompression of neural structures, closure was performed.

Statistical Analysis

All statistical analyses were performed using R for Windows (version 3.1.2). Intergroup differences were analyzed by using Fisher's exact test, the chi-square test, or Mann–Whitney U-test where appropriate. The level of significance was set at $P < 0.05$.

Results

We screened 44 patients; however, one of the 24 patients who underwent OLM did not return for the 6-month postoperative follow-up and was excluded. Ultimately, we included 20 and 23 who underwent PELD and OLM, respectively.

In the PELD group, all patients underwent PELD via a unilateral route. In the OLM group, 22 patients underwent OLM via a bilateral route, and only one via a unilateral route. The sociodemographic and clinical characteristics of the patients are summarized in Table 1. There were no significant differences of preoperative demographic characteristics between 2 groups.

The clinical and radiologic outcomes of PELD and OLM for LLDH are shown in Table 2. The mean follow-up period was 27.5 ± 5.7 months (range: 24 – 37 months). In both groups, there were significant improvements in leg and back pain postoperatively ($P < 0.001$; Fig. 3). Although there was no significant difference in the improvement of leg pain between the

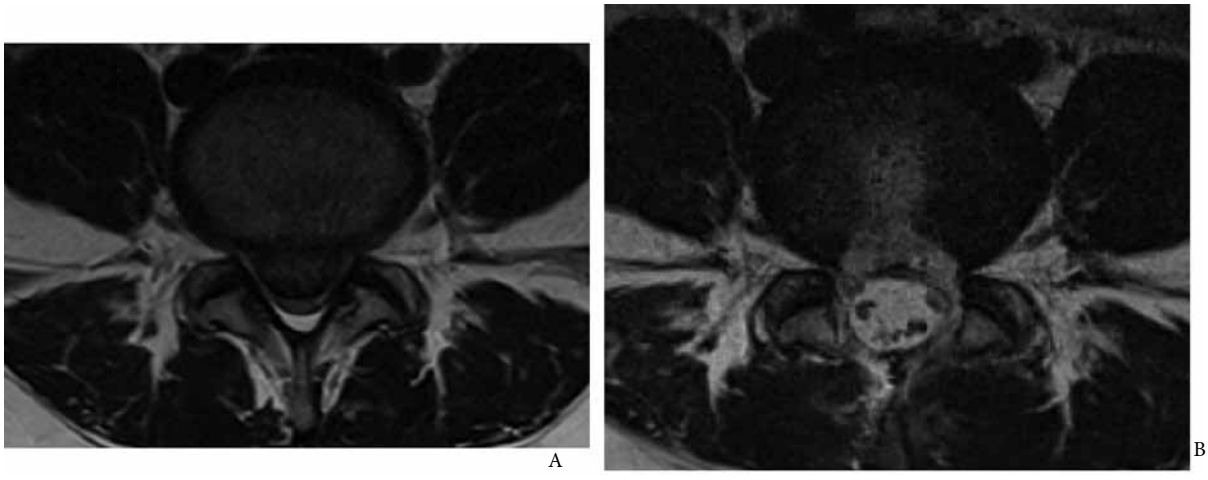

Fig. 2. *A 24-year-old girl presents with radiating pain in the left leg. A: Magnetic resonance imaging (MRI) showing a large central disc herniation compressing the thecal sac at L4-5. B: After open lumbar microdiscectomy via a bilateral approach, MRI shows a large annular defect and partial removal of the nucleus pulposus with no compressive lesion.*

groups, the improvement in back pain was significantly higher in the PELD group than in the OLM group (4.9 ± 1.5 vs. 2.5 ± 1.0, $P < 0.001$). The final ODI scores (%) in the PELD and OLM groups were 12.5 ± 7.5 and 20.2 ± 7.2, respectively ($P = 0.002$). The surgical satisfaction rate was significantly higher in the PELD group (91.3 ± 6.5%) than the OLM group (84.3 ± 5.2%, $P < 0.001$). The mean operation time was significantly shorter in the PELD group (67.8 minutes, range: 35 – 90 minutes) than the OLM group (136.7 minutes, range: 90 – 350 minutes, $P < 0.001$). The mean volume of intraoperative bleeding in the OLM was 200.9 mL (range: 80 – 450 mL), whereas it was negligible in the PELD group. Mean hospital stay was significantly shorter in the PELD group (1.5 days, range: 0.5 – 3 days) than the OLM group (7.2 days, range: 3 – 14 days, $P < 0.001$).

Disc height (%) decreased significantly postoperatively in the OLM group (from 23.7 ± 3.3 to 19.1 ± 3.7, $P < 0.001$) but not in the PELD group (from 23.6 ± 3.2 to 23.4 ± 4.2; $P = 0.703$). The segmental angle of the operated level increased from 10.3° to 15.4° in the PELD group, which was significantly higher than that in the OLM group (9.6° to 11.6°; $P = 0.038$).

The disc fragment was completely removed in all cases except in one case of PELD that required an

Table 1. *Sociodemographic, clinical, and radiological characteristics of the patients.*

	PELD	OLM	*P* value
No. of patients	20	23	
Age	33.9 ± 11.1	38 ± 11.6	0.237
Gender (M/F)	14/6	13/10	0.158
Level			0.100
L2-3	1	0	
L3-4	1	0	
L4-5	17	17	
L5-S1	1	6	
Symptom duration (months)	3.3 ± 2.8	3.2 ± 1.8	0.360
Symptom		.	0.380
pain	15	16	
pain & weakness	5	7	
Occupation			0.699
Light	18	18	
Medium	2	4	
Heavy	0	1	
Disc location			0.323
Central	17	22	
Paramedian	3	1	

PELD: percutaneous endoscopic lumbar discectomy, OLM: open lumbar microdiscectomy

Table 2. *Comparison of clinical and radiologic outcomes of PELD and OLM for large lumbar disc herniation.*

	PELD	OLM	*P* value
preop VAS leg	7.5 ± 1.1	7.3 ± 1.1	0.662
preop VAS back	6.9 ± 1.4	6.1 ± 1.0	0.053
postop VAS leg	1.7 ± 1.2	2.3 ± 0.8	0.061
postop VAS back	2.0 ± 0.6	3.7 ± 1.0	< 0.001
preop ODI (%)	61.6 ± 13.9	66.1 ± 11.1	0.237
postop ODI (%)	12.5 ± 7.5	20.2 ± 7.2	0.002
Improvement of VAS leg	5.8 ± 1.8	5.0 ± 1.6	0.153
Improvement of VAS back	4.9 ± 1.5	2.5 ± 1.0	< 0.001
Improvement of VAS ODI	49.1 ± 15.1	46.1 ± 12.1	0.488
Surgical satisfaction rate (%)	91.3 ± 6.5	84.3 ± 5.2	< 0.001
preop DH (%)	23.6 ± 3.2	23.7 ± 3.3	0.988
postop DH (%)	23.4 ± 4.2	19.1 ± 3.7	0.001
preop segmental angle (°)	10.3 ± 7.0	9.6 ± 5.3	0.712
postop segmental angle (°)	15.4 ± 7.0	11.6 ± 4.4	0.038
operation time (mins)	67.0 ± 12.0	136.7 ± 53.0	< 0.001
intraoperative bleeding (ml)	negligiable	200.9 ± 86.9	
Hospital stay (days)	1.5 ± 1.1	7.2 ± 3.5	< 0.001
time return to work (weeks)	4.2 ± 1.4	8.6 ± 8.8	0.002

PELD: percutaneous endoscopic lumbar discectomy, OLM: open lumbar microdiscectomy, preop: preoperative, postop: 24 months postoperatively, VAS: visual analogue scale (0 – 10), ODI: Oswestry Disability Index (0 – 100%), Improvement: the difference between preoperative score and postoperative score, DH: disc height

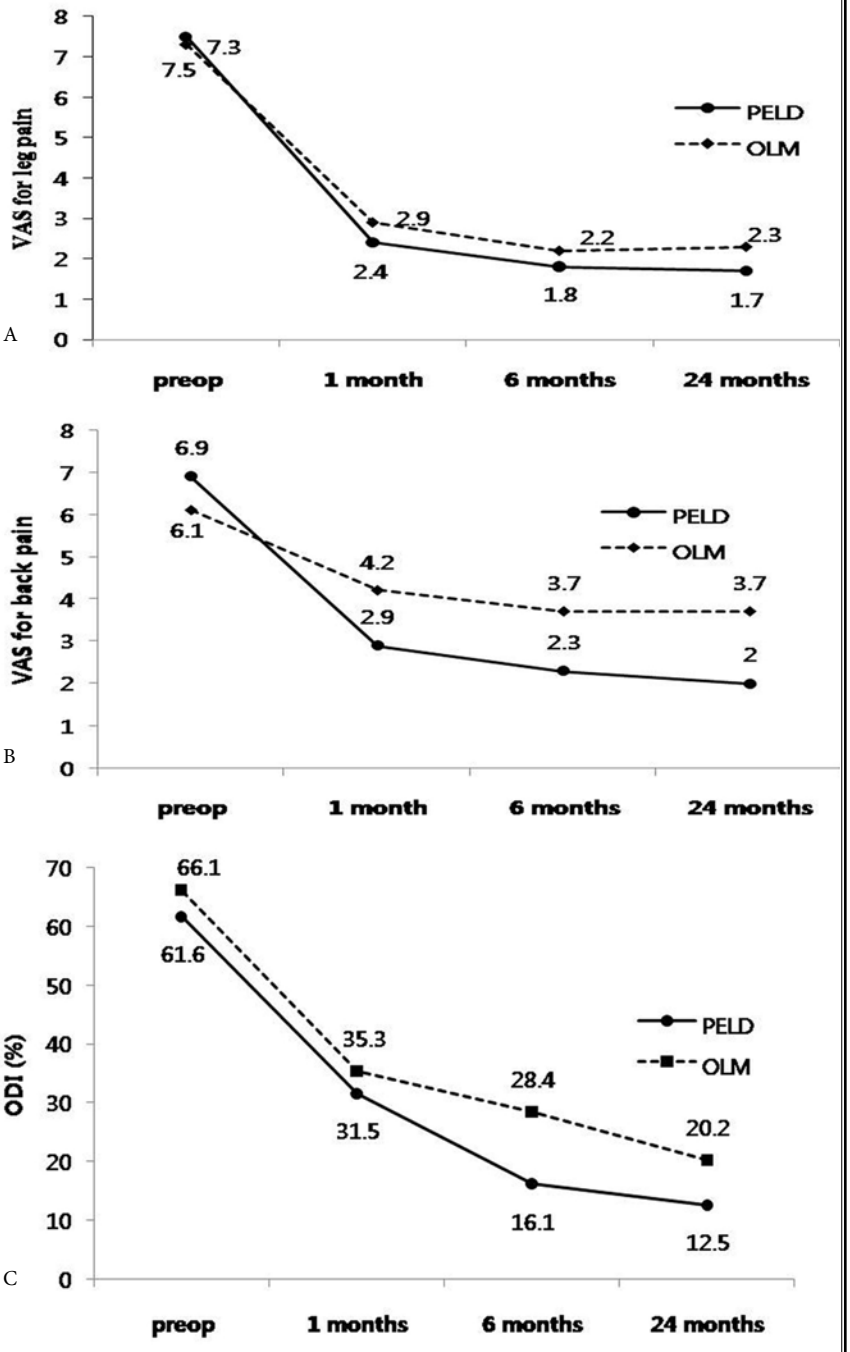

Fig. 3. *Surgical outcomes during follow-up (1, 6, and 24 months). A: Visual analogue scale (VAS) for leg pain. B: VAS for back pain. C: Oswestry Disability Index (ODI, %).*

eventual open discectomy. The incomplete removal was due to inappropriate location of the working cannula, which was located farther away from the herniated fragment. Another case exhibited recurrence 2 months after PELD, and the patient underwent open discectomy. One patient in the OLM group underwent anterior lumbar interbody fusion because of instability and disabling mechanical back pain one year postoperatively. There were no serious complications including cauda equina syndrome and neural injury in either group. Infection and cerebrospinal fluid leakage were not observed.

Discussion

Although a few cases of LLDH associated with cauda equina syndrome have been reported, this is a rare phenomenon (1,2). Patients with LLDH usually suffer from more severe back and leg pain than those with general lumbar disc herniation. LLDH usually produces large quantities of proinflammatory mediators and cytokines (21). The surgical treatment of LLDH is the same as that of general lumbar disc herniation. However, the optimal surgical procedure to address back pain and instability, including among unilateral or bilateral laminectomy, full laminectomy, or even fusion, remains controversial (1,2). Micro-endoscopic discectomy or tubular discectomy was recently introduced as an effective treatment for LLDH (16,17). Micro-endoscopic discectomy produces fewer traumas to soft tissues and results in rapid recovery. Micro-endoscopic discectomy or

tubular discectomy have conflicting results compared to conventional microdiscectomy for patients with self-reported leg and back pain, and recovery rate (22). Moreover, the basic surgical techniques are the same as those of conventional microdiscectomy, except for the use of a tubular retractor. Other minimally invasive surgical techniques such as PELD are becoming more widespread; PELD is considered a safe and good option for selected cases (11,23-25). However, the surgical technique for PELD completely differs from those of conventional and tubular microdiscectomy in terms of non-violation of the back muscles and facet joint, and minimal injury to the intervertebral disc.

Recent reports advocate herniotomy of disc materials. Balderston et al (26) insist there is no increased rate of re-herniation or reoperation in patients only undergoing excision. Faulhauer and Manicke (27) also report fewer re-herniations in the fragment-removal group as well as better clinical outcomes with respect to postoperative problems of instability compared to patients undergoing conventional discectomy; they report the recurrence rates in the fragment-removal and conventional discectomy groups were 2% and 7%, respectively. Moreover, a report of radiologic results demonstrates intervertebral instability is significantly less common in patients undergoing herniotomy in which the nucleus pulposus in the central area of the disc is preserved (28,29). Considering the association between instability and clinical outcomes, the above mentioned studies support our attempt to use the minimally invasive PELD technique to preserve the remaining central disc material as much as possible.

Postoperative mechanical back pain following open discectomy is not uncommon. Parker et al (30) report that 32% of patients suffered above moderate back pain after lumbar discectomy, and 9% suffered severe back pain and subsequently underwent fusion surgery. In addition, Dvorak et al (31) report that 70% of patients suffered low back pain during long-term follow-up after discectomy. A recent study on the long-term outcomes of open lumbar discectomy shows that the outcome deteriorates over time; furthermore, increased back pain worsens clinical outcomes and is correlated with radiologic degeneration (32).

Percutaneous endoscopic discectomy and annuloplasty is reported to result in satisfactory outcomes in the treatment of discogenic back pain (23,24,33). The back pain associated with disc herniation may originate from an annular tear or compression of the dura mater and the posterior longitudinal ligament. The annular tears are subsequently sealed off by richly vascularized and innervated cellular tissue (34). PELD not only decompresses the dural sac and decreases intradiscal pressure, but also ablates new vessel nerve formation and granulation around the annular fissure (23,24,33); this is a major advantage of PELD over conventional microdiscectomy.

PELD provides direct access to the annular defect site where the pathological disc fragment can be readily found. A large disc herniation pushes the neural structures dorsally away from the posterior longitudinal ligament, making a shallow angle of approach safer than that for a small disc herniation, which incurs a possibility of neural injury upon a shallow-angled working channel insertion (Fig. 4). There are other concerns that increasing discal pressure may result in injury to the thecal sac and nerve root when the working cannula penetrates the annulus. A few patients experienced approach-related back pain during the procedure in the present study; the pain was well controlled by intravenous analgesics. There were no cases in which the procedure was discontinued or conversion to open surgery occurred. It is thought that the nucleus pulposus had already lost its pressure after a large amount of the disc prolapsed, which did not affect adjacent neural tissues.

Compared to conventional OLM, PELD has the advantages of avoiding excessive nerve root retraction as well as preserving the lamina, facet joint, and posterior ligament structures. Excessive retraction or manipulation of neural structures in a narrow space can cause paresis (35). Another advantage is that PELD preserves intact disc tissue, avoiding invasion of intra-discal tissue (Fig. 5). Radiography and magnetic resonance images showed preservation of disc height and recovery of the torn annulus during follow-up (15).

This study has some limitations worth mentioning. The study was retrospective with a small sample size and short follow-up period. A prospective randomized trial comparing PELD and OLM is required to verify the present results. The PELD technique described herein has a steep learning curve similar to that of conventional PELD and is therefore not recommended for sequestrated or migrated disc, cases with concomitant foraminal narrowing, or L5-S1 disc herniation with high iliac crest.

Conclusion

The indications for PELD can be extended to treat large disc herniations. PELD demonstrated potential

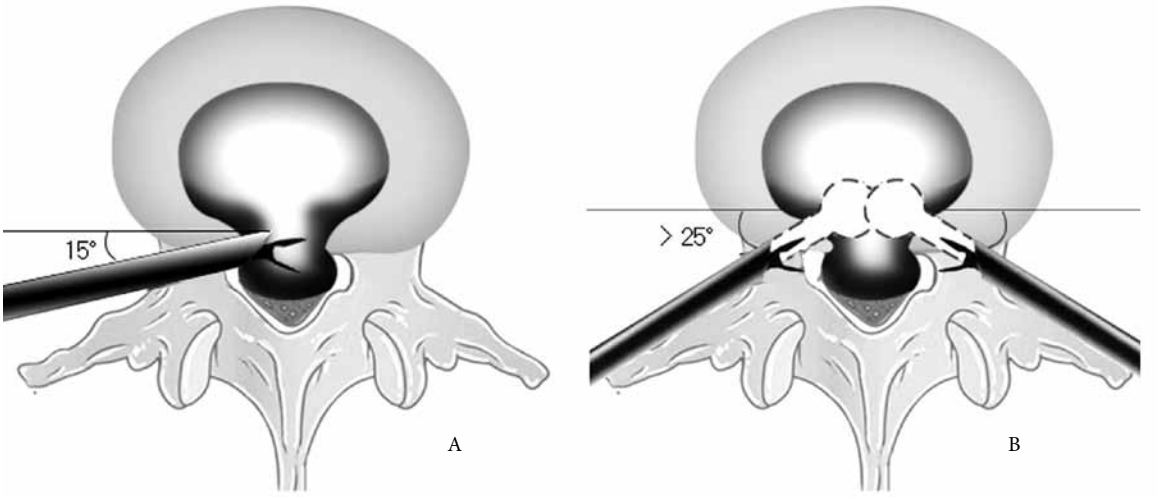

Fig. 4. *Schematic drawing showing 2 percutaneous endoscopic lumbar discectomy techniques for large lumbar disc herniation. A: The current approach angle of the current technique is approximately 15° from the horizontal plane on the axial section; this approach provides direct access to the annular defect site where the pathological disc fragment is located. A large disc herniation pushes the neural structures dorsally away from the posterior longitudinal ligament, safely making a shallow angle of approach. B: The existing inside-out posterolateral transforaminal approach, which has an approach angle exceeding 25°. The technique involves an intradiscal working tunnel and cavity (dotted line) and a large annulotomy opening, which are created using a biting forceps and bilateral approaches.*

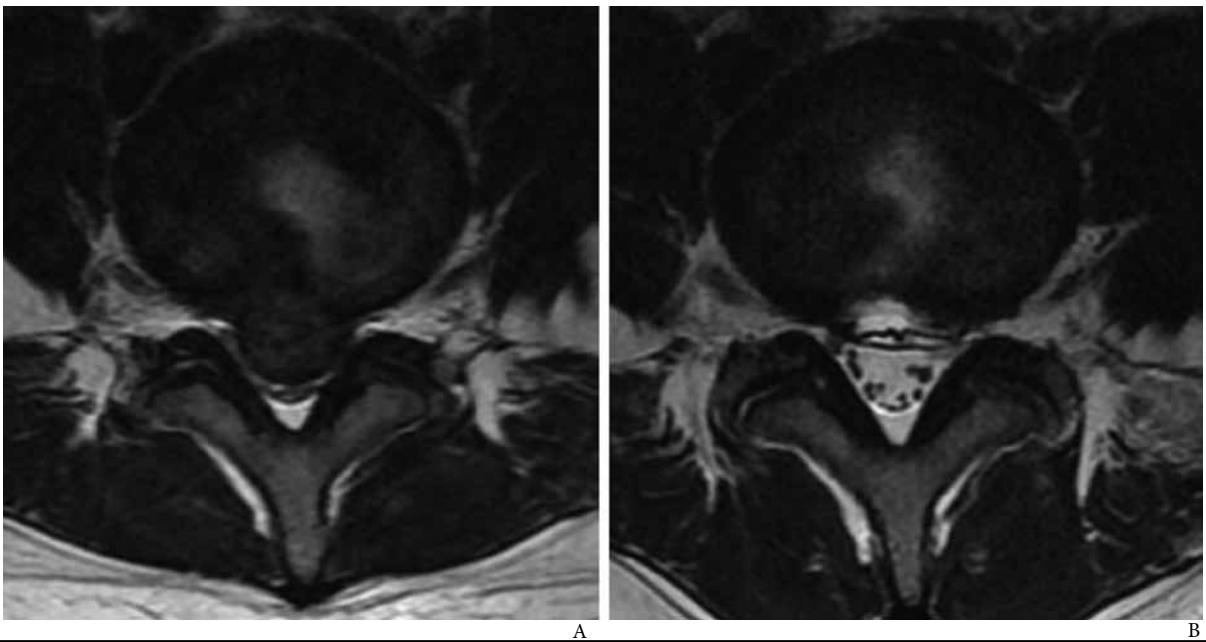

Fig. 5. *A 25-year-old girl presents with severe back and right leg pain due to large disc herniation at the L4-5 level. A: Preoperative MRI showing a large disc herniation covering the entire thecal sac. B: MRI showing complete removal of the herniated disc after percutaneous endoscopic lumbar discectomy.*

advantages, including a rapid recovery, improvements in back pain, and disc height preservation. Considering the anatomic structure, PELD utilizing a minimally invasive approach without injury to the back muscles, facet joints, or central nucleus may be an ideal surgical procedure for LLDH.

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