Retrospective Study

Bi-Needle PELD with Intra-Discal Irrigation Technique for the Management of Lumbar Disc Herniation

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Background: Lumbar disc herniation (LDH) is the most common cause of sciatica. Percutaneous endoscopic discectomy (PELD) is indicated when conservative treatments fail, which has been proved effective. During conventional PELD, ruptured discs and loose fragments inside discs are removed as much as possible to guarantee a lower reherniation rate, but it inevitably would lead to deterioration of disc degeneration and loss of disc height after PELD. Ensuring sufficient decompression while alleviating the post-operation disc degeneration process is still a clinical problem.

Objective: To evaluate the imaging and clinical outcomes of bi-needle PELD with intradiscal irrigation technique for the treatment of lumbar disc herniation (LDH).

Study Design: Multicenter retrospective cohort study.

Setting: Shanghai Changzheng Hospital, Naval Medical University, Shanghai, China.

Methods: A total of 48 patients who underwent bi-needle PELD (B-PELD) or conventional-PELD (C-PELD) for LDH in our 2 spine centers were included in this study. There were 26 cases in the C-PELD group (male 12 cases, female 14 cases) with an average age of 34.6 ± 6.8 years. And there were 22 patients in the B-PELD group (male 10 cases, female 12 cases) with an average age of 35.1 ± 6.4 years. The difference in postoperative disc degeneration (Pfirrmann grades, disc-vertebra height ratios [D-V H ratios]), visual analog scale (VAS) of low back pain, and reoperation rates were compared between the 2 groups.

Results: There was no significant difference in gender, age, disease duration, and surgical level between the 2 groups ($P > 0.05$). The postoperative VAS of back pain was 2.31 ± 0.53 for the C-PELD group and 0.63 ± 0.74 for the B-PELD group; the difference was significant ($P = 0.013$). The difference between the preoperative and postoperative D-V H ratios in the C-PELD group was significant ($P < 0.0001$), while it was not significant in the B-PELD group ($P = 0.6708$). The difference between the loss of D-V H ratios after surgery was significant between the 2 groups ($P = 0.0003$). The loss of D-V H ratios was higher in the C-PELD group. The difference between the preoperative and postoperative Pfirrmann grades in the B-PELD group was not significant ($P = 0.7261$); however, it was significant in the C-PELD group ($P = 0.0012$). The reoperation rate in the C-PELD group was 7.7%, and the reoperation rate in the B-PELD group was 4.5%; the difference was not significant ($P = 1$).

Limitations: This study employed a retrospective design, and its inherent selection bias and limited statistical power should be considered.

Conclusions: Bi-needle technique with saline irrigation maneuver showed a significant advantage of restoration of disc height and amelioration of disc degeneration compared to conventional PELD surgery.

Key words: Bi-needle technique, PELD, minimally invasive surgery, lumbar disc herniation

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Lumbar disc herniation (LDH) is the most common cause of sciatica, which is one of the most expensive disorders for society in terms of disability and work absenteeism. Several randomized controlled trials (RCTs) concluded that surgical treatment provides more effective and rapid pain relief for patients who are indicated for surgery (1). The long-term results of the Spine Patient Outcomes Research Trial (SPORT) showed significantly greater improvement in pain, function, and satisfaction in the surgery group compared to the non-operative group (2).

Currently, the development of endoscopes and instruments, the increased experience of surgeons, and the great demand by patients for a minimally invasive procedure, have led to rapid advancement in minimally invasive spinal surgery (MISS). Percutaneous transforaminal endoscopic lumbar discectomy (PELD) has become one of the most popular MISS techniques that have been used in the last 2 decades for LDH (3). However, there are still some flaws in this technique, including postoperative (post-op) deterioration of disc degeneration and loss of disc height, which leads to a slightly higher rate of reoperation and low back pain (4). Chen has reported that the reoperation rate for PELD (8.4%) was even higher than the micro-endoscopic discectomy (MED) (4). Intra-discal decompression was reported to lower the reoperation rate but meanwhile led to iatrogenic injuries to non-pathological disc tissues, which led to disc degeneration and height loss (1). Not only an early technique with indirect decompression in which the central nucleus tissue was removed, but the recently developed technique with direct herniotomy of extrusion also requires removing part of normal nucleus pulposus (NP) tissues; both ways will lead to disc height loss after surgery (5). The disc height loss was one of the sources of chronic postsurgical pain (5). Carragee has also indicated aggressive disc decompression will lead to a higher rate of low back pain with disc height loss (6).

A targeted approach to treat the herniation within the spinal canal shows a minimally invasive way with less normal disc removal, which theoretically may restore the disc height. However, it may also be associated with a higher rate of reherniation and reoperation. Therefore, the amount of normal disc removal to achieve the balance of clinical results is still controversial (7-10).

In the present study, we alternatively introduced an intradiscal irrigation maneuver for PELD. Instead of mechanical decompression of normal disc, a needle was inserted into the annulus to trigger an inside-out flow to drift out the deep non-adhesion loose fragment and change the inflamed environment in the deep disc. The needle was placed into the center of the disc, and the flow came out from the annular fissure. This automatic biomechanical decompression cannot be achieved by mechanical decompression in a transforaminal approach because of the limitation of the entry angle. Furthermore, the inflamed central environment in the deep disc cannot be alleviated by the low flow pressure through the endoscope tunnel. This technique was first reported as bi-needle PELD (B-PELD) (11); afterward, the intradiscal needle was modified to enter on the opposite side to prevent interference with foraminoplasty, and saline was used to perform the irrigation maneuver instead of methylene blue (10-11). This study was designated to compare the change of postoperative disc height and degeneration (Pfirrmann grades), clinical results, and reoperation rates between the B-PELD group and conventional-PELD (C-PELD) group.

Methods

This multicenter retrospective study was approved by our institutional review board. The study included patients who underwent B-PELD or C-PELD in 2 spine centers (Shanghai Changzheng hospital, Zhongshan Hospital) with 1-year postoperative follow-up and who were diagnosed with symptomatic disc herniation at one level with no prior or subsequent surgery at any other spinal level.

The exclusion criteria included multiple levels of discectomy; concomitant surgery in addition to PELD performed at the same or different levels; and evidence of stenosis, infection, fractures, or tumors.

Surgical Procedure

All surgeries were performed by 2 senior surgeons in the 2 hospitals. Local anesthesia was performed with the patients in a prone position on a radiolucent table.

B-PELD Surgery

The marker on the skin of the target disc was defined with the guidance of C-arm fluoroscopy. One needle was inserted into the superior articular process, and foraminoplasty and working cannula were addressed on the symptomatic side. The second needle was inserted through the annulus on the contralateral side for the purpose of inside-out intradiscal irrigation (Figs. 1-3). Before discectomy, a disc provocative test was performed under direct endoscopic visualization by injection of a syringe of air into the annulus.

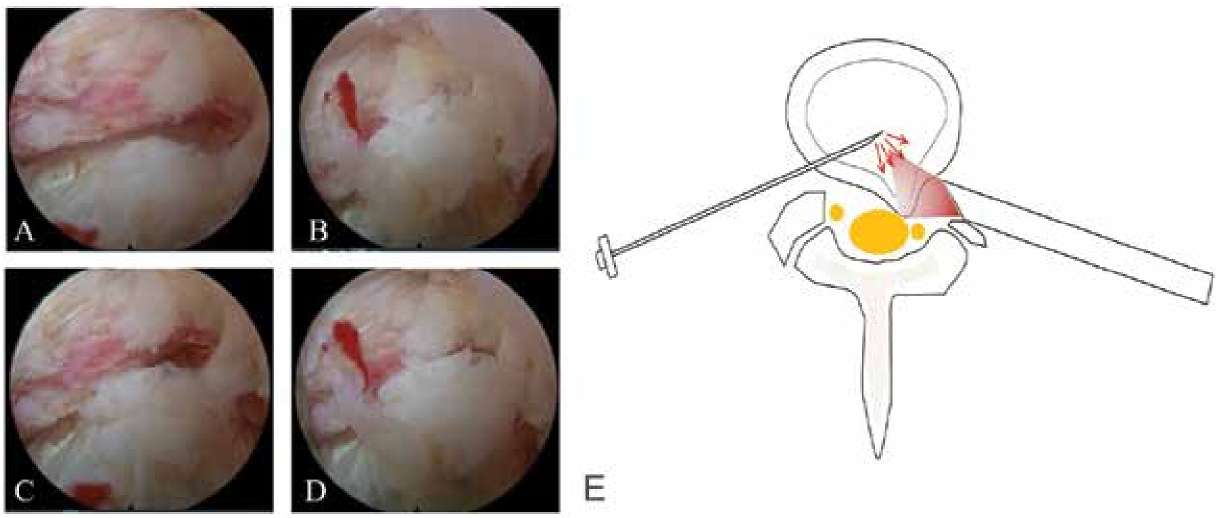

Fig. 1. *The endoscopic images of the irrigation process of B-PELD.* A-D: *the intradiscal loose NP fragment was gradually pushed out by saline irrigation of B-PELD,* E: *the model of needle irrigation maneuver was presented.*

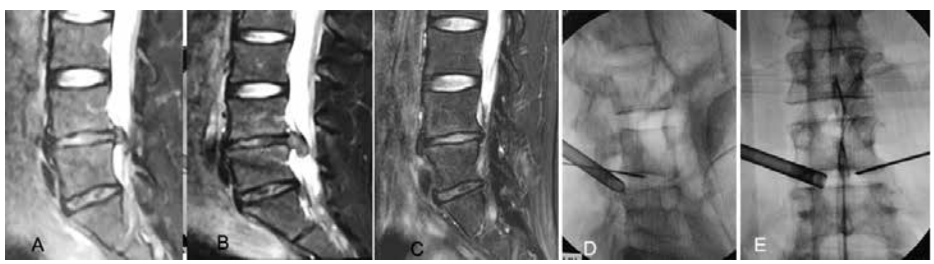

Fig. 2. *A 23-year-old female with L4/5 intervertebral disc herniation. A and B show L4/5 disc extrusion in the preoperative MRI, note that the signal of nucleus pulposus is inhomogeneous and decentered. C shows the L4/5 disc herniation has disappeared after surgery and the signal of L4/5 is homogeneous and centered. D and E show the radiographic images of B-PELD of intraoperative C-arm fluoroscopy.*

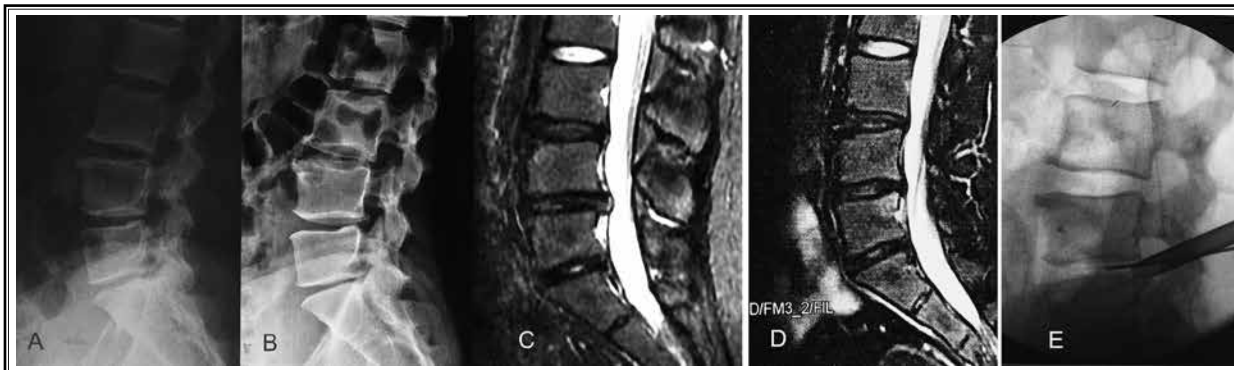

Fig. 3. *A 23-year-old female with L4/5 intervertebral disc herniation. A shows the lateral radiographs preoperatively, B shows the lateral radiographs postoperatively, note the height of L4/5 disc is maintained. C shows the L4/5 disc herniation in preoperative MRI, note the signal of L4/5 is decentered and darkened. D shows the L4/5 disc herniation has disappeared in postoperative MRI, note the signal of L4/5 is centered and lightened.*

Bubbles from the annular fissure of the index level can be identified under direct visualization through endoscopy in real-time. Before herniotomy, an irrigation maneuver was performed by a pressure-induced injection of saline into the disc. The sequestered or the loose degenerative fragment was drifted out; in this way, 'biomechanical' decompression was performed, and a thorough exploration for any migrated remnant in the spinal canal was completed (Fig. 1). The intradiscal irrigation maneuver was repeated 4-6 times to ensure there was no loose remanent fragment left in the disc. At last, radiofrequency was performed.

C-PELD Surgery

C-PELD was performed according to the standard procedure (12). After decompression of herniated or extruded fragment within the spinal canal, a sub-annulus decompression of degenerative NP or any loose fragment was performed. At last, intradiscal radiofrequency was performed.

Postoperative Treatment and Follow-Up

After surgery, mannitol and dexamethasone were given for 1 day; the drainage was taken out 24-48 hours after the surgery. Ambulation started 7 days after surgery. All patients were discharged after 3 days of hospitalization. Lumbar support belts were taken for 4 weeks.

All patients were followed up on the 6th and12th month postoperatively. VAS of low back pain was recorded for each patient. Standing lateral radiographs and MRI were performed in the follow-ups. A modified Mochida method was used for measuring the disc-vertebra height ratio (D-V H ratio) from 3 points of the endplate of the involved segment (anterior point, middle point, and posterior point) on radiographs (Fig. 4) (12). The D-V H ratio from the 3 points was averaged to calculate the D-V H ratio for this level.

$$\text{D-V H ratio} = \frac{(a + b + c)}{(A + B + C)}$$

The Pfirrmann Grading System (Fig. 5) was used to classify degeneration of the disc into 5 grades (13). The reoperation cases of the operative level in both groups were recorded. These data were recorded before surgery and in the follow-ups.

Statistical Analysis

Demographic data and clinical results comparison between the 2 groups were performed via an independent t test or chi-square test using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). The change of D-V H ratios and Pfirrmann grades between preoperative and postoperative data (12-month follow-up) were compared to each other by pared t test in the 2 groups, respectively. The difference in change of D-V H ratios and Pfirrmann grades after the surgery (the preoperative data minus and the follow-up data) between the 2 groups were compared using an independent t test. The reoperation rate between the 2 groups was compared using Fisher's exact test.

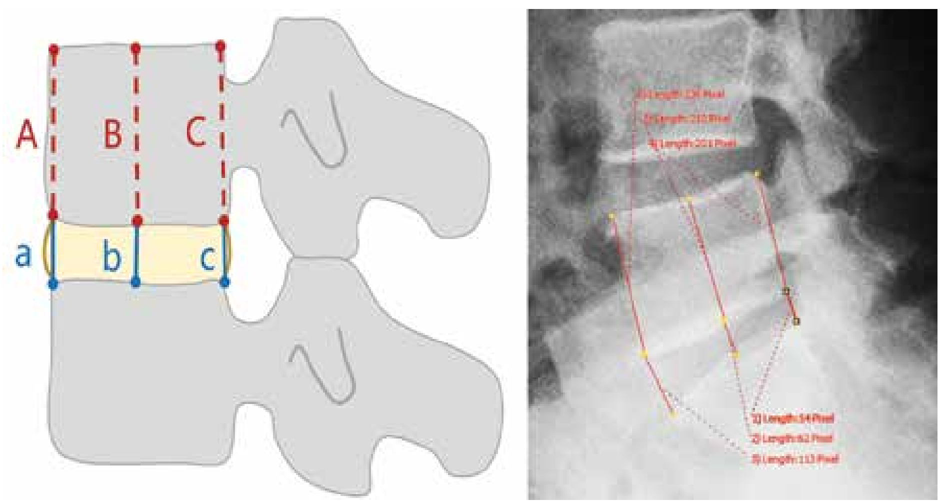

Fig. 4. *Diagram of modified Mochida method for D-V H ratio. The anterior, middle, and posterior vertebrae height were defined as A, B, C, and the anterior, middle, posterior vertebrae height were defined as a, b, c. The D-V H ratio was calculated as the sum of a, b, c compared to the sum of A, B, C. D-V H ratio = (a+b+c)/(A+B+C).*

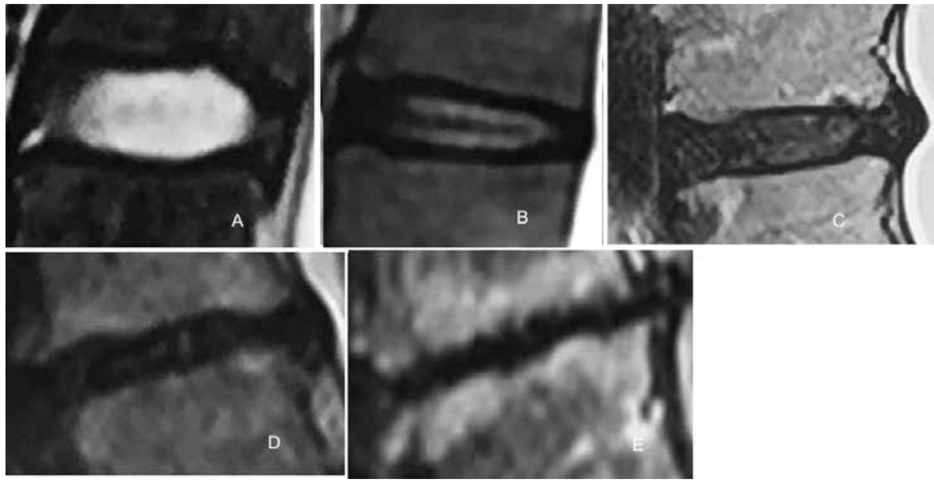

Fig. 5. *The classification of disc degeneration using Pfirrmann grading system.* Fig. A *shows a Grade-I disc,* Fig. B *shows a Grade-II disc,* Fig. C *shows a Grade-III disc,* Fig. D *shows a Grade-IV disc, and* Fig. E *shows a Grade-V disc.*

Results

1. Demographic date and comparison between the 2 groups

A total of 48 patients were included in this study. There were 26 cases in the C-PELD group (male 12 cases, female 14 cases) with an average age of 34.6 ± 6.8 years. And there were 22 patients in the B-PELD group (male 10 cases, female 12 cases) with the average age of 35.1 ± 6.4 years. There was no significant difference in gender, age, disease duration, and surgical level between the 2 groups (Table 1).

2. Clinical results comparison between the 2 groups

The postoperative VAS of back pain was 2.31± 0.53 for the C-PELD group and 0.63 ± 0.74 for the B-PELD group; the difference was significant (P = 0.013).

3. D-V H ratio comparison between the 2 groups

The difference between the preoperative and postoperative D-V H ratios in the C-PELD group was significant ($P < 0.0001$), while it was not significant in the B-PELD group ($P = 0.6708$) (Fig. 6). The difference between the change of D-V H ratios after surgery was significant between the 2 groups ($P = 0.0003$). The loss of D-V H ratios was higher in the C-PELD group (Fig. 7). The percentage of postoperative/preoperative D-V H ratios was (86.2 ± 2.5) % for the C-PELD group and (99.2 ± 2.6) % for the B-PELD group, and the difference was significant (Fig. 8 and Table 2).

Table 1. *Demographic data comparison between the 2 groups.*

	C-PELD Group (n = 26)	B-PELD Group (n = 22)	t/χ^2 Value	*P* Value
Gender (M/F)	12/14	10/12	0.002	0.96
Age (years)	34.6 ± 6.8	35.1 ± 6.4	-0.25	0.81
Disease duration (months)	11.0 ± 4.1	12.3 ± 3.9	-1.17	0.25
Surgical Level			0.03	0.99
L3/4	7	6		
L4/5	15	13		
L5/S1	4	3		

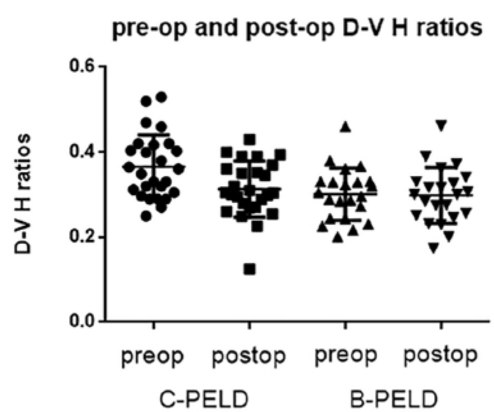

Fig. 6. *D-V H ratio comparison between the 2 groups. The difference between the preoperative and postoperative D-V H ratios in the C-PELD group was significant, while it was not significant in the B-needle PELD group, P < 0.05.*

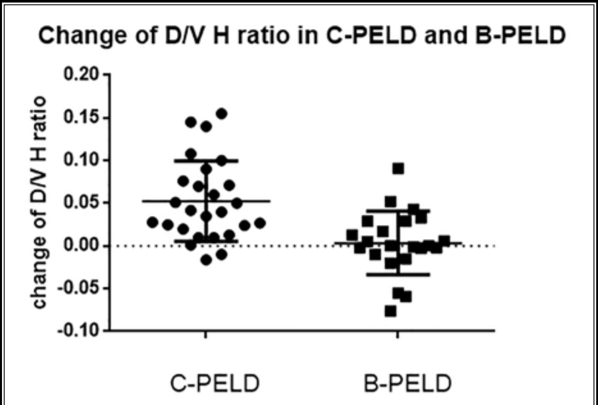

Fig. 7. *Change of D-V H ratios between the 2 groups. There was a significant difference between the 2 groups in a change of D-V H ratios, P < 0.05. The loss of D-V H ratios was higher in the C-PELD group, P < 0.05.*

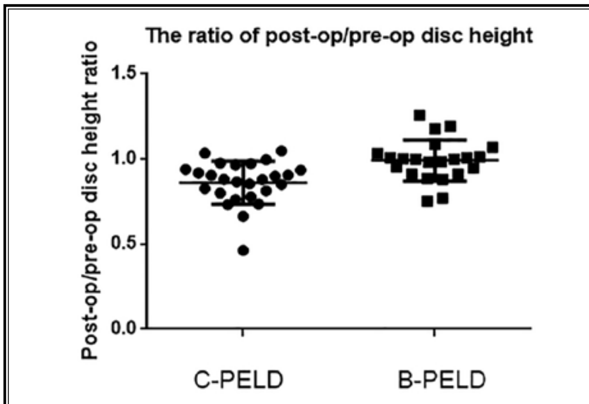

Fig. 8. *Postoperative/preoperative D-V H ratios between 2 groups. The percentage of postoperative/preoperative D-V H ratios was (86.2 ± 2.5)% for the C-PELD group and (99.2 ± 2.6% for the B-PELD group, and the difference was significant P < 0.05.*

Table 2. *Comparison results of both groups after surgery.*

	C-PELD Group (n = 26)	B-PELD Group (n = 22)
VAS back pain	2.31 ± 0.53	0.63±0.74 (*P* = 0.013)
D-V H ratio (Preop VS Postop)	*P* < 0.0001	*P* = 0.6708
change of D-V H ratios	0.0524 ± 0.009	0.0034 ± 0.008 (*P* = 0.0003)
postop/preop D-V H ratios	(86.2 ± 2.5)%	(99.2 ± 2.6)%
Pfirrmann grades (Preop VS Postop)	*P* = 0.0012	*P* = 0.7261
Change of Pfirrmann grades	0.4048 ± 0.1176	0.05556 ± 0.1560 (*P* = 0.0774)
Reoperation rate	7.7%	4.5% (*P* = 1)

4. Pfirrmann grades for disc degeneration

A total of 21 patients in the C-PELD group and 18 patients in the B-PELD group had a lumbar MRI at an average one-year follow-up. The difference between the preoperative and postoperative Pfirrmann grades in the B-PELD group was not significant (*P* = 0.7261), but it was significant in the C-PELD group (*P* = 0.0012) (Fig. 9). The change of Pfirrmann grades after surgery in the B-PELD group was 0.05556 ± 0.1560 and was 0.4048 ± 0.1176 in the C-PELD group (*P* = 0.0774) (Figs. 2,3,9,10 and Table 2).

5. Reoperation rate of the 2 groups

The reoperation rate in the C-PELD group was 7.7%, and the reoperation rate in the B-PELD group was 4.5%; the difference was not significant by Fisher's exact test (*P* = 1) (Table 2).

Discussion

Intradiscal discectomy in PELD was reported to lower the reherniation rate (14). However, excessive normal disc removal was known to cause disc height loss, deterioration of disc degeneration, and segmental instability (1,6). Yeung has refined Yeung endoscopic spin system (YESS) by a selective endoscopic discectomy to selectively remove the degenerative stained NP by indigo carmine (14). In this study, however, we found that the adhesion degenerative NP tissues within the disc were not necessary to be removed unless it was sequestered. Kambin has reported the removal of disc material with the aid of high negative pressure (15). We assumed that removal of the non-adhesion fragment by intradiscal positive high pressure (Fig. 1) would prevent the early reherniation while sustaining the disc height, changing the inflamed environment, and reducing low back pain after PELD. In this study, the reoperation rate in B-PELD was equal to the C-PELD group, while the postoperative low back pain was less in the B-PELD group.

Acceleration of disc degeneration is another sequela of PELD surgery. Gun Keorochana (16) has proved that a normal disc would accelerate degeneration after needle puncture. Li reported that PELD was less invasive than open lumbar microdiscectomy (OLM), the disc height loss, and Pfirrmann-grade increase were less than OLM (1). During a discectomy, iatrogenic disc injury is inevitably encountered. Disc height and Pfirrmann grades are associated with disc degeneration. In the 3-year follow-up, Sang Soo Eun reported disc height lost 18.46% after C-PELD (12), and Sang Ho Lee reported disc height lost 9.81%, and Pfirrmann grade increased an average of 0.2 after limited PELD (1). Meanwhile, Hiroshi Takahashi also found Pfirrmann grades increased an average of 0.24 after discectomy (17). In this study, we found that D-V H ratios lost 13.85% in the C-PELD group and 0.01% in the B-PELD group, and Pfirrmann grades increased 0.4 in the C-PELD group and 0.06 in B-PELD surgery (Figs. 5 and 8). This might be accounted for the reduced low back pain after B-PELD surgery.

The possible mechanism for preventing the acceleration of disc degeneration in B-PELD is in speculation. In former reports, Pfirrmann grades were always reported to increase after discectomy (16). This indicated the procedure might interfere with the integrity of the disc or does not change the internal detrimental environment of NP tissue. However, Sang Ho Lee reported 6 patients of the 30 patients in the PELD group had improved disc signal changes (Pfirrmann grades from III to II), 8 patients had deteriorated disc signal changes after surgery (1). In this study, the averaged Pfirrmann grades were not significantly deteriorated in the B-PELD group. A few cases had even improved Pfirrmann grades in follow-ups; the signal of nucleus pulposus in T2 or fat suppression phase has been centered or improved after surgery (Fig. 2, 3, and 10). This indicated the irrigation maneuver changed the biomechanical

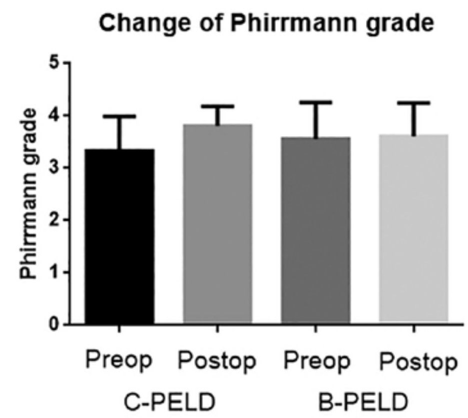

Fig. 9. *Pfirrmann grades for disc degeneration between 2 groups. There was no significant difference between the preoperative and postoperative Pfirrmann grades in the B-PELD group ($P > 0.05$); however, the difference was significant in the C-PELD group ($P < 0.05$).*

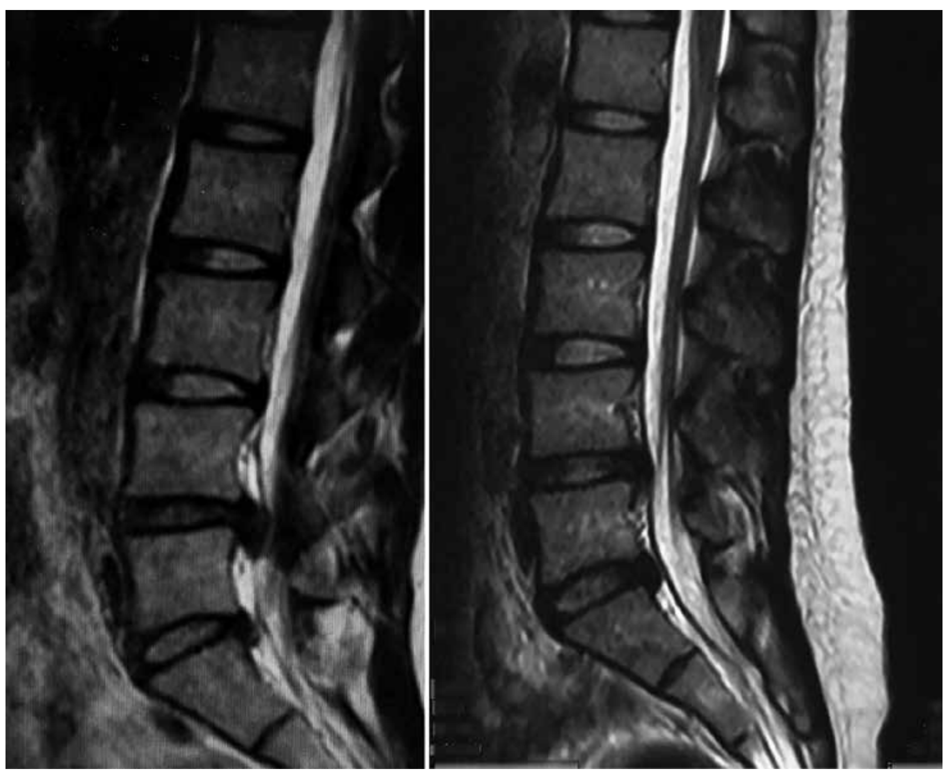

Fig. 10. *A female with L4/5 disc herniation. The left image shows the L4/5 disc signal darkened preoperatively. The right image shows the disc signal lightened and the height increased.*

environment of the disc instead of providing new injury to the disc. It was reported that the inflammatory environment was a noxious environment for NP cells and the autoimmunity reaction induced by the herniated NP would initiate inflammation in the disc (18). Meanwhile, the nutrient deficient and anaerobic environment of the disc also leads to lactic acid accumulation. This aberrant environment has an adverse effect on the re-adhesion and regeneration of NP tissue after surgery, which is one of the reasons for reherniation. The routine irrigation system through the endoscope tunnel could not infiltrate into the central NP, whereas the intra-disc irrigation maneuver could infiltrate into the central NP and change the noxious environment for NP cells. This has been proved in our former study when using methylene blue for discography; only intra-disc saline irrigation can wash off the remnant methylene blue, while common irrigation could not (10-11).

It was reported that disc height loss was associated with acceleration of disc degeneration, stenosis of the foramen, and increased stress on the facet joint, which would lead to low back pain. Carragee reported that compared to limited discectomy, subtotal discectomy had a higher rate of postoperative low back pain because of narrowing of disc space (6). Disc height loss was significant, especially at the long-term follow-up after PELD (12). Song reported the D-V H ratio at 3-year follow-up was 85.7% of the preoperative ratio (19). In our study, the D-V H ratio loss was much higher in the C-PELD group than B-PELD group (Fig. 11). An aggressive sub-annular discectomy was performed in C-PELD, thus leading to excessive NP loss and annulus injury. In comparison, inside-out irrigation drifted out the non-adhesion fragment, preserving more NP tissues and annulus fibrosus, thus relatively normal NP was preserved, and disc height was sustained in the B-PELD group. In addition, the release of symptoms with the increase of lumbar lordosis might also contribute to the restoration of disc height. Song reported lumbar lordosis recovered apparently after PELD (19). Therefore, if lumbar lordosis increases, the disc height will be elevated, especially on the anterior side. In this study, there was no significant difference in the reoperation rate between the B-PELD group and C-PELD group, indicating the preserved relatively normal NP tissues remain vital and functional after surgery and do not contribute to a high reoperation rate.

A limitation of this study is the design is not a randomized controlled trial. The number of patients is not large, and the follow-up time is still not long enough to show a significant difference in the reoperation rate between these 2 groups. In this study, the bi-needle technique with saline irrigation maneuver showed the advantage of restoration of disc height and sustain of disc viability. Further study, including both long-term follow-up and trying this maneuver in mini-open discectomy, should be carried out.

Fig. 11. *The comparison between disc height loss between 2 cases of B-PELD and C-PELD. A and B show preoperative and 6-month follow-up lateral radiographs of a patient with L3/4 disc herniation in the B-PELD group; noted the disc height was maintained postoperatively. C and D show preoperative and 6-month follow-up lateral radiographs of a patient with L5/S1 disc herniation in the C-PELD group; note the disc height was lost apparently after surgery.*

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