Clinical Outcomes of Percutaneous Endoscopic Transforaminal Discectomy for the Treatment of Disc Herniation: A 3-Year Retrospective Study

Ann. Ital. Chir., 2024 95, 3: 353–363
https://doi.org/10.62713/aic.3142

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AIM: Percutaneous endoscopic transforaminal discectomy (PELD) is a new minimally invasive spine surgery for patients with lumbar disc herniation (LDH). Based on the 3-year follow-up data, the effect of PELD on the clinical outcomes of patients with LDH through a retrospective cohort study was analyzed in this article, so as to provide guidance for clinical selection of surgical options.
METHODS: The clinical data of 150 patients with LDH admitted to our hospital from January 2019 to October 2020 were retrospectively analyzed. According to the surgical methods recorded in the medical record system, the patients were divided into the open lumbar microdiscectomy (OLM) group (n = 50) and the PELD group (n = 100). The surgical and postoperative recovery indicators of the two groups were compared after matching. These included incision length, intraoperative blood loss, operation time, postoperative ambulation time and hospital stays, recovery rate, short-term complication rate, Lumbar visual analogue scale (VAS) score, and Oswestry Disability Index (ODI) score.
RESULTS: Compared with the OLM group, the PELD group had shorter incision length, shorter operation time, shorter postoperative ambulation time, shorter hospital stays, less intraoperative blood loss, lower short-term complication rate, lower lumbar pain and dysfunction scores at 3 months, 6 months, and 1 year after operation, higher short-term excellent-and-good recovery rate, and higher quality-of-life scores at 3 years after operation ($p < 0.05$).
CONCLUSIONS: Compared with OLM, PELD in the treatment of LDH patients can reduce the operation time, blood loss, and length of hospital stays, suggesting a short-term postoperative recovery effect. Compared with OLM, PELD can also reduce the incidence of short-term complications, enhance the effect of pain control and improvement of dysfunction in the medium term, and improve the long-term quality of life.

Keywords: percutaneous endoscopic transforaminal discectomy; intervertebral disc herniation; pain; quality of life

Introduction

Lumber disc herniation (LDH) involves the rupture and protrusion of lumbar intervertebral disc tissues (including nucleus pulposus, annulus fibrosus, and cartilage plate) due to external force after different degrees of degenerative changes (degeneration and aging). The main features are lumbar pain or radiating pain in the lower limbs, and local numbness [1, 2]. The condition of most LDH patients can be improved by conservative treatment, but a small number of patients require surgical treatment [3, 4]. Currently, the surgical treatment of LDH includes open lumbar microdiscectomy (OLM) and percutaneous endoscopic transforaminal discectomy (PELD) [5, 6]. Clinical studies have shown that OLM produces good results in LDH patients, but the large incision during the operation can cause muscle tissue damage around the lumbar spine, leading to complications [7, 8]. PELD belongs to a new type of minimally invasive surgery, which has been popularized in the treatment of LDH. PELD not only takes less time, but also produces less tissue damage [9]. Previous studies have shown that PELD and OLM have comparable efficacy for LDH and comparable risk of complications after LDH treatment [10, 11]. However, there is still controversy regarding the superiority of OLM versus LDH. Therefore, the purpose of this study was to analyze the clinical outcomes of PELD in the treatment of LDH patients. The goal of this research is to improve the efficacy and safety of LDH treatment, promote the postoperative recovery of patients, and provide guidance for clinical practice.

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Materials and Methods

Research Objectives

A total of 150 patients with LDH admitted to our hospital from January 2019 to October 2020 were retrospectively analyzed. According to the surgical plan, they were divided into the OLM group and the PELD group. Inclusion criteria: (1) Presence of clinical symptoms such as low back pain, radiating pain in the lower limbs, and numbness or

weakness of the lower limbs to varying degrees in preoperative evaluation. LDH patients were diagnosed by lumbar X-ray and magnetic resonance imaging; (2) Age ≥65 years; (3) The effect of conservative treatment for 3 months was poor; (4) Complete clinical data and effective postoperative follow-up. Exclusion criteria: (1) Imaging examination showed moderate or severe central spinal canal stenosis and disc herniation calcification; (2) Contraindications to surgery including liver, kidney, hematopoietic system diseases, metabolic bone diseases, or severe osteomalacia; (3) Highly displaced and dissociated intervertebral disc herniation; (4) Patients that were excluded due to loss of follow-up or other circumstances.

This study was approved by the Ethics Committee of Huantai County People's Hospital (LP2024-3-01), and the data of this study were obtained through the hospital's case system records. Since all patients' identifying information was confidential, the requirement for informed consent was waived by Huantai County People's Hospital. Furthermore, this study adhered to the tenets of the Declaration of Helsinki.

Methods

OLM Group

The surgical method for the OLM group was as follows: before operation, the specific segment for operation was determined according to the imaging results, and the patients were placed in the prone position under general anesthesia. During operation, the segment of disc herniation was identified and marked with the help of a C-arm X-ray machine, and an incision about 3–5 cm was made in the posterior midline position. Under the microscopic view, the skin of the affected area was cut layer by layer to expose the lamina, and then the bone window was opened to expose the nerve root using laminectomy forceps. During this procedure, attention was paid to the protection of the nerve root and the dural sac, and the nucleus pulposus tissue in the herniated intervertebral disc was removed. The incision was sutured after making sure that the nerve root was fully decompressed.

PELD Group

The surgical method for the PELD group was as follows: During the operation, the specific segment of intervertebral disc herniation was identified and marked with the help of C-arm X-ray machine. The position 10–12 cm away from the posterior midline was used as the puncture point, and the puncture needle was inserted into the intervertebral disc through the intervertebral foramen. The guide wire was inserted by the puncture needle, and then the puncture needle was removed. An incision of about 1 cm was made at the location of the patient's puncture point, and the channel was expanded along the guide wire. The expansion cannula and an oval working channel with an oblique angle were inserted respectively. The transforaminal endoscope was inserted through the working channel. With the help of the transforaminal endoscope, the nucleus pulposus tissue was removed by surgical forceps and bipolar radiofrequency, and hemostasis was carried out at the same time. After sufficient decompression of the nerve root, the endoscope was removed, the incision was sutured again, and sterile gauze was used to cover it.

All intraoperative procedures were performed by the same team of surgeons, and special personnel were responsible for postoperative follow-up. In addition, all data were blinded so that data collectors and analysts were unaware of the group assignments to avoid bias in data collection and analysis, ensuring data reliability.

Observation Indicators

Main observation indicators: (1) Surgical indicators: mainly included incision length, intraoperative blood loss, operation time, postoperative ambulation time, and hospital stays; (2) Excellent-and-good recovery rate: the efficacy was evaluated by the modified MacNab standard 3 months after operation; Excellent: With pain disappearing, the patients can work and perform activities normally; Good: With all symptoms relieving, occasionally without neuralgia, the patients are able to partially participate in work; Poor: The patient still has significant persistent nerve contraction, and the symptoms are still present after surgery without any improvement [12]; Excellent rate = number of excellent + number of good cases/total number of cases × 100%; (3) Short-term complication rate: mainly included dural tear, wound infection, pressure ulcer, and lower extremity venous thrombosis, etc. Complication rate = number of complications/total number of cases × 100%.

Secondary outcome measures: (1) Excellent-and-good recovery rate: the efficacy was evaluated by modified MacNab standard at 6 months after operation; Excellent: With pain disappearing, the patients can normally work and perform activities; Good: With all symptoms relieving, occasionally without neuralgia, the patients are able to partially participate in work; Poor: The patient still has significant persistent nerve contraction, and the symptoms are still present after surgery without any improvement [13]; Excellent rate = number of excellent + number of good cases/total number of cases × 100%; (2) Lumbar visual analogue scale (VAS) score: the score ranged from 0–10 points and the score was inversely proportional to the pain. The Cronbach's α coefficient of the scale was 0.833, and the content validity was 0.798 [14]. The VAS was administered before operation and 3 months, 6 months, 1 year, 2 years, and 3 years after operation. (3) Oswestry Disability Index (ODI) score: The ODI included a total of 10 items, each item was scored 0–5, and the total score was 50. The score was inversely proportional to the dysfunction. The Cronbach's α coefficient of the scale was 0.856, and the content validity was 0.810 [15]. The ODI was administered before operation and 3 months, 6 months, 1 year, 2 years, and 3

Table 1. Comparison of general characteristics between the two groups.

Indicators	Before matching		χ^2/t	p	After matching		χ^2/t	p
	PELD group (n = 100)	OLM group (n = 50)			PELD group (n = 32)	OLM group (n = 32)		
Gender			0.000	1.000*			0.066	0.798*
Male	48 (48.00)	24 (48.00)			13 (40.63)	12 (37.50)		
Female	52 (52.00)	26 (52.00)			19 (59.37)	20 (62.50)		
Age (years)	57.85 ± 4.50	55.10 ± 4.64	3.492	0.001△	55.96 ± 3.38	56.35 ± 3.45	0.457	0.649△
Degree of education			0.251	0.616*			0.068	0.794*
Junior high school or below	68 (68.00)	36 (72.00)			20 (62.50)	21 (65.63)		
High school or above	32 (32.00)	14 (28.00)			12 (37.50)	11 (34.37)		
Body mass index (kg/m^2)	21.20 ± 2.14	20.86 ± 2.25	0.902	0.369△	21.14 ± 2.40	20.95 ± 2.38	0.318	0.752△
Medical insurance type			0.017	0.898*			0.000	1.000*
Employee medical insurance or resident medical insurance	95 (95.00)	47 (94.00)			30 (93.75)	29 (90.63)		
Without health insurance	5 (5.00)	3 (6.00)			2 (6.25)	3 (9.37)		
Coexisting diseases			8.721	0.013*			1.400	0.497*
Hypertension	2 (2.00)	7 (14.00)			2 (6.25)	1 (3.13)		
Diabetes	3 (3.00)	2 (4.00)			1 (3.13)	0 (0.00)		
None	95 (95.00)	41 (82.00)			29 (90.63)	31 (96.88)		
Duration of disease (years)	6.95 ± 1.10	6.02 ± 1.05	4.955	0.001△	6.45 ± 1.15	6.50 ± 1.20	0.170	0.865△
Segment of lesion			11.350	0.010*			0.312	1.000*
L2–3	6 (6.00)	7 (14.00)			4 (12.50)	5 (15.63)		
L3–4	42 (42.00)	30 (60.00)			13 (40.63)	14 (43.75)		
L4–5	35 (35.00)	6 (12.00)			10 (31.25)	9 (28.13)		
L5–S1	17 (17.00)	7 (14.00)			5 (15.63)	4 (12.50)		
Pfirrmann classification			0.125	0.989*			0.348	0.951*
Level II	25 (25.00)	12 (24.00)			8 (25.00)	9 (28.13)		
Level III	34 (34.00)	16 (32.00)			10 (31.25)	8 (25.00)		
Level IV	26 (26.00)	14 (28.00)			7 (21.88)	7 (21.88)		
Level V	15 (15.00)	8 (16.00)			7 (21.88)	8 (25.00)		
LDH typing			0.055	0.814*			0.064	0.800*
Central type	40 (40.00)	21 (42.00)			14 (43.75)	13 (40.63)		
Paracentral type	60 (60.00)	29 (58.00)			18 (56.25)	19 (59.37)		
Degree of displacement			0.770	0.680*			0.104	0.950*
Mild	42 (42.00)	20 (40.00)			13 (40.63)	14 (43.75)		
Medium	40 (40.00)	18 (36.00)			11 (34.38)	11 (34.38)		
Severe	18 (18.00)	12 (24.00)			8 (25.00)	7 (21.88)		
Degree of adhesion			0.427	0.808*			0.082	0.960*
Mild	46 (46.00)	21 (42.00)			15 (46.88)	14 (43.75)		
Medium	38 (38.00)	19 (38.00)			10 (31.25)	11 (34.38)		
Severe	16 (16.00)	10 (20.00)			7 (21.88)	7 (21.88)		
Presence of dural tear risks			0.011	0.918*			0.000	1.000*
Yes	8 (8.00)	5 (10.00)			3 (9.38)	2 (6.25)		
None	92 (92.00)	45 (90.00)			29 (90.62)	30 (93.75)		
The softness of the herniated disc			0.086	0.780*			0.000	1.000*
Good	80 (80.00)	41 (82.00)			27 (84.38)	28 (87.50)		
Worse off	20 (20.00)	9 (18.00)			5 (15.62)	4 (12.50)		
Complicated with spinal stenosis			0.011	0.918*			0.000	1.000*
Yes	8 (8.00)	5 (10.00)			5 (15.62)	4 (12.50)		
None	92 (92.00)	45 (90.00)			27 (84.38)	28 (87.50)		

Note: * denotes χ^2 test; △ indicates *t* test. PELD, percutaneous endoscopic transforaminal discectomy; OLM, open lumbar microdiscectomy; LDH, lumbar disc herniation.

Table 2. Comparison of surgical indicators between the two groups ($\bar{x} \pm s$).

Group	Length of incision (cm)	Duration of surgery (min)	Intraoperative blood loss (mL)	Time to get out of bed after surgery (d)	Length of stay (d)
PELD group (n = 32)	1.05 (0.85, 1.25)	68.80 ± 10.58	54.50 (45.20, 63.80)	2.52 ± 0.38	7.00 (6.00, 8.00)
OLM group (n = 32)	3.05 (2.40, 3.70)	74.56 ± 12.14	70.50 (55.5, 85.50)	2.86 ± 0.44	8.00 (7.00, 9.00)
t/Z	16.801	2.023	4.467	3.308	3.584
p	0.001▲	0.047△	0.001▲	0.002△	0.001▲

Note: △ indicates *t* test; ▲ indicates a nonparametric test.

Table 3. Comparison of short-term postoperative complications between the two groups [n (%)].

Group	Dural tear	Wound infection	Pressure sore	Venous thrombosis of the lower extremities	Incidence rate
PELD group (n = 32)	0 (0.00)	0 (0.00)	1 (3.13)	0 (0.00)	1 (3.13)
OLM group (n = 32)	2 (6.25)	2 (6.25)	1 (3.13)	1 (3.13)	6 (18.75)
χ^2					4.010
p					0.045*

Note: * indicates the *p* value for the χ^2 test.

years after operation. (4) World Health Organization Quality of Life-BREF (WHOQOL-BREF) score: There were 26 items in total, covering four dimensions including physiology, psychology, environment, and social relations. Each item was scored 1–5, and the total score was 130. The score was proportional to the quality of life, Cronbach's α coefficient of the scale was 0.814, and content validity was 0.770 [16].

Statistical Methods

SPSS 25.0 statistical software (IBM Corporation, Armonk, NY, USA) was used to analyze the data, and the count data were expressed as [n (%)]. If the sample size was $\geq$40 and the theoretical frequency was T $\geq$5, the chi-square test was used, and the test statistic was χ^2. If the sample size was $\geq$40 but the theoretical frequency was $1 \leq T < 5$, the correction formula for the chi-square test was used. If the sample size was less than 40 or the theoretical frequency T was less than 1, Fisher's exact probability method was used. The Shapiro-Wilk method was used to test whether the continuous variables conformed to the normal distribution. The variables that were normally distributed were expressed as ($\bar{x} \pm s$) and analyzed using the *t* test. Non-normally distributed variables were expressed as median and quartiles [M (P25, P75)], and the Mann-Whitney U test was used. *p* values < 0.05 were considered statistically significant. For propensity score matching, gender, age, education level, body mass index, type of medical insurance, comorbidity, course of disease, lesion segment, Pfirrmann classification, LDH classification, degree of displacement, degree of adhesion, risk of dural tear, hardness of herniated disc, and the complication of spinal stenosis were selected as independent covariates, and the surgical method of LDH patients was included as the dependent variable. The propensity score value was calculated by Logistic regression analysis, and then the patients in the two groups were ranked according to the propensity score value. Individuals with similar propensity score values in the OLM and PELD groups were matched according to the 1:1 ratio nearest neighbor matching method using SPSS 25.0 (IBM Corporation, Armonk, NY, USA) statistical software. The caliper value was set at 0.02.

Results

Comparison of Basic Characteristics between the Two Groups

A total of 150 patients were enrolled in the study before matching, including 100 in the PELD group and 50 in the OLM group. After excluding 86 cases with unsuccessful matching, a total of 64 cases were included in the study, with 32 cases in each group. After matching, there was no significant difference between the two groups in gender, age, education level, body mass index, medical insurance type, combined diseases, course of disease, lesion segment, Pfirrmann classification, LDH classification, degree of displacement, degree of adhesion, risk of dural tear, hardness of the herniated disc, or presence of spinal stenosis ($p > 0.05$), as detailed in Table 1.

Comparison of Surgical Indicators between the Two Groups

Compared with the OLM group, the PELD group had shorter incision length, shorter operation time, shorter postoperative ambulation time, shorter hospital stays, and less blood loss ($p < 0.05$), as shown in Table 2.

Table 4. Comparison of excellent-and-good recovery rate between the two groups [n (%)].

Group	Excellent	Good	Poor	Excellent-and-good rate
PELD group (n = 32)	19 (59.38)	12 (37.50)	1 (3.13)	31 (96.87)
OLM group (n = 32)	14 (43.75)	11 (34.38)	7 (21.87)	25 (78.13)
χ^2				5.143
p				0.023*

Note: * indicates the significance of the χ^2 test.

Table 5. Comparison of lumbar VAS scores between the two groups before and at different times after surgery ($\bar{x} \pm$ s, score).

Group	Before surgery	Three months after surgery	Six months after surgery	One year after surgery	Two years after surgery	Three years after surgery
PELD group (n = 32)	5.96 ± 0.68	3.62 ± 0.54	2.12 ± 0.40	1.98 ± 0.38	1.90 ± 0.32	1.68 ± 0.28
OLM group (n = 32)	6.05 ± 0.70	4.05 ± 0.56	2.70 ± 0.45	2.30 ± 0.42	2.04 ± 0.36	1.80 ± 0.30
t	0.522	3.127	5.449	3.196	1.644	1.654
p	0.604$^{\triangle}$	0.003$^{\triangle}$	0.001$^{\triangle}$	0.002$^{\triangle}$	0.105$^{\triangle}$	0.103$^{\triangle}$

Note: $^{\triangle}$ is the p value for the t test. VAS, visual analogue scale.

Comparison of Short-Term Postoperative Complications between the Two Groups

The incidence of short-term postoperative complications such as dural tear, wound infection, pressure ulcer, and lower extremity venous thrombosis in the PELD group was lower than that in the OLM group ($p < 0.05$), as shown in Table 3.

Comparison of Excellent-and-Good Recovery Rates between the Two Groups

The excellent-and-good recovery rate of the PELD group was higher than that of the OLM group at 3 months after operation ($p < 0.05$), see Table 4 for details.

Comparison of Lumbar VAS Scores between the Two Groups before and at Different Times after Surgery

Before operation, there was no significant difference in the lumbar VAS scores between the two groups ($p > 0.05$). The VAS scores of the PELD group were lower than those of the OLM group at 3 months, 6 months, and 1 year after operation ($p < 0.05$), and there was no significant difference between the two groups at 2 years and 3 years after operation ($p > 0.05$). See Table 5 for details.

Comparison of ODI Scores between the Two Groups before and at Different Times after Operation

Before operation, there was no significant difference in ODI scores between the two groups ($p > 0.05$). The ODI scores of the PELD group were lower than those of the OLM group at 3 months, 6 months, and 1 year after operation ($p < 0.05$), and there was no significant difference between the two groups at 2 years and 3 years after operation ($p > 0.05$), as shown in Table 6.

Comparison of WHOQOL-BREF Scores between the Two Groups before and 3 Years after Surgery

Before operation, there was no significant difference in WHOQOL-BREF scores between the two groups ($p > 0.05$). At 3 years after surgery, the WHOQOL-BRE scores for physiology and psychology in the PELD group were higher than those in the OLM group ($p < 0.05$), and there was no significant difference in the WHOQOL-BREF scores for environment and social relations ($p > 0.05$). See Table 7 for details.

Typical Cases

Figs. 1,2 shows the preoperative magnetic resonance imaging examination on the left posterior lumbar 5 (L5) sacral 1 (S1) intervertebral disc protrusion and nerve root compression. Fig. 3 shows the ventral protrusion of the nerve root into the nucleus pulposus during the operation. Fig. 4 shows nerve root release without compression after removal of the nucleus pulposus.

Discussion

In this retrospective cohort study, PELD had a higher rate of excellent-and-good recovery (96.87%) than OLM (78.13%), and a lower rate of short-term postoperative complications (3.13%) than OLM (18.75%). PELD shortened the operation time, and reduced surgical bleeding, postoperative pain, and dysfunction in patients with LDH. Moreover, it can promote postoperative recovery and improve the quality of life.

Shi H *et al.* [17] found that PELD had a smaller intraoperative incision, less blood loss and faster postoperative recovery compared with open surgery. The present study also found that the incision length of the PELD group was shorter than that of the OLM group, and that the intraop-

Table 6. Comparison of ODI scores between the two groups before and at different times after surgery ($\bar{x} \pm s$, score).

Group	Before surgery	Three months after operation	Six months after operation	One year after surgery	Two years after surgery	Three years after surgery
PELD group (n = 32)	28.70 ± 3.98	17.66 ± 3.25	12.90 ± 2.68	10.75 ± 2.10	10.48 ± 1.35	9.80 ± 1.02
OLM group (n = 32)	29.15 ± 4.04	21.38 ± 3.84	15.12 ± 2.75	12.16 ± 2.24	10.64 ± 1.42	9.95 ± 1.06
t	0.449	4.183	3.270	2.598	0.462	0.577
p	0.655△	0.001△	0.002△	0.012△	0.646△	0.566△

Note: △ is the *p* value for the *t* test. ODI, Oswestry Disability Index.

Table 7. Comparison of WHOQOL-BREF scores between the two groups before and 3 years after surgery ($\bar{x} \pm s$, score).

Group	Physiology		Psychology		Environment		Social relations	
	Before surgery	Three years after surgery	Before surgery	Three years after surgery	Before surgery	Three years after surgery	Before surgery	Three years after surgery
PELD group (n = 32)	46.30 ± 5.33	61.45 ± 4.42	47.74 ± 4.24	63.32 ± 4.38	50.32 ± 3.90	68.26 ± 5.12	51.58 ± 5.48	72.15 ± 5.56
OLM group (n = 32)	46.19 ± 5.28	57.72 ± 4.15	46.98 ± 4.30	59.96 ± 4.20	50.45 ± 3.84	67.88 ± 4.45	52.20 ± 5.35	71.80 ± 5.40
t	0.083	3.480	0.712	3.312	0.134	0.317	0.458	0.255
p	0.934△	0.001△	0.479△	0.003△	0.894△	0.752△	0.649△	0.799△

Note: △ is the *p* value for the *t* test. WHOQOL-BREF, World Health Organization Quality of Life-BREF.

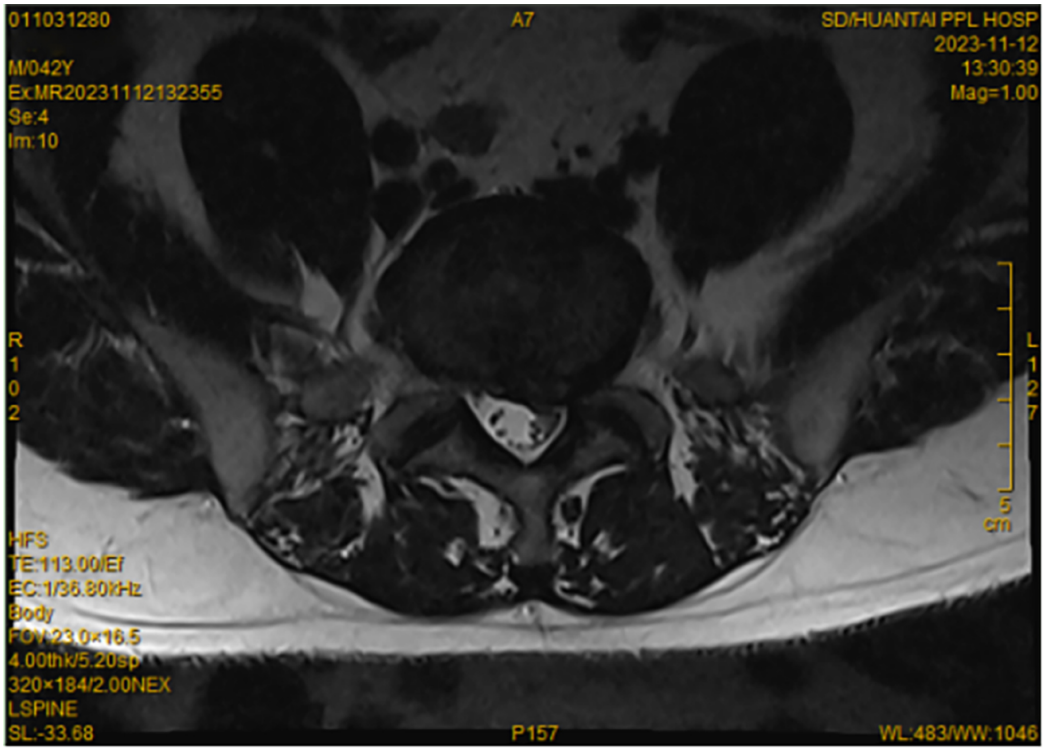

Fig. 1. Magnetic resonance imaging axial view of the left posterior lumbar 5 (L5)-sacral 1 (S1) intervertebral disc protrusion and nerve root compression.

erative blood loss was less than that of the OLM group. The reason is that during the PELD procedure, removal of the diseased intervertebral disc and release of the compressed nerve root can be completed under the endoscope. The surgeon can clearly identify the diseased intervertebral disc, compressed nerve root, and dura sac, and complete the operation efficiently with the help of small incision without damaging the normal spinal anatomical structure. This reduces unnecessary injury, thereby reducing intraoperative blood loss [18, 19, 20]. The postoperative am-

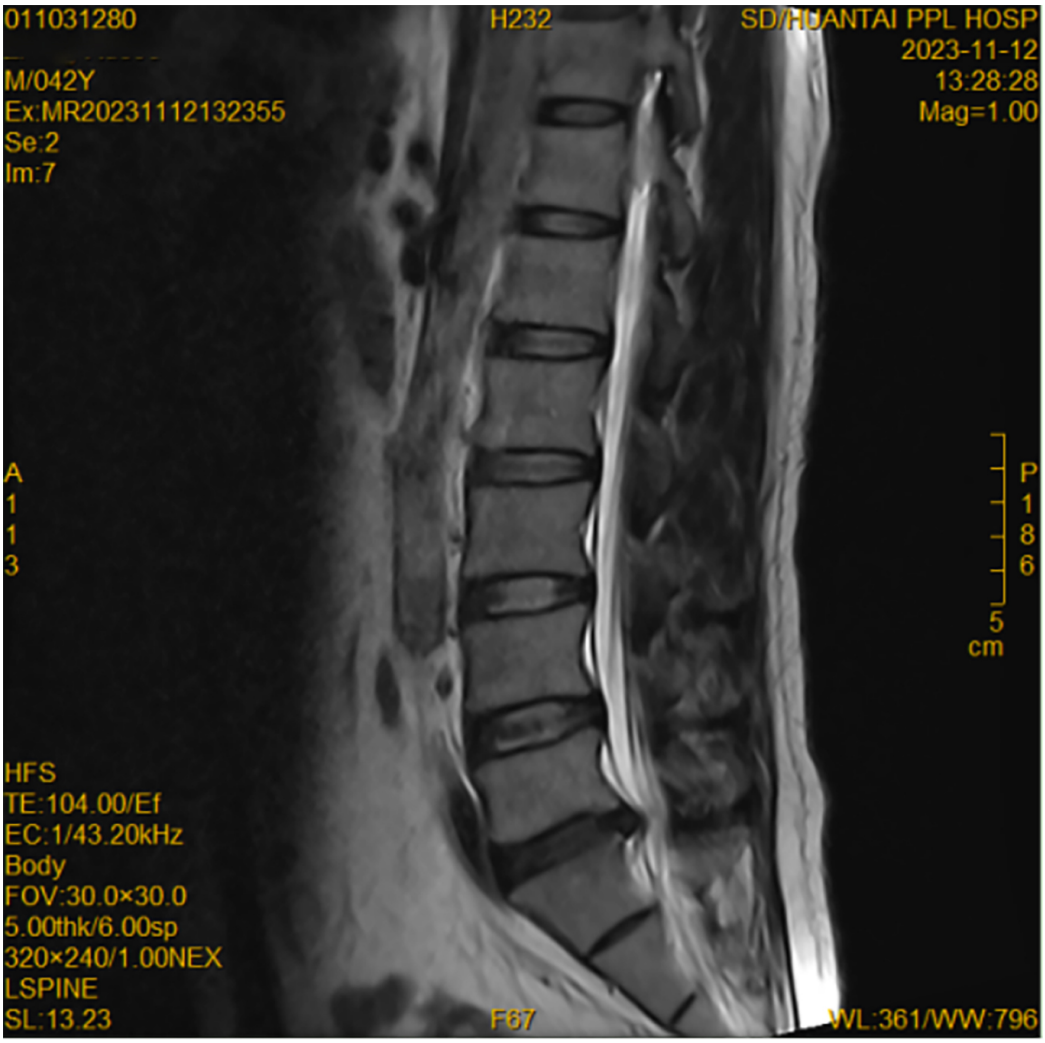

Fig. 2. Magnetic resonance imaging sagittal view of the left posterior L5-S1 intervertebral disc protrusion and nerve root compression.

bulation time and hospital stays in the PELD group were shorter than those in the OLM group, because the PELD group had shorter incision length, less intraoperative bleeding, and less injury, so the patients recovered more quickly after surgery. The operation time of the PELD group is shorter than that of the OLM group; the main reason is that the PELD procedure has a clearer intraoperative field of vision, which allows doctors to carry out surgical treatment more efficiently. The study by KONG L *et al*. [21] found that PELD had a lower incidence of postoperative complications than open surgery. The present study also found that the incidence of short-term complications in the PELD group was lower than that in the OLM group. The main reason is that PELD is performed under local anesthesia, and the lesion is directly viewed and treated through the endoscopic system, which reduces unnecessary soft tissue injury and postoperative complications. The study by LV J *et al*. [22] found that the postoperative recovery for PELD and open surgery was equivalent. However, the results of the present study showed that the excellent-and-good recovery rate of PELD group was higher than that of the OLM group at 3 months after surgery. The reason for the difference in the results of LV J *et al*.'s study [22] may be that the sample size was large and the patients were mostly older, whereas the sample size of this study was small and the patients were mostly middle-aged and elderly. PELD has a small incision and does not require dissection of the sacrospinal muscles behind the lumbar spine. Under the monitoring of the endoscope, the surgical field can be enlarged to ensure the smooth operation of the surgeon and improve the surgical effect [23, 24]. PELD has a better short-term recovery effect in the treatment of LDH patients.

LDH patients usually recover about 3 months after surgery. However, most of the existing studies involve only the short-term effect during the first several months after surgery, and there are few clinical reports on the mid-term and long-term effects. Therefore, the outcomes at 3 months, 6 months, 1 year, 2 years, and 3 years after surgery were analyzed in order to observe several time points. ZHU H *et al*. [25] found that PELD can reduce postoperative pain

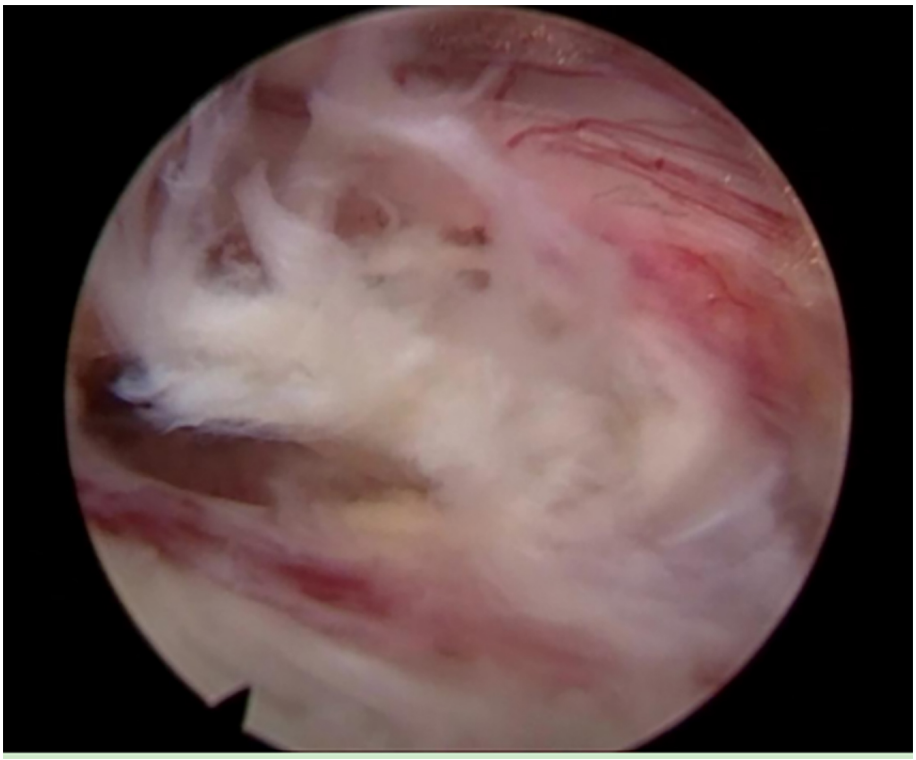

Fig. 3. Ventral protrusion of the nerve root into the nucleus pulposus during the operation.

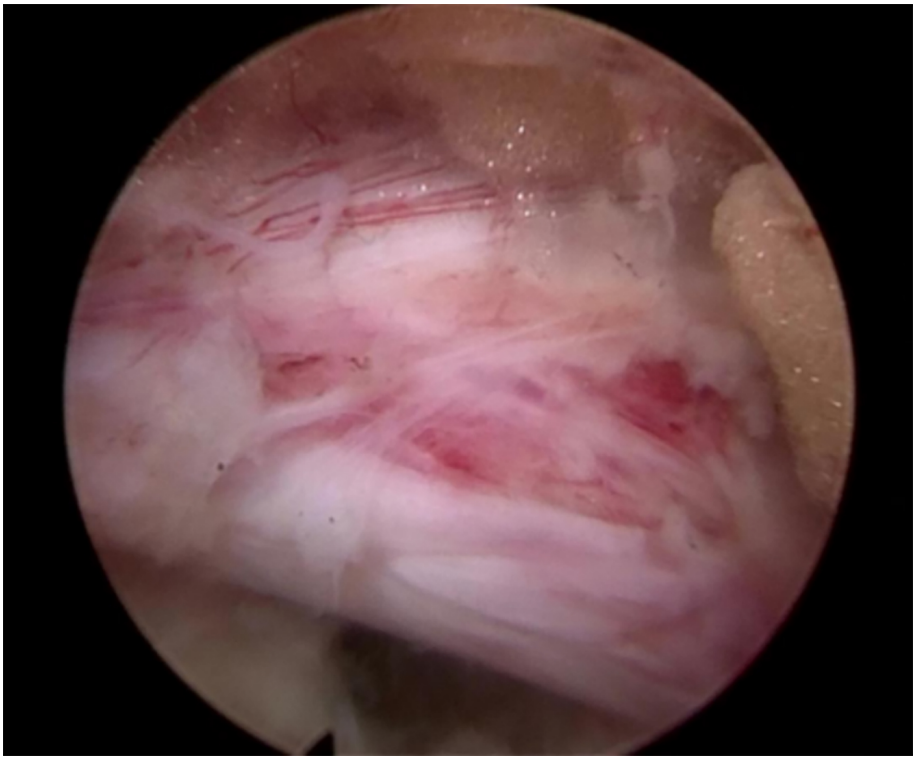

Fig. 4. Nerve root release without compression after removal of the nucleus pulposus.

and dysfunction, and improve the quality of life of patients compared with open surgery. The VAS and ODI scores of the PELD group were lower than those of the OLM group at 3 months, 6 months, and 1 year after surgery, suggesting that PELD has better mid-term effects on pain control and functional improvement in LDH patients. This is because PELD is less traumatic, and surgeons can locate and remove the intervertebral disc tissue more accurately, reducing the

damage to the surrounding normal tissue, thereby mitigating the postoperative pain and discomfort. The recovery period after PELD is faster, and patients can get out of bed earlier and carry out functional exercise to improve their dysfunction [26, 27]. The WHOQOL-BREF scores of physical and psychological aspects in PELD group were higher than those in the OLM group at 3 years after surgery, suggesting that PELD treatment of LDH patients has better long-term quality of life. The main reason is that PELD can reduce pain and improve dysfunction, and patients can also gradually increase their activity through rehabilitation exercise, and slowly return to normal work and life, thus improving their quality of life [28, 29, 30].

A strength of this study was the analysis of short-term, midterm, and long-term effects of PELD versus OLM in the treatment of LDH patients. Specifically, we evaluated the efficacy, complications, and quality of life of LDH patients at 3 months, 6 months, 1 year, 2 years, and 3 years after surgery, which is critical for understanding the clinical outcome of PELD more comprehensively. An improved understanding of the efficacy and safety of PELD in the treatment of LDH will provide a more powerful basis for clinical practice.

This article still has limitations: First, this study only selected patients with LDH who underwent surgery in our hospital within a specific time frame, which may limit the generalizability of the findings. Second, this study adopted a retrospective cohort study design, which could not completely control for potential confounding factors. However, we were able to match the two groups based on key baseline characteristics. Third, in this study, the imaging indicators and long-term recurrence rates of the two groups were not statistically analyzed; thus, the conclusions obtained are not comprehensive. Future studies can make up for these limitations through more elaborate design and multicenter studies.

Conclusions

In conclusion, this retrospective study comparing PELD with OLM for the treatment of LDH demonstrates that PELD offers several advantages. PELD results in shorter incision length, reduced surgical time, shorter postoperative recovery time and hospital stays, reduced blood loss, lower rate of short-term complications, and lower postoperative pain and functional impairment scores compared to OLM. Additionally, PELD exhibits higher rates of short-term excellent recovery and better quality-of-life scores at the 3-year follow-up. These findings suggest that PELD is a favorable option for LDH patients to enhance the short-term recovery outcomes, reduce short-term complication rates, improve pain control ability and function in the medium term, and ultimately, improve long-term quality of life.

Availability of Data and Materials

The datasets used and analyzed during the current study were available from the corresponding author on reasonable request.

Author Contributions

SG, TW and YLW designed the research study. SG, JZ and SW performed the research. SG and YXW analyzed the data. SG wrote this article. All authors revised the manuscript critically for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Huantai County People's Hospital (LP2024-3-01), and the data of this study were obtained through the hospital's case system records. Since all patients' identifying information was confidential, the requirement for informed consent was waived by Huantai County People's Hospital. Furthermore, this study adhered to the tenets of the Declaration of Helsinki.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

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