ORIGINAL RESEARCH

Risk Factors Involved in the Early and Medium-Term Poor Outcomes of Percutaneous Endoscopic Transforaminal Discectomy: A Single-Center Experience

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Objective: To investigate the risk factors involved in the early and medium-term poor outcomes of percutaneous endoscopic transforaminal discectomy (PETD) treatment of lumbar disc herniation (LDH) at the L4-5 level.

Methods: Between January 2015 and May 2020, we recruited 148 LDH patients at the L4-5 level who underwent PETD surgery. The patients were divided into Groups A and B, according to the surgical outcomes. Good and excellent outcomes were categorized into Group A, and generally good and poor outcomes were categorized into Group B. Clinical parameters (age, gender, symptom duration, hospital stay, operation time, blood loss, straight-leg raising (SLR), visual analog scale (VAS), Oswestry Disability Index (ODI) score and modified MacNab criteria) and radiologic parameters (foraminal height (FH), intervertebral height index (IHI), intervertebral angle (IVA), sagittal range of motion (sROM), and lumbar lordosis (LL)) were collected and analyzed using univariate and multiple logistic regression analyses.

Results: At the 6-month follow-up post operation, univariate analysis revealed that the symptom duration, SLR, IHI, and sROM were strongly associated with poor outcomes. However, multiple logistic regression analysis demonstrated that prolonged symptom duration, large SLR angel, and large sROM were independent risk factors for poor outcomes. At the 2-year follow-up post operation, univariate analysis suggested that advanced age, prolonged symptom duration, large preoperative VAS score, small FH, small IHI, and large sROM were potential risk factors for poor outcomes. However, multiple logistic regression analysis demonstrated that prolonged symptom duration, small IHI, and large sROM were independent risk factors for poor outcomes.

Conclusion: Our study demonstrated that prolonged symptom duration, large SLR angel, and large sROM were independent risk factors for poor outcomes immediately following PETD at the L4-5 level. However, prolonged symptom duration, small IHI, and large sROM were independent risk factors for poor outcomes at medium-term post PETD at the L4-5 level.

Keywords: percutaneous endoscopic transforaminal discectomy, risk factors, lumbar disc herniation, early and medium-term, surgical outcomes

Introduction

Since the introduction of the contemporary endoscopic discectomy proposal in 1986 by Kambin,[1] percutaneous endoscopic lumbar discectomy (PELD) is widely used to treat various types of lumbar intervertebral disc herniation, with favorable clinical outcomes.[2–4] The main advantages of PELD include local anesthesia, minimal tissue destruction, favorable outcomes, rapid recovery, and minimal invasion.[5–8] Although prior investigations revealed that PELD achieves satisfactory clinical efficacy,[2,4–8] literature reports and our own experiences revealed that a small number of patients still suffer from pain and disability after PELD, and some patients even require secondary surgery.[9–12] The Sang study reported that following PELD, 9.6% patients undergo revision surgery on the same segment, and 26.6% undergo revision

surgery on other segments.[13] The risk factors governing poor outcomes following PELD were previously analyzed in multiple literatures.[12,14] However, few literatures analyzed the influence of biomechanical factors after PETD. This, in fact, is of great significance to the complete understanding of the poor curative effect of PELD.[14] Studies revealed that some common radiological parameters, such as, foraminal height, intervertebral angle, and sagittal range of motion (sROM) are related to spinal instability.[14] Spinal instability is more likely to lead to biomechanical alterations within the affected intervertebral disc, which may be related to poor outcomes. In addition, it was reported that lumbar lordosis and intervertebral height index are related to low back and leg pain after PELD. Therefore, we investigated whether the radiologic risk factors, foraminal height, intervertebral height index, intervertebral angle, sagittal range of motion, and lumbar lordosis, influence poor outcomes after PETD. Given that the recurrent L4-5 segment disc herniation incidence is relatively high, compared to other segments,[15,16] the purpose of our study was to investigate the risk factors involved in the early and medium-term poor outcomes of percutaneous endoscopic transforaminal discectomy (PETD) treatment of lumbar disc herniation (LDH) at the L4-5 level.

Patients and Methods
Study Population

This study included 148 patients with LDH, who were treated via PETD between January 2015 and May 2020. All patients included in this study were of various types of lumbar disc herniation, which followed the surgical indications of PETD. We separated all patients into two distinct groups, based on their surgical outcomes (modified MacNab criteria) following surgery: Group A included patients who expressed good and excellent outcomes. Group B included patients who showed generally good and poor outcomes. This study was approved by the Human Research Ethics Council at our hospital. All patients provided written informed consent for treatment, data collection, and analysis.

The inclusion criteria were as follows:

1. Single segment LDH (L4/5) was confirmed by magnetic resonance imaging (MRI) and computed tomography (CT) scan, which was consistent with the corresponding symptoms and signs;
2. Unresponsive to conservative measures for a minimum of 6 weeks;
3. A follow-up period of at least 24 months was obtained.

The exclusion criteria were as follows:

1. Previous history of L4/5 surgery or other spinal surgery;
2. Congenital spinal dysplasia, spinal tumor, infection, and fractures;
3. Preoperative dynamic radiographs demonstrate intervertebral instability;
4. Severe spinal stenosis;
5. Multiple segments of LDH.

Surgical Technique

All operations were conducted under local anesthesia. Patients were placed in the lateral decubitus position on a special bed used for fluoroscopic spinal injection. The median line of the spinous process and the contour line of the iliac bone were marked on the body surface prior to the operation. The surgical site was disinfected, and local anesthesia was provided at the entrance of the needle entry point, which was about 8–14 cm lateral to the spine midline. Next, an 18G needle was inserted, with the entry point on the lateral edge of the paravertebral muscle, under fluoroscopic guidance. Figure 1A depicts the anteroposterior fluoroscopic view of the standard point of the initial needling on the medial pedicular line. Figure 1B reveals the lateral fluoroscopic view of the standard point of the initial needling, which was the surface of the superior articular process (SAP). Subsequently, the needle was removed and replaced with guidewire, and a working channel was inserted, according to the guidewire (Figure 1C-E). Using bipolar radiofrequency and endoscopic forceps, we next cleared the soft tissues in the working-channel, and removed the unnecessary nucleus pulposus tissue, under continuous liquid flow of 0.9% saline solution. The goal of this surgery was to ensure
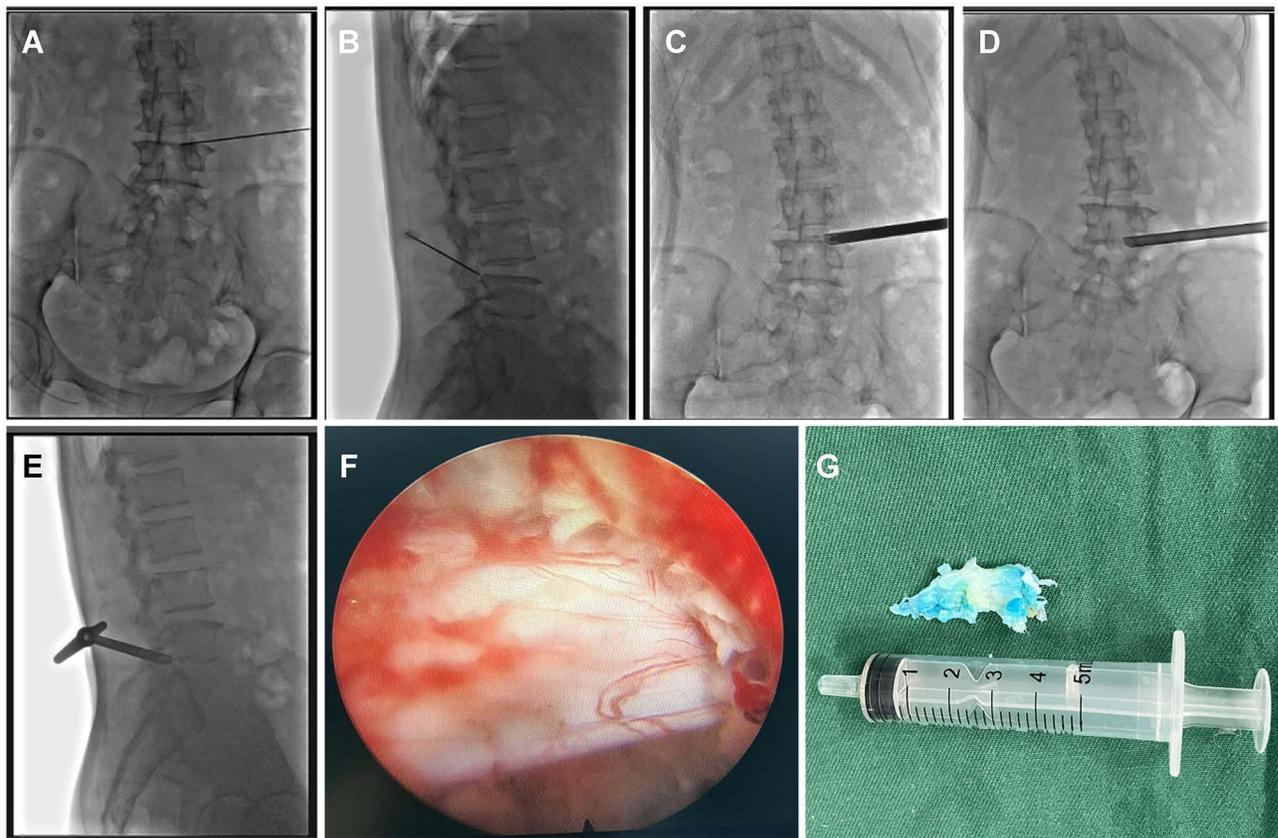
Figure 1 (**A**) The anteroposterior fluoroscopic view of the standard point of the initial needling on the medial pedicular line. (**B**) Reveals the lateral fluoroscopic view of the standard point of the initial needling, which was the surface of the superior articular process (SAP). (**C-E**) A working channel was inserted, according to the guidewire. (**F**) The nerve roots were fully exposed, and the pulsation was adequate. (**G**) The nucleus pulposus tissue was extracted.

that the nerve roots were fully exposed, and the pulsation was adequate (Figure 1F). Finally, the working channel and endoscope were removed, the skin was closed, and the nucleus pulposus tissue was extracted (Figure 1G).

Outcomes Measurements

Clinical Measurements

Clinical outcomes were evaluated using the visual analog scale (VAS), the Oswestry Disability Index (ODI) score, and the modified MacNab criteria. The general clinical data of patients (age, gender, symptom duration, hospital stay, operation time, blood loss, straight-leg raising) was collected and analyzed.

Blood Loss

The intraoperative bleeding volume mainly included three categories (blood loss during puncture, blood loss during channel placement, and blood loss with the endoscope). Blood loss during puncture and channel placement was collected via a syringe, and the blood loss with endoscope was determined by surgeon through the penetration degree of blood in gauze and drainage-fluid color.

Visual Analogue Score (VAS)

The VAS score system (score from 0 to 10) is widely used to assess the degree of low back and leg pain. A score of 0 represents no pain; 1–3 represents slight pain that the patient can endure; 4–6 represents that the patient is in pain that can be endured, and the patient can sleep; and 7–10 indicates intolerable pain.

Oswestry Disability Index (ODI)

ODI is widely used to assess patient progress during routine clinical practice. The system includes 10 sections: pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life and traveling. For each section of six statements the total score is 5. If all 10 sections were completed, the score was calculated as follows: patient score out of total possible score × 100. If one section was missed (or not applicable) the score was calculated as: (total score/(5 × number of questions answered)) × 100%.

Modified MacNab Criteria

The modified MacNab criteria is widely used to evaluate the surgical effect. Excellent represents no pain, no restriction of mobility, the patient can return to normal work and activity levels. Good represents occasional nonradicular pain, relief of presenting symptoms, the patient can return to modified work. Generally, good represents some improvement in functional capacity, but the patient remains handicapped and/or unemployed. Poor represents continuing root symptoms, requiring additional operative intervention at the index level, regardless of the length of postoperative follow-up period.

Imaging Parameter Measurements

1. Foraminal height (FH) was measured by the distance between the inferior edge of the upper pedicle and superior border of the lower pedicle.
2. According to a study by Koji Akeda et al, the intervertebral height index (DHI) was calculated as intervertebral height index (IHI)= $[(A + C)/(B + D)] \times 100$, A, anterior disc height, C, posterior disc height, B, superior disc depth, D, inferior disc depth.[17]
3. The intervertebral angle (IVA) was measured by the intersection angle between the inferior and superior endplate of the intervertebral disc; if the angular intersection located in the dorsal lumbar spine was marked as positive, then, the ventral part was marked as negative.
4. The sagittal range of motion (sROM) of L4-5 was defined as the sum of absolute value of the hyperflexion and hyperextension angles.
5. Lumbar lordosis (LL) was measured by the intersection angle between the superior endplate of S1 and the upper endplate tangent of L1.

All measurements were performed by 2 senior spinal surgeons. A schematic diagram of the measurement method is presented in Figures 2 and 3.

Statistical Analyses

Statistical analyses were performed using the SPSS 26.0 software. The variables are presented as the mean ± standard deviation (SD). Paired *t*-test was used for intra group comparison. Independent sample *t*-test and chi square test were used for univariate analysis. Multiple logistic regression analysis was used to identify independent risk factors for poor outcomes. *P* value <0.05 was defined as statistically significant.

Results

Overall, we recruited 148 patients for this investigation. Compared to before surgery, the VAS and ODI scores were markedly improved at all follow-up time points (Table 1). The excellent and good rates of the modified Macnab criteria were 84.46% and 83.11% at the 6-month and 2-year follow-ups post operation, respectively (Table 1). Table 2 summarizes the parameter differences between Groups A and B at the 6-month and 2-year follow-ups post operation.

The 6-Month Follow-Up results Post PETD

Table 2 summarizes the results of the univariate analyses examining both clinical parameters and radiologic biomechanical information from before operation and at the 6-month follow-up post PELD. Based on our results, the symptom duration (P = 0.006), straight-leg raising (SLR) (P = 0.002), intervertebral height index (IHI) (P = 0.018), and sagittal range of motion (sROM) (P = 0.002) were strongly associated with poor outcomes at the 6-month follow-up post
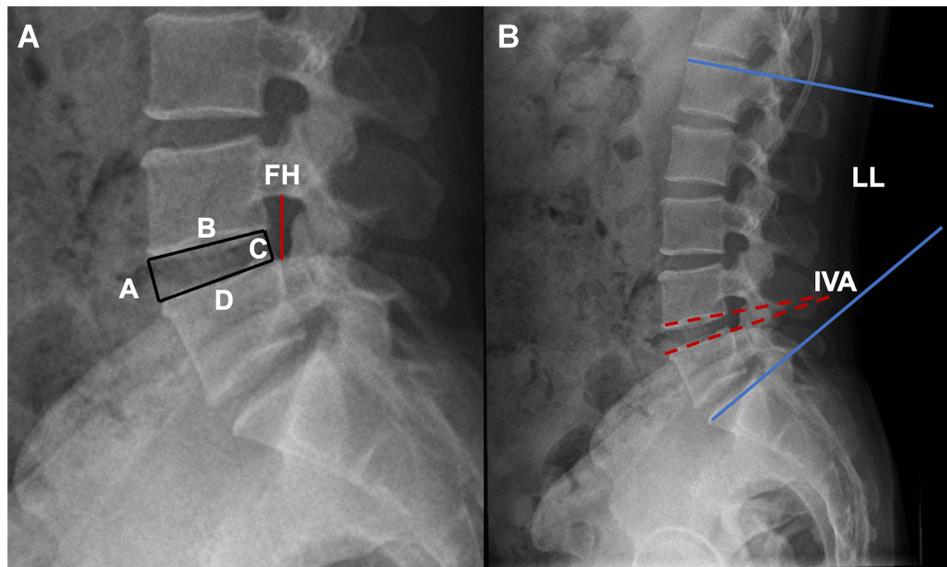
Figure 2 Radiographic measurement of IHI, FH, IVA and LL. (**A**) The intervertebral height index (IHI)= [(A + C)/ (B + D)] × 100, A, anterior disc height, C, posterior disc height, B superior disc depth, D inferior disc depth. (**A**) Foraminal height (FH) was measured by the distance between the inferior edge of the upper pedicle and superior border of the lower pedicle. (**B**) The intervertebral angle (IVA) was measured by the intersection angle between the inferior and superior endplate of the intervertebral disc; if the angular intersection located in the dorsal lumbar spine was marked as positive, then, the ventral part was marked as negative. (**B**) Lumbar lordosis (LL) was measured by the intersection angle between the superior endplate of S1 and the upper endplate tangent of L1.
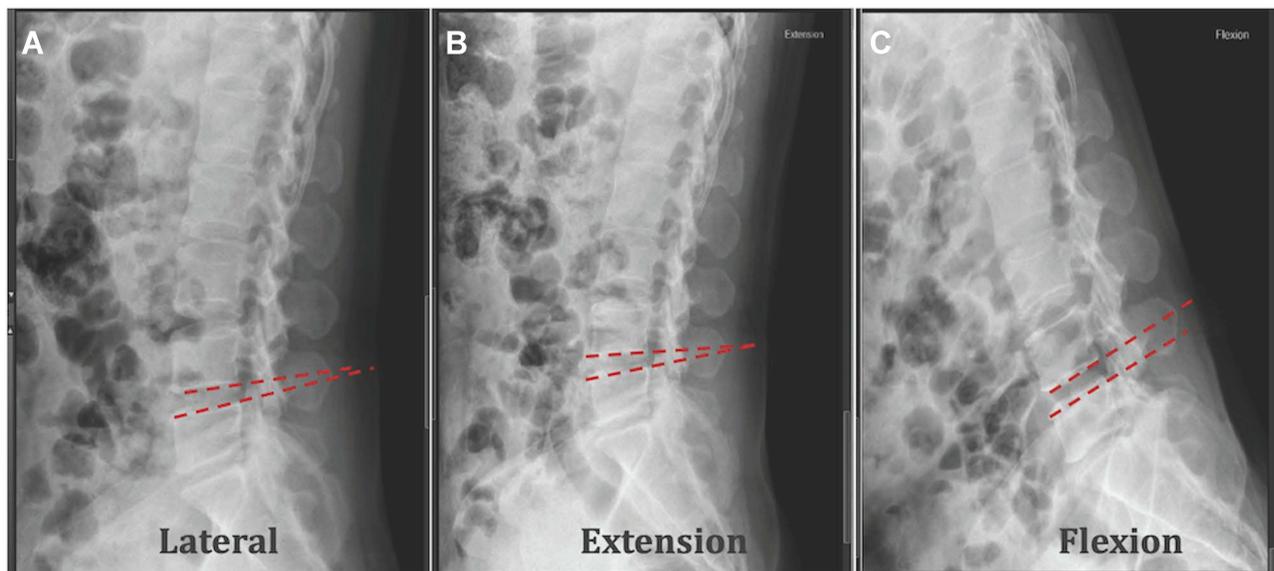

Figure 3 (**A**) Normal lateral measurement IVA. (**B** and **C**) The sagittal range of motion (sROM) of L4-5 was defined as the sum of absolute value of the hyperextension and hyperflexion angles.

operation (Table 2). Using multivariate analysis, we analyzed the variables that proved significant in univariate analysis, namely, symptom duration, SLR, IHI, and sROM (Table 3). Our multiple logistic regression analyses revealed that prolonged symptom duration (P = 0.003), large SLR angel (P = 0.031), and large sROM (P = 0.024) were independent risk factors for poor outcomes at the 6-month follow-up post operation.

The 2-Year Follow-Up Results Post PETD

Our univariate analysis revealed that the advanced age (P = 0.047), prolonged symptom duration (P = 0.007), large preoperative VAS score (P = 0.038), small foraminal height (FH) (P = 0.018), small IHI (P = 0.011), and large

Table 1 Comparison of VAS, ODI, and Macnab Score Among Before Operation, 1 Week, 6 Months and 2 Years After Operation

Parameter	Mean (SD)	t	P
VAS			
Pre- operation	7.24±0.06		
Post- operation 1 week	2.11±0.05	71.30	< 0.001
Post- operation 6 months	2.20±0.09	44.45	< 0.001
Post- operation 2 years	1.98±0.11	39.66	< 0.001
ODI (%)			
Pre- operation	76.07±0.37		
Post- operation 1 week	17.76±3.87	120.39	< 0.001
Post- operation 6 months	16.69±0.76	70.85	< 0.001
Post- operation 2 years	14.95±0.95	59.61	< 0.001
Macnab score	Post- operation 6 month		Post- operation 24 month
Excellent	18		69
Good	107		54
Fair	18		12
Poor	5		13
Satisfactory (excellent or good) results	84.46%		83.11%

Abbreviations: VAS, Visual analog scale; ODI, Oswestry disability index; SD, standard deviation.

Table 2 Summarizes the Differences in Parameters Between Groups A and B at the 6-Month and 2-Year Follow-Ups Post Operation

	Post-op 6 Months			Post-op 2 Years		
	Group A (n=125)	Group B (n=23)	P	Group A (n=123)	Group B (n=25)	P
Gender (M:F)	40:85	8:15	0.793	39:84	9:16	0.676
Age (Y)	47.96±1.46	47.52±2.78	0.903	46.73±1.41	53.60±3.15	0.047
Symptom duration (mon)	27.83±2.50	61.00±10.84	0.006	27.88±2.56	58.10±10.07	0.007
Hospital stay (day)	2.90±0.20	2.61±0.31	0.538	2.89±0.20	2.72±0.28	0.720
Operation time (min)	58.80±0.54	59.35±1.76	0.768	58.98±0.56	58.40±1.49	0.681
Blood loss (mL)	48.36±0.43	46.74±1.20	0.142	48.01±0.45	48.60±0.89	0.580
Pre-op VAS	7.27±0.63	7.04±0.18	0.170	7.29±0.65	6.96±0.15	0.038
SLR (°)	44.88±1.36	53.70±2.25	0.002	46.10±1.38	47.00±2.57	0.783
FH (mm)	1.69±0.33	1.59±0.46	0.077	1.70±0.03	1.52±0.07	0.018
IHI	27.68±0.38	25.44±0.75	0.018	27.73±0.37	25.40±0.82	0.011
IVA (°)	6.45±0.43	7.50±0.82	0.324	6.37±0.41	7.83±1.00	0.156
sROM (°)	10.43±0.41	13.57±0.74	0.002	10.24±0.38	14.28±1.00	0.000
LL (°)	31.82±1.26	37.58±2.88	0.072	32.55±1.20	33.55±3.56	0.791

Abbreviations: SLR, Straight-leg raising; FH, Foraminal height; IHI, Intervertebral height index; IVA, Intervertebral angle; sROM, sagittal range of motion; LL, lumbar lordosis; Pre-op VAS, Preoperative Visual analog scale.

sROM (P < 0.001) were potential risk factors for poor outcomes at the 2-year follow-up post PETD (Table 2). Based on this univariate analysis, there were no significant correlations between poor outcomes and risk factors, such as, gender, hospital stay, operation time, blood loss, SLR, intervertebral angle (IVA), and lumbar lordosis (LL) (P > 0.05, Table 2). Using multiple logistic regression analysis, we revealed that prolonged symptom duration (P = 0.023), small IHI (P = 0.009), and large sROM (P = 0.004) were independent risk factors for poor outcomes at the 2-year follow-up post operation (Table 3).

Table 3 Summarizes the Independent Risk Factors for Poor Outcomes at the 6-Month and 2-Year Follow-Ups Post Percutaneous Endoscopic Transforaminal Discectomy

	Post-op 6 Month			Post-op 2 Year		
	OR	95% CI	P	OR	95% CI	P
IHI	0.884	0.777—1.005	0.059	0.834	0.728—0.955	0.009
FH				0.857	0.135—5.421	0.870
sROM	1.147	1.018—1.293	0.024	1.220	1.064—1.400	0.004
Age				1.012	0.977—1.050	0.500
Symptom duration (mon)	1.023	1.008—1.038	0.003	1.018	1.002—1.033	0.023
Pre-vas				0.505	0.244—1.045	0.066
SLR (°)	1.043	1.004—1.084	0.031			

Abbreviations: IHI, Intervertebral height index; FH, Foraminal height; sROM, sagittal range of motion; Pre-op VAS, Preoperative Visual analog scale; SLR, Straight-leg raising.

Discussion

With the continuous development of minimally invasive spinal surgery technology, PELD has gradually become a common procedure for treating LDH.[6,18,19] This is likely due to the associated reduced muscle injury and bleeding, diminished scar formation in the spinal canal, and relatively short hospital stay.[5–8,20,21] In total, 148 cases of LDH, who were treated with PETD, were analyzed in this study. The VAS and ODI scores of all patients improved significantly at each follow-up, compared to the preoperative values (Table 1). According to the modified Macnab standard, the overall optimal surgery rate was 81.60% at the 6-month follow-up post PETD, and 83.11% at the 2-year follow-up post PETD, which corroborated with earlier published reports.[6,18,22] Although PELD achieves favorable clinical outcomes, and is minimally invasive in treating LDH,[7,20,21,23] our current study reported over 10% of patients with unsatisfactory clinical outcomes in the early and medium-term follow-ups post operation. Prior literature evaluated the relevant risk factors of poor outcomes following PELD.[12,14] However, limited literatures analyzed the influences of biomechanical factors, which are crucial to the complete understanding of poor curative effect following PELD.[14] In this study, we evaluated the poor outcomes following PETD, particularly, in relation to radiologic parameters (FH, IHI, IVA, sROM, and LL), as well as clinical parameters (age, gender, symptom duration, hospital stay, operation time, blood loss, SLR, and VAS).

Herein, we revealed that both prolonged symptom duration and large sROM are independent risk factors for poor outcomes in the early and middle-term follow-ups post operation. In addition, large SLR angle is an independent risk factor for poor outcomes in the early term follow-up post operation, whereas, smaller IHI is an independent risk factor for poor outcomes in the middle-term follow-up post operation.

Multiple studies discussed the effect of symptom duration on the lumbar discectomy efficacy.[24–27] The Bailey study demonstrated that patients with symptoms that last over a year exhibited higher ODI scores at the 6- (P < 0.01) and 12-month (P < 0.05) follow-ups post operation, compared to patients with symptoms that last less than a year. However, there was no difference at the 2-year follow-up post operation.[26] The authors speculated that the symptoms that lasted over 12 months likely resulted in delayed improvement.[26] In our study, prolonged symptom duration was an independent risk factor for poor efficacy in the early and middle-term follow-ups post PETD. We speculated that even though the materials compressing the nerve were removed, the key period for the recovery of the lower back and leg pain fell within the 6-month time point following PELD.[24] In case of patients with longer preoperative symptoms, the functional recovery was slow during this period, and, therefore, it was difficult to recover fully from the LDH symptoms. Hence, at the 6-month follow-up post operation, there were still residual numbness, weakness or other non-painful symptoms related to the long-term nerve compression, which still affected function.[24] Residual numbness and weakness are primarily related to the distal deformation and demyelination of nerve fibers, and it requires a long rehabilitation time. Therefore, during postoperative follow-up, patients usually have long-lasting numbness and/or weakness following pain relief.[28] Naturally, early surgical intervention is advocated for the treatment of lumbar disc herniation, which will contribute to the postoperative functional recovery and shortened disability period.

Previous studies examining the relationship between PELD clinical outcomes and SLR revealed that patients with positive SLR achieved better PELD outcomes, compared to patients with negative SLR.[29] A positive SLR indicates that the nerve root is compressed by the intervertebral disc protrusion or that it adheres to the surrounding tissue, which can, in turn, enhance nerve root tension, and produce radiating pain during straight lifting.[30,31] Prior studies suggested that the nerve root blood flow decreases significantly when SLR is positive. Following discectomy, however, the blood flow increases significantly.[31] The Patel study reported that SLR positive patients, particularly those with dominant leg pain, achieve better prognosis after PELD surgery, and are, therefore, considered good candidates for PELD.[32] Our research conclusions strongly coincided with this study, and showed that the large SLR angle was an independent risk factor for poor efficacy in the early term follow-up post PELD. Our results demonstrated that PELD for lumbar disc hernia is more beneficial in patients with smaller SLR angle. Therefore, careful physical examination prior to operation is highly necessary.

A large sROM represents high disc pressure, and indicates insufficient intervertebral space stability.[33] The sROM value is more than just a radiological measurement parameter. In fact, it can also indirectly reflect the state of muscles, lumbar facets, and the intervertebral space.[33–35] It was reported that weakness and enhanced fat infiltration of back paravertebral muscles leads to spinal instability, and a high sROM value, which is an important factor governing poor postoperative outcomes.[36] In cases when the facet joint structure is altered due to injury, degeneration, or spinal surgery, its function becomes impaired, which, in turn, results in the decline of spinal stability while increasing sROM.[37] Hasegawa speculated that the stability of moderately degenerated intervertebral disc segments is worse than the stability of severely degenerated disc segments, and it can lead to spinal collapse.[38] Therefore, a large sROM represents that the paravertebral muscle, intervertebral disc, and facet joint have all degenerated, which severely impacts the curative effect of PETD surgery. In our study, sROM was demonstrated to be an independent risk factor for poor efficacy in the early and middle-term follow-up post PETD. We speculated that this phenomenon occurred due to the following reasons: First, PETD could not sufficiently enhance spinal stability. Second, some patients did not exercise for a long time after surgery. Thus, they experienced a decline in lumbar muscle strength. Third, most patients returned to normal life and work without the use of a lumbar protective device. Taken together, a large sROM can easily cause spinal instability, which may induce postoperative lower back pain, and even recurrence. Therefore, before PELD surgery, routine X-ray examination of lumbar hyperflexion and hyperextension should be advocated. Patients with a large sROM angle would benefit more from open surgery than PELD.

Intervertebral height (IH) is a parameter that reflects the height of the intervertebral disc and cartilage endplate. Prior investigations suggested that a loss in IH is strongly related to LDH.[39,40] Studies reported that the reduction and collapse of IH is significantly associated with an acute or chronic dysfunction of the lumbar spine.[41] In addition, it was reported that a decrease in IH following lumbar discectomy may be an important contributing factor for long-term back and leg pain.[40,42] At present, there are numerous ways to measure IH,[43–45] however, there is no consensus on the ideal technique for IH measurement since IH is affected by varying population, age, gender, body mass index (BMI), magnification, and position of patient during scan.[46,47] This lack of unified standards can introduce significant differences between researchers, and even within the same study. In order to conduct extensive research with accurate IH measurement, a simple and repeatable technique is required for the measurement of IH. Therefore, here, we introduced a more appropriate parameter, IHI. Previous studies reported that IHI has great stability and measurement consistency, which helps to minimize differences in overall size between subjects.[46,47] Moreover, the age, spine size, and position of patients do not affect the final measurement, which allows IHI to perform a reliable analysis.[46–48] It is generally accepted that, after discectomy, IH decreases over time.[49] The average IH decreases by 11.2% within the first 12-month post operation, and further decreases by 16.6% by the 60-month follow-up post operation.[49,50] A smaller IHI represents a greater possibility of postoperative neuro-foramen and spinal canal stenosis. This may affect the postoperative VAS pain and ODI disability scores, thereby, affecting the overall quality of life of patients. In addition, a small IHI can increase the load of small joints, which may be another reason for the poor postoperative efficacy of PELD patients.[43] In our study, IHI was an independent risk factor for poor efficacy in the middle-term follow-up post operation; however, it was not an independent risk factor in the early term follow-up post PELD. This phenomenon can be explained by the fact that the early loss of intervertebral space after PELD was not obvious enough to cause symptomatic neuro-foramen

and spinal canal stenosis. With the extension of follow-up time, the loss of intervertebral space became more obvious, and the biomechanics of the spine changed. Therefore, the load of small joints increased, thus increasing the post-operative pain score. Patients with smaller IHI prior to operation were, therefore, more likely to develop symptomatic neuro-foramen and spinal canal stenosis during the middle postoperative period, which was the primary reason for the dissatisfaction of postoperative outcomes. We suggest that clinicians pay more attention to the IHI value before PELD surgery. Patients with low IHI should be more cautious about receiving PELD surgery, and they must be monitored closely after surgery.

Previous studies reported a correlation between advanced age and poor PELD outcomes. As such, age is considered a susceptibility factor for postoperative recurrence of LDH.[51–53] The nucleus pulposus of elderly patients contains less water and has poor elasticity. Hence, most elderly patients display annular collagen alterations and annular tears within the intervertebral discs. Therefore, the healing and reconstruction of the external annulus following surgical intervention is worse in the elderly, compared to young adults.[54,55] However, there are contradictory reports that suggest that age is not a predictor of poor PTED outcomes.[56] In the early term follow-up post PELD, our univariate analysis revealed that there was a significant relationship between age and poor efficacy, but our multivariate regression analysis revealed that the age was not a significant factor. This result, however, may be due to unintentional selection bias.

In terms of biomechanical analysis, small or negative ISA and LL values represent a heavy front spinal load, and relatively wide posterior intervertebral space. When the residual intervertebral disc tissue becomes compressed by the forward spinal pressure, the nucleus pulposus tissue of patients with small or negative IVA and LL values tend to move backward from its original position, and become extruded from the rupture of annulus fibrous.[14] In our study, the poor postoperative efficacy of L4-5 level LDH was not significantly correlated with small IVA and LL values, which was inconsistent with previous publications. This phenomenon may be related to our relatively short follow-up time, but may also be related to our routine recommendation that patients maintain an upright head position following surgery. This posture allowed the IAV to become positive, while reconstructing part of the LL, which successfully prevented the nucleus pulposus from moving backward.

Theoretically, a smaller FH value prior to operation may be more likely to cause nerve root compression and damage to the benefits of PELD decompression. However, the Toop study reported that the FH reduction did not produce a negative impact on the clinical outcomes or quality of life scores.[57] At the 2-year follow-up, our univariate analysis revealed a significant relationship between FH and poor efficacy, however, our multiple regression analysis exhibited no significant difference. Thus, it was speculated that FH does not truly represent neuro-foramen stenosis. Neuro-foramen stenosis may only occur when the FH reduction is very serious, and this may lead to patient dissatisfaction with decompression. Hence, based on our analyses, the preoperative FH was not an independent risk factor for poor PELD efficacy in our study.

This study had several intrinsic defects. First, the number of dissatisfied cases was relatively small, and this was a single-center retrospective study. Second, the follow-up time was relatively short. Third, the overall spinal parameters, such as, spinal kyphosis (TK), distance from the C7 plumb line (C7PL) to the central sacral vertical line (CSVL), and the sagittal vertical axis (SVA) were not analyzed. Therefore, it is necessary to conduct prospective studies, with a larger sample of unsatisfactory cases and longer follow-up period, to validate all the risk factors of poor efficacy post PELD in the future.

Conclusions

This study revealed that both prolonged symptom duration and large sROM were independent risk factors for poor outcomes in the early and middle-term follow-ups post PETD. Large SLR angle was an independent risk factor for poor outcomes in the early term follow-up post PETD. Alternately, small IHI was an independent risk factor for poor outcomes in the middle-term follow-up post PETD. Understanding these risk factors can facilitate physicians to better communicate with patients during the pre-, intra-, and postoperative periods, and aid in the selection of appropriate patients for PETD surgery.

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Disclosure

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