

## Original Article

# Outcomes and safety of unilateral biportal endoscopy for lumbar spinal stenosis

Jing Yu\*, Xiaoxuan Sun\*, Zhihao Wu, Guantong Wang, Qun Guo, Hongyu Wang

Department of Orthopedic, Nanjing First Hospital, Nanjing Medical University, Nanjing 210000, Jiangsu, China.

\*Equal contributors and co-first authors.

Received October 11, 2025; Accepted February 11, 2026; Epub March 15, 2026; Published March 30, 2026

**Abstract:** Objective: To assess the outcomes and safety of unilateral biportal endoscopy (UBE) technique in treating lumbar spinal stenosis (LSS). Methods: A total of 180 LSS cases treated in Nanjing First Hospital, Nanjing Medical University (March 2022-March 2025) were selected, including 85 patients (PTED group) treated with percutaneous transforaminal endoscopic discectomy (PTED) and 95 patients (UBE group) with UBE surgery. Therapeutic outcomes, surgical metrics (operative duration, intraoperative blood loss, and postoperative drainage), clinical indicators (hospitalization duration/costs), lumbar functional recovery (Oswestry Disability Index [ODI]), pain (Visual Analogue Scale [VAS]), laboratory findings (C-reactive protein, CRP; interleukin-6, IL-6; creatine kinase, CK), and safety (infection, nerve root damage, and dural sac rupture) were comparatively assessed across groups. Furthermore, to gain in-depth insights into the predictors of treatment response, both univariate and multivariate analytical methods were applied. Results: The groups were equivalent in excellent-and-good rates, hospitalization expenses, and overall complication rates. UBE recipients showed higher values in intraoperative bleeding, drainage volume, and hospital stay than PTED-treated cases, but with shorter operative duration. Both cohorts displayed reduced ODI and VAS (lumbago and lower leg pain) scores at one and three months postoperatively compared to their preoperative levels; although differences in postoperative ODI and lower back VAS scores were non-significant between groups, the VAS of leg pain was statistically lower in the UBE group versus the PTED group. In the UBE group, all laboratory indices presented a postoperative rise but remained notably lower relative to the PTED group's values. L5-S1 involvement, combined-type stenosis, a Schizas grade D, and comorbid hypertension were independent predictors of suboptimal efficacy in LSS patients, as established by univariate and multivariate analysis. Conclusion: When used to treat LSS, UBE demonstrates therapeutic efficacy, safety, and treatment costs comparable to PTED. Yet, UBE contributes to shortened surgical duration, milder post-surgical leg pain, and aids in lessening the abnormal rise of laboratory examination indexes. Nonetheless, UBE is linked to increased intraoperative bleeding, greater drainage volume, and a longer hospitalization period.

**Keywords:** Unilateral biportal endoscopy technique, lumbar spinal stenosis, therapeutic outcomes, safety

## Introduction

Lumbar spinal stenosis (LSS) is a degenerative spinal condition featuring the narrowing of the space in the spinal canal and/or intervertebral foramen. Older individuals are particularly susceptible to this condition [1, 2]. Symptomatic LSS has been reported to occur in around 11% of the adult population, with risk escalating as age increases. Globally, LSS impacts an estimated 100 million people [3]. LSS patients often experience persistent low back pain and lower limb pain. They may also have discomfort symptoms such as numbness, tingling, and

abnormal sensations in the lower legs, which limits their continuous walking ability [4]. This phenomenon is linked to the way spinal stenosis in LSS triggers restricted blood flow and venous congestion; these physiological changes further result in nerve root ischemia, a condition that can give rise to neurogenic claudication [5]. The first-line therapy for LSS patients mainly consists of conservative treatments such as drug therapy, exercise therapy and block therapy. For patients who do not respond to conservative treatment, surgical therapy is required to improve clinical outcomes [6]. Standard laminectomy procedures typically

## Surgical treatment for lumbar spinal stenosis

require extensive retraction, resulting in potential injury to the supraspinal/interspinous ligament complex, dissected tissues, and bilateral paraspinous muscles (especially the multifidus), in addition to influencing spinal stability [7]. Optimizing surgical treatment strategies for LSS remains essential to improve patient results.

Percutaneous transforaminal endoscopic discectomy (PTED) is a commonly used minimally invasive spinal surgery that can be widely applied in managing lumbar degenerative disorders. Clinically, it boasts notable advantages such as a small incision, minimal soft tissue trauma, enhanced operative safety, and accelerated patient convalescence [8]. However, the efficacy of this surgery is limited and it is difficult to achieve the maximum effect for LSS patients with unstable lumbar vertebrae or those requiring revision surgery [9]. Unilateral biportal endoscopy (UBE) achieves a broader field of view and flexible operating space by using dual channels for surgical area exposure and continuous lavage. It not only enables precise decompression while maintaining the integrity of the spinal structure but also allows for less invasive treatment of extramineral foramin lesions [10]. This surgery has advantages such as small trauma, quick recovery, and a shallow learning curve in LSS treatment, and can also be used for the treatment of multi-level spinal stenosis [11]. Earlier investigations have further revealed that UBE is clinically safer than open surgery when applied to elderly patients or multimorbid patient populations [12].

Limited comparative evidence exists regarding the clinical outcomes of UBE versus PTED in LSS patients. Therefore, this study was designed to evaluate and compare the efficacy of these two techniques. There are several innovations in this study: (1) Different from previous studies, which mostly ignored the detection of laboratory examination indexes, we comparatively analyzed the curative effect, surgical related parameters, clinical indices, lumbar function recovery, pain, laboratory examination indexes, and safety of LSS patients under the two surgical interventions, which is helpful to comprehensively evaluate and verify the clinical advantages of UBE in treating LSS patients; (2) Based on the above, efficacy-associated determinants in LSS patients are deeply

explored, presenting the first evaluation and identification of the independent predictors of curative effects in LSS, which can provide more reliable references and evidence-based arguments for the clinical management of LSS patients and the people who benefit from treatment.

### Information and methodology

#### *General data*

From March 2022 to March 2025, our research team recruited 180 LSS inpatients from Nanjing First Hospital, Nanjing Medical University, with 85 of them receiving PTED (PTED group) and 95 undergoing UBE (UBE group). Approval for this study was granted by the Ethics Committee of Nanjing First Hospital, Nanjing Medical University. When conducting inter-group analysis of baseline data, no statistically meaningful differences were found ( $P > 0.05$ ), verifying group comparability.

#### *Patient selection criteria*

Inclusion criteria: LSS [13] was identified via combined physical examination and imaging assessments; Persistent ( $\geq 3$  months) lumbar pain, lower limb radiating pain, or neurogenic claudication; Satisfactory overall condition that can tolerate surgery; Initial surgical management for LSS in our hospital; Symptom persistence despite more than 3 months of non-surgical treatment modalities; Complete clinical data.

Exclusion criteria: Lumbar instability (flexion-extension radiographs showing  $> 15^\circ$  angular motion or  $> 3$  mm translation), requiring fusion surgery; Vascular claudication, herniated discs, spondylolisthesis  $\geq$  grade II, or localized spinal infection/stenosis; Prior surgery at involved or adjacent segments; Notable spinal deformities (scoliosis/kyphosis); Concurrent malignancies.

#### *Treatment methods*

Participants assigned to the PTED group underwent PTED treatment: The patient was placed in a lateral position with the affected side upward, and the waist was elevated. After fluoroscopy to determine the responsible segment, local infiltration anesthesia was performed at the puncture point 6-10 cm lateral to the mid-

## Surgical treatment for lumbar spinal stenosis

line of the posterior spine at the level of the intervertebral space of that segment until the facet joints were reached. Subsequently, a ~7 mm longitudinal incision was made. The puncture needle was inserted with a guidewire and a dilator was placed along it to gradually expand the soft tissue. Using the guidewire, a portion of the facet joint was removed with a bone grinding drill to enlarge the intervertebral foramen. Through the intervertebral foramen, the working channel was placed along the guidewire into the spinal canal and then inserted into the intervertebral canaloscope for exploration. The hyperplastic bone and the surrounding ligamentum flavum were removed, and the dura mater ventral side, nerve roots, and intervertebral discs were exposed. After cutting the annulus fibrosus, the nucleus pulposus was removed with a pituitary rongeur and radiofrequency ablation was performed on the intervertebral disc until the nerve root was completely released and the dural pulsation was observed as being good under the microscope. Finally, adequate hemostasis was achieved and the incision was sutured layer by layer.

UBE was implemented in the UBE group. Taking the L5/S1 segment as an example, the patient was placed in the prone position and intubated under general anesthesia. Under the guidance of C-arm X-ray fluoroscopy, the inner edge of the vertebral arch and the horizontal line at the junction of the L5 spinous process root and the lamina were marked on the body surface. A cut about 5-6 mm long was made at the intersection point above 15 mm from the intersection point, serving as the viewing channel, and a cut about 8-10 mm long was made at the intersection point 15 mm below to serve as the working channel. The channel dilators were separately inserted to gradually separate the muscle fibers, facilitated by normal saline injection to create the operative working space. An arthroscope (0° or 30°) was then placed in the viewing channel, and continuous normal saline irrigation was performed; surgical instruments were introduced through the working channel and used as an outflow channel. After the endoscope and the instruments formed a triangular operational relationship, a radiofrequency knife was used to remove the soft tissue on the surface of the lamina, exposing the superior/inferior laminae and articular processes. The bone structure was handled using rongeurs and an

electric drill, and the attachment site of the ligamentum flavum was explored with a curette and an incision was made to facilitate the removal of the ligamentum flavum. The nerve tissue was gently separated using a neural dissector, revealing the disc herniation, which was then removed with pituitary forceps following hemostasis achieved via radiofrequency ablation. The direction of the channel was further adjusted to perform contralateral spinal canal decompression and the resection of the ligamentum flavum and hypertrophic articular process. The surgical field was thoroughly rinsed, and the incision was sutured, with a negative-pressure drain placed. The drainage volume and characteristics were closely monitored. The indication for removing the drainage tube was a continuous drainage volume of less than 30 mL for 24 hours and the drainage fluid being pale blood-like (usually removed within 48 hours following the procedure). Additionally, the postoperative medication regimens, like the use of anti-infective agents, analgesics, and anti-inflammatory drugs, were consistent in both groups.

All patients received nursing care. Preoperative health education related to the disease and treatment was provided; guidance on various preoperative examinations and fasting/water restriction requirements was also given. Following the procedure, patients were instructed on condition observation and position management, as well as diet and functional training.

### *Endpoints*

(1) Efficacy. The assessment followed the modified MacNab standard [14]. Excellent: Complete symptom resolution that allows for reintegration into regular work and daily activities. Good: Disappearance of symptoms except occasional pain, with the patient being able to perform light-duty work. Fair: Persistent pain was alleviated but symptoms were not fully eliminated, rendering the patient unable to carry out relevant work. Poor: No symptom alleviation or worsened conditions, requiring reoperation. The excellent-and-good rate represents the combined percentage of cases rated as excellent or good.

(2) Surgical metrics. Surgery duration, intraoperative bleeding, and drainage volume were

## Surgical treatment for lumbar spinal stenosis

collected. Bleeding was assessed via gravimetric gauze measurement and suction output, with the formula: (weight of blood-saturated gauze - dry gauze weight) + volume in suction device.

(3) Clinical parameters. The hospitalization duration and associated costs were documented.

(4) Lumbar function recovery [15]. The Oswestry Dysfunction Index (ODI) questionnaire was administered pre-surgery (T0), one month post-op (T1), and three months post-op (T3). The evaluation items covered personal care, sitting, standing, and walking domains, each scored from 0 (no impairment) to 5 (severe disability). On a 100-point scale, higher scores correspond to greater dysfunction.

(5) Pain [16]. Pain assessments at T0, T2, and T3 were conducted using the Visual Analogue Scale (VAS). With a scoring spectrum from 0 to 10, the numerical score is proportional to the pain felt by the patient.

(6) Laboratory markers. Blood was drawn from all participants after an overnight fast at baseline (T0) and on postoperative day 3 (T1). The collected samples were centrifuged to isolate serum for enzyme-linked immunosorbent assay (ELISA)-based quantification of C-reactive protein (CRP), interleukin-6 (IL-6), and creatine kinase (CK).

(7) Safety. By documenting adverse events (infection, nerve root damage, and dural sac rupture), the safety profile was comparatively assessed.

### *Statistical methods*

The statistical analyses of measurement and counting data, shown as frequency and percentage [n (%)] and mean  $\pm$  standard deviation (SD), respectively, were carried out with SPSS 21.0. Image rendering and export utilized GraphPad Prism 7.0. Measurement data were confirmed by the Shapiro-Wilk test to follow normality. Counting data comparisons were conducted using the  $\chi^2$  test. For measurement data, the independent samples t-test was used for identifying inter-group differences, the paired t-test for examining pre- vs. post-interventional changes, and the repeated measures

analysis of variance was used for determining alterations across time points. We further performed univariate and multivariate (binary logistic regression) analyses to determine predictors of the best clinical outcomes in LSS. Statistical significance was present when  $P < 0.05$ .

## **Results**

### *Baseline characteristics of the patient cohorts*

The participants' general data were compared (**Table 1**), revealing no statistically between-group disparities in gender, age, body mass index (BMI), involved spinal segment, stenosis type, Schizas classification, or hypertensive/diabetic status ( $P > 0.05$ ).

### *Therapeutic results for the two LSS patient groups*

The excellent/good rate, reflecting therapeutic efficacy, did not differ significantly between the PTED and UBE cohorts ( $P > 0.05$ ; **Table 2**).

### *Surgical metrics for the two patient groups*

As detailed in **Table 3**, the UBE technique resulted in a markedly shorter operative duration relative to the PTED approach ( $P < 0.01$ ), but was associated with increased intraoperative bleeding and greater postoperative drainage volume ( $P < 0.001$ ).

### *Clinical indices across study groups*

The clinical indices of LSS patients treated with either PTED or UBE are summarized in **Table 4**. The UBE procedure was found to require a longer postoperative hospital stay ( $P < 0.001$ ), but incurred comparable overall hospitalization costs than PTED ( $P > 0.05$ ).

### *Lumbar function recovery and pain assessments across groups*

Both groups of LSS patients were subjected to evaluations of lumbar function recovery (ODI scale) and pain (low back/leg pain by VAS), with results shown in **Figure 1**. Although the groups were statistically similar at baseline ( $P > 0.05$ ), all scores significantly decreased at T2 and T3 within groups ( $P < 0.01$ ). ODI scores and low back VAS scores did not differ significantly across the groups at various postoperative

## Surgical treatment for lumbar spinal stenosis

**Table 1.** Patient profile by study group

Indicators	PTED group (n=85)	UBE group (n=95)	$\chi^2/t$	P
Sex			0.989	0.320
Male	34 (40.00)	45 (47.37)		
Female	51 (60.00)	50 (52.63)		
Age (years)	57.00 (54.50, 63.00)	60.00 (56.00, 65.00)	-1.562	0.118
Body mass index (kg/m <sup>2</sup> )	23.00 (22.00, 24.00)	23.00 (22.00, 25.00)	-0.250	0.802
Involved spinal segment			0.653	0.722
L3-4	34 (40.00)	33 (34.74)		
L4-5	28 (32.94)	32 (33.68)		
L5-S1	23 (27.06)	30 (31.58)		
Stenosis type			0.951	0.622
Central	21 (24.71)	24 (25.26)		
Lateral recess	28 (32.94)	37 (38.95)		
Combined	36 (42.35)	34 (35.79)		
Schizas classification			1.266	0.531
B	30 (35.29)	29 (30.53)		
C	32 (37.65)	33 (34.74)		
D	23 (27.06)	33 (34.74)		
Hypertension	7 (8.24)	12 (12.63)	0.918	0.338
Diabetes	14 (16.47)	19 (20.00)	0.373	0.541

Note: PTED, percutaneous transforaminal endoscopic discectomy; UBE, unilateral biportal endoscopy.

**Table 2.** Therapeutic outcomes for LSS patient cohorts

Indicators	PTED group (n=85)	UBE group (n=95)	$\chi^2$	P
Excellent	60 (70.59)	76 (80.00)		
Good	16 (18.82)	14 (14.74)		
Fair	9 (10.59)	5 (5.26)		
Poor	0 (0.00)	0 (0.00)		
Excellent-and-good	76 (89.41)	90 (94.74)	1.774	0.183

Note: LSS, lumbar spinal stenosis; PTED, percutaneous transforaminal endoscopic discectomy; UBE, unilateral biportal endoscopy.

**Table 3.** Comparative surgical metrics of the two cohorts

Indicators	PTED group (n=85)	UBE group (n=95)	t	P
Surgical duration (min)	128.67±19.94	120.07±18.98	2.963	0.004
Intraoperative blood loss (mL)	94.16±19.97	116.75±24.94	6.656	< 0.001
Drainage volume (mL)	36.25±8.42	49.23±8.67	10.160	< 0.001

Note: PTED, percutaneous transforaminal endoscopic discectomy; UBE, unilateral biportal endoscopy.

**Table 4.** Assessment of relevant clinical indices in both groups

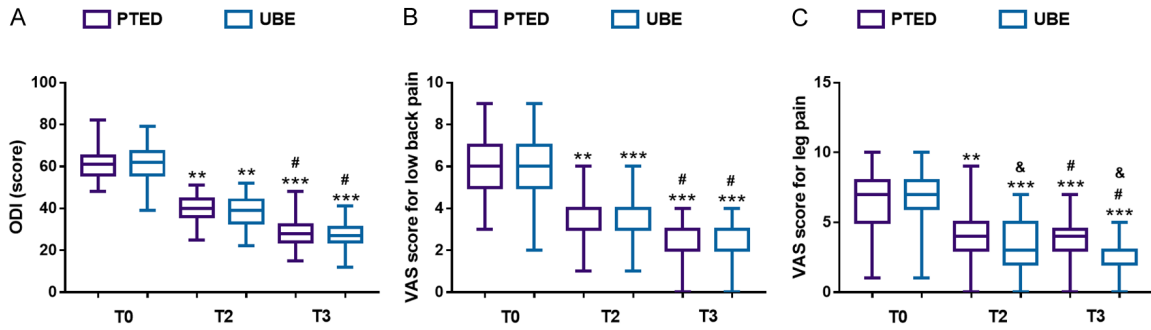
Indices	PTED group (n=85)	UBE group (n=95)	z	P
Hospitalization duration (d)	4.00 (3.00, 5.00)	5.00 (4.00, 6.00)	-4.513	< 0.001
Hospitalization costs (ten thousand yuan)	12774.00 (11147.00, 14483.00)	13918.00 (10711.00, 16268.00)	-1.486	0.137

Note: PTED, percutaneous transforaminal endoscopic discectomy; UBE, unilateral biportal endoscopy.

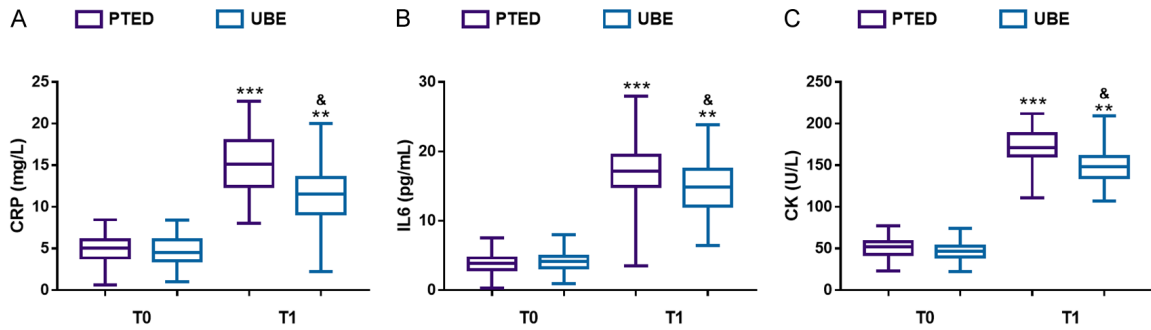
time points ( $P > 0.05$ ). However, the UBE procedure resulted in superior reductions in VAS

scores for leg pain at the T2 and T3 intervals compared to PTED ( $P < 0.05$ ).

## Surgical treatment for lumbar spinal stenosis



**Figure 1.** Functional recovery and pain assessments. A. ODI changes across various time points. B. VAS scores for low back pain over time. C. VAS scores for leg pain over time. Note: PTED, percutaneous transforaminal endoscopic discectomy; UBE, unilateral biportal endoscopy; ODI, Oswestry Disability Index; VAS, Visual Analogue Scale; \*\* $P < 0.01$ , \*\*\* $P < 0.001$  versus preoperative (T0) within the same group; # $P < 0.05$  versus 1-month postoperative (T2) within the same group; & $P < 0.05$  versus the PTED group at the same time point. T3: 3 months post-surgery.



**Figure 2.** Laboratory markers in the two LSS cohorts. A. CRP concentrations across time points. B. IL-6 dynamics. C. CK changes across various time points. Note: PTED, percutaneous transforaminal endoscopic discectomy; UBE, unilateral biportal endoscopy; LSS, lumbar spinal stenosis; CRP, C-reactive protein; IL-6, interleukin-6; CK, creatine kinase; \*\* $P < 0.01$ , \*\*\* $P < 0.001$  (intra-group comparison to preoperative baseline, T0); & $P < 0.05$  (comparison to the PTED group at the matched time point). T1: 3 days postoperatively.

### Laboratory markers of LSS patients in the two groups

Laboratory markers (CRP, IL-6, CK) were measured in both LSS patient groups (**Figure 2**). The values were comparable at baseline ( $P > 0.05$ ). A statistically significant increase from baseline to T1 was noted for all indices ( $P < 0.01$ ). The rise was, however, substantially less pronounced in the UBE group relative to the PTED cohort ( $P < 0.05$ ).

### Safety in the two patient cohorts

Statistical significance was absent in the comparison of total incidence of surgical complications (infection, nerve root damage, and dural sac rupture). The rate was 3.16% in the UBE group, comparable to the 5.88% noted in the PTED group ( $P > 0.05$ ) (**Table 5**).

### Analysis of influencing factors on the curative effect of LSS patients

Univariate screening (**Table 6**) revealed several potential contributors to optimal outcomes in LSS, namely the involved spinal segment, stenosis type, Schizas classification, hypertension, or diabetes ( $P < 0.05$ ), while ruling out gender, age, and treatment modality ( $P > 0.05$ ). The assignment of values for the above factors with differences is shown in **Table 7**.

Multivariate analysis (**Table 8**) identified L5-S1 involvement, combined-type LSS, a Schizas D classification, and comorbid hypertension as factors that adversely affected optimal treatment outcomes ( $P < 0.05$ ). In contrast, diabetes was excluded as an independent predictor ( $P > 0.05$ ). To illustrate, the risk of poor postoperative efficacy was 5.35 and 2.71 times higher

## Surgical treatment for lumbar spinal stenosis

**Table 5.** Therapeutic safety assessment in LSS cohorts

Indicators	PTED group (n=85)	UBE group (n=95)	$\chi^2$	P
Infection	2 (2.35)	0 (0.00)		
Nerve root damage	2 (2.35)	0 (0.00)		
Dural sac rupture	1 (1.18)	3 (3.16)		
Total	5 (5.88)	3 (3.16)	0.784	0.376

Note: LSS, lumbar spinal stenosis; PTED, percutaneous transforaminal endoscopic discectomy; UBE, unilateral biportal endoscopy.

**Table 6.** Factors associated with optimal clinical outcomes in LSS patients (univariate analysis)

Indicators	Optimal treatment outcomes		$\chi^2$	P
	Excellent (n=136)	Non-optimal (n=44)		
Sex			0.348	0.555
Male (n=79)	58 (42.65)	21 (47.73)		
Female (n=101)	78 (57.35)	23 (52.27)		
Age (years)			2.987	0.084
< 60 (n=94)	76 (55.88)	18 (40.91)		
≥ 60 (n=86)	60 (44.12)	26 (59.09)		
Involved spinal segment			7.185	0.007
L3-4 or L4-5 (n=127)	103 (75.74)	24 (54.55)		
L5-S1 (n=53)	33 (24.26)	20 (45.45)		
Stenosis type			7.877	0.005
Central or lateral recess (n=110)	91 (66.91)	19 (43.18)		
Combined (n=70)	45 (33.09)	25 (56.82)		
Schizas classification			9.695	0.002
B or C (n=124)	102 (75.00)	22 (50.00)		
D (n=56)	34 (25.00)	22 (50.00)		
Hypertension (n=19)	9 (6.62)	10 (22.73)	9.138	0.003
Diabetes (n=33)	20 (14.71)	13 (29.55)	4.890	0.027
Treatment modality			2.152	0.142
PTED (n=85)	60 (44.12)	25 (56.82)		
UBE (n=95)	76 (55.88)	19 (43.18)		

Note: LSS, lumbar spinal stenosis; PTED, percutaneous transforaminal endoscopic discectomy; UBE, unilateral biportal endoscopy.

**Table 7.** Assignments

Indicators	Variable	Assignment
Involved spinal segment	X1	L3-4 or L4-5=0 (reference group), L5-S1=1
Disease type	X2	Central or lateral recess =0 (reference group), combined =1
Schizas classification	X3	B or C=0 (reference group), D=1
Hypertension	X4	No =0 (reference group), yes =1
Diabetes	X5	No =0 (reference group), yes =1
Optimal treatment outcomes	Y	Excellent =0 (reference group), Non-optimal =1

in hypertensive individuals and Schizas grade D than in non-hypertensive cases and those with lower grades (B/C), respectively. Additionally, patients with combined-type LSS faced a

2.47-fold higher possibility of experiencing sub-optimal outcomes than those with a single disease type, while a 2.26-fold higher risk was found in individuals with L5-S1 involvement

## Surgical treatment for lumbar spinal stenosis

**Table 8.** Determinants of optimal treatment outcome in LSS (multivariate analysis)

Indicators	B	SE	WALD	P	OR	95% CI
Involved spinal segment	0.816	0.403	4.095	0.043	2.262	1.026-4.989
Stenosis type	0.905	0.388	5.434	0.020	2.473	1.155-5.295
Schizas classification	0.995	0.395	6.259	0.012	2.705	1.241-5.897
Hypertension	1.678	0.552	9.235	0.002	5.353	1.814-15.797
Diabetes	0.725	0.461	2.471	0.116	2.065	0.836-5.102

Note: LSS, lumbar spinal stenosis.

compared to subjects with L3-4 or L4-5 involvement. Although diabetes was excluded as a significant contributor, the risk was estimated to be 2.07 times higher than in diabetes-free cases.

### Discussion

This study mainly comparatively assessed the clinical application effects of PTED and UBE in LSS. First, we found that the efficacy of the two therapies was comparable (89.41% vs. 94.74%). However, UBE helped shorten surgical duration, but with relatively higher intraoperative bleeding, drainage volume, and hospital stays; the hospitalization cost was comparable. This is because UBE can allow the surgeon to operate multi-angle instruments in a 270° field of view with the help of an independent endoscope channel and working channel design, thus maximizing the efficiency of bone structure treatment and enhancing surgical efficiency. On the other hand, the single-channel design of PTED helps to minimize tissue damage, thereby reducing intraoperative bleeding. However, as it requires frequent repositioning of the working channel when dealing with complex bone stenosis, the operation time may be prolonged. Cheng et al. [17] also observed shorter operation durations with UBE for single-level lumbar lateral recess stenosis, while PTED led to less intraoperative bleeding and surgical drainage, consistent with our findings. Chen et al. [18] highlighted UBE's superior surgical maneuverability and a clearer field of view for degenerative lumbar conditions, as well as PTED's advantages in blood loss minimization and hospital stay reduction, which complements the present study. In the study by Yang et al. [19], UBE treatment for single-segment lumbar disc herniation had hospitalization costs comparable to those of PTED but superior cost-effectiveness, complementing the results of this study.

Subsequently, the evaluation of lumbar function and pain (low back/leg) pre- and postoperatively (1 and 3 months) indicated the two techniques' comparable efficacy in improving lumbar function and easing lumbago, while highlighting the superiority of UBE in leg pain relief. This might be attributed to UBE's dual-channel design, which can realize subperiosteal dissection by establishing an operating plane outside the articular process, thus retaining the attachment point of the multifidus muscle to the maximum extent. In addition, UBE's endoscopic wide-angle visual field combined with fine instruments can achieve accurate resection of hyperplastic osteophyte without destroying articular process integrity, which is helpful to promote the early functional recovery of patients and reduce pain. These results align with the report by Sun et al. [20], which found that for LSS patients, UBE is as effective as PTED in enhancing lumbar function and reducing low back pain, and is more effective at relieving leg pain. Laboratory tests compared and analyzed three indicators: CRP, IL-6, and CK. As an acute-phase inflammatory protein, CRP is capable of reflecting surgical infections or stress stimuli. Similar to CRP, IL-6 serves as an early postoperative inflammatory marker, being able to monitor surgery-induced inflammation. Changes in CK levels are closely linked to surgical incision length and depth, as well as the muscle damage extent [21]. Our findings revealed that for LSS patients receiving either of the two treatment modalities, all the aforementioned indicators showed abnormal elevation on the 3rd postoperative day. Nevertheless, mild elevations were noted in UBE-managed cases, suggesting that UBE causes relatively milder inflammatory responses and less muscle damage in LSS patients. In addition to preserving the multifidus muscle attachment point and maintaining articular process integrity, UBE also realizes dynamic visualization operation in the aqueous medium environ-

## Surgical treatment for lumbar spinal stenosis

ment to enable real-time observation of the dural sac pulsations, avoiding excessive traction while ensuring sufficient nerve decompression. This trait helps alleviate the inflammatory response and muscle damage of LSS patients in multiple aspects.

From a safety perspective, UBE-treated LSS cases exhibited a lower, albeit statistically non-significant, overall complication rate (including infection, nerve root damage, and dural sac rupture) than PTED-treated patients (3.16% versus 5.88%). This can be attributed to the continuous normal saline perfusion system during the UBE procedure, which can prevent blood leakage from small blood vessels through water pressure control while maintaining a clear surgical field, which is helpful for precise operation and avoiding damage to the body [22, 23]. Dural sac ruptures typically occur in women, patients aged over 70, or those with spondylolisthesis or facet cysts. They also frequently occur in severe LSS patients, or in scenarios when surgeons are not proficient in endoscopic dissection or have inadequate hemostasis [24]. Researchers have proposed some preventive measures, like removing the ligamentum flavum layer by layer and controlling intraoperative blood pressure to prevent bleeding [25]. Additionally, the UBE technique can relieve bilateral nerve root compression through a unilateral approach, with some certain widening effects on the spinal canal space as well as bilateral facet structure preserving function, thus ensuring the safety and accuracy of the surgery [26]. In the study by Ding et al. [27], UBE applied to lumbar degenerative disease patients showed lower complication and recurrence rates compared to PTED, though not statistically significant, similar to our results of this study.

Finally, the factors predictive of suboptimal efficacy in LSS patients, as determined by both univariate and multivariate analysis, included L5-S1 involvement, combined-type stenosis, a Schizas grade D, and hypertensive status. Hence, the aforementioned clinical characteristics can complicate the achievement of optimal therapeutic results in LSS patients. L5-S1 involvement may be associated with incomplete decompression, a limited visual field, and a difficult patient recovery due to lateral recess stenosis, key nerve roots, and a heavy biome-

chanical load, thereby increasing the risk of poor curative effects. The combined-type stenosis suggests that such patients have more complex conditions and involve a wider range of affected areas, which further increases the difficulty of decompression in the surgery. However, a Schizas grade D, typically indicating extremely serious nerve compression, is linked to possible irreversible nerve tissue damage, resulting in the difficulty for surgery to exert the maximum curative effect. Comorbid hypertension suggests chronic microcirculation disorders and the possible presence of other systemic diseases in the patient, which is not conducive to the relief of postoperative symptoms and the recovery of function. It is worth noting that though diabetes was shown by univariate analysis as a significant correlate of adverse prognoses, the significance was absent in the multivariate model. It suggests that instead of being independent, diabetes may impact prognosis through interactions with other factors (e.g., Schizas D classification) or via medicating or confounding by other stronger predictors (hypertension, etc.). Research by Zhang et al. [28] demonstrated that incorporating Enhanced Recovery After Surgery (ERAS) principles into UBE procedures leads to superior short-term results. This combination promotes faster patient mobilization and a shorter hospital stay, ultimately working to maximize the overall curative effect.

This study presents some limitations, requiring further refinement. Firstly, as a retrospective non-random study, this study has limited imaging evaluation and failed to fully control the potential confounding factors. In the future, prospective, large-sample evaluations incorporating imaging data should be supplemented to improve the accuracy of research results. Secondly, the follow-up time is relatively short, and a 3-5 year long-term follow-up should be supplemented in the future to further determine the long-term prognosis of UBE-treated LSS patients. Finally, there are no investigations into patients' psychological states and quality of life. Supplementing relevant analyses is helpful for further understanding the potential clinical advantages of UBE in the treatment of LSS patients.

Collectively, UBE and PTED for LSS are similar in therapeutic outcomes, safety, hospitaliza-

tion expenses, lumbar function enhancement, and lumbago mitigation. However, the former is more effective in shortening procedure duration and alleviating leg pain, although with greater drainage and longer hospital stays. Importantly, L5-S1 involvement, combined-type stenosis, a Schizas classification D, and hypertension correlated with reduced likelihood of optimal curative effects in those affected.

### Disclosure of conflict of interest

None.

**Address correspondence to:** Hongyu Wang, Department of Orthopedic, Nanjing First Hospital, Nanjing Medical University, Nanjing 210000, Jiangsu, China. Tel: +86-025-85453107; E-mail: wanghongyu1369@163.com

### References

- [1] Malik KN, Giberson C, Ballard M, Camp N and Chan J. Pain management interventions in lumbar spinal stenosis: a literature review. *Cureus* 2023; 15: e44116.
- [2] Webb CW, Aguirre K and Seidenberg PH. Lumbar spinal stenosis: diagnosis and management. *Am Fam Physician* 2024; 109: 350-359.
- [3] Katz JN, Zimmerman ZE, Mass H and Makhni MC. Diagnosis and management of lumbar spinal stenosis: a review. *JAMA* 2022; 327: 1688-1699.
- [4] Yuan H and Yi X. Lumbar spinal stenosis and minimally invasive lumbar decompression: a narrative review. *J Pain Res* 2023; 16: 3707-3724.
- [5] Abdou A, Kades S, Masri-Zada T, Asim S, Bany-Mohammed M and Agrawal DK. Lumbar spinal stenosis: pathophysiology, biomechanics, and innovations in diagnosis and management. *J Spine Res Surg* 2025; 7: 1-17.
- [6] Nagai S, Inagaki R, Michikawa T, Kawabata S, Ito K, Hachiya K, Takeda H, Ikeda D, Kaneko S, Yamada S and Fujita N. Efficacy of surgical treatment on polypharmacy of elderly patients with lumbar spinal canal stenosis: retrospective exploratory research. *BMC Geriatr* 2023; 23: 169.
- [7] Mittal A, Mishra R, Patel H, Shetty A and Shrivastava A. Revisiting post-laminectomy kyphosis and challenges in its management: a case report. *Cureus* 2024; 16: e62359.
- [8] Liu X, Yuan S, Tian Y, Wang L, Gong L, Zheng Y and Li J. Comparison of percutaneous endoscopic transforaminal discectomy, microendoscopic discectomy, and microdiscectomy for symptomatic lumbar disc herniation: minimum 2-year follow-up results. *J Neurosurg Spine* 2018; 28: 317-325.
- [9] Xie P, Feng F, Chen Z, He L, Yang B, Chen R, Wu W, Liu B, Dong J, Shu T, Zhang L, Chen CM and Rong L. Percutaneous transforaminal full endoscopic decompression for the treatment of lumbar spinal stenosis. *BMC Musculoskeletal Disord* 2020; 21: 546.
- [10] Wei R, Liu W, Yu M, Zhu Y, Yao R, Wang B and Li-Ling J. Delta large-channel endoscopy versus unilateral biportal endoscopy decompressive laminectomy for lumbar spinal stenosis: a prospective randomized controlled trial. *J Orthop Surg Res* 2025; 20: 10.
- [11] Zhao Y, Guo Y, Pan X, Li H, Gao X, Si H and Xu W. Bilateral synchronous UBE for unilateral laminotomy and bilateral decompression as a potentially effective minimally Invasive approach for two-level lumbar spinal stenosis. *Sci Rep* 2025; 15: 2461.
- [12] Bai G, Qiu X, Wei G, Jing X and Hu Q. Unilateral biportal endoscopic decompression combined with percutaneous pedicle screw fixation offers new treatment option for thoracolumbar burst fractures with secondary spinal stenosis. *Sci Rep* 2025; 15: 877.
- [13] Anderson DB, Beard DJ, Rannou F, Hunter DJ, Suri P, Chen L and Van Gelder JM. Clinical assessment and management of lumbar spinal stenosis: clinical dilemmas and considerations for surgical referral. *Lancet Rheumatol* 2024; 6: e727-e732.
- [14] Zhang Z, Yin Z, Bu R, Wang X, Tao B, Zhang L, Zhang X and Zhang J. Efficacy and safety of unilateral interlaminar endoscopic decompression for lumbar spinal stenosis: a retrospective study of 176 cases with a 3-6 year follow-up. *Orthop Surg* 2025; 17: 2992-3001.
- [15] Taspinar G, Angin E and Oksuz S. The effects of Pilates on pain, functionality, quality of life, flexibility and endurance in lumbar disc herniation. *J Comp Eff Res* 2023; 12: e220144.
- [16] Rathbone J, Rackham M, Nielsen D, Lee SM, Hing W, Riar S and Scott-Young M. A systematic review of anterior lumbar interbody fusion (ALIF) versus posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), posterolateral lumbar fusion (PLF). *Eur Spine J* 2023; 32: 1911-1926.
- [17] Cheng X, Wu Y, Chen B and Tang J. A comparative study of unilateral biportal endoscopic decompression and percutaneous transforaminal endoscopic decompression for geriatric patients with lumbar lateral recess stenosis. *J Pain Res* 2023; 16: 2241-2249.
- [18] Chen Y, Lin W, Lei S, You Y, Zhang X, Ma Y and Wang D. Comparing the efficacy and safety of unilateral biportal endoscopic decompression with percutaneous endoscopic lumbar decom-

## Surgical treatment for lumbar spinal stenosis

- pression for lumbar degenerative diseases: a meta-analysis. *World Neurosurg* 2024; 187: e383-e398.
- [19] Yang YF, Yu JC, Zhu ZW, Li YW, Xiao Z, Zhi CG, Xie Z, Kang YJ, Li J and Zhou B. Comparison of clinical outcomes and cost-utility between unilateral biportal endoscopic discectomy and percutaneous endoscopic interlaminar discectomy for single-level lumbar disc herniation: a retrospective matched controlled study. *J Orthop Surg Res* 2024; 19: 755.
- [20] Sun W, Wang J, Hu Y, Tao J and Yang C. Efficacy and safety of unilateral biportal endoscopy compared with transforaminal route percutaneous endoscopic lumbar decompression in the treatment of lumbar spinal stenosis: minimum 1-year follow-up. *J Pain Res* 2025; 18: 1071-1080.
- [21] Sasaoka R, Nakamura H, Konishi S, Nagayama R, Suzuki E, Terai H and Takaoka K. Objective assessment of reduced invasiveness in MED. Compared with conventional one-level laminotomy. *Eur Spine J* 2006; 15: 577-582.
- [22] Kim JE, Choi DJ, Park EJJ, Lee HJ, Hwang JH, Kim MC and Oh JS. Biportal endoscopic spinal surgery for lumbar spinal stenosis. *Asian Spine J* 2019; 13: 334-342.
- [23] Fan Z, Wu X, Guo Z, Shen N, Chen B and Xiang H. Unilateral biportal endoscopic lumbar interbody fusion (ULIF) versus endoscopic transforaminal lumbar interbody fusion (Endo-TLIF) in the treatment of lumbar spinal stenosis along with intervertebral disc herniation: a retrospective analysis. *BMC Musculoskelet Disord* 2024; 25: 186.
- [24] Liang J, Lian L, Liang S, Zhao H, Shu G, Chao J, Yuan C and Zhai M. Efficacy and complications of unilateral biportal endoscopic spinal surgery for lumbar spinal stenosis: a meta-analysis and systematic review. *World Neurosurg* 2022; 159: e91-e102.
- [25] Lee HG, Kang MS, Kim SY, Cho KC, Na YC, Cho JM and Jin BH. Dural injury in unilateral biportal endoscopic spinal surgery. *Global Spine J* 2021; 11: 845-851.
- [26] Zhuang HX, Guo SJ, Meng H, Lin JS, Yang Y and Fei Q. Unilateral biportal endoscopic spine surgery for lumbar spinal stenosis: a systematic review and meta-analysis. *Eur Rev Med Pharmacol Sci* 2023; 27: 4998-5012.
- [27] Ding H, Han X, Xing Y, Liu Y, He D and Han X. Clinical and radiological comparison of unilateral biportal endoscopic and percutaneous transforaminal endoscopic discectomy in the treatment of lumbar spinal degenerative disease. *Orthop Surg* 2025; 17: 1105-1113.
- [28] Zhang Z, Shao J, Liu S, Meng H, Fan Z, Lin J, Li X and Fei Q. Perioperative enhanced recovery after surgery (ERAS) clinical pathway for unilateral biportal endoscopy with unilateral laminotomy for bilateral decompression. *Orthop Surg* 2025; 17: 2699-2707.