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ORIGINAL RESEARCH

A Comparative Study of Unilateral Biportal Endoscopic Decompression and Percutaneous Transforaminal Endoscopic Decompression for Geriatric Patients with Lumbar Lateral Recess Stenosis

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Purpose: The purpose of this research was to compare the efficacy of unilateral biportal endoscopic decompression (UBE) and percutaneous transforaminal endoscopic decompression (PTED) in the treatment of elderly patients with single-level lumbar lateral recess stenosis (LRS).

Materials and Methods: Data from January 2020 to March 2022 were analyzed. Thirty-eight patients in the PTED group and thirty-nine patients in the UBE group completed the minimum 12-month follow-up. The demographic data and perioperative outcomes were reviewed. Clinical outcomes were evaluated using the VAS for back and leg pain, the Oswestry Disability Index (ODI), and the modified MacNab criteria.

Results: Both groups of patients completed surgery and a one-year follow-up. There was no significant difference between the two groups in demographics data. UBE has the advantage in operative duration and X-ray time; as far as incision length, blood loss, and drainage volume are concerned, PTED is advantageous. Under the modified MacNab criteria, UBE exhibited a good-to-excellent rate similar to that of PTED (84.6% vs 81.6%, P>0.05). There were no significant differences at any point in time between UBE and PTED with respect to ODI, VAS, or back pain scores (P>0.05). UBE and PTED did not differ significantly in terms of complications.

Conclusion: Both PTED and UBE achieved favorable outcomes in single-level LRS. For operative time and X-ray times, UBE is more advantageous, while PTED offers better estimates of blood loss, incision length, and drainage volume.

Keywords: lateral recess stenosis, unilateral biportal endoscopic decompression, percutaneous transforaminal endoscopic decompression, endoscopic, minimally invasive surgery

Introduction

As one of the lumbar degenerative diseases presenting with intermittent neurological claudication, back pain, and radicular leg pain, lumbar spinal stenosis (LSS) is the most common reason for lumbar surgery in adults over 60 years of age.[1]

Anatomically, LSS is composed of 3 types: central stenosis, lateral recess stenosis (LRS), and foraminal stenosis.[2] A lateral recess between the dural sac and foraminal space is a tunnel through which nerve roots travel downward and laterally.[3] LRS is usually caused by herniation of the disc, hypertrophy of the ligamentum flavum and posterior longitudinal ligaments, and hyperplasia of the articular process, and especially the posterior edge of the inferior vertebral body.

For patients with severe walking disability and radicular pain refractory to conservative management, including physical therapy, medication, and nerve-block procedures, surgery should be considered.[4] By enlarging the area of the

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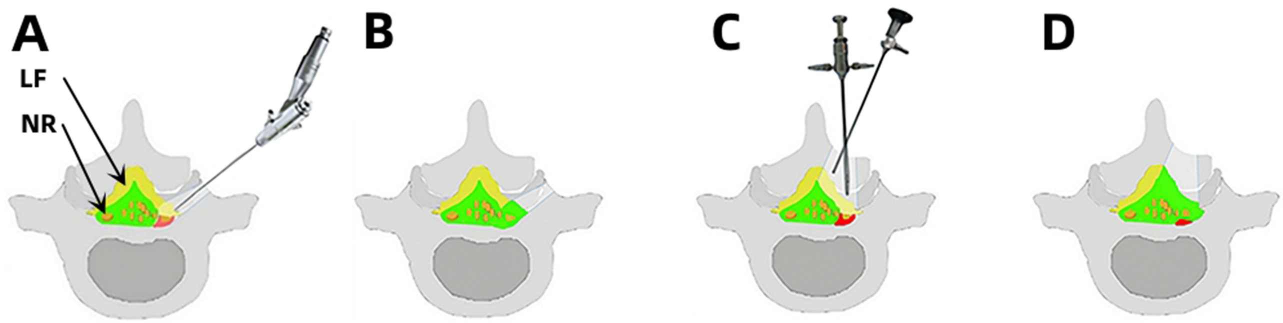

Figure 1 Illustrations of the pathologic features of LRS and decompression (Red: The disc material and posterior edge of the vertebral body; LF: The ligamentum flavum; NR: The nerve root). (**A** and **B**) Decompression of PTED. (**C** and **D**) Decompression of UBE.

lateral recess, the unilateral LRS is decompressed, and unilateral radicular symptoms are alleviated (Figure 1). The current standard surgical treatment for LRS is open laminectomy. However, paraspinal muscle atrophy might occur due to ischemia and denervation after extensive dissection of the paraspinal muscles.[5,6] In addition, resection of the posterior ligaments and bone will increase the risk of lengthened duration of hospital stay, postoperative back pain, infection, and blood loss. In addition, open decompressive laminectomy might cause spinal instability.[7] As fusion leads to a satisfactory short-term outcome and prevents iatrogenic instability, surgeons perform posterior fusion with screw fixation.[8] However, in the long term, posterior fusion could be vulnerable to adjacent segmental degeneration.[9]

In recent years, attempts have been made to develop minimally invasive decompression using various endoscopic techniques.[10] Several studies have reported good clinical results with percutaneous transforaminal endoscopic decompression (PTED) for treating lumbar degenerative diseases.[11,12] However, PTED requires extensive experience and specialized equipment due to its steep learning curve. To overcome these limitations of PTED, the unilateral biportal endoscopic decompression (UBE) was introduced and used by several investigators.[13] The UBE has an approachable learning curve with the advantages of excellent magnification, illumination, and visualization capabilities.

It has been shown in previous studies that both LSS and disc herniation can benefit from UBE.[14,15] However, only a few studies have evaluated these two approaches for LRS. Hence, the present study aimed to compare the clinical outcomes of two minimally invasive decompressive surgeries in Chinese elderly patients with single-level LRS.

Methods

Demographic Characteristics

We retrospectively reviewed the parameters of the consecutive 77 patients from January 2020 to March 2022 in our hospitals. We obtained written informed consent from the patients before we collected dated, and our hospital's ethics committee approved our research. The inclusion criteria were as follows: 1) Patients over 60 years old with unilateral lumbar radicular symptoms without severe back pain and refractory to conservative management for at least three months; 2) A diagnosis of single-level LRS based on clinical history, physical examination, and imaging studies; and 3) The absence of significant instability, infection, fracture, or previous spinal surgery history. The exclusion criteria were as follows: 1) Central or foraminal stenosis; 2) Spondylolisthesis or motion instability; and 3) Bilateral radicular symptoms or multilevel spinal stenosis. The demographic parameters are shown in Table 1.

Measures

The VAS and ODI scores were used to assess clinical outcomes preoperatively and three months, six months, and twelve months after surgery. During the final follow-up, surgical satisfaction was assessed by using modified Macnab criteria.[16] Postoperative CT or MRI were performed before discharge and during follow-up.

Table 1 Preoperative Demographic Characteristics

Characteristics	UBE Group (n=39)	PTED Group (n=38)	P value
Age (year)	69.08±7.23	69.45±7.28	0.823
Sex (male/female)	12/27	14/24	0.573
Duration of symptoms (month)	13.67±8.99	13.18±9.86	0.821
Duration of follow up (month)	12–36	12–38	–
Comorbidities (yes/no)	17/22	23/15	0.137
Side (right/left)	17/22	19/19	0.573
Type of stenosis	Lateral recess	Lateral recess	–
Level			0.933
L3-L4	6	5	
L4-L5	18	19	
L5-S1	15	14	

Surgical Procedures

Two experienced spine surgeons with more than 15 years of experience in spinal surgery performed the surgical procedures.

The UBE procedure (based on the left side of L5-S1) was performed following methods that we have published.[17] After general anesthesia, fluoroscopy was used to mark the L5-S1 intervertebral space after the patient was placed on a Wilson frame in the prone position with the abdomen free. The initial target point is the junction of the spinous process and the inferior lamina of the left L5. The first line is along the inner edge of the pedicles of L5-S1; the second line indicates the intervertebral space of L5-S1. The observation and operation incision points on the body surface along the second line were approximately 0.5–1.0 cm from the intersection of the two lines. There were two incision points on the skin measuring 0.8–1.0 cm. The soft tissue covering the S1 and L5 laminae was bluntly expanded to form the working and observation portals. The working portal was used for instruments, and the endoscopic portal was used for endoscopy and the corresponding sheath (Figure 2). The plasma scalpel removed the soft tissue on the surfaces of the laminae of L5-S1. Having identified the ipsilateral spinolaminar junction on the left side of L5, part of the inferior lamina of L5 and the inferior articular process of L5 were removed, and the origin of ligamentum flavum was exposed; part of the superior lamina and the medial margins of the superior articular process (SAP) of S1 were removed until the end of the ligamentum flavum was exposed. The ipsilateral ligamentum flavum was removed until the lateral border of the nerve root was achieved. A drainage tube was placed after hemostasis. The imaging examination was performed before discharge (Figure 3).

The following steps (based on L4-L5) were performed as previously described in the PTED group:[18] The patient was placed in the lateral decubitus position with a soft pillow under the waist. Incisions were made 1–4 cm above the iliac crest and 8–10 cm from the midline. A mixed local anesthetic with 20 mL lidocaine (2%) and 30 mL epinephrine (1:200,000) solution was used. The entry point required 5 mL, the trajectory 20 mL, the articular process 15 mL, and the

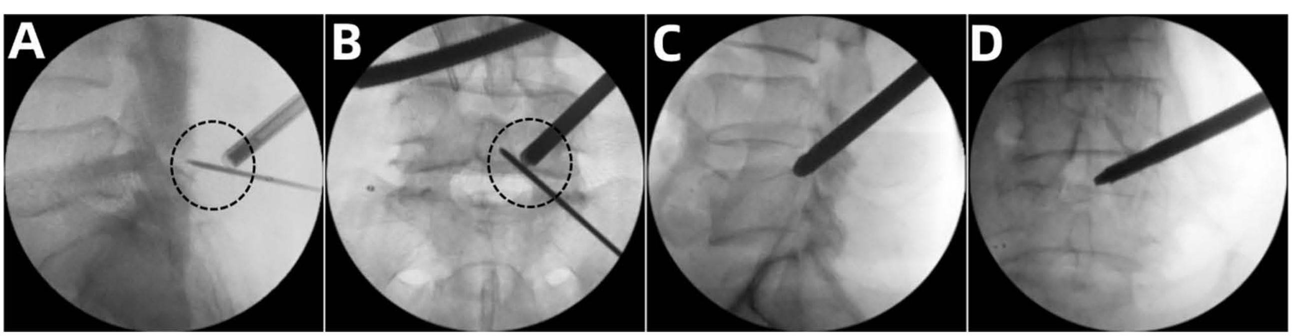

Figure 2 Intraoperative fluoroscopic views. (**A** and **B**) The target point of UBE (Black circle: The junction of the spinous process and the inferior lamina of the left L5). (**C** and **D**) The drill of the PTED.

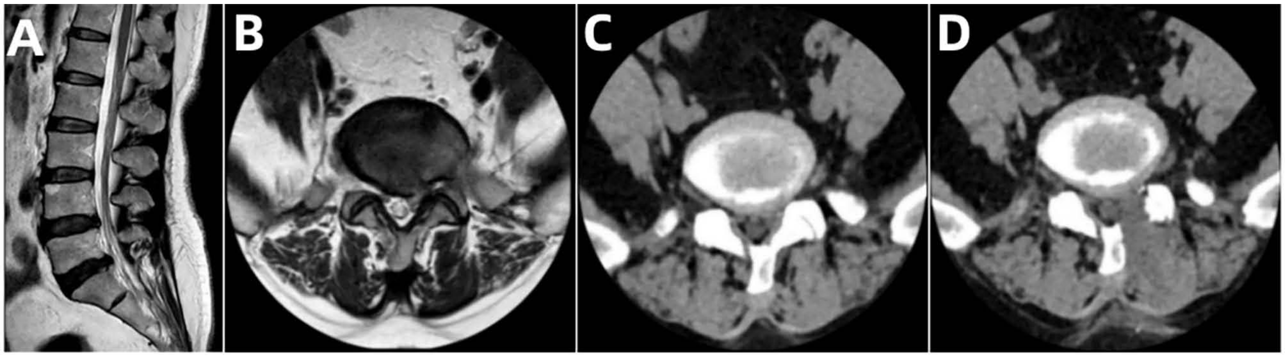

Figure 3 Pre- and postoperative CT and MRI of UBE. (**A**–**C**) Preoperative CT and MRI showing LRS. (**D**) Postoperative CT showing lateral recess enlargement.

foraminal channel 10 mL. Then, skin and subcutaneous fascia incisions measuring 0.8–1.0 cm were made. For the first foraminoplasty, the ventral osteophytes on the SAP of L5 were removed using ring bone drills (Figure 2). After placing the working cannula with a diamond burr and forceps, the inferior ventral portion of the SAP of L5 was removed as a secondary foraminoplasty. The ligamentum flavum was removed along with hypertrophied facet joints, and the ventral hypertrophied posterior longitudinal ligament and extruded disc material were removed for complete nerve root decompression. A posterior edge of the L4 and L5 vertebral bodies was removed until the nerve pulsated with the heartbeat. In the final step, a drainage tube was placed after achieving hemostasis. The imaging examination was performed before discharge (Figure 4).

Statistical Analysis

Statistics were analyzed using SPSS 25. The ODI and VAS of back and leg pain scores were compared using repeated measures analysis of variance. Demographic characteristics and perioperative outcomes were assessed using independent sample t tests, Fisher's exact tests, or Mann–Whitney *U*-tests. The level of statistical significance was set at $P < 0.05$.

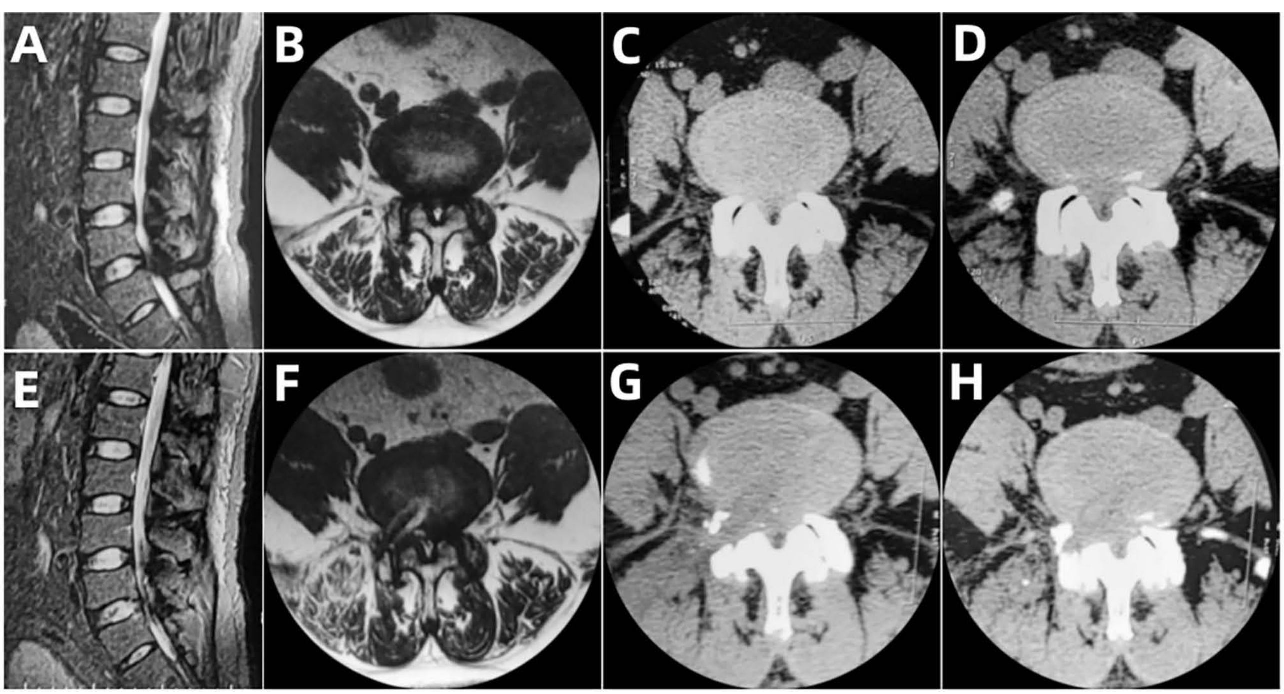

Figure 4 Pre- and postoperative CT and MRI of PTED. (**A**–**D**) Preoperative CT and MRI showing LSS. (**E**–**H**) Postoperative CT and MRI showing lateral recess enlargement.

Table 2 Perioperative Outcomes

Characteristics	UBE Group (n=39)	PTED Group (n=38)	P value
Duration of surgery (minute)	53.84±11.55	62.23±14.32	0.006
Estimated blood loss (mL)	45.64±16.19	13.28±3.72	0.000
Incision length (cm)	2.24±0.36	1.24±0.25	0.000
Times of X-ray	5.79±1.24	10.58±3.64	0.000
Time to ambulation (day)	1.18±0.56	1.00±0.00	0.051
Drainage volume (mL)	37.49±46.01	16.74±7.10	0.008
Hospital stay (day)	6.58±1.63	5.92±1.36	0.055
Complications (yes/no)	2/37	1/37	0.571
Modified MacNab			
Excellent	19	16	
Good	14	15	0.722
Fair	5	5	
Poor	1	2	

Results

Perioperative and Clinical Outcomes

From January 2020 to March 2022, 77 patients with LRS were treated with PTED and UBE. All 38 patients in the PTED group and 39 patients in the UBE group were followed up for more than 12 months after surgery. An overview of surgical duration, blood loss estimates, incision length, X-ray times, time to ambulation, drainage volume, and length of hospital stay is presented in Table 2. PTED was advantageous with respect to the estimated blood loss, incision length, and drainage volume, while UBE conferred advantages in operative time and X-ray times. UBE achieved 84.6% (33/39) good-to-excellent scores compared to PTED with 81.6% (31/38). At any follow-up time point, VAS scores for back and leg pain and ODI scores were similar between the two groups (Figure 5).

Complications

In PTED, one patient experienced weakened strength of the ankle extensor muscle during the first foraminoplasty; conditions spontaneously resolved with conservative management after surgery. A dural tear was caused in UBE when the ligamentum flavum was removed with forceps. A second dural tear was caused when the instrument expanded and separated the soft tissue covering the laminar space at L5-S1 in UBE. There were no other serious complications related to surgery.

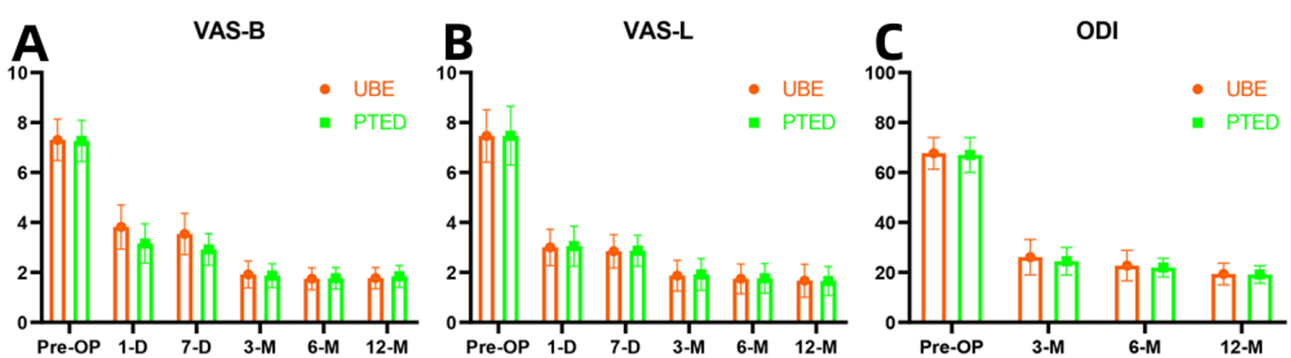

Figure 5 Clinical outcomes at different follow-up time points. (**A**) VAS score for back pain in both groups. (**B**) VAS score for leg pain in both groups. (**C**) ODI score for both groups.

Discussion

Apart from the times of X-ray and the operative duration, PTED offered advantages considering the estimated blood loss, the length of the incision, and the drainage volume. However, the significant improvements in the clinical outcomes revealed that PTED and UBE were effective in treating single-level LRS for Chinese patients over 60.

Classically, open laminectomy is used to treat LRS.[19] However, this open decompression usually involves extensive dissection of paraspinal muscles, which would result in fatty degeneration and iatrogenic instability. Although fusion with screw fixation could prevent iatrogenic instability, it could be vulnerable to adjacent segmental degeneration. In addition, substantial bleeding in fusion with screw fixation is associated with greater incidence of morbidities and prolonged hospital stays for aging patients.

To perform decompression of the lateral recess and avoid the complications of conventional open laminectomy and fusion, percutaneous endoscopic lumbar decompression for LRS was developed.[20,21] PTED might avoid serious injury of the posterior ligament structures, which confers benefits in hospitalization, intraoperative bleeding, faster recovery and nerve-root retraction. In this research, the inferior ventral portion of the SAP and the posterior edge of the vertebral body were removed with the first and secondary foraminoplasty procedures, which allowed adequate expansion of the lateral recess and achieved adequate decompression of the nerve root.

Local anesthesia might reduce the complications of general anesthesia in elderly patients with comorbidities. With epinephrine in the mixed local anesthetic, no severe bleeding events occurred when removing the ventral portion of the SAP and the posterior edge of the inferior vertebral body.[22] Thanks to local anesthesia, the surgeon can detect when the surgical equipment touches the nerve root of the awake patient.

However, only a few hospitals in developing countries are expected to have access to costly endoscopic instruments. In addition, the field of vision with a single portal technique is narrow because a common portal is used for observation and operation. In addition, it is not easy to perform secondary foraminoplasty, remove the posterior edge of the vertebral body, and place the tube correctly with a high iliac crest.

Since it was first reported in 1996, UBE has been widely used for lumbar diseases to overcome the lack of endoscopic surgical instruments.[23,24] As a minimally invasive spinal surgery, UBE is technically similar to PTED in the use of endoscopy and similar to open laminotomy in the anatomic structure.[25] Therefore, the learning curve of UBE is no longer steep for surgeons.[26] In addition, no other endoscopic systems or specialized supporting instruments are needed to complete the procedure. All of these factors make the UBE more generalizable to developing countries. Moreover, the operating instruments of the UBE are not restricted by the working port. Ordinary arthroscopic and spine instruments can significantly improve working efficiency.[14] Compared to open microdiscectomy or microscopic lumbar decompressive laminectomy, the UBE could achieve the same clinical efficacy while reducing intraoperative bleeding, bed rest time, low fever usage, and early discharge after surgery.[27] In addition, UBE is not affected by high iliac crests, unlike PTED.[28] We have attempted to achieve complete decompression in the dorsal region of the nerve root and thecal sac. To expose the nerve root, an ipsilateral laminotomy was performed, and the ligamentum flavum was removed. After ipsilateral medial facetectomy was performed, the traversing nerve root was fully exposed.

This research indicates that PTED requires longer operation than UBE. The structure under UBE is similar to that under traditional open surgery. The observation and operation channels can be separated, and large instruments in open surgery can improve decompression efficiency. After removing the lamina and ligamentum flavum, the space behind the nerve root is sufficient, and there is no need to remove the intervertebral disc. However, PTED requires more time to remove the dorsal ligamentum flavum and some of the nucleus pulposus. The nucleus pulposus in elderly patients is less elastic, and the disc fragment is accessible for detachment from the annulus fibrosis again. The time of hemostasis may be longer. To expand the bony lateral recess, the bone at the posterior edge of the vertebral body must also be removed, which can easily cause bone bleeding. Furthermore, we decreased the irrigation pressure to avoid epidural pressure and muscle swelling caused by high irrigation pressure, which also caused bleeding to increase.[29] As a result, PTED may require a longer hemostasis time and a longer total operative time than UBE, indicating that UBE is more effective for decompressing nerve roots than PTED.

PTED had significantly longer X-ray times than UBE (10.58±3.64 vs 5.79±1.24). For PTED, the process of local anesthesia administration, the first foraminoplasty, and the placement of the working cannula require fluoroscopy. For

UBE, fluoroscopy determines the correct target point of the spinous process and inferior lamina. Therefore, in terms of X-ray times, UBE is superior to PTED.

Theoretically, there is relatively more extensive trauma to the muscles as a result of UBE than PTED based on the drainage volume and estimated blood loss. We have not included the serum creatine kinase, which could reflect the degree of trauma. When creating the operation spaces before decompression, the fascia and paraspinal system, mainly including the multifidus and erector spinal muscles, need to be bluntly dissected. Creating an artificial working space may cause paraspinal muscle edema and damage the posterior ligamentous complex. Therefore, UBE will result in more blood loss and muscle trauma than PTED.

Accidental dural tears occurred in two patients in UBE.[15,30] One instance of damage occurred when the LF was removed with forceps with bleeding obscuring the field of vision. Therefore, it is essential to ensure hemostasis before the next steps. Another damage incident was caused when creating the artificial working space of the L5-S1 level with instruments. The laminar space is larger at L5-S1 than at other levels, so we must be cautious when separating soft tissue and avoid inserting instruments too deep into the laminar space. In addition, CT observation before the operation is important to determine laminar space at the L5-S1 level.

Among the patients with PTED, one complained of weakness in the tibialis anterior and was prescribed drugs. When the first foraminoplasty of the SAP of L5 is performed, the bone drill compresses the nerve root. For geriatric patients with LRS, the interpedicular distance (intervertebral foraminal height) decreased with age, and hyperplasia of the articular process led to a reduction in the intervertebral foramen area. During the first foraminoplasty, the bone drill led to compression of the exiting nerve root (L4). To avoid compression of the exiting nerve root for patients with a reduction in the intervertebral foraminal area, we should place the working cannula first and perform foraminoplasty under direct vision. In addition, timely withdrawal of the instruments is important if the ankle dorsiflexor muscles become weaker. Regarding the safety of anesthesia, the mix of local anesthesia might be better for the patient than general anesthesia.

In our research, the inclusion criteria were unilateral lumbar radicular symptoms without severe back pain and the absence of significant instability. We do not recommend these two endoscopic techniques for patients with lumbar instability. But with the development of technology, endoscopic interbody fusion technology will gradually solve this problem.

This study has some limitations. First, we did not measure the dual cross-sectional area because we believe that the clinical efficacy is due to the expansion of the dual cross-sectional area. Furthermore, this study was retrospective and had a limited sample size and a short follow-up period. To confirm the long-term outcomes, a larger multicenter and prospective study with laboratory and radiological imaging data is necessary for future research.

Abbreviations

LRS, lateral recess stenosis; PTED, Percutaneous transforaminal endoscopic decompression; UBE, unilateral biportal endoscopic; SAP, superior articular process; VAS, The visual analog scale; ODI, Oswestry Disability Index.

Data Sharing Statement

The data used to support the findings of this study are available from the corresponding author upon request.

Ethics Approval and Consent to Participate

The Ethics Committee of the Chengde Medical University Affiliated Hospital approved this retrospective study. Written informed consent was obtained from participants before data collection. This study was conducted following the Declaration of Helsinki.

Consent for Publication

Written informed consent was obtained from all participants.

Author Contributions

Xiaokang Cheng and Yuxuan Wu are co-first authors. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

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