

Original Research Article

Unilateral biportal endoscopy for lumbar spinal stenosis: outcomes and potential to reduce fusion in Schizas grade D patients

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ABSTRACT

Background: Unilateral biportal endoscopy (UBE) is an established minimally invasive technique for the surgical management of lumbar spinal stenosis (LSS). However, prospective evidence regarding its effectiveness in severe stenosis, particularly Schizas Grade D disease, remains limited. This study evaluated the clinical and radiological outcomes of UBE with unilateral laminotomy for bilateral decompression in patients with LSS, with particular emphasis on severe stenosis.

Methods: This prospective single-surgeon study included 134 consecutive patients with LSS who underwent UBE decompression between April 2021 and September 2023. Patients with pre-existing instability or other indications for fusion were excluded. Clinical outcomes were assessed using the Visual Analog Scale (VAS) for back and leg pain and the Oswestry Disability Index (ODI) at a minimum follow-up of 12 months. Particular attention was paid to the outcomes of patients with Schizas Grade D stenosis.

Results: Of the 134 patients, 128 completed the 12-month follow-up. Mean VAS leg pain improved from 7.92 to 0.63 ($p < 0.001$), while mean ODI improved from 69.66 to 39.34 ($p < 0.001$). Among the 42 patients with Schizas Grade D stenosis, two patients (4.8%) required revision surgery, with one patient (2.4%) subsequently undergoing instrumented fusion. Two dural tears (4.8%) occurred in this subgroup. No patient developed postoperative instability requiring unplanned fusion during the follow-up period.

Conclusions: UBE provides safe and effective decompression for carefully selected patients with lumbar spinal stenosis, including severe Schizas Grade D disease, resulting in significant pain relief and functional improvement. The low revision and subsequent fusion rates observed in this series suggest that motion-preserving decompression may be a viable treatment strategy for selected stable spines, although larger comparative studies with longer follow-up are required.

Keywords: Lumbar spinal stenosis, Minimally invasive spine surgery, Schizas grade D, Unilateral biportal endoscopy, Unilateral laminotomy for bilateral decompression

INTRODUCTION

Degenerative lumbar spinal stenosis (LSS) is one of the most common causes of pain, neurogenic claudication, and functional disability in the elderly population and represents a leading indication for spinal surgery in individuals older than 65 years of age. Conventional

surgical management has traditionally involved open decompressive laminectomy, which, although effective in relieving neural compression, is associated with considerable morbidity, including increased intraoperative blood loss, postoperative pain, prolonged hospitalization, and the potential for iatrogenic instability resulting from extensive resection of posterior osteoligamentous

structures and facet joints. Preservation of posterior stabilizing structures has therefore become an important principle in minimizing postoperative instability and adjacent segment degeneration, driving the evolution of minimally invasive decompression techniques.^{1,2}

In recent years, minimally invasive surgical (MIS) techniques have gained increasing acceptance as alternatives to conventional open procedures for the management of lumbar spinal stenosis.³ Among these, unilateral biportal endoscopy (UBE) has emerged as an effective and versatile minimally invasive approach for lumbar decompression.⁴ UBE utilizes two independent portals, one for endoscopic visualization and the other as a working channel, allowing bilateral decompression through a unilateral approach while preserving normal anatomical structures. The technique provides excellent visualization of the neural elements and surrounding anatomy while minimizing bone and soft tissue disruption, thereby reducing surgical trauma and facilitating earlier postoperative recovery. In addition, the continuous saline irrigation used during UBE has been reported to improve visualization of the operative field and may help reduce postoperative infection rates.^{3,5,6} These technical advantages have encouraged the application of UBE to increasingly complex degenerative spinal disorders, including severe lumbar canal stenosis.^{3,7,8}

Although an increasing body of literature supports the effectiveness of unilateral biportal endoscopy for the treatment of lumbar spinal stenosis, evidence regarding its role in severe stenosis remains relatively limited. Particular interest has focused on patients with Schizas Grade D stenosis, which represents the most advanced morphological stage of lumbar canal narrowing and is characterized by complete obliteration of the cerebrospinal fluid space on axial T2-weighted magnetic resonance imaging.⁹ Severe stenosis of this magnitude presents unique technical challenges because adequate neural decompression must be achieved while preserving the stabilizing posterior osteoligamentous structures and facet joints. With improvements in endoscopic instrumentation and surgical technique, UBE has emerged as a potential motion-preserving alternative for the management of severe lumbar spinal stenosis, although prospective clinical data in this subgroup remain limited.^{7,10}

Recent randomized controlled trials and large prospective cohort studies have demonstrated that decompression alone provides clinical outcomes comparable to decompression combined with fusion in carefully selected patients with lumbar spinal stenosis while avoiding the additional morbidity associated with instrumented stabilization. Furthermore, several studies have shown only a modest correlation between the radiological severity of lumbar canal stenosis and the severity of clinical symptoms or disability, emphasizing the importance of individualized, symptom-driven surgical decision-making rather than relying solely on imaging findings. Although unilateral biportal endoscopy has

demonstrated encouraging clinical and radiological outcomes for lumbar spinal stenosis, prospective studies specifically evaluating its effectiveness in patients with severe Schizas Grade D stenosis remain limited.^{2,11-15}

Given these considerations, the present prospective study was designed to evaluate the clinical and radiological outcomes of unilateral biportal endoscopic decompression in patients with lumbar spinal stenosis, with particular emphasis on those presenting with severe Schizas Grade D stenosis.⁹ The primary objectives were to evaluate the adequacy of neural decompression, clinical and functional outcomes, perioperative safety, and the incidence of subsequent revision or fusion procedures following UBE decompression in patients with severe lumbar spinal stenosis. By providing prospective data from a consecutive single-surgeon series, this study aims to further define the role of UBE in the management of severe lumbar spinal stenosis.

METHODS

This prospective observational study included patients with degenerative lumbar spinal stenosis who underwent unilateral biportal endoscopic (UBE) decompression with unilateral laminotomy for bilateral decompression between April 2021 and September 2023 at Smt. Kashibai Navale Medical College and General Hospital, Pune, India. All procedures were performed by a single senior spine surgeon with more than 10 years of dedicated spine surgery experience who had completed over 30 UBE procedures before commencement of the study, thereby minimizing the influence of the surgical learning curve. A total of 134 consecutive patients were enrolled in the study. Inclusion criteria were symptomatic lumbar spinal stenosis confirmed by magnetic resonance imaging with radiological findings corresponding to clinical symptoms and failure of at least 6-12 weeks of conservative treatment.

Patients with radiological evidence of overt spinal instability (e.g., spondylolisthesis greater than Grade I, dynamic instability exceeding 5 mm translation or 10°-15° angulation on flexion-extension radiographs), active spinal infection, previous surgery at the index level, isolated soft disc herniation without significant stenosis, or spinal pathology requiring instrumentation were excluded. Patients with clear indications for instrumented fusion because of significant instability or spinal deformity were not included, as the study was designed to evaluate UBE decompression in patients considered suitable for decompression without mandatory fusion.

Surgical technique

All patients underwent surgery under general or spinal anesthesia, depending on clinical assessment and anesthetic considerations. Patients were positioned prone on a radiolucent operating table, and the target level was confirmed using C-arm fluoroscopy. A left-sided approach

was routinely utilized, as the operating surgeon was right-hand dominant.

Two standard UBE portals were established: a viewing portal and a working portal. The viewing portal was typically created approximately 2.5-3 cm cranial to the working portal. The working portal was established at the mid-to-lower pedicle level, targeting the medial border of the lamina to facilitate drilling of the cranial lamina. Continuous gravity-assisted saline irrigation was maintained at a height of approximately 2.5 feet above the operating table, and an irrigation pump was not routinely used. A 0° 4-mm arthroscope was introduced through the viewing portal.

Decompression was performed using the authors' "Z-technique," a sequential stepwise decompression strategy designed to achieve adequate bilateral neural decompression while preserving the stabilizing posterior osteoligamentous structures and facet joints. The technique consisted of three principal stages:

Ipsilateral Decompression: The cranial lamina was drilled to expose the proximal attachment of the ligamentum flavum, using the midline cleft as an important anatomical landmark. Ipsilateral laminotomy was then extended caudally to the distal attachment of the ligamentum flavum, ensuring adequate exposure of the underlying neural structures while preserving as much of the stabilizing posterior elements as possible.

Contralateral Decompression ("Over-the-Top"): Sublaminar decompression was performed on the contralateral side using an over-the-top approach. The contralateral superior articular process was undercut to achieve adequate decompression of the exiting nerve root, followed by decompression of the traversing nerve root to the inferior border of the pedicle while preserving the integrity of the contralateral facet joint as much as possible.

Flavectomy and Adhesion lysis: The ligamentum flavum was removed either en bloc or in a piecemeal fashion, depending on the extent of stenosis and local anatomical considerations. Any epidural adhesions encountered were carefully released to facilitate adequate mobilization of the neural elements. Adequate decompression was confirmed by free mobilization of the dural sac and traversing nerve root, visualization of the contralateral pedicle, and complete removal of the compressive ligamentum flavum.

Outcome assessment

Clinical outcomes were assessed preoperatively and at 1, 3, and 12 months postoperatively using standardized clinical and radiological measures.

Visual Analog Scale (VAS): Back pain and leg pain were assessed using a 10-point Visual Analog Scale, where 0

indicated no pain and 10 indicated the worst imaginable pain.

Oswestry Disability Index (ODI): Functional disability was evaluated using Version 2.1a of the Oswestry Disability Index, with scores ranging from 0% (no disability) to 100% (maximum disability).

Schizas Grading: Preoperative magnetic resonance imaging was used to classify the severity of central lumbar spinal stenosis at the most severely affected level according to the Schizas classification system (Grades A-D). Grade A represents absent or minor stenosis with visible cerebrospinal fluid, Grade B demonstrates individual nerve rootlets occupying the dural sac, Grade C is characterized by loss of identifiable rootlets with preservation of posterior epidural fat, and Grade D represents extreme stenosis with complete obliteration of the cerebrospinal fluid space and posterior epidural fat. All MRI grading was performed by the senior author (Dr. SS). Formal assessment of interobserver and intra observer reliability was not undertaken and is acknowledged as a limitation of the study.

Radiological assessment

Preoperative magnetic resonance imaging was performed in all patients to confirm the diagnosis and assess the severity of lumbar spinal stenosis. Postoperative magnetic resonance imaging was obtained selectively in patients with persistent or new symptoms, or when objective assessment of the adequacy of decompression was clinically indicated. Routine postoperative MRI for all patients was not included in the study protocol; representative postoperative MRI images demonstrating decompression are presented in Figures 1-3. Assessment of postoperative stability was primarily based on clinical evaluation, including the development of new or worsening mechanical back pain or radiculopathy suggestive of instability. Routine dynamic flexion-extension radiographs were not systematically obtained during follow-up unless clinically indicated.

Statistical analysis

Descriptive statistics were used to summarize the study population. Continuous variables were expressed as mean $\pm$ standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Preoperative and postoperative Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scores were compared using paired t-tests or Wilcoxon signed-rank tests, as appropriate according to data distribution. A p-value of less than 0.05 was considered statistically significant. Statistical analyses were performed using SPSS software version 28.0 (IBM Corp., Armonk, NY, USA).

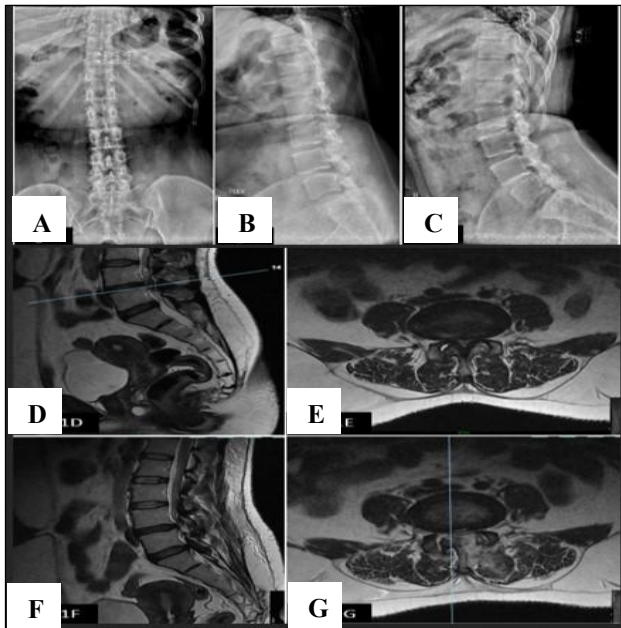


Figure 1: Case example 1: a 48-year-old female with a one-year history of left greater than right leg radiating pain. (A-C) Anteroposterior (AP), lateral in flexion, and lateral in extension radiographs; (D and E) sagittal and axial T2-weighted MRI images demonstrating severe neural compression, Schizas grade; (D, F and G) postoperative MRI images showing adequate decompression.

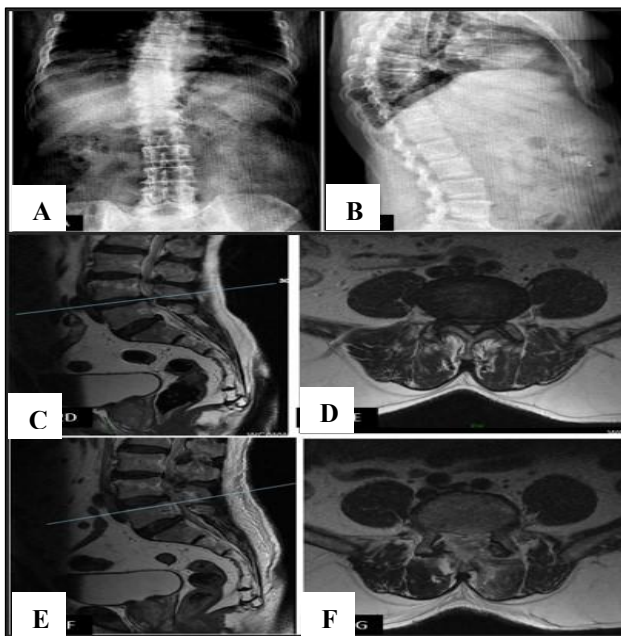


Figure 2: Case Example 2: 72-year-old male with lumbar canal stenosis at L4-L5, presenting with left lower limb radiculopathy. (A and B) Show anteroposterior (AP), lateral x-rays, (C and D) display sagittal and axial T2-weighted MRI images demonstrating significant neural compression at L4-L5, (E and F) represent postoperative MRI images showing satisfactory decompression.

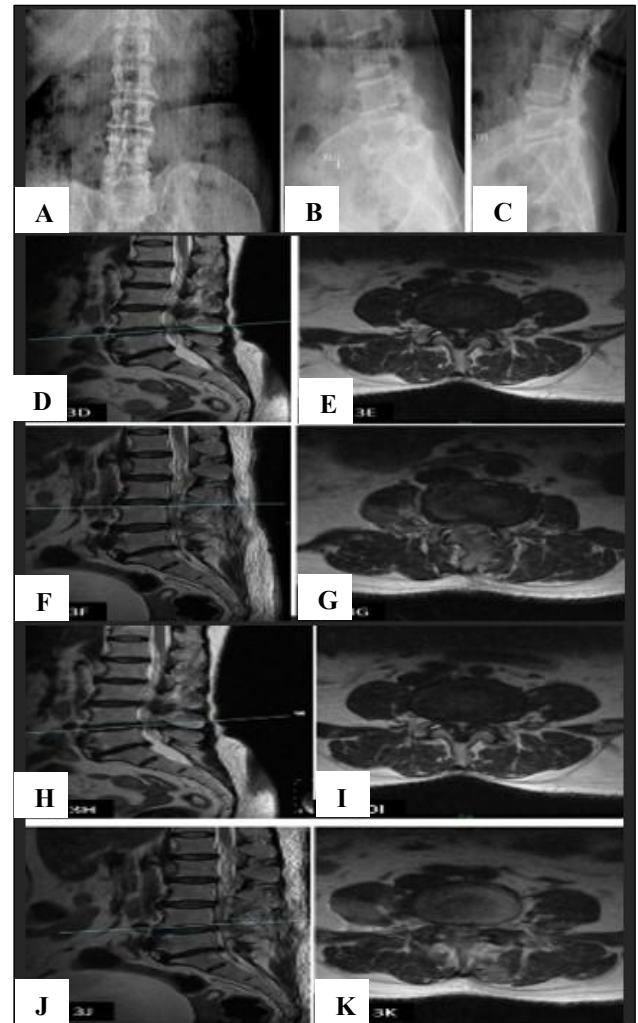


Figure 3: Case Example 3: 65-year-old male with lumbar canal stenosis at both L3-L4 and L4-L5, presenting with left lower limb radiculopathy. (A to C) Show AP, lateral in flexion, and lateral in extension radiographs, D and E) Depict preoperative sagittal and axial T2-weighted MRI images at the L3-L4 level, demonstrating severe neural compression, (F and G) Display preoperative sagittal and axial T2-weighted MRI images at the L4-L5 level, also showing significant neural compression, (H and I) Present postoperative sagittal and axial MRI images at the L3-L4 level, indicating adequate decompression, (J and K) show postoperative sagittal and axial MRI images at the L4-L5 level, confirming satisfactory decompression.

RESULTS

Of the 134 patients enrolled, 128 (95.5%) completed the minimum 12-month follow-up and were included in the final analysis. The mean age of the cohort was 51.0 ± 12.4 years (range, 28-82 years). There were 15 patients (11.7%) older than 70 years and 6 patients (4.7%) older than 80 years. The cohort comprised 70 males (54.7%) and 58 females (45.3%). A total of 161 lumbar levels were decompressed in the 128 patients included in the final

analysis, reflecting both single-level and multilevel procedures. The most commonly operated level was L4-L5 (71 cases), followed by L5-S1 (30 cases). Forty-two patients had Schizas Grade D stenosis at their most severely affected level (Table 1).

Table 1: Baseline patient demographics and clinical characteristics (n=128).

Characteristics	Value
Mean age (years±SD)	51.0±2.4
Age range (years)	28-82
Patients >70 years, N (%)	15 (11.7)
Patients >80 years, N (%)	6 (4.7)
Gender - Male, N (%)	70 (54.7)
Gender - Female, n (%)	58 (45.3)
Mean BMI (kg/m ² ±SD)	26.8±3.2
Mean symptom duration (months±SD)	8.4±6.1
Smoking, n (%)	23 (18.0)
Diabetes mellitus, N (%)	28 (21.9)
Hypertension, N (%)	45 (35.2)
Single level surgery, N (%)	95 (74.2)
Two level surgery, N (%)	28 (21.9)
Three level surgery, N (%)	5 (3.9)
Total levels operated	161
L2-L3 level, N (%)	9 (7.0)
L3-L4 level, N (%)	18 (14.1)
L4-L5 level, N (%)	71 (55.5)
L5-S1 level, N (%)	30 (23.4)
Schizas Grade A, N (%)	12 (9.4)
Schizas Grade B, N (%)	38 (29.7)
Schizas Grade C, N (%)	36 (28.1)
Schizas Grade D, N (%)	42 (32.8)
Preoperative VAS back pain	3.66±2.00
Preoperative VAS leg pain	7.92±0.89
Preoperative ODI (%)	69.66±4.78

SD: Standard Deviation; BMI: Body Mass Index; VAS: Visual Analog Scale; ODI: Oswestry Disability Index

Clinical outcomes

Significant improvements in Visual Analog Scale (VAS) scores for back and leg pain and Oswestry Disability Index (ODI) scores were observed at the 12-month follow-up (Table 2).

Complications and revisions

Perioperative data, complications, and revision surgeries are summarized in Table 3. Two dural tears occurred, both in patients with Schizas Grade D stenosis (4.8% of this subgroup). One was managed conservatively with endoscopic assessment and postoperative bed rest, whereas the other required conversion to open surgery for primary dural repair. Five patients reported persistent leg pain during follow-up, of whom three improved with conservative management. Two patients with Schizas Grade D stenosis required revision surgery because of

persistent symptoms. One underwent open decompression at the index level, whereas the other subsequently underwent instrumented fusion.

No surgical site infections were observed. One patient developed a contralateral epidural hematoma with a neurological deficit 12 hours after surgery, requiring open evacuation. The patient recovered normal motor power by 3 months of follow-up. No new permanent major neurological deficits were recorded. Importantly, no patient, including those with Schizas Grade D stenosis who did not undergo revision surgery, developed clinical or symptomatic evidence of postoperative instability or listhesis requiring unplanned fusion during the 12-month follow-up period.

Table 2: Preoperative and 12-month postoperative clinical outcomes.

Outcome measures	Pre-op (Mean±SD)	12-month post-op (Mean±SD)	P value
VAS back pain (0-10)	3.66±2.00	0.69±1.26	<0.001
VAS leg pain (0-10)	7.92±0.89	0.63±1.23	<0.001
ODI (%)	69.66±4.78	39.34±6.82	<0.001
ODI-Schizas Grade D subgroup	70.2±4.9	40.1±7.1	<0.001

VAS: Visual Analog Scale; ODI: Oswestry Disability Index; SD: Standard Deviation

Table 3: Perioperative data, complications, and revisions.

Parameters	Value
Mean operative time (minutes±SD)	72.4±18.6
Mean estimated blood loss (mL±SD)	45.2±22.8
Mean hospital stay (days±SD)	1.8±0.6
Overall complications, N (%)	4 (3.1)
Dural tears - total, N (%)	2 (1.6)
Dural tears - Schizas Grade D, N (%)	2 (4.8)
Dural tears requiring open repair, N (%)	1 (0.8)
Epidural hematoma, N (%)	1 (0.8)
Surgical site infection, N (%)	0 (0.0)
New major neurological deficit, N (%)	0 (0.0)
Persistent leg pain, N (%)	5 (3.9)
Revision surgery - total, N (%)	2 (1.6)
Revision surgery-Schizas Grade D, N (%)	2 (4.8)
Subsequent fusion-Schizas Grade D, N (%)	1 (2.4)
New postoperative instability, N (%)	0 (0.0)
Return to work (weeks±SD)	3.2±1.8
Patient satisfaction (excellent/good), N (%)	122 (95.3)

DISCUSSION

This prospective study demonstrates that unilateral biportal endoscopic (UBE) decompression is a safe and effective minimally invasive technique for the management of lumbar spinal stenosis, including patients with severe Schizas Grade D stenosis. Significant improvements were observed in pain and functional outcomes, with low complication and revision rates during the 12-month follow-up period. Importantly, satisfactory clinical outcomes were achieved without evidence of clinically significant postoperative instability requiring unplanned fusion in the majority of patients. These findings support the role of UBE as a tissue-preserving decompression strategy for carefully selected patients with severe lumbar spinal stenosis.^{3,7,8,10}

The significant improvements observed in Visual Analog Scale (VAS) scores for both back and leg pain and in Oswestry Disability Index (ODI) scores are consistent with the growing body of evidence supporting the effectiveness of UBE for lumbar spinal stenosis. The relatively low baseline back pain scores and higher leg pain scores in our cohort suggest that neurogenic claudication and radiculopathy were the predominant clinical manifestations, making these patients particularly suitable for decompression-focused surgery. Although the mean age of our cohort was younger than that reported in many contemporary lumbar stenosis series, the inclusion of elderly patients, including those older than 70 and 80 years, suggests that satisfactory outcomes can be achieved across a broad age spectrum with appropriate patient selection. These findings are comparable with previous studies that have demonstrated significant improvements in pain and functional outcomes following UBE decompression for degenerative lumbar spinal stenosis.^{3,5,10,16-18}

A particular focus of the present study was the management of patients with severe Schizas Grade D stenosis, a subgroup that often presents significant technical challenges because adequate neural decompression must be balanced against preservation of stabilizing posterior structures. In our series, only one of the 42 patients with Schizas Grade D stenosis subsequently required instrumented fusion during the follow-up period, while no clinically significant postoperative instability requiring unplanned fusion was observed in the remaining patients. These findings suggest that, in carefully selected patients without preoperative instability, UBE can achieve satisfactory decompression while preserving segmental stability. This observation is consistent with the principles of minimally invasive decompression and with previous reports demonstrating that preservation of the posterior osteoligamentous complex and facet joints may reduce the risk of postoperative instability while maintaining favorable clinical outcomes.^{7,12}

The preservation of posterior stabilizing structures is an important principle underlying minimally invasive

decompression techniques. Previous studies have demonstrated that endoscopic decompression for severe lumbar spinal stenosis can achieve effective neural decompression with limited resection of the lamina and facet joints, thereby potentially reducing the risk of postoperative instability. The surgical strategy employed in the present study similarly emphasized targeted bony decompression and preservation of the posterior osteoligamentous complex wherever feasible. The stepwise "Z-technique" facilitated adequate bilateral decompression through a unilateral approach while minimizing unnecessary bone and facet joint resection. Although the present study was not designed to quantitatively evaluate facet preservation, the low incidence of subsequent instability and fusion observed during follow-up supports the concept that meticulous tissue-preserving decompression can achieve satisfactory clinical outcomes in carefully selected patients.^{5,7}

The present findings should also be interpreted in the context of the evolving evidence regarding decompression alone versus decompression combined with fusion for degenerative lumbar spinal stenosis. Several high-quality randomized controlled trials and long-term follow-up studies have demonstrated that the routine addition of fusion does not necessarily result in superior clinical outcomes for appropriately selected patients and may increase surgical morbidity and the risk of adjacent segment degeneration. Our findings do not suggest that fusion should be avoided when clear indications such as instability or deformity are present. Rather, they indicate that, in carefully selected stable patients with severe lumbar spinal stenosis, minimally invasive UBE decompression can provide satisfactory clinical outcomes with a low requirement for subsequent fusion during intermediate follow-up. These observations are consistent with the growing trend toward individualized, tissue-preserving surgical strategies for degenerative lumbar spinal stenosis.^{1,2,6,12,19,20}

The safety profile observed in the present study was comparable with that reported in the contemporary UBE literature. Two incidental dural tears occurred, both in patients with severe Schizas Grade D stenosis, reflecting the technical challenges associated with advanced canal compromise and epidural adhesions. One patient required conversion to open dural repair, whereas the other was managed successfully with conservative measures. A single postoperative epidural hematoma required surgical evacuation, with complete neurological recovery during follow-up. No surgical site infections or permanent major neurological deficits were observed. Overall, the complication profile compares favorably with previously published UBE series and systematic reviews, which have reported low rates of infection, neurological injury, and revision surgery despite the technical complexity of endoscopic decompression.^{5,7,10}

This study has several limitations that should be considered when interpreting the findings. First, the

follow-up period of 12 months is sufficient to evaluate early and intermediate clinical outcomes but may not capture late recurrent stenosis or delayed postoperative instability. Second, the study was conducted at a single institution by a single experienced surgeon, which ensured technical consistency but may limit the generalizability of the results. Third, Schizas grading was performed by a single observer, and formal interobserver or intra observer reliability assessment was not undertaken. Fourth, postoperative magnetic resonance imaging and dynamic flexion-extension radiographs were obtained selectively according to clinical indications rather than systematically in all patients, limiting comprehensive radiological assessment of decompression adequacy and postoperative stability. Fifth, the absence of a comparative control group precludes definitive conclusions regarding the superiority of UBE over conventional decompression or fusion procedures. Finally, the relatively young mean age of the study population and the absence of a formal sample size calculation should be considered when extrapolating these findings to the broader population of patients with degenerative lumbar spinal stenosis. Future multi centre prospective studies with longer follow-up, standardized postoperative imaging protocols, and comparative study designs are warranted to further validate these findings.

CONCLUSION

Unilateral biportal endoscopic (UBE) decompression is a safe and effective minimally invasive technique for the management of lumbar spinal stenosis, including carefully selected patients with severe Schizas Grade D stenosis. In this prospective series, UBE was associated with significant improvements in pain and functional outcomes, acceptable complication rates, and a low incidence of subsequent revision and fusion procedures during 12 months of follow-up. Preservation of posterior stabilizing structures may allow adequate neural decompression while maintaining segmental stability in appropriately selected patients. Larger prospective comparative studies with longer follow-up and standardized radiological assessment are required to further define the role of UBE in the management of severe lumbar spinal stenosis.

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Ethical approval: The study was approved by the Institutional Ethics Committee (Approval No: IRB-2021-LSS-001)

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