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# Clinical efficacy of AUSS/UNSES-TLIF in the treatment of single-segment degenerative lumbar spinal stenosis: a retrospective study

Zhide Liu[1], Shiyuan Hao[1], XiangLong Li[1], En Song[2] and Yabo Yao[1*]

## Abstract

**Objective** To explore the clinical efficacy and advantages of Arthroscopic-assisted Uni-portal Spinal Surgery (AUSS)-Transforaminal Lumbar Interbody Fusion (TLIF) in the treatment of degenerative lumbar spinal stenosis (LSS).

**Methods** This study included 71 patients with lumbar spinal stenosis who underwent surgical treatment at the Department of Spine Surgery, Second Affiliated Hospital of Xi'an Medical University, between January 2022 and December 2023. Among these, 34 patients underwent AUSS-TLIF surgery, and 37 patients underwent minimally invasive TLIF (MIS-TLIF) surgery. Preoperative and postoperative Visual Analog Scale (VAS) scores for low back and leg pain, Oswestry Disability Index (ODI) scores, intervertebral disc height, anterior-posterior diameter of the canal (APDC), surgical-related parameters (such as operative time, intraoperative blood loss, postoperative drainage, postoperative C-reactive protein levels, and length of hospital stay), and surgical outcomes were compared and analyzed between the AUSS-TLIF and MIS-TLIF groups.

**Results** All 71 patients were followed up. There were no significant differences in preoperative VAS scores or ODI index between the AUSS-TLIF and MIS-TLIF groups ($P > 0.05$). Three days postoperatively, both groups showed significant reductions in back and leg symptoms, with VAS scores significantly lower than preoperatively ($P < 0.05$). However, the AUSS-TLIF group had lower VAS scores at 3 days and 3 months postoperatively compared to the MIS-TLIF group, with a statistically significant difference ($P < 0.05$). At 12 months postoperatively, there was no significant difference in VAS scores between the two groups ($P > 0.05$). Both groups showed significant improvement in lumbar function at 3 and 12 months postoperatively, with ODI scores significantly lower than preoperatively ($P < 0.05$). However, the AUSS-TLIF group had a significantly lower ODI score at 3 months postoperatively compared to the MIS-TLIF group ($P < 0.05$), with no significant difference at 12 months ($P > 0.05$). There were no significant differences in preoperative intervertebral disc height or APDC between the two groups ($P > 0.05$). CT scans at 12 months postoperatively showed a significant increase in intervertebral disc height and APDC in both groups compared to preoperative values ($P < 0.05$), with no significant difference between the groups ($P > 0.05$). The AUSS-TLIF group had lower surgical blood loss, postoperative drainage, and postoperative inflammatory markers compared to the MIS-TLIF group ($P < 0.05$), but the AUSS-TLIF group had a significantly longer operative time compared to the MIS-TLIF group ($P < 0.05$).

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**Conclusion** Both AUSS-TLIF and MIS-TLIF achieve good clinical outcomes, but AUSS-TLIF, as an endoscopic surgery with an open surgical concept, offers advantages including greater flexibility, smaller trauma, less blood loss, shorter operative time, and shorter hospital stay. It provides a better perioperative experience for patients.

**Keywords** AUSS-TLIF, MIS-TLIF, LSS, Minimally invasive treatment

## Introduction

Lumbar Spinal Stenosis (LSS) is a clinical syndrome characterized by "low back or lower limb pain" [1], caused by morphological and structural changes in the lumbar vertebrae and soft tissues (such as facet joints, lamina, yellow ligament, and intervertebral discs), leading to narrowing of the central spinal canal, nerve root canals, and foramina. This results in compression of the nerve roots or cauda equina, triggering a series of clinical symptoms [2].LSS often leads to intermittent claudication, low back pain, and leg pain or numbness, significantly impacting the patient's daily life. In recent years, the incidence of LSS has been increasing annually, with approximately 103 million patients diagnosed each year, and the prevalence remains high in China [3], The disease is also affecting a younger population, placing a heavy burden on society and healthcare systems. For patients with mild symptoms and a short disease duration, conservative treatments (such as bed rest, immobilization, traction, and medication) typically provide the greatest benefit. However, for patients with severe symptoms, such as significant lower limb pain, numbness, and intermittent claudication that severely impact daily activities and work, and who have not shown significant improvement with 3–6 months of conservative treatment, surgical intervention is recommended. Surgery often provides better short-term and long-term outcomes compared to conservative treatment [4].

The primary goal of surgery for LSS is to decompress the responsible segment thoroughly, relieve pressure on the affected nerves, and maintain or restore spinal stability. In recent years, more surgeons have advocated for limited decompression using smaller or minimally invasive techniques. These techniques decompress the affected segment, aiming to relieve symptoms while preserving spinal structure to maintain lumbar stability postoperatively. However, decompression alone is not suitable for all patients. It is generally considered that when lumbar instability is present preoperatively, or when the intervertebral disc has undergone significant degeneration, spinal fusion surgery is a more effective treatment than decompression alone. Fusion surgery can significantly improve symptoms, restore spinal stability, and enhance patients' quality of life [5]. Compared to traditional open posterior lumbar fusion, fusion surgery via the Wiltse approach minimizes damage to the paraspinal muscles and reduces destruction of the posterior longitudinal ligament complex. It also offers advantages such as smaller incisions, less blood loss, and reliable decompression [6–8], and was once the most favored fusion approach by clinicians. However, with the advancement of surgical instruments and treatment concepts, new minimally invasive spinal surgeries have emerged. The Unilateral Biportal Endoscopic (UBE) technique combines the benefits of open and minimally invasive surgery and can be used for lumbar fusion under endoscopy, offering significant advantages to LSS patients [9, 10]. Nevertheless, UBE faces challenges such as unstable instruments and vision issues during the procedure [11, 12].To address these limitations, Professor En Song introduced the Arthroscopic-assisted Uni-portal Spinal Surgery (AUSS) technique, which differs from UBE in that both the working and observing channels are located within the same incision.Therefore, it has also been named Uni-portal Non-Coaxial Spinal Endoscopic Surgery (UNSES). This allows for clearer visualization, a larger working space, and more flexibility in operation [13–15].To evaluate the clinical efficacy of the AUSS technique in lumbar fusion surgery, we included LSS patients who met the inclusion criteria and underwent AUSS-TLIF and MIS-TLIF treatments between January 2022 and December 2023.We compared preoperative and postoperative pain VAS scores [16], ODI index [17], anterior-posterior diameter of the canal (APDC), and intervertebral disc height, as well as surgical-related parameters between the two techniques. This study aims to provide evidence for the clinical application of the AUSS technique.

## Materials and methods

### General information

This study was approved by the Ethics Committee of the Second Affiliated Hospital of Xi'an Medical University (Ethical approval number: X2Y2024108). Informed consent was obtained from all participants.

A total of 71 patients with lumbar spinal stenosis (LSS) who underwent surgical treatment at the Department of Spine Surgery, Second Affiliated Hospital of Xi'an Medical University, between January 2022 and December 2023, were included in the study. Among these, 34 patients underwent AUSS-TLIF and 37 patients underwent MIS-TLIF. Demographic data were collected, including gender, age, lesion location, duration of conservative treatment, and follow-up duration. Preoperative imaging included dynamic lumbar X-rays(Fig. 1a-b), computed tomography (CT)(Fig. 1c-e), and magnetic

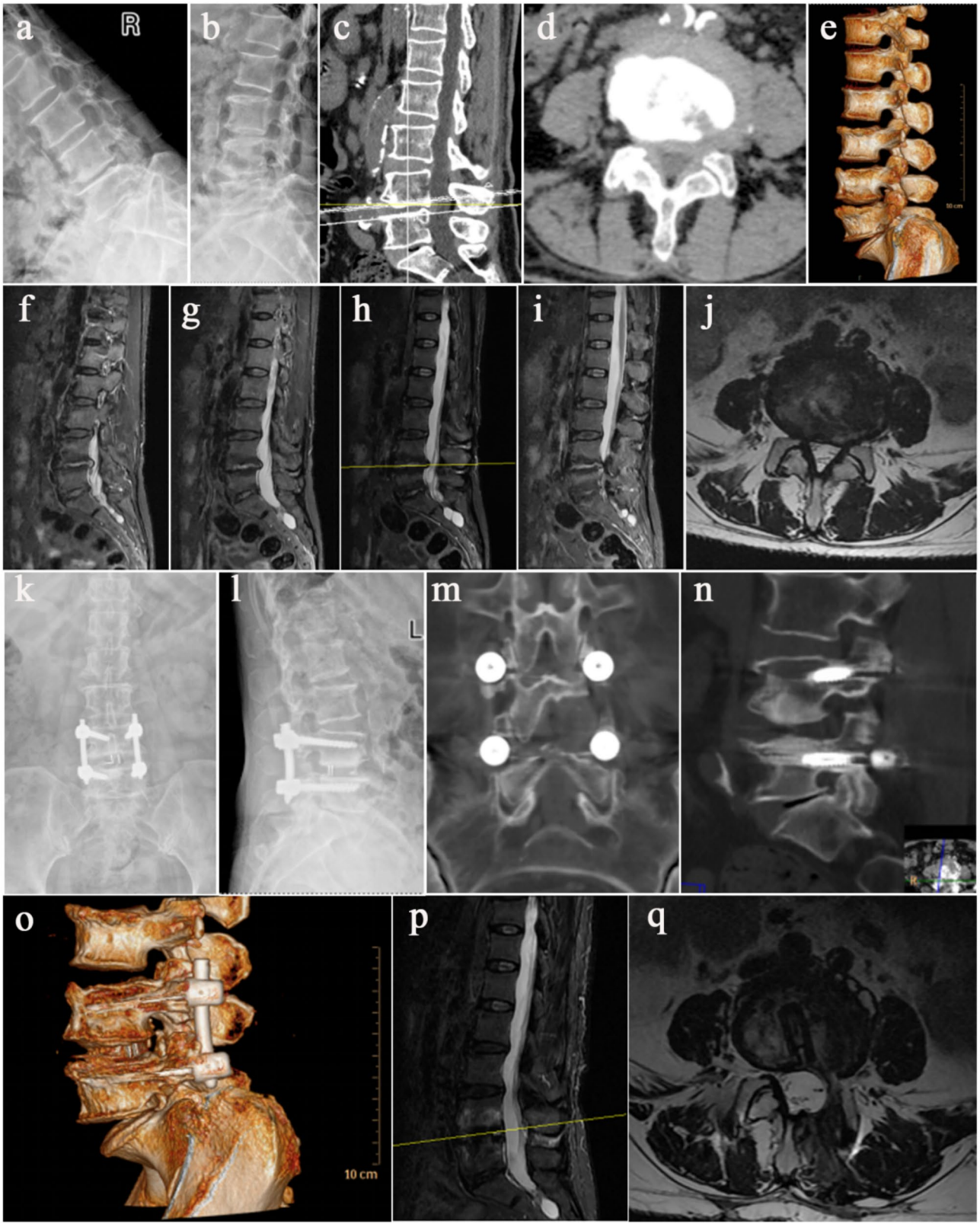


**Fig. 1** Imaging examination before and after AUSS-TLIF surgery. (**a-b**) Preoperative dynamic X-ray of the lumbar spine; (**c-e**) Preoperative lumbar spine CT scans; (**f-j**) Preoperative lumbar spine MRI scans; (**k-l**) Postoperative anteroposterior and lateral X-rays of the lumbar spine; (**m-o**) Postoperative lumbar spine CT scans; (**p-q**) Postoperative lumbar spine MRI scans

resonance imaging (MRI)(Fig. 1f-j). All participants were able to complete follow-up through outpatient visits.

### Inclusion and exclusion criteria

#### *Inclusion criteria*

(1) Patients with LSS at the L4/5 or L5/S1 single-level segment, presenting with low back and leg pain or intermittent claudication.
(2) Failure to respond to more than 3 months of conservative treatment.
(3) Preoperative dynamic lumbar X-rays indicating lumbar instability or MRI showing intervertebral disc degeneration classified as Pfirrmann grade IV or V.

#### *Exclusion criteria*

(1) Multisegmental LSS or LSS at segments other than L4/5 and L5/S1.
(2) Comorbidities such as tuberculosis, infection, or tumors.
(3) A history of previous lumbar spine surgery.
(4) Preoperative severe neurological dysfunction, such as cauda equina syndrome.
(5) Presence of nerve root anomalies.

### Treatment methods

#### *AUSS-TLIF group*

The patient was placed in a prone position under general anesthesia. C-arm fluoroscopy was used to confirm the surgical segment. A 1.5 cm longitudinal incision was marked on the lower third of the line connecting the lateral edges of the superior and inferior pedicles of the vertebrae. Additional markings were made at the superior outer edge of the pedicles on both sides of the vertebral body as puncture sites for percutaneous pedicle screws. After routine sterilization and draping, a puncture needle was inserted along the marked point on the pedicle under fluoroscopic guidance. Once the needle position was confirmed, a guidewire was inserted and fixed on both sides. The skin incision was made at the marked surgical site, and subcutaneous tissue was gradually expanded. An arthroscope (Bioran, 30°) was placed, and a radiofrequency probe (Anhui Beikobang, 3.8 mm, 90°) was used to dissect soft tissues, exposing the yellow ligament, V-point, facet joints, and the upper and lower edges of the vertebral laminae. The inferior and superior facet joints were resected sequentially, followed by decompression of the central spinal canal and lateral recesses. Decompression was continued until the nerve roots were relaxed. Subsequently, the intervertebral space and endplates were prepared, and autologous bone graft was packed. An appropriately sized interbody fusion cage (Xiamen Dabo) was inserted. After adequate hemostasis, percutaneous pedicle screws (Xiamen Dabo) were placed along the guidewire. The incision was extended to connect with the incision for the lower pedicle screw on the same side. A connecting rod was placed, and fluoroscopy confirmed proper screw and rod placement. The surgical area was irrigated, a drain was placed, and the incisions were closed in layers (Fig. 2).

#### *MIS-TLIF group*

The preoperative preparation was the same as for the AUSS-TLIF group. C-arm fluoroscopy was used to identify the projections of the bilateral pedicles and the outer edge of the symptomatic-side pedicle, with the line connecting these points serving as the surgical incision. After routine disinfection and draping, the skin was incised, and subcutaneous tissue was separated using the Wiltse approach [18]. A dilator (Xiamen Dabao) was inserted to expose the symptomatic-side facet joint, which was resected. Decompression of the central spinal canal and lateral recess was then performed, followed by exploration until the nerve root was relaxed. The intervertebral disc space was accessed via the foramina, the intervertebral space and endplates were treated, and an appropriately sized interbody fusion cage was inserted, filled with autologous bone. On the same side, pedicle screws were inserted through the Wiltse approach (Xiamen Dabao), and on the opposite side, percutaneous pedicle screws were placed (Xiamen Dabao). The connecting rod was then placed, and fluoroscopy confirmed proper screw and rod positioning. The surgical area was irrigated, a drain was placed, and the incisions were closed in layers.

### Postoperative treatment

(1) Postoperative pain management, anti-swelling treatment, and neuro-nutrition therapy were administered. Patients were instructed on axial repositioning and lower limb exercises to prevent complications associated with prolonged bed rest.
(2) C-reactive protein (CRP) was rechecked 48 h after surgery.
(3) Postoperative drainage volume was recorded, and when the drainage volume was < 30 ml/d, the drain was removed.
(4) Pre-discharge, at 3 months, and at 12 months postoperatively, lumbar spine X-rays(Fig. 1k-l), CT scans(Fig. 1m-o) and MRI (Fig. 1p-q)were performed. Patients were instructed to wear a lumbar brace for at least 3 months.

### Efficacy assessment

Clinical outcomes, including operative time, intraoperative blood loss, postoperative drainage volume, and length of hospital stay, were recorded and analyzed for

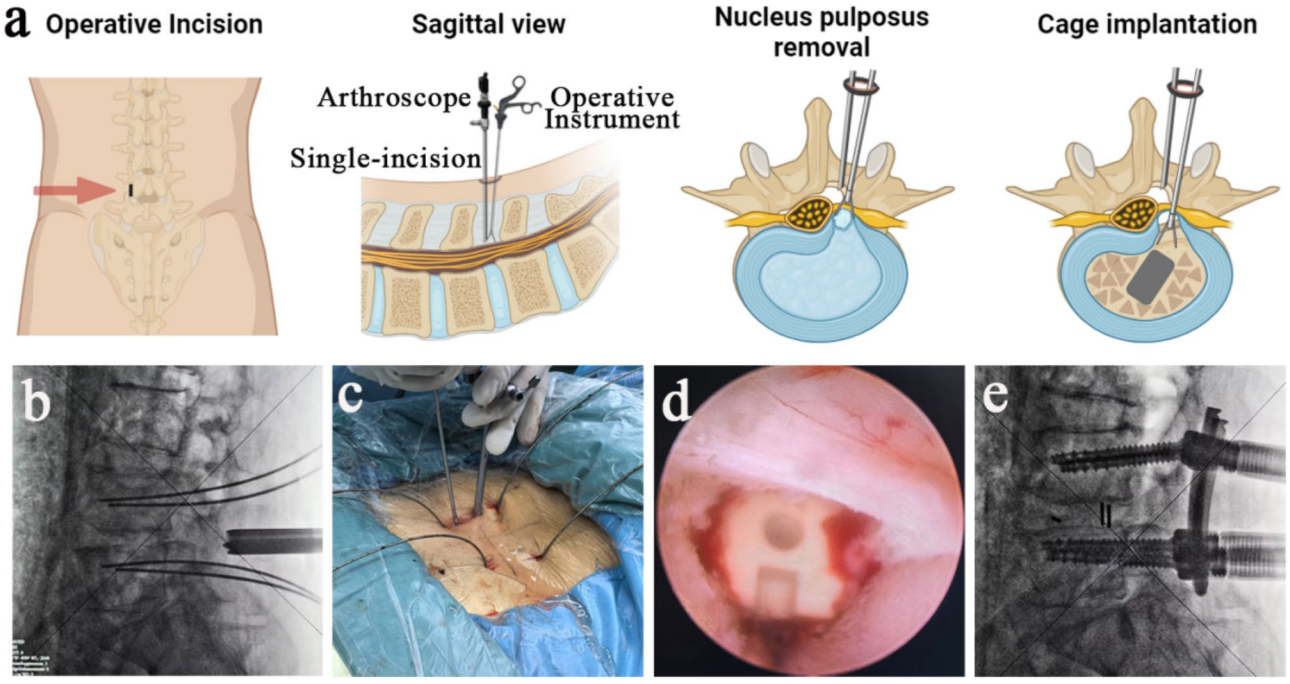


**Fig. 2** AUSS-TLIF surgical procedure. (**a**) Schematic diagram of the AUSS-TLIF procedure; (**b**) Preoperative fluoroscopy to identify the intervertebral space to be fused; (**c**) Intraoperative relationship between various instruments; (**d**) Insertion of the interbody fusion cage under endoscopic guidance; (**e**) Postoperative fluoroscopy to confirm the appropriate positioning of the interbody fusion cage and pedicle screws

**Table 1** Demographic characteristics of both groups

| Variable | AUSS-TLIF group | MIS-TLIF group | Statistics | *P*-value |
|---|---|---|---|---|
| Cases | 34 | 37 | | |
| Male/female | 15/19 | 15/22 | $\chi^2 = 0.0929$ | 0.7605 |
| Age (years) | 63.18 ± 7.73 | 64.03 ± 6.97 | t = 0.4808 | 0.6322 |
| BMI (kg/m$^2$) | 25.02 ± 3.27 | 24.85 ± 3.12 | t = 0.2086 | 0.8354 |
| Diseased segment | | | | |
| L4/5 | 18 | 20 | $\chi^2 = 0.0088$ | 0.9252 |
| L5/S1 | 16 | 17 | | |
| Conservative time (months) | 10.00 ± 3.98 | 9.92 ± 3.45 | t = 0.0906 | 0.9281 |

both groups. C-reactive protein (CRP) levels were measured 48 h postoperatively to assess the severity of muscle injury and inflammatory response. Postoperative complications were also documented.Visual Analog Scale (VAS) scores for low back and leg pain were recorded preoperatively, 3 days postoperatively, and at 3 months and 12 months postoperatively. The Oswestry Disability Index (ODI) was used to assess functional outcomes preoperatively, at 3 months, and at 12 months after surgery. At 12 months postoperatively, clinical outcomes were evaluated based on the modified MacNab criteria to assess the satisfaction rate [18].The intervertebral fusion status was assessed according to the Bridwell classification, with grade I and II considered as successful fusion. Additionally, at 12 months postoperatively, lumbar disc height and anterior-posterior disc circumference (APDC) were measured using CT. Statistical analysis was performed using SPSS 25.0 software. Chi-square tests were used for categorical data, rank-sum tests for ordinal data, and independent sample t-tests for continuous data. A p-value of $< 0.05$ was considered statistically significant.

## Results

### Baseline information

A total of 71 patients were followed up, including 34 patients who underwent AUSS-TLIF surgery and 37 patients who underwent MIS-TLIF surgery. There were no statistically significant differences between the two groups in terms of age, gender, BMI, affected segment or conservative time ($P > 0.05$) (Table 1).

### VAS scores for low back and leg pain and ODI index

There were no statistically significant differences in the preoperative VAS scores for low back and leg pain or ODI index between the two groups ($P > 0.05$). Compared to the preoperative scores, both groups showed

**Table 2** Pain visual analog scale (VAS) scores and Oswestry disability index (ODI) scores

| Parameters | AUSS-TLIF (*N* = 34) | MIS-TLIF (*N* = 37) | Statistics | *P*-value |
|---|---|---|---|---|
| VAS score | | | | |
| Pre-operation | 7.44 ± 1.67 | 7.57 ± 1.39 | t = 0.3436 | 0.7322 |
| 3 days after operation | 2.82 ± 1.84 | 4.92 ± 2.21 | t = 4.261 | < 0.001** |
| 3 months after operation | 1.53 ± 0.78 | 2.27 ± 1.27 | t = 2.900 | 0.0050* |
| 12 months after operation | 0.50 ± 0.61 | 0.73 ± 0.60 | t = 1.581 | 0.1183 |
| ODI score(%) | | | | |
| Pre-operation | 71.50 ± 8.39 | 74.77 ± 7.91 | t = 1.667 | 0.1000 |
| 3 month after operation | 19.48 ± 6.38 | 26.55 ± 7.01 | t = 4.370 | < 0.001** |
| 12 month after operation | 7.84 ± 4.22 | 8.53 ± 4.21 | t = 0.6747 | 0.5021 |

The ODI score does not include sexual function assessment

ODI scores = Actual score/45 × 100%

**Table 3** Perioperative-related indicators

| Characteristics | AUSS-TLIF (*N* = 34) | MIS-TLIF (*N* = 37) | Statistics | *P*-value |
|---|---|---|---|---|
| Surgical duration(min) | 205.47 ± 25.08 | 136.86 ± 17.06 | t = 13.38 | < 0.001** |
| Intraoperative blood loss (ml) | 107.68 ± 25.60 | 123.11 ± 28.60 | t = 2.354 | 0.0215* |
| Postoperative drainage volume (ml) | 79.97 ± 27.53 | 96.32 ± 33.62 | t = 2.200 | 0.0312* |
| CRP (mg/L) | 17.16 ± 5.41 | 22.45 ± 6.45 | t = 3.670 | < 0.001** |
| Length of hospital stay (d) | 13.62 ± 4.01 | 15.49 ± 4.06 | t = 1.921 | 0.0589 |

CRP: C-reactive protein, measured at 48 h postoperatively

**Table 4** Intervertebral disc height and the anterior-posterior diameter of the Canal

| Measurement indicators | AUSS-TLIF group | MIS-TLIF group | Statistics | *P*-value |
|---|---|---|---|---|
| Intervertebral space height | | | | |
| Pre-operation | 6.94 ± 0.96 | 6.85 ± 1.13 | t = 0.3540 | 0.7244 |
| 12 months after operation | 10.36 ± 0.70 | 10.57 ± 0.63 | t = 1.150 | 0.2542 |
| APDC | | | | |
| Pre-operation | 12.85 ± 1.43 | 12.85 ± 1.53 | t = 0.01201 | 0.9904 |
| 12 months after operation | 15.72 ± 1.33 | 15.91 ± 0.97 | t = 0.6728 | 0.5033 |

APDC: Anterior-posterior diameter of the canal

significant reductions in postoperative VAS scores and ODI index, with statistical significance ($P < 0.05$). At 3 days and 3 months postoperatively, the VAS scores of the AUSS-TLIF group were significantly lower than those of the MIS-TLIF group ($P < 0.05$). At 3 months postoperatively, the ODI index of the AUSS-TLIF group was significantly lower than that of the MIS-TLIF group ($P < 0.05$). However, at 12 months postoperatively, there were no statistically significant differences in the VAS scores or ODI index between the two groups ($P > 0.05$) (Table 2).

#### Perioperative indicators

Both groups successfully completed the surgeries. There were no significant differences in hospital stay between the two groups. The AUSS-TLIF group had significantly less intraoperative blood loss, postoperative drainage volume, and postoperative C-reactive protein (CRP) levels at 48 h compared to the MIS-TLIF group. However, the surgery time was significantly longer in the AUSS-TLIF group than in the MIS-TLIF group ($P < 0.05$) (Table 3).

#### Intervertebral disc height and anterior-posterior diameter of the canal (APDC)

There were no statistically significant differences between the two groups in terms of preoperative APDC and intervertebral disc height ($P > 0.05$). Compared with preoperative values, both groups showed significant increases in APDC and intervertebral disc height at 12 months postoperatively ($P < 0.05$). Between-group comparisons at 12 months postoperatively revealed no significant differences in APDC or intervertebral disc height ($P > 0.05$) (Table 4).

#### Efficacy evaluation and complications

Both groups of patients successfully completed the surgeries. In the AUSS-TLIF group, one patient experienced cage migration, and two patients developed postoperative dysesthesia. No cases of cerebrospinal fluid (CSF) leakage or infection were reported, resulting in a complication rate of 3/34 (8.8%). In the MIS-TLIF group, one patient experienced cage migration, one patient developed postoperative dysesthesia, two patients had cerebrospinal fluid leakage, and one patient had an infection, yielding

**Table 5** Efficacy evaluation and complications

| Parameters | AUSS-TLIF (*N* = 34) | MIS-TLIF (*N* = 37) | Statistics | *P*-value |
|---|---|---|---|---|
| Complications | | | | |
| Cage migration | 1 | 1 | $\chi^2 = 3898$ | 0.5324 |
| Postoperative dysesthesia | 2 | 1 | | |
| Cerebrospinal fluid leakage | 0 | 2 | | |
| Infection | 0 | 1 | | |
| The status of fusion | | | | |
| Grade I | 23 | 24 | $\chi^2 = 0.4427$ | 0.5058 |
| Grade II | 9 | 12 | | |
| Grade III | 0 | 1 | | |
| Grade IV | 2 | 0 | | |
| Clinical outcome | | | | |
| Excellent | 25 | 25 | $\chi^2 = 0.2659$ | 0.6061 |
| Good | 8 | 10 | | |
| Average | 1 | 2 | | |
| Poor | 0 | 0 | | |

a complication rate of 5/37 (13.5%). There was no significant difference in the complication rates between the two groups.Similarly, the excellent rate based on the MacNab criteria and the fusion rate evaluation showed no statistically significant differences between the groups ($P > 0.05$) (Table 5).

## Discussion

Spinal fusion surgery, as a routine procedure in spine surgery, is commonly used to treat lumbar instability, spondylolisthesis, or lumbar radiculopathy caused by severe disc degeneration [19]. Compared to traditional TLIF, MIS-TLIF has advantages in terms of incision length, muscle injury, blood loss, and postoperative recovery time, but it also increases the difficulty of surgery [20]. However, with the advent of spinal endoscopy techniques, endoscopic-assisted fusion surgeries have gradually been applied in clinical practice, such as UBE-TLIF and single-axis endoscopic TLIF. Endoscopic-assisted fusion is even more minimally invasive compared to MIS-TLIF, requiring smaller incisions and less soft tissue damage while achieving similar surgical outcomes. Additionally, with endoscopic visualization, surgeons have a magnified, clear view of the surgical field, making it easier to identify neural tissues and intervertebral disc structures [21, 22].Nevertheless, previous endoscopic surgeries had certain drawbacks, such as the need for specialized equipment and instruments for single-axis endoscopic TLIF, and limited visualization during bone grafting, which could compromise the effectiveness of grafting and fusion [23]. Moreover, single-axis endoscopic TLIF is challenging with a steep learning curve [24]. UBE-TLIF, with its dual-channel design, is easier to learn compared to single-axis endoscopic TLIF. However, its limited operating space makes cavity creation difficult, and the confined space within the surgical channel can lead to difficulties in fluid irrigation, which may cause unnecessary complications such as pseudo-myeloid high pressure, dura tears, and infections [25–28].Considering the advantages of MIS-TLIF, single-axis endoscopic TLIF, and UBE-TLIF, this study employed the AUSS-TLIF approach to treat patients with lumbar spinal stenosis (LSS). This is the first report on the AUSS-TLIF technique. AUSS was proposed by Professor Song En in 2021 [13], using a single incision on the affected side where both the endoscope and operative instruments are introduced simultaneously.

Previous studies have reported the use of AUSS-assisted methods in treating lumbar disc herniation combined with ligamentum flavum suspension and bone anchoring annular sutures [15]; AUSS-assisted unilateral lamina opening for bilateral decompression (AUSS-ULBD) in the treatment of lumbar spinal stenosis [13]; and AUSS-ULBD for treating epidural fat hypertrophy [14]. These studies have confirmed the clinical feasibility and utility of the AUSS technique. In this study, we retrospectively analyzed patients who met the inclusion criteria at the same time period in the Second Affiliated Hospital of Xi'an Medical University, with a minimum follow-up of 12 months, comparing AUSS-TLIF and MIS-TLIF. Both groups showed good outcomes, with no significant differences in VAS scores, ODI index, and radiological indicators at 12 months postoperatively. Additionally, the modified MacNab evaluation and the status of fusion also showed no significant statistical differences between the two groups, indicating that AUSS-TLIF is a promising and effective technique.However, in terms of short-term experience, AUSS-TLIF demonstrated some interesting results. First, at 3 months post-surgery, the VAS scores and ODI index indicated that AUSS-TLIF patients had a better surgical experience compared to the MIS-TLIF group. We believe this advantage stems from the smaller

incision, less muscle and soft tissue damage, and earlier mobilization, although the smaller incision may also have positively influenced the patient's psychological recovery. Secondly, AUSS-TLIF patients had significantly less intraoperative blood loss and postoperative drainage, which could be attributed to the minimal trauma and the ability of the endoscopic technique to help the surgeon identify bleeding points more quickly and thoroughly stop the bleeding. Additionally, the use of irrigation during surgery helps flush out inflammatory substances and bacteria from the wound, leading to lower CRP levels and a reduced risk of infection.

In this study, a few patients still experienced postoperative complications. Based on the results of this study and previous research, both MIS-TLIF and UBE-TLIF have been associated with reports of dural tears, pseudomyeloid hypertension, and intraspinal infections. Many MIS-TLIF patients experience dura tears due to unclear surgical visualization, while infections may occur if the wound is not thoroughly irrigated, common issues with open surgeries. UBE-TLIF and single-axis endoscopic TLIF address the visualization problem and benefit from continuous irrigation to reduce postoperative inflammation. As such, they present advantages over MIS-TLIF. However, UBE-TLIF has some limitations: its observational and operational instruments are housed in separate channels, and both are in close contact with surrounding tissues, which may lead to the formation of epidural vortices, causing pseudo-myeloid high pressure, and even dura tears or epidural abscesses in adjacent segments.Thus, the AUSS technique, derived from UBE, uses a single incision, leaving a gap between the endoscope and instruments, facilitating smooth fluid drainage and preventing unnecessary complications caused by high epidural pressure.

However, compared to MIS-TLIF, AUSS-TLIF requires a longer operative time, a characteristic shared by most endoscopic-assisted fusion surgeries. Nevertheless, its simplicity, flexibility, and short learning curve make it easier for most surgeons to master. In addition, AUSS has some overlooked advantages. First, during fusion surgery, the endoscope can reach the endplates and intervertebral disc spaces, making the disc preparation more visible. This results in more thorough endplate and disc handling, leading to better fusion outcomes, a point often neglected in MIS-TLIF surgeries [29]. Second, the fusion device can be placed under direct endoscopic observation, ensuring proper sizing and avoiding nerve root or dura damage. Third, although not explored in this study, we have observed that for multilevel lumbar spinal stenosis, AUSS has great advantages due to its flexible operational range. It can achieve multilevel decompression through a single incision, a clinical innovation that we are currently researching further. Moreover, our team has applied AUSS in the treatment of conditions such as cervical radiculopathy, ossification of the ligamentum flavum, and epidural hematomas, with excellent clinical outcomes.

Of course, this study has some limitations. As a retrospective, single-center study, the choice between MIS-TLIF and AUSS-TLIF was made based on the surgeon's judgment, which may introduce selection bias. Additionally, the sample size was small and the follow-up period was relatively short. To obtain more reliable conclusions, further prospective, randomized, controlled studies with larger sample sizes and longer follow-up periods are necessary to further investigate the clinical efficacy of AUSS-TLIF.

## Conclusion

Both AUSS-TLIF and MIS-TLIF can achieve good clinical outcomes in the treatment of lumbar spinal stenosis. However, AUSS-TLIF is associated with less tissue damage and offers several advantages as an endoscopic procedure with an open surgery philosophy. These include clear visualization, flexible operation, reduced blood loss, shorter hospital stays, and a lower risk of complications, ultimately providing patients with a better perioperative experience.

### Author contributions

YY designed and supervised the study. ZL performed most of the data collection and analysis. SH and XL assisted in data collection and analysis. ZL drafted the manuscript. ES revised the manuscript. All authors contributed to this manuscript.

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### Data availability

No datasets were generated or analysed during the current study.

## Declarations

### Competing interests

The authors declare no competing interests.

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