Original Article

Clinical Outcomes of Spinal Canal Decompression Using Unilateral Biportal Endoscopic Spine Surgery for Elderly Degenerative Scoliosis Patient with Lumbar Stenosis

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Abstract

This study aims to investigate the clinical effectiveness of unilateral biportal endoscopy (UBE) in the treatment, prevention and management of lumbar spinal stenosis caused by senile scoliosis. From May 2019 to May 2023, we used UBE technology to treat 57 cases of elderly scoliosis-induced lumbar spinal stenosis. The responsible segments included 14 cases at L3/4, 20 cases at L4/5, and 23 cases at L5/S1. Subjective assessment of pain intensity and the functional status of the lumbar spine was conducted using the Visual Analogue Scale (VAS) and the Japanese Orthopaedic Association (JOA). Evaluations were performed preoperatively, as well as 1-day, 3- and 12-month postoperatively. The Nakai classification system was employed for evaluating the therapeutic outcome at the final follow-up. All patients were followed-up, and at 3 and 12 months post-surgery, the JOA and VAS scores were significantly lower than those before surgery, with the scores at 12 months post-surgery being significantly lower than those at 3 months post-surgery ($p < 0.05$). The surgical excellence rate was as follows: 34 cases were excellent, 18 cases were good and 5 cases were fair. During the operation, dural tears occurred in five cases, with small tears and no cauda equina herniation was detected. Therefore, no special treatment was administered and no cerebrospinal fluid leakage occurred during the postoperative follow-up period. Local sensory numbness occurred in the plantar region of the affected limbs in 19 cases, with symptoms disappearing in four cases after the removal of the drainage tube postoperatively. In the remaining 15 cases, residual symptoms were alleviated with anti-inflammatory and analgesic medications. Until the final follow-up, there were no cases of recurrence or sudden lumbar disc relapse. Unilateral Biportal Endoscopic techniques offer a more convenient and clearer surgical field without significantly impairing the paraspinal muscles. This approach facilitates minimally invasive spinal surgery for elderly patients with scoliosis-related spinal stenosis who are unable to tolerate traditional open surgeries.

Keywords: Elderly scoliosis; minimally invasive lumbar surgery; spinal stenosis; unilateral biportal endoscopic

Introduction

Senile scoliosis is a degenerative spinal disorder. As individuals age, intervertebral discs undergo gradual degeneration, triggering asymmetric degeneration and hyperplasia of small joints. This represents the primary pathological change in senile scoliosis, potentially resulting in spinal dislocation, instability, morphological abnormalities and biomechanical changes in the spine. These changes can compress and damage the dural sac and corresponding nerve roots. (1). Pellisse et al. (2015) reported that, compared to conditions such as hypertension, diabetes, osteoarthritis and chronic cardiopulmonary diseases, patients often present with comorbidities including lumbar spinal stenosis and segmental instability of the spine (2). Most of these patients experience lower back pain, nerve root-related leg pain and numbness, as well as intermittent claudication (3). The selection of surgical methods and how to safely, quickly and efficiently complete spinal surgery are arduous tasks faced by orthopaedic surgeons. Although conventional spinal orthopaedic surgery can effectively alleviate neuropathic pain (4), it requires extensive dissection of

paraspinal muscles and cutting of the posterior ligament complex, which can cause significant trauma and bleeding, and it is difficult for elderly patients to tolerate.

With the rapid advancement of minimally invasive technology and people's growing awareness of minimally invasive treatment, spinal endoscopic technology has become an indispensable part of clinical practice (5). Heo et al. proposed the concept of unilateral biportal endoscopic (UBE) in 2017 and successfully applied it to lumbar stenosis surgery (6). Similar to traditional open lumbar discectomy techniques, yet distinct from coaxial endoscopic techniques, the UBE approach offers advantages such as convenient and flexible operation, clear and unrestricted vision, and simple surgical instrument requirements, and has gradually gained attention from researchers. For elderly patients with scoliosis, addressing the nerve root pain and intermittent claudication caused by lumbar spinal stenosis is a desired therapeutic outcome.

Since 2019, we have been studying the clinical application of UBE technology in the treatment of senile scoliosis with spinal stenosis and conducting retrospective analysis of relevant cases to evaluate early postoperative clinical outcomes. We hereby reported the research results as followed.

Materials and Methods

Data and methods

This study was a single-center retrospective case series study, which was approved by the hospital ethics committee prior to data collection.

General information

From May 2019 to May 2023, we used UBE technology to treat 57 cases of elderly scoliosis-induced lumbar spinal stenosis. Among them, there were 27 males and 30 females; the age range was 62-80 years old, with an average of (71.3 ± 5.3) years. The responsible segments included 14 cases at L3/4, 20 cases at L4/5, and 23 cases at L5/S1. The inclusion criterias were: (i) elderly patients with lumbar spinal stenosis due to scoliosis who have failed conservative treatment and require surgical intervention; (ii) treatment utilising the UBE technique; (iii) the primary outcome measures included the degree of relief from numbness and pain in the lumbosacral region and lower limbs, as well as mobility function; (iv) retrospective study. The exclusion criterias were: (i) lumbar lesions extending over two segments; (ii) history of lumbar surgery or severe lumbar spondylolisthesis; (iii) coexisting conditions such as lumbar tumours, infections and tuberculosis that could potentially influence the outcomes of this study. There were 57 cases of lower back pain, 51 cases of hip pain, 44 cases of lower limb pain, 28 cases of numbness and 50 cases of intermittent claudication. Following a rigorous ethical review, the research protocol had been unanimously endorsed by the hospital's ethics committee, and all patients and their families had provided written informed consent.

Operation method

All surgical procedures were performed by the same senior spinal surgeon with over six years of clinical experience in UBE technology and a cumulative volume of more than 400 UBE procedures, to ensure standardised operation and consistent surgical quality.

Patients underwent general anesthesia and were positioned prone on the surgical table. A "C" arm machine was employed to obtain standardised anterior-posterior and lateral images of the lumbar spine, facilitating the determination of the distance between the responsible intervertebral spaces, identification of the surgical puncture points, and marking of two incisions. The head end served as the observation pathway, while the tail end provided the working pathway. Preoperative routine disinfection and draping were conducted, and a sharp blade was used to gradually incise the skin and subcutaneous tissue at the marked sites. The muscles and fascia layers were incised deeper, and a dilator and a dissector were employed to gradually enlarge the space, utilising dilation and bone surface disruption to establish an operational space and form an observation pathway. Finally, a 4.0 mm diameter, 30° arthroscopic lens (Karl Storz, Tuttlingen, Germany) matched with a standard UBE working instrument system was inserted. Using a radiofrequency ablation device or an arthroscopic radiofrequency probe, soft tissue structures obstructing the field of view were removed, effectively controlling bleeding and exposing the upper and lower vertebral laminae. Subsequently, the lower edge of the lamina and the facet joints were removed using a gun clamp, power drill or arthroscopic milling tool. A curette and nerve stripper were utilised to loosen and separate the dural sac and ligamentum flavum that were adhered together, and the excess ligamentum flavum was removed. Following this, a nerve retractor was employed to pull the dural sac aside, allowing for a complete visualisation of the protruding intervertebral disc and compressed nerve root. Gun clamps and a power drill were used to gradually enlarge the nerve root canal

and lateral recess, ultimately achieving decompression. Precise hemostasis was achieved using a radiofrequency ablation device, fully exposing the intervertebral disc and completely removing the nucleus pulposus tissue. For patients with severe spinal stenosis, bilateral decompression of the spinal canal can be achieved through a UBE technique by removing the hypertrophic and proliferative ligamentum flavum on both sides, as well as the medial portion of the proliferative facet joint. Under endoscopic monitoring, a drainage tube was placed, and the surgical incision was closed using intradermal suturing techniques (Figure 1 and 2).

Postoperative treatment

All patients were administered neurotrophic therapy postoperatively: mecobalamin 0.5 mg was administered orally three times daily for 4 weeks as a standard regimen, and the treatment course was extended to 8-12 weeks for patients with persistent numbness symptoms at the 1-month follow-up, and underwent a complete blood count examination within 24 hours. On the second postoperative day, the drainage tube was removed, allowing patients to ambulate with the assistance of a lumbar support or brace. Patients were routinely advised to avoid weight-bearing activities that require bending at the waist to pick up objects, and were instructed to engage in moderate exercises for lumbar and back muscle function under supervision. Symptomatic analgesia was administered as required.

Observation indicators

Subjective assessment of pain intensity and the functional status of the lumbar spine was conducted using the Visual Analogue Scale (VAS) and the Japanese Orthopaedic Association (JOA). Evaluations were performed preoperatively, as well as 1-day, 3- and 12-month postoperatively. The Nakai classification system was employed for evaluating the therapeutic outcome at the final follow-up, which was categorised into four levels: excellent, good, fair and poor.

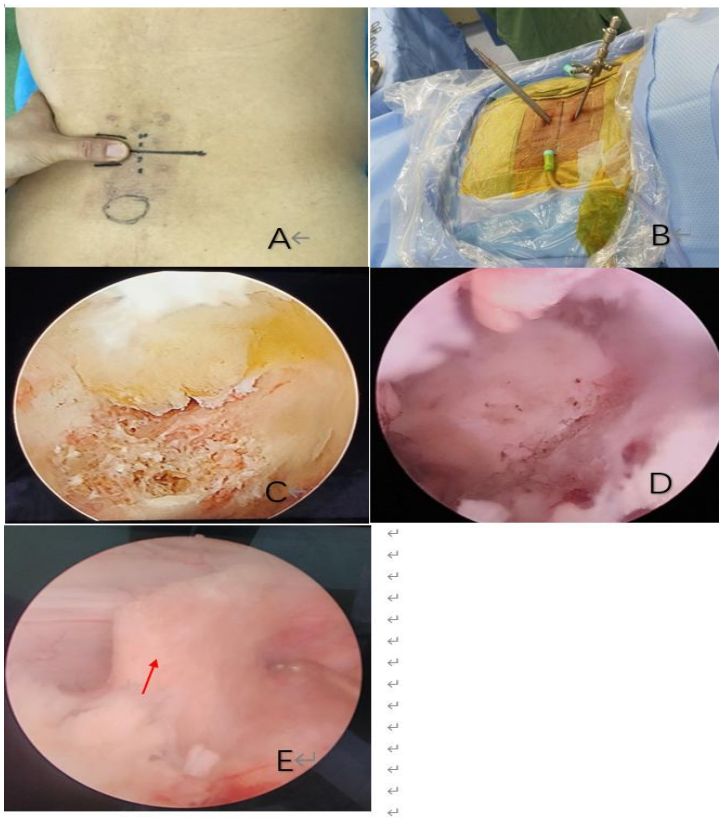


FIGURE 1: (A) Preoperative localisation markers (approximately 3cm between incisions); (B) The establishment of observation and operation channels; (C) Significant cohesion and proliferation of articular processes; (D) The microscopic resection of part of the articular processes and lamina; (E) Obvious hypertrophy of the ligamentum flavum (indicated by the arrow)

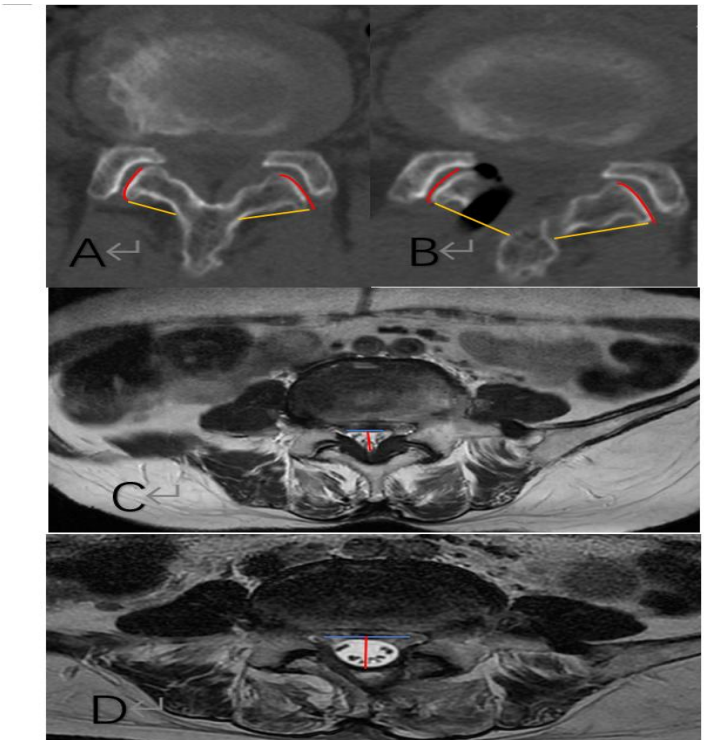


FIGURE 2: The figure presents preoperative and postoperative radiographic images of a patient with lumbar spinal stenosis and elderly scoliosis, who exhibited radiating pain in the left lower limb. The patient underwent a right-sided approach L4/5 segment decompression; (A) Preoperative lumbar CT transverse section, showing the distance from the root of bilateral spinous processes to the north side of the facet joint surface (yellow line segment) and the width of bilateral facet joint surfaces (red arc line) on the CT pedicle notch section; (B) Preoperative axial MRI of the spinal canal, displaying the transverse diameter (blue line segment) and sagittal diameter (red line segment) of the dural sac; (C) Postoperative CT transverse section of the pedicle notch, illustrating the fenestration width of the right lamina (yellow line segment) and the remaining width of bilateral facet joint surfaces (red arc line); (D) Postoperative 3-month axial MRI of the spinal canal, demonstrating complete rebound of the dural sac, with the transverse diameter (blue line segment) and sagittal diameter (red line segment) of the spinal canal dural sac expanded compared to pre-operation

Statistical processing

SPSS statistics (version 19; IBM Corp., Armonk, NY, USA) was used to perform statistical analysis and calculation on experimental data, all expressed as ($x \pm s$); Comparison of VAS scores and JOA at different time points before and after surgery, using one-way repeated measures data analysis of variance, and pairwise comparison using q-test; $p<0.05$ indicated a statistically significant difference.

Result

All patients in this group successfully completed the surgery, with a mean operation duration of 65.79 ± 11.08 minutes and a mean hospitalisation period of 6.03 ± 1.30 days. Postoperatively, their haemoglobin levels were found to have decreased by an average of 2.24 ± 0.97 g/L compared to pre-operative levels. All patients were followed-up, and at 3 and 12 months post-surgery, the JOA and VAS scores were significantly lower than those before surgery, with the scores at 12 months post-surgery being significantly lower than those at 3 months post-surgery ($p < 0.05$), as shown in Table 1. Using the Nakai grading system for the final follow-up, the surgical excellence rate was as followed: 34 cases were excellent, 18 cases were good and five cases were fair. During the operation, dural tears occurred in five cases, with small tears and no cauda equina herniation was detected. Therefore, no special treatment was administered, and no cerebrospinal fluid leakage occurred during the postoperative follow-up period. Local sensory numbness occurred in the plantar region of the affected limbs in 19 cases; among them, 11 cases were accompanied by dorsum pedis numbness, and seven cases were accompanied by distal calf numbness with symptoms disappearing in four cases after the removal

TABLE 1: Comparison of VAS and JOA for lumbar and leg pain before and after surgery in 57 elderly patients with scoliosis and lumbar spinal stenosis

Project	Preoperative	Postoperative 1-day	Postoperative 3-month	Postoperative 12-month
Lumbodynia VAS	4.89 ± 1.15	2.29 ± 0.62 ▲	1.87 ± 0.46 Δ	1.02 ± 0.54 ▲Δ
Leg pain VAS	5.02 ± 1.12	1.56 ± 0.91 ▲	1.19 ± 0.88 Δ	0.84 ± 0.64 ▲Δ
JOA	10.89 ± 1.49	17.49 ± 1.58 ▲	20.09 ± 1.81 Δ	22.05 ± 1.66 ▲Δ

Compared with preoperative ▲ $p<0.05$; compared with 3 moths postoperative ▲Δ $p<0.05$; compared with 1 day postoperative Δ $p<0.05$
JOA: Japanese Orthopaedic Association; VAS: Visual analogue scale

of the drainage tube postoperatively. In the remaining 15 cases, residual symptoms were alleviated with anti-inflammatory and analgesic medications combined with extended neurotrophic therapy within 3 months after surgery. Until the final follow-up, there were no cases of recurrence or sudden lumbar disc relapse.

Discussion

Degenerative spinal conditions are commonly observed in the elderly and patients with senile lumbar scoliosis often exhibit decompressive and progressive axial spinal pain in the lumbar region. Most of these patients also suffer from symptoms of lumbar disc herniation and lumbar spinal stenosis. Although traditional laminotomy and discectomy procedures have achieved favourable outcomes, they pose significant trauma to elderly patients. In recent years, various minimally invasive spinal surgeries have been widely adopted for the treatment of lumbar degenerative diseases (7,8). Percutaneous endoscopic discectomy stands as a representative minimally invasive spinal surgery technique for the treatment of lumbar disc herniation (9). Currently, single-level minimally invasive spinal surgery has become the mainstream approach (4). The UBE technique allows for complex procedures such as fenestration and decompression of the lumbar spinal canal under a magnified view, utilising conventional joint surgical instruments, fully embodying the concept of endoscopic spinal surgery (4). For elderly patients with scoliosis-related spinal stenosis, traditional open surgery may be intolerable. Therefore, the primary objectives of surgery are to maximise the release of adherent and compressed nerve roots, enlarge the spinal canal, and remove protruding lumbar discs, while preserving the original structural tissue of the lumbar spine to maintain its integrity, particularly the preservation of lumbar and back muscles, which is crucial for the recovery and prognosis of elderly patients. Randomised trials have shown that percutaneous endoscopic techniques offer unique advantages, such as smaller skin incisions, less bone resection and early return to normal activities after surgery. Compared to traditional open microsurgery, these techniques result in less tissue damage during surgery, shorter operation time and significantly reduced hospitalisation time, which can reduce patient costs (10,11).

In elderly patients with scoliosis-induced spinal stenosis, low back pain is primarily attributed to instability in the lumbar and dorsal spinal structures, which triggers muscle spasms, ultimately leading to chronic pain in these regions. The application of two-channel spinal endoscopy surgery offers a minimally invasive approach, eliminating the need for muscle dissection and preserving the integrity of the lumbar posterior structures to the greatest extent possible. A comparative analysis of pre- and post-operative low back pain levels in this study reveals a significant alleviation of symptoms among patients, who were predominantly elderly (average age 71.3 ± 5.3 years). Notably, there was no significant decrease in haemoglobin levels post-surgery, and patients experienced less postoperative discomfort and quicker recovery. They were encouraged to ambulate with the assistance of a lumbar support and engage in targeted rehabilitation exercises for lumbar and dorsal muscle function, aiming to bolster muscle strength and vitality, rectify lumbar facet joint disorders and fully minimise the occurrence of low back pain (12).

The UBE procedure effectively removes etiological factors causing stenosis on the ventral side of bilateral dura mater and nerve roots through the manipulation of intraoperative working channels. It also efficiently enlarges ipsilateral lateral recesses, extirpates ipsilateral ligamentum flavum, and excises a portion of the cohesive facet joints. In a study conducted by Lønne and Cha (2016), significant improvements were observed in 41 patients who underwent a full-backside ligamentum flavum resection procedure using a disc microscope for the treatment of lumbar spinal stenosis over a two-year observation period (13). These findings align with the results of this study, indicating

that the UBE procedure achieves adequate decompression and offers excellent efficacy in treating lumbar spinal stenosis.

In this cohort of elderly patients undergoing surgery, the nerve roots were adequately exposed and decompressed, leading to a significant reduction in postoperative lower back pain and leg pain. One-month post-surgery, a notable improvement in VAS scores was observed, and this improvement persisted over time until the final follow-up treatment, with no instances of intermittent claudication or recurrent low back pain. The advantage of the UBE technique lies in its minimal trauma to patients and less damage to surrounding normal bony tissue structures and soft tissues. One-month post-surgery, a significant increase in the JOA scores was noted, and this improvement continued over time. The follow-up period for this cohort of patients ranged from 3 to 12 months. According to the Nakai evaluation criteria, 34 patients achieved excellent results, 18 patients achieved good results and five patients achieved acceptable results. Five cases involved dural tears, but the tears were small and no cauda equina herniation was detected, thus requiring no special treatment. No cerebrospinal fluid leakage occurred during the postoperative follow-up period. Local sensory numbness in the sole of the affected limb was observed in 19 cases, with symptoms disappearing in four cases after the removal of the drainage tube postoperatively, likely due to stimulation of the nerve root caused by the placement of the drainage tube during surgery. In the remaining 15 cases, residual symptoms were alleviated with anti-inflammatory and analgesic medications, suggesting postoperative numbness was caused by tractional stimulation of the nerve root. At the final follow-up, no patients experienced a sudden recurrence of lumbar disc herniation.

Owing to the limited number of cases in this study and its retrospective nature, a multicentre analysis was not feasible. Therefore, future research should compare the UBE technique with other related surgical procedures to validate its decompressive efficacy and minimally invasive nature. Additionally, due to the short duration of follow-up and the exclusive focus on elderly patients with degenerative scoliosis-related spinal stenosis, the long-term surgical outcomes require further verification.

Conclusion

In summary, unilateral bi-channel endoscopic techniques offer a more convenient and clearer surgical field without significantly impairing the paraspinal muscles. This approach facilitates minimally invasive spinal surgery for elderly patients with scoliosis-related spinal stenosis who are unable to tolerate traditional open surgeries. Recent clinical follow-up results have confirmed the efficacy of this treatment strategy.

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Conflict of interest: The authors declare no conflicts of interest.

Ethics statement: This study was a single-centre retrospective case series approved by the Ethics Committee of Ningbo Yinzhou No. 2 Hospital (approval number: [YN2019 028]); written informed consent was obtained from all patients and their families.

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