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A retrospective study on the efficacy of unilateral biportal endoscopic discectomy treating lumbar disc herniation and concomitant grade I stable degenerative lumbar spondylolisthesis

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Abstract

Background The purpose of this study was to retrospectively assess the clinical and radiographic outcomes of unilateral biportal endoscopic discectomy (UBED) in treating patients with single-level lumbar disc herniation (LDH) and concomitant grade I stable degenerative lumbar spondylolisthesis (DLS).

Methods We reviewed patients diagnosed with single-level LDH and concomitant grade I stable DLS who underwent UBED from June 2021 to June 2023. Preoperative and postoperative slippage percentage, disc height (DH), visual analogue scale (VAS) for back pain and leg radiation pain, and Oswestry disability index (ODI) were compared by a paired-sample test. Demographics and postoperative slip progression were recorded.

Results A total of 32 patients with a mean age of 72.16 ± 8.07 years were enrolled. 27 underwent L4/5 UBED, 4 underwent L5/S1 UBED, and 1 underwent L3/4 UBED. The postoperative mean vertebral slip percentage increased significantly and the mean DH at the surgical level decreased significantly at the last follow-up. VAS scores for back and leg pain reduced significantly after surgery, and ODI scores improved significantly postoperatively. Only one patient suffered postoperative slip progression. Two cases of postoperative cerebrospinal fluid leakage were reported.

Conclusions The application of UBED to treat LDH and concomitant grade I stable DLS demonstrated effective pain relief and improved quality of life for patients, with a low incidence of postoperative slip progression. UBED is a safe and effective surgical technique for treating older patients with LDH and concomitant grade I stable DLS.

Keywords Lumbar disc herniation, Degenerative lumbar spondylolisthesis, Discectomy, Decompression, Unilateral biportal endoscopy

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Background

Lumbar disc herniation (LDH) is one of the most common degenerative lumbar diseases, typically presenting with low back pain and radiating leg pain. Surgical intervention is recommended for LDH patients who fail to respond to conservative therapy [1]. Lumbar discectomy via minimally invasive techniques has demonstrated excellent long-term clinical outcomes, and has gradually become the mainstream approach for treating LDH [2–4]. Among these techniques, the unilateral biportal endoscopy (UBE) technique was initially introduced in the 1980s and has undergone significant advancements over the years [5]. Its advantages over open surgery, such as smaller incisions, faster rehabilitation, and reduced tissue damage have promoted its widespread adoption as a novel minimally invasive surgical technique for the lumbar spine [5]. UBE has been frequently utilized in treating lumbar spinal stenosis and LDH to achieve spinal canal decompression [6].

Degenerative lumbar spondylolisthesis (DLS) demonstrated by radiography at the same level as disc herniation, fusion surgery should be considered if segmental instability exists. Segmental instability is defined as a dynamic change of over 20 degrees in angulation at the L5/S1 level, over 15 degrees at the next cephalad level, or sagittal vertebral translation exceeding 4 mm on upright flexion-extension lateral radiographs. Stable DLS refers to cases of DLS without segmental instability on dynamic radiographs [7]. For LDH patients concomitant with stable DLS, the optimal surgical approach remains controversial. Even a minimally invasive posterior approach inevitably damages the posterior supporting structures, and removing the herniated intervertebral disc may affect the middle column, potentially leading to postoperative iatrogenic instability at the surgical segment.

LDH patients underwent unilateral biportal endoscopic discectomy (UBED) achieved effective pain relief, a short hospital stay and early ambulation [8]. However, whether LDH patients with stable grade I DLS at the same level develop segmental instability after UBED remains unknown. The purpose of this study was to retrospectively assess the clinical and radiographic outcomes of patients diagnosed with LDH and concomitant grade I stable DLS underwent UBED.

Methods

All methods were conducted in accordance with regulations of the Declaration of Helsinki. The study protocol was approved by the Ethics Committee of the authors' institution. Patient's consent was waived as this was a retrospective study.

Patient selection

Inclusion criteria. (1) age > 18 years old; (2) patients diagnosed with LDH complaining of low back pain and radiating leg pain; (3) patients diagnosed with grade I DLS at the same segment according to the Meyerding classification system, without intervertebral instability as confirmed by dynamic radiologic evidence; (4) symptoms persisting for more than 12 weeks with no response to conservative treatment; (5) patients who underwent single-level ipsilateral UBED with a follow-up period of ≥ 12 months.

Exclusion criteria. (1) patients had LDH without DLS, multilevel LDH, or recurrent LDH; (2) DLS with segmental instability, spondylolisthesis secondary to non-degenerative etiologies, or spondylolisthesis grade ≥ II; (3) patients underwent fusion surgery; (4) presence of cauda equina syndrome, scoliosis, tumor, or infectious disease.

Surgical technique

Taking L4/5 left intervertebral disc herniation with stable grade I degenerative L4 spondylolisthesis as a model. The patient was positioned in a prone position with the abdomen free after successful general anesthesia. Confirming the L4/5 intervertebral site by using C-arm fluoroscopy, and the surgeon positioned on the patient's left side. Two 1.5 cm-length incisions were made lateral to the midline, and the cranial one for endoscope insertion and continuous saline irrigation located at the inferior margin of the upper lamina, while the caudal one for surgical instrument access and saline outflow located at the superior margin of the lower lamina. Progressively expand the paraspinal muscles by serial dilators, and subsequently remove the soft tissue by radiofrequency ablation until reaching the lamina bone surface. Confirm the correct intervertebral segment again. Identify the interlaminar space, and remove partial medial inferior articular process of L4 vertebrate and partial lamina of both upper and lower vertebrae through a Kerrison rongeur or osteotome to expose the ligamentum flavum. Dissect and eliminate the ligamentum flavum carefully to expose the intraspinal fatty tissue. After clearing the extradural fat, identify and retract the nerve root. Using pituitary forceps to perform discectomy when exposing herniated disc. Finally, insert a drain tube and close the two small incisions.

Radiographic measurements and clinical outcomes

Vertebral slippage percentage was recorded preoperatively and at the final follow-up on standing lateral radiographs. The slippage percentage was calculated by dividing the anteroposterior displacement of the upper vertebra by the anteroposterior diameter of the lower vertebra on the lateral radiograph. Postoperative slip progression was defined as an increase of more than 5% in

Table 1 Demographics of included patients. ($\bar{x}\pm$ SD)

Total number	32
Male/female (n)	9/23
Age (years)	72.16 ± 8.07
Weight (kg)	59.31 ± 9.01
Surgical level (n)	
L3/4	1
L4/5	27
L5/S1	4
Surgery duration (minutes)	86.72 ± 11.40
Postoperative hospital stay (days)	5.88 ± 1.79
Follow-up (months)	21.88 ± 8.94
Complications (n)	
Cerebrospinal fluid leak	2

the slippage percentage compared to the preoperative neutral lateral radiograph. Disc height (DH) was measured as the average value of the anterior and posterior heights of the corresponding intervertebral disc on a plain lateral radiograph. Preoperative and final follow-up DH values were recorded. The visual analogue scale (VAS; range 0 to 10) for both back pain and radiating leg pain was assessed to quantify pain intensity. The Oswestry disability index (ODI) score reflected the degree of disability. The sex-related question in the ODI questionnaire was excluded from this study due to cultural sensitivity, as many elderly patients in our country were uncomfortable answering it. The final ODI score was expressed as a percentage, calculated by dividing the total score from all completed sections by the maximum possible ODI score of 45. A score of 0% indicated no pain or disability, while 100% represented the worst possible pain and disability. Demographic data, including gender, age, weight, surgical level, operative time, complications associated with UBE, time interval to first ambulation, length of postoperative hospital stay, and follow-up duration were collected from patients' information in the clinical record system.

Statistical analysis

Continuous data were expressed as mean ± standard deviation ($\bar{x}$ ± SD). Preoperative and postoperative comparisons of slippage percentage, DH, VAS scores for back and leg pain, and ODI scores were matched using the paired-sample test. A $p < 0.05$ was considered statistically significant. All statistical analyses were performed by IBM SPSS Statistics ver. 26.0 (IBM Co., Armonk, NY, USA).

Results

From June 2021 to June 2023, a total of 32 patients diagnosed with LDH and concomitant grade I DLS underwent UBED were enrolled for the study. This group comprised 9 males and 23 females, with a mean age of 72.16 ± 8.07 years and a mean weight of 59.31 ± 9.01 kg. Of the enrolled cases, 27 underwent L4/5 UBED, 4 underwent L5/S1 UBED, and 1 underwent L3/4 UBED. The average surgical time was 86.72 ± 11.40 min, and the mean postoperative hospital stay was 5.88 ± 1.79 days. The average follow-up duration was 21.88 ± 8.94 months. 2 patients were diagnosed with cerebrospinal fluid leakage due to excessive and clear drainage fluid. Both of them were managed with bed rest and sufficient fluid intake. The other 31 patients were completed drain tube removal and their first ambulation on the first postoperative day. (Table 1)

Table 2 Preoperative and postoperative comparisons of outcomes

Outcome	Preoperative	Final follow-up	*p* value
Vertebral slip percentage (%)	13.83 ± 2.86	16.40 ± 3.04	< 0.05
DH (mm)	0.86 ± 0.19	0.75 ± 0.16	< 0.05
VAS back score	4.15 ± 1.65	1.09 ± 1.00	< 0.05
VAS leg score	6.06 ± 0.72	0.91 ± 1.06	< 0.05
ODI score (%)	67.22 ± 11.44	17.71 ± 9.40	< 0.05

Values are presented as $\bar{x}$ ± SD. DH, disc height. VAS, visual analogue scale. ODI, Oswestry disability index

The mean postoperative vertebral slip percentage increased to 16.40 ± 3.04% at the last follow up from preoperative 13.83 ± 2.86% ($p < 0.05$), which was statistically significant. However, only one patient suffered postoperative slip progression at the 37-month follow-up, with a 7.08% increase in slippage percentage. DH at the surgical level decreased significantly, from 0.86 ± 0.19 mm preoperatively to 0.75 ± 0.16 mm postoperatively ($p < 0.05$). Postoperative VAS scores for both back and leg pain were significantly reduced compared to preoperative scores ($p < 0.05$). ODI scores also improved significantly from 67.22 ± 11.44% preoperatively to 17.71 ± 9.40% ($p < 0.05$). (Table 2)

Case example

A 51-year-old woman complained of low back pain and right leg radiating pain for 2 years. Lateral X-ray revealed grade I DLS at L4. Flexion-extension lateral X-ray showed an angulation change of 2.3° and vertebral translation of 1.3 mm, indicating stable spondylolisthesis at L4. Magnetic resonance imaging (MRI) and CT revealed lumbar disc hernia and lumbar spinal stenosis at L4/5. After failed conservative treatment, the patient underwent L4/5 UBED and decompression. Postoperatively, the patient reported slight low back pain (VAS score 2) and complete relief of right leg pain (VAS score 0). At 16-month follow-up, there was no sign of postoperative slip progression. (Fig. 1)

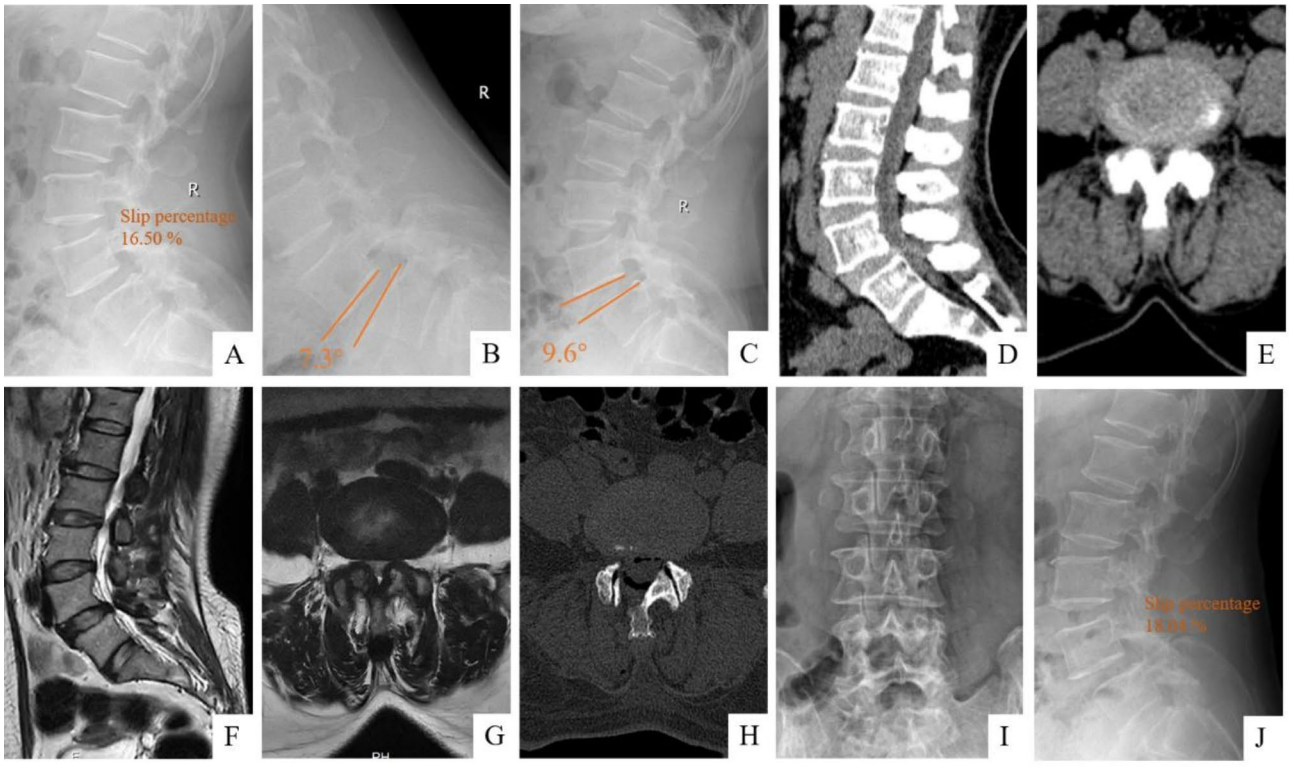

Fig. 1 A 51-year-old woman had disc herniation and spinal stenosis at L4/5 and concomitant stable grade I degenerative L4 spondylolisthesis underwent unilateral biportal endoscopic discectomy and decompression at L4/5. Preoperative upright lateral (**A**) and flexion-extension lateral (**B**, **C**) X-ray, sagittal (**D**) and axial (**E**) images on computed tomography (CT), and sagittal (**F**) and axial (**G**) images on T2-weighted magnetic resonance imaging. Postoperative axial (**H**) image on CT. Anterior-posterior (**I**) and lateral (**J**) X-ray at 16-month follow-up

Discussion

This retrospective study comprised 32 patients diagnosed with LDH and concomitant stable grade I DLS underwent UBED and were followed up for a mean duration of 21.88 months. The intensity of back and leg pain among enrolled patients decreased significantly after UBED surgery, and their postoperative functional status showed a marked improvement compared to preoperative conditions. Though the lumbar vertebral slip percentage at the surgical level worsened postoperatively compared with preoperative status, this change did not impact pain relief or functional improvement in operated patients, and only one patient suffered postoperative slip progression. The results of this study suggest UBED is an effective and safe method to treat elderly patients with LDH and concomitant stable DLS. To our knowledge, this is the first study to report clinical and radiographic outcomes of UBED treating LDH and concomitant stable DLS patients.

Surgical treatments for LDH have evolved significantly over the past decades. Compared to traditional open discectomy surgery, minimally invasive surgical techniques have gradually emerged due to several advantages such as smaller incisions, less tissue damage, and less blood loss [2, 3]. Fine long-term clinical outcomes further support the efficacy of these minimally invasive techniques [2, 3]. As a novel minimally invasive surgical procedure, UBE has demonstrated advantages over traditional open surgery in treating degenerative lumbar diseases. Several studies have shown that LDH patients acquired good and long-term pain relief, functional disability improvement and high patient satisfaction after undergoing UBED [9–12]. The UBE system, with its two independent working channels, allows for a complete discectomy that mimics traditional open discectomy but with reduced trauma. Even in cases of high-grade up-migrated or down-migrated LDH, UBED can be performed successfully, leading to excellent clinical outcomes [13, 14].

Compared to other minimally invasive spine surgery technologies, the UBE system has its own advantages and disadvantages. Jiang et al. [15] compared two groups of LDH patients treated by percutaneous endoscopic lumbar discectomy (PELD) and UBED respectively, and found both groups of patients experienced similar pain relief and patient satisfaction. However, patients in the UBED group had more blood loss, longer surgery times, extended hospital stays and higher hospitalization costs. This could be attributed to PELD causing less injury to the paravertebral muscles and preserving more bony structures [16]. Another study compared paraspinal muscle injury in LDH patients undergoing

microdiscectomy (MD), percutaneous endoscopic interlaminar discectomy (PEID), PELD and UBED by measuring the cross-sectional area of the paraspinal muscle lesions on postoperative magnetic resonance imaging, and the results indicated that PELD was the least invasive surgical procedure [17]. UBED integrates the conventional open discectomy procedure with endoscopic magnification and illumination, providing a broad view and allowing for flexible handling; such advantages contribute to its relatively short learning curve for surgeons [9]. Despite the fact that the UBE system may cause more tissue and bone damage compared to the transforaminal endoscopy system, its short learning curve allows less-experienced surgeons to perform discectomy more effectively. Notably, there is limited literature on minimally invasive techniques to treat patients with LDH and concomitant DLS. Oshima et al. [18] reported patients with concomitant LDH and L5 spondylolysis treated by microendoscopic discectomy, the results showed patients experienced significant symptom relief without requiring additional surgery during the follow-up period.

The optimal surgical approach for DLS remains controversial, particularly regarding the necessity of instrumented fusion. Decompression alone to treat DLS has been shown to be inferior to decompression with instrumented fusion over a period of two years, and intraoperative adding instrumentation was associated with longer operation time, more blood loss and extended hospital stays [19, 20]. Since the UBED procedure is similar to conventional open discectomy, involving the removal of the partial medial inferior articular process of the upper vertebra, partial lamina of both upper and lower vertebrae, ligamentum flavum, annulus fibrosus, and herniated intervertebral disc, patients with LDH and concomitant DLS may experience postoperative slip progression, potentially leading to more severe back pain and lumbar stenosis postoperatively. Our results demonstrated patients with LDH and concomitant DLS developed an increased vertebral slip percentage and decreased DH after decompression alone. Despite these statistically significant changes, the patients still obtained effective pain relief following the UBED procedure. Only one patient experienced postoperative slip progression, with the slip percent increasing by 7.08% at the 37-month follow-up, and this patient reported slight low back pain but complete remission of leg pain. The slip percentage in the remaining postoperative patients increased by less than 5%, and the short surgery time demonstrated that UBED is an effective and safe surgical strategy for elderly patients. Restabilization is a natural phase of DLS, characterized by radiographic features such as disc space narrowing, osteophyte formation, vertebral endplate sclerosis, and ligament ossification [7]. The postoperative decrease in DH observed in the enrolled patients suggests progression into the lumbar restabilization phase. Additionally, all patients were able to ambulate after drain tube removal on the first postoperative day, indicating the UBED procedure does not delay early rehabilitation.

Two cases in our study were diagnosed with postoperative cerebrospinal fluid leakage, possibly caused by an intraoperative dural tear. However, during the surgical procedures of the two patients, no obvious dural tear was observed in the endoscopic field. This may be explained by a delayed dural tear or a dural tear located on the ventral side of the dural sac. Park et al. [21]. retrospectively analyzed 29 cases of dural tears among 643 UBE patients, and found that the most common tear site was the thecal sac area, followed by the traversing nerve and exiting nerve areas. A meta-analysis investigating UBE complications reported that dural tear was the most common complication with an incidence of 2.9 ~ 5.8%, [22] and 6.25% (2/32) of the cerebrospinal fluid leak rate in our study was consistent with the reported incidence. The primary cause of dural tear was considered to be intraoperative instrument handling [21]. Therefore, cautious and gentle handling is particularly important during the procedure. The average postoperative hospital stay in our study was 5.88 days, slightly longer than reported in other studies [10, 17]. Firstly, some patients opted for conservative treatment before deciding on surgery during the hospitalization, that is why we calculated the postoperative days only. Secondly, patients received rehabilitation instructions in our department after surgery due to their limited access to rehabilitation services once they were discharged home. Generally, the postoperative hospital stay of 5.88 days in this study was considered relatively short.

Limitations

There are several limitations to this study. First, the small sample size resulted in limited statistical power, potentially leading to biases. Decompression alone in treating DLS patients has been associated with a higher reoperation rate [19]. However, in our study, none of the 32 patients required readmission for progressive vertebral slip or adjacent segment disease. It is possible that the small sample size or insufficient follow-up contributed to a false-negative result. Second, radiographic evaluation at follow-up was not comprehensive. Stable DLS after discectomy may develop into segmental instability, which is diagnosed by upright flexion and extension lateral radiographs. However, during postoperative follow-up, if a patient does not complain of significant low back pain, flexion and extension X-rays are rarely re-examined. Finally, clinical and radiographic outcomes of UBED were not compared to other minimally invasive techniques such as PELD. Further comparative studies are needed to

better evaluate the efficacy and safety of UBED relative to alternative procedures.

Conclusions

UBED for treating LDH and concomitant grade I stable DLS demonstrated positive clinical outcomes, including a short hospital stay, early rehabilitation, effective pain relief, and improved quality of life. UBED may increase slip percentage and decrease DH, but rarely results in postoperative slip progression. Therefore, UBED is a safe and effective surgical technique to treat LDH and concomitant grade I stable DLS for elderly patients.

Abbreviations

LDH	Lumbar disc herniation
UBE	Unilateral biportal endoscopy technique
DLS	Degenerative lumbar spondylolisthesis
UBED	Unilateral biportal endoscopic discectomy
DH	Disc height
VAS	Visual analogue scale
ODI	Oswestry disability index
MRI	Magnetic resonance imaging
PELD	Percutaneous endoscopic lumbar discectomy
MD	Microdiscectomy
PEID	Percutaneous endoscopic interlaminar discectomy

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Author contributions

Conceptualization, H Wang and H Dai; Methodology, H Wang and C Xiao; Investigation, H Wang, K Zhang and C Xiao; Formal Analysis, K Zhang and M Xie; Writing - Original Draft, H Wang and C Xiao; Writing - Review & Editing, H Wang, K Zhang, M Xie and H Dai; Supervision and Project Administration, H Dai. All authors provided final approval.

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Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Affiliated Traditional Chinese Medicine Hospital, Southwest Medical University (BY2024033). All methods were conducted in accordance with regulations of the Declaration of Helsinki. The requirement for written informed consent was waived due to the retrospective nature of the study and approved by the Ethics Committee of the Affiliated Traditional Chinese Medicine Hospital, Southwest Medical University.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

Not applicable.

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