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Original Article

Case series of unilateral biportal endoscopic-assisted transforaminal lumbar interbody fusion in the treatment of recurrent lumbar disc herniation

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Abstract: Objective: To explore the clinical effect of unilateral biportal endoscopic-assisted transforaminal lumbar interbody fusion (UBE-TLIF) in the treatment of recurrent lumbar disc herniation (RLDH). Methods: The clinical data of 44 patients with RLDH treated by UBE-TLIF in our hospital from August 2020 to December 2020 were analysed retrospectively. The study indicators included intraoperative blood loss, operation time, bed rest time, and hospital stay. The follow-up data included the visual analogue score (VAS) of low back pain, Japanese Orthopaedic Association score (JOA), Oswestry disability index (ODI) score, and the short form 36 health survey questionnaire (SF-36) score preoperatively and 1 week and 6 months postoperatively. Results: The average operation time was 179.15 ± 42.06 minutes, the average intraoperative blood loss was 132.67 ± 41.92 ml, the average bed rest time was 1.51 ± 0.42 days, and the average hospital stay was 4.82 ± 1.13 days. The VAS score of low back pain after the operation was lower than that before the operation (all $P<0.0001$). The ODI score, JOA score, and SF-36 scores at postoperative follow-up were significantly different from those before the operation ($P<0.05$). The satisfaction rate was 86.4% at 7 days after the operation and 95.4% at 6 months after the operation. The proportion of significant clinical efficacy was 18.2% (postoperative day 7) and 63.6% (postoperative month 6). Conclusions: UBE-TLIF has the advantages of a rapid recovery, less intraoperative blood loss, a short bed rest and hospital stay, and a good medium-term clinical effect. It is a safe, reliable minimally invasive technique for surgical treatment of RLDH.

Keywords: Lumbar vertebrae, lumbar disc herniation, endoscopy, bone graft fusion

Introduction

Recurrent lumbar disc herniation (RLDH) is usually defined as the recurrence of herniated disc material at the same level after primary discectomy with a more than six-month pain-free interval after the primary surgery [1, 2]. The incidence of RLDH varies from 7% to 18% of patients following primary discectomy [3-7]. The treatment of RLDH includes both conservative treatment and surgical treatment. At present, percutaneous transforaminal endoscopic discectomy (PTED), microendoscopic discectomy (MED), and traditional laminectomy are the main surgical methods [2].

MED is one of the techniques applied for the treatment of lumbar disc herniation and lumbar spinal stenosis. Compared to traditional laminectomy, it can significantly reduce surgical trauma, reduce bleeding, and speed up the recovery of patients after surgery [8, 9]. However, due to the narrow tubular channel, this technique restricts the free movement of the surgical instruments and increases the difficulty of the operation.

Percutaneous endoscopic lumbar discectomy (PELD) is another common minimally invasive technique for treating lumbar disc herniation. It also has limited blood loss and a short hospital stay advantage [10, 11]. Whether using the percutaneous transluminal approach or the percutaneous intervertebral foramen approach, endoscopic spine surgery is performed through a single channel that includes light, irrigation, visualization, and instrumentation. Restricted visualization is a technical difficulty faced by

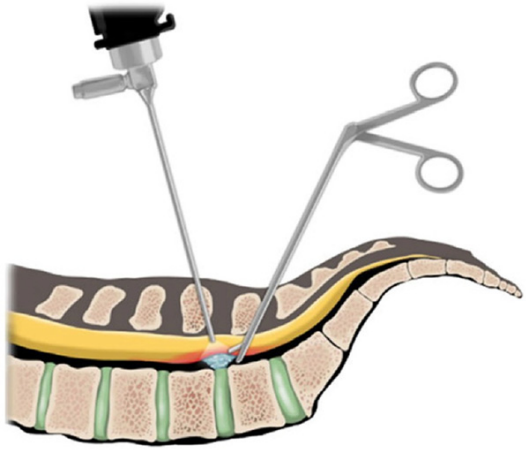

Figure 1. Schematic diagram of the two-channel decompression approach.

surgeons, especially in a case of severe spinal stenosis or a need for bilateral decompression [12, 13]. In addition, fully familiarizing the surgeon with the total endoscopic technique requires a very steep learning curve.

In recent years, unilateral biportal endoscopic (UBE), which is a modified minimally invasive spinal endoscopic technique, has emerged gradually. It has two channels: one channel provides a surgical field of vision and continuous irrigation, and the other channel is used for instrument operation, which can reduce the influence of a limited visual field and operative restrictions [14, 15]. Although this technique has been widely used, its indications are limited to lumbar degenerative diseases treated by surgery for the first time.

The innovation of this study was to apply UBE-TLIF in the treatment of RLDH. The purpose of this study was to explore the possibility of applying this technique to lumbar revision surgery and to broaden the indications of this technique. To the best of our knowledge, this article is the first report of an attempt to use UBE-TLIF to treat RLDH.

Materials and methods

General information

This was a retrospective study of patients with RLDH who received UBE-TLIF surgery in our hospital from August 2020 to December 2020. The diagnostic criterion of RLDH is the recurrence of related symptoms after primary surgery, such as waist and leg pain, numbness, weakness, and changes in sensation, muscle strength, and the reflexes of the lower limbs, combined with X-ray, CT, MRI and other examinations to prove that the same space is protruding again. Inclusion criteria: 1) Recurrent lumbar disc herniation; 2) PELD was performed after the first lumbar disc herniation; 3) Radicular symptoms; 4) Conservative treatment was ineffective, with indications for surgery; 5) Symptoms lasting for more than 4 weeks; and 6) Imaging findings consistent with the symptoms. Exclusion criteria: 1) Foraminal and extraforaminal lumbar disc herniation; 2) Multisegment disc; 3) Central lumbar canal spinal stenosis; 4) Cauda equina syndrome; or 5) Discogenic low back pain. This study was approved by the Ethics Committee of Xi'an Honghui Hospital, and all patients receiving UBE-TLIF surgery provided preoperative informed consent.

Operation methods

An X-ray fluoroscopy machine was used to determine the surgical incision site, including the ipsilateral endoscopic surgical incision, the lateral posterior intervertebral fusion approach incision, the pedicle screw placement incision, and body surface marking. Routine disinfection and sheet draping were performed. After placement of the channel, two soft tissue dilators intersected at the upper lamina and the base of the spinous process in the surgical space, and the position was confirmed to be accurate by fluoroscopy. The head of the working sleeve was located in the interlaminar space of the operation area. Under the supervision of the endoscope, the target area was burned with plasma electrotonic, and most of the bone of the corresponding upper and lower articular processes of the affected side intervertebral foramen and part of the lamina of the upper and lower segments were removed to expose the outlet nerve root. Additionally, the lateral recess of the lower lumbar spine was fully expanded, and the nerve root was decompressed. The ligamentum flavum was incised from the center to the outside to expose the dural sac and nerve roots in the spinal canal. A schematic diagram of the decompression approach is shown in **Figure 1**.

In the working sleeve tube travelling tongue terminal protecting the nerve root, cage insertion faced the Kambin triangle within the annulus. Under endoscopic monitoring, the herniated disc was removed, the intervertebral space was treated with nucleus pulposus forceps and an endplate curette to expose the osseous endplate, and the intervertebral bone graft bed was prepared.

The decompressed bone tissue was clipped into grains and filled into the intervertebral space. (If the amount of autogenous bone was insufficient, allogeneic bone could be used.) The test mould was placed along the implantation channel of the fusion cage, the size of the fusion cage was determined, and then the fusion cage filled with autogenous bone was implanted into the intervertebral space along the channel.

A fluoroscopy machine was used to determine that the cage was in the proper position. Hollow pedicle screws and connecting rods were implanted under the guidance of X-ray or robotic systems. The internal fixation position was determined by fluoroscopy. Each surgical incision was closed with a subcutaneous suture and covered with a sterile dressing.

Postoperative treatment

After the operation, the suspected bleeding points were carefully cauterized, and tube drainage was placed. All patients were routinely given antibiotics after surgery and intravenously administered dexamethasone and mannitol to alleviate any pain caused by the early postoperative oedema reaction to LDH. A straight leg raising exercise was performed on the second postoperative day to prevent nerve root adhesion and to encourage the patient to wear a support belt and get out of bed as soon as possible.

Observation indicators and efficacy evaluation

Basic clinical data of the patients were collected, including intraoperative blood loss, operation time, bed rest time, and length of stay. All patients were followed up after surgery, and clinical data, including visual analogue scale (VAS), Japanese Orthopaedic Association Score (JOA), Oswestry Disability Index (ODI) score, and the short form 36 health survey questionnaire (SF-36) score, were collected before surgery and 1 week and 6 months after surgery. The improvement rate of the JOA 7 days and 6 months after surgery [improvement rate (%) = (posttreatment score - pretreatment score) × (29 - pretreatment score)] × 100% was calculated. Standard of curative effect definitions: 100% improvement: cured, improvement is more than 60%: significantly effective, improvement is 25%-60%: effective, and less than 25%: ineffective. The results of the short-term and long-term postoperative satisfaction questionnaire and possible complications were recorded to observe the safety of this method. Patients were followed up by a research assistant for 6 months, and relevant clinical data were collected.

Statistical analysis

Measured data are expressed as the mean ± standard deviation ($x \pm s$). SPSS 20.0 (Inc, Chicago, IL, USA) was applied for statistical analysis. Quantitative data are expressed as the mean ± SD. One-way analysis of variance (ANOVA) was performed to compare the VAS score, JOA score, ODI score and SF-36 score before surgery and 7 days and 3 months postoperatively, and then the LSD t-test was performed. The counted data were tested by χ^2 test. A P value <0.05 was considered significant.

Results

General information

As shown in **Table 1**, a total of 44 patients meeting the criteria were included in this study, including 20 men and 24 women aged 44 to 73 years old, with an average age of 55.43 ± 9.82 years old. Ten patients showed only nerve root symptoms, and 34 patients showed neurological symptoms combined with corresponding innervation muscle weakness. The level of intervertebral disc protrusion was L3-4 in 2 cases, L4-5 in 22 cases, and L5-S1 in 20 cases. Protrusion type: central type in 8 cases, paracentral type in 36 cases. The duration of symptoms ranged from 28 days to 10 months, with an average of 4.61 ± 0.75 months.

Basic clinical data results

The average operating time was 179.15 ± 42.06 minutes, the average intraoperative blood loss was 132.67 ± 41.92 ml, the average

Table 1. Patients' general information and some recent clinical results

Data	Value
Age	55.43 ± 9.82
Gender	
Male	20
Female	24
BMI	24.60 ± 2.42
Symptom	
Simple leg pain	10
Leg pain combined with decreased muscle strength	34
Duration of symptoms (months)	4.61 ± 0.75
Location of herniated disc	
Central type	8
Paracentral	36
Segments	
L3-4	2
L4-5	22
L5-S1	20
Operation time	179.15 ± 42.06
Intraoperative blood loss	132.67 ± 41.92
Bedtime	1.51 ± 0.42
Hospital stay	4.82 ± 1.13
Complication rate	2 (4.54%)

bed rest time was 1.51 ± 0.42 days, and the average length of stay was 4.82 ± 1.13 days.

Follow-up results

All patients were followed up for 6 months. The VAS scores of lumbago and leg pain at 7 days after surgery were lower than those before surgery (P<0.0001) and further decreased during follow-up, as shown in **Table 2**. Six months after surgery, the VAS scores of low back and leg pain were 0.67 ± 0.44 points and 1.01 ± 0.45 points, the ODI score was 11.12 ± 3.56 points, the JOA score was 27.15 ± 3.24 points, and the total physiological score of the SF-36 score was 50.55 ± 7.34 points. The total psychological score was 49.48 ± 8.91 points, and the difference was significant (P<0.05). As shown in **Table 3**, the satisfaction rate in the early postoperative period was 86.4%, and the very satisfied rate was 36.4%. The satisfaction rate 6 months after the operation was 95.4%, and the very satisfied rate was 40.9%. The improvement rates of the JOA were 41.8 ± 10.6% and 87.7 ± 8.2% at the follow-up of 7 days and 6 months after surgery, respectively. According to the improvement rate of JOA, the percentages of significant clinical efficacy 7 days and 6 months after surgery were 18.2% and 63.6%, respectively (**Table 4**). Outpatient CT reexamination at 6 months postoperatively showed good interbody fusion in all patients.

Complications

Complications occurred in 2 cases (4.54%), which were caused by severe local adhesions formed in the previous operation. During this operation, dural rupture occurred during decompression and release of the nerve root adhesions. There were no internal fixation-related complications, nerve injury, epidural haematoma formation, infection, or death.

Typical case

Patient Li, a 48-year-old woman, was admitted to the hospital with the chief complaint of low back pain with radiating pain to the lower limb for 2 weeks. Two months ago, she underwent intervertebral foramen surgery in our hospital for the same symptoms (L5-S1). Physical examination: no significant changes were observed in the nerve root innervation area of S1, and the corresponding innervation muscle strength had decreased to grade IV. Sagittal (**Figure 2A**) and plain (**Figure 2B**) MRI scans suggested para-central lumbar disc herniation at the L5-S1 level. The admission diagnosis was considered to be recurrent lumbar disc herniation (L5-S1). UBE-TLIF was adopted based on the patient's condition.

First, (**Figure 2C**) most of the bone of the corresponding upper and lower articular processes of the affected side of the intervertebral foramen and part of the upper and lower segments of the lamina were excised through the intervertebral foramen with the aid of the endoscope by using high-speed grinding and a rongeur to expose the outlet of the compressed nerve root. Then, the herniated disc was

Table 2. Comparison of clinical indicators before and after surgery

Follow-up	Case	VAS (lower back pain)		VAS (leg pain)		JOA (score)		ODI (score)		SF-36 (score)			
										PCS		MCS	
Before surgery (1)	44	5.71 ± 1.62		7.57 ± 2.01		8.71 ± 5.22		54.18 ± 10.42		29.60 ± 8.83		27.32 ± 9.17	
7days after surgery (2)	44	2.23 ± 0.68		1.80 ± 0.73		16.40 ± 4.96		36.89 ± 9.13		-		-	
6 months after surgery (3)	44	0.67 ± 0.44		1.01 ± 0.45		27.15 ± 3.24		11.12 ± 3.56		50.55 ± 7.34		49.48 ± 8.91	
F value		218.45		326.12		143.15		333.04		166.26		200.57	
P value		<0.0001*		<0.0001*		<0.0001*		<0.0001*		<0.0001*		<0.0001*	
Paired comparison		*T* value	*P* value	*T* value	*P* value	*T* value	*P* value	*T* value	*P* value	*T* value	*P* value	*T* value	*P* value
(1):(2)		14.59	<0.0001*	24.66	<0.0001*	23.44	<0.0001*	9.13	<0.0001*	-	-	-	-
(1):(3)		38.10	<0.0001*	31.43	<0.0001*	49.56	<0.0001*	31.46	<0.0001*	11.21	<0.0001*	10.43	<0.0001*

*The difference is significant (P<0.05). "-" means no data; VAS: Visual Pain Simulation Score; JOA score: Japanese Orthopaedic Association score; ODI: Oswestry Disability Index; SF-36: Quality of Life Scale; PCS: total physiological score; MCS: total psychological score.

Table 3. Patient satisfaction follow-up results

Follow up	Satisfaction, n (%)			
	Very satisfied	Satisfied	Generally satisfied	Dissatisfied
7 days after surgery	16 (36.4)	22 (50.0)	4 (9.1)	2 (4.5)
6 months after surgery	18 (40.9)	24 (54.5)	2 (4.5)	0 (0.0)

Table 4. Clinical efficacy follow-up observation

Follow up	Improvement rate ($\bar{x} \pm s$, %)	Clinical effect, n (%)		
		Significantly effective	Efficient	Invalid
7 days after surgery	41.8 ± 10.6	4 (18.2)	17 (77.3)	1 (4.5)
6 months after surgery	87.7 ± 8.2	14 (63.6)	8 (36.4)	0 (0)

excised (**Figure 2D**), and an appropriately sized cage was selected for interbody fusion (**Figure 2E**). The intervertebral disc resected during the operation is shown in (**Figure 2F**). Then, percutaneous internal fixation was placed to restore the stability of the spine. The patient's symptoms were relieved after surgery. X-ray examination 3 days after surgery indicated good internal fixation (**Figure 2G**, **2H**).

The images of a patient before and after surgery are shown in **Figure 3**. General picture of the patient walking before surgery (**Figure 3A**), general picture of the patient walking after surgery (**Figure 3B**), and photo of the healing surgical incision (**Figure 3C**).

Discussion

Unilateral biportal endoscopic-assisted transforaminal lumbar interbody fusion (UBE-TLIF) technology shows several advantages in this study: First, rapid low back pain recovery, little intraoperative blood loss, short bed rest time, and a short hospital stay were observed. Second, short-term improvements in low back pain and quality of life (ODI) satisfied the patients and the incidence of complications was very low. These results show that UBE-TLIF can minimize tissue damage to achieve the purpose of minimal invasiveness on the premise of ensuring a curative effect.

Although traditional laminectomy and discectomy are effective methods for the treatment of symptomatic lumbar disc herniation, the muscle and ligament damage caused by the operation may lead to postoperative back pain and muscle atrophy [16, 17]. Therefore, functional recovery and pain control after traditional open decompression may take more time. Low back pain after a mechanical injury caused by open surgery has also been reported. According to Lee et al., after long-term follow-up, 70% of patients had back pain after routine open decompression surgery [18]. According to Konieczny and other researchers, 32% of patients experienced back pain after lumbar discectomy, and 9% of them finally received spine fusion surgery to control the pain [19]. According to reports by Wang et al., invasive operations that include opening the endplates, reduce the height of the vertebral body and aggravate back pain during the postoperative period [20]. Scar formation in the epidural space and adhesion of the sheath to the paravertebral muscle structure may lead to the reappearance of clinical symptoms and make revision surgery more difficult [21, 22]. Therefore, some minimally invasive techniques, such as transforaminal lumbar interbody fusion and percutaneous endoscopic lumbar discectomy, have been widely used to minimize posterior ligament complex injury [23, 24].

Percutaneous discectomy is better than traditional operations in protecting posterior structures, such as the upper and lower lamina, ligament structures, and muscles. However, due to the limited operating space of the intraoperative instruments and intervertebral foramen stenosis after degenerative changes, the indications for this technique are limited. MED is considered an alternative to open surgery because it causes less damage to soft tissues, has a faster recovery, and has less intraoperative bleeding [25]. However, this technique still requires a dilator to establish a working channel, which destroys the paravertebral muscles [26].

In contrast, UBE-TLIF with just one small muscle incision can achieve high-resolution visualization of the operation area and virtually unlimited access by all of the laminectomy instruments. High-resolution endoscopes make it easier to identify the anatomy of intervertebral

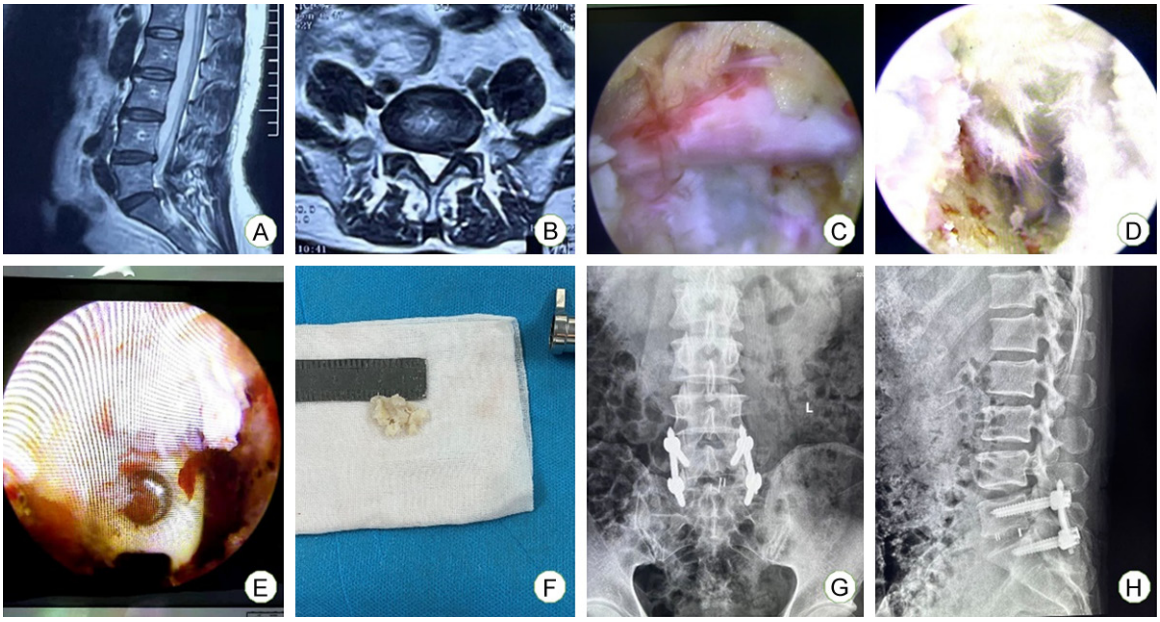

Figure 2. UBE-TLIF was performed in a typical case of recurrent lumbar disc herniation: A, B. Sagittal MRI and plain MRI indicate a para-central lumbar disc herniation at the L5-S1 level; C. Most of the bone of the corresponding upper and lower articular processes of the affected side of the intervertebral foramen and part of the upper and lower segments of the lamina was excised through the intervertebral foramen with the aid of an endoscope by using a grinding drill and an osseous ronognus to expose the outlet nerve root and the compressed nerve root; D. Removal of the herniated disc; E. An appropriate size fusion device was selected for interbody fusion; F. Intraoperative resection of the intervertebral disc; G, H. The X-ray results 3 days after the operation.

Figure 3. Images of patients before and after surgery: A. General picture of the patient walking before surgery; B. General picture of the patient walking after surgery; C. The healing wound after surgery.

discs and remove broken discs and bone slices, similar to traditional techniques. UBE-TLIF is a new method that combines the advantages of interlaminar endoscopy and microsurgery. The use of single-channel systems, such as intervertebral foramen microscopy, make the surgery difficult because the combined channels (endoscope and instruments) restrict the independent movement of the instruments. In contrast, UBE-TLIF system instruments have unrestricted activities under independent channels. In addition, conventional arthroscopy equipment and standard laminectomy instruments can be used for the surgery without the

need for additional instruments. Compared to the expensive equipment of the transforaminal endoscopic surgical system, this technology is easier to develop and popularize in primary hospitals. Any spinal surgeon who is familiar with PELD and MED can perform the technique immediately without the need for a steep learning curve [27].

According to Kambin et al., the patient satisfaction rate with UBE surgery is as high as 87% [28]. However, this study did not use generally accepted assessment criteria, such as VAS, ODI, and SF-36 scores. A recent study by Um et al. reported the results of high-resolution endoscope-assisted UBE surgery for lumbar disc herniation [29]. Their research showed that after 1 month, the ODI score improved from 67.2 ± 1.7 to 24.3 ± 8.5, and the lower extremity pain VAS score decreased from 8.3 ± 1.1 to 2.4 ± 1.1. However, this study only provided short-term clinical results and did not carry out long-term follow-up. In comparison, the improvement in the ODI score and VAS score of postoperative follow-up patients in our study was better than that reported by the above researchers.

The unique feature of this study is the application of UBE technology to assist with the transforaminal lumbar interbody fusion, which can be challenging in some patients with recurrent lumbar disc herniation. The details of the operation were described in detail, and follow-up was carried out for a longer period to evaluate its long-term clinical effects and its safety and reliability.

Progress in lumbar disc herniation surgery technology now allows for full endoscopy under continuous irrigation surgery. The increasing popularity of minimally invasive surgery has made it possible to retain an increasing number of soft tissues [30]. Compared to the traditional operation, due to the preservation of the back muscles, UBE has a smaller incision, less blood loss during the operation, less low back pain post-operation, and a relatively short hospital stay. These advantages have expanded the scope of the indications for UBE surgery [31], such as lumbar spinal stenosis, cervical spine degenerative disease, and even short segment fusion surgery. High-resolution video equipment may retain the facet joint and lateral ligament complex to reduce the pulling on nerve roots. Another advantage is that UBE-TLIF preserves the epidural blood vessels and part of the ligamentum flavum. The combination of these advantages improves the quality of life (ODI score). The patient satisfaction after UBE-TLIF is even higher than that after MIS-TLIF [32]. This result may be due to less tissue destruction, faster pain relief, a shorter hospital stay, good pain results, and improved quality of life.

Compared with the open decompression time previously reported in the literature, the time for UBE-TLIF surgery has not been reduced in this study [33], which may be because the working channel can only provide the operator with one hand to operate the instrument, and the other hand needs to control the endoscope to keep the operating field clear, so it is difficult to simultaneously control any bleeding, and this prolongs the operation time. In addition, the unclear local anatomy and nerve root adhesion caused by the previous operation are also possible factors for the relatively long operation time. With continuous familiarization with the operating techniques and continuous enrichment of surgical experience, the operation time may be further reduced.

Not all patients are suitable for this technique, and our initial attempt involved patients who were undergoing interlaminar decompression for the first time, such as simple nucleus pulposus removal. Using the UBE technique when RLDH occurs, it was found that local visual field adhesion was serious, the anatomical structure had been destroyed, and there was a greater risk of penetrating the dura mater. Although the results of this study show a certain degree of safety, we do not recommend that beginners perform this operation directly. The surgeon must have experience in performing MIS-TLIF surgery and be able to successfully complete ordinary UBE surgery. In our research centre, a surgeon tried to carry out this technique, but he did not successfully enter the spinal canal to find the nerve root for 2 hours because he was lost under the microscope. After a long period of normal saline infusion through the working channel, the patient developed water poisoning, delirium and coma, which finally improved gradually with treatment in the ICU. Therefore, we suggest that if the surgeon cannot successfully expose the

Kambin triangle or find the nerve root within 1 hour, it should be changed to a routine open operation or an MIS-TLIF operation, which should not cause unnecessary complications for the patients.

There are still some shortcomings. First, this is the first attempt to apply UBE-TLIF in the treatment of RLDH, so there will inevitably be research errors and defects. All of the patients included in this study were from the orthopaedic department of our hospital, and its representativeness has some limitations. Second, this study is limited by its retrospective study design method and small sample size. Due to the nature of retrospective studies, surgeons' preference for patients seems to be an inherent factor causing selection bias, which may affect the clinical results. Third, the study is only a retrospective case observation study, and the number of cases is relatively small. Because of the limitations, it is necessary to carry out large samples or prospective randomized controlled trials in the future.

This study shows that UBE-TLIF is a safe and reliable minimally invasive technique for the surgical treatment of recurrent lumbar disc herniation.

Disclosure of conflict of interest

None.

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