Observational Study

Medicine

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Clinical outcomes of unilateral biportal endoscopic discectomy (UBE) compared with conventional open lumbar discectomy with 3D microscope (OLDM) assisted

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Abstract

The open lumbar discectomy with 3D microscope (OLDM) is considered the most common surgical procedure for herniated or ruptured discs of the lumbar spine, while unilateral biportal endoscopic (UBE) technique is a rapidly growing surgical treatment for spinal surgery. UBE as a new endoscopic technique has been applied to conventional arthroscopic systems for treating the spinal disease. In this research, we aimed to evaluate and compare the perioperative parameters and clinical outcomes, including operative time, intraoperative, blood loss, pain and modification, hospital stay, patient's satisfaction, and complications, between OLDM and UBE for lumbar disc herniation. A total of 76 patients with lumbar disc herniation were included in this study from February 2019 to February 2022. All of them had received spinal surgery who underwent OLDM (42 cases) and UBE (34 cases) in Affiliated Hospital of Nantong University and Affiliated Nantong Hospital 3 of Nantong University. Respectively, all the patients had 1 level lumber disc herniation. Perioperative metrics were compared between the 2 groups: estimated blood loss, operation time, length of hospital stay, and complications of the patients. The visual analog scale (VAS) for back and leg pain, and Oswestry Disability Index (ODI) and modified MacNab criteria were tested before surgery and 3 days, 3 months and 12 months following surgery. Compared with the OLDM group, the UBE group had obviously shorter operative time, less intraoperative blood loss, and shorter hospital stay. In addition, the VAS and ODI scores had a significantly reduction in 2 groups after operation. There was no great difference of VAS and ODI scores in preoperative and 3 days, 3 months, and 12 months after operation between the 2 groups. Meanwhile, there was no significant difference in the rate of operational conversion and complications between the 2 groups. Application of OLDM yielded similar clinical outcomes to UBE for treatment of lumbar disc herniation containing pain control and patient satisfaction. Nevertheless, UBE was associated with several advantages relative to OLDM in terms of surgical time, intraoperative blood loss, short-term postoperative pain relief and postoperative hospitalization.

Abbreviations: LDH = lumbar disc herniation, ODI = Oswestry Disability Index, OLDM = open lumbar discectomy with 3D microscope, UBE = unilateral biportal endoscopic, VAS = visual analog scale.

Keywords: endoscopic lumbar discectomy, lumbar disc herniation, lumbar discectomy with microscope, minimally invasive surgery, unilateral biportal endoscopic

1. Introduction

In adults, symptomatic lumbar disc herniation (LDH) is one of the main reasons leading to sciatic pain and low back pain and presents a heavy health and economic problem to patients and society.[1,2] The compression from the protruding disc on the dorsal and the ventral nerve roots results in leg pain (sciatica), low back pain, restriction of truck movement and muscle spasm.[3] As the largest and the most medially located back muscle, the multifidus muscle spans the lumbosacral junction, which could maintain the erector posture of the truck and to rotate and abduct the trunk.[4] Besides, the lumbar spinal nerve is also innervated by the dorsal root.[5,6]

JH and RC contributed to this article equally.

This work was supported by Jiangsu Provincial Key Medical Center (YXYZA2016001).

The requirement for informed consent was waived because of animal study.

No individual person's data were included in this study.

The authors have no conflicts of interest to disclose.

All data generated or analyzed during this study are included in this published article.

The research received approval from the ethics committee of our institution.

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How to cite this article: Hao J, Chen R, Zheng J, Xu S, Xue H, Yao Y. Clinical outcomes of unilateral biportal endoscopic discectomy (UBE) compared with conventional open lumbar discectomy with 3D microscope (OLDM) assisted. Medicine 2025;104:6(e41440).

Received: 24 August 2024 / Received in final form: 14 January 2025 / Accepted: 16 January 2025

http://dx.doi.org/10.1097/MD.0000000000041440

Consequently, spinal surgery is necessary for patients with LDH to relieve their pain.

Operation for LDH could be classified into minimally invasive procedures and microscopic open lumbar discectomy. Since 1934, the treatment of open lumbar discectomy has been considered as a standard surgery for LDH, when Barr and Mixter reported disc removal and partial laminectomy for treating LDH.[7] With the development of microscope, the open lumbar discectomy has been refined as a traditional laminectomy.[8] As is reported that, open lumbar discectomy with 3D microscope (OLDM) is the most commonly recommended surgery for recurrent LDH. Though OLDM shows similar results to those of primary open lumbar discectomy, some approach-related complications has been concerned owing to segmental instability and scar tissue, which results from inevitable damages to vertebral motion segment and facet joint. In other words, compared with open surgery, minimally invasive surgery leads to less damage and trauma to the posterior column of the spine.[9–11] Even though the decompression range is greater than minimally invasive operation, open surgery could cause never root adhesion. As a result of larger wound and scar formation, postoperative recovery needs longer time in open surgery, let alone other complications. As a consequence, more consideration should be took in the choice of surgical methods by surgeons. Nowadays, as a kind of minimally invasive technology, the method of unilateral biportal endoscopic (UBE) has become possible with less intraoperative and postoperative. With the advantage of little trauma, rapid postoperative recovery, and less damage to spinal stability, the technology of UBE is favored by patients and surgeons.

Two portals were utilized to complete the decompression in the unilateral biportal endoscopic technique, which are not coaxial. Surgeons use viewing portal to expose the operational field with arthroscopy and continuous flushing to maintain clear vision, and then, through the posterior interlaminar approach, the working portal is adopted for neural decompression, that is little difference with the traditional posterior open surgery. This technique has a clear advantage with 2 separated percutaneous portals and do not interfere with each other. Another advantage of this technique is that the whole operation is flexible and convenient and the endoscopic and surgical instruments could be operated freely without portals limitation. Parts of the spinal canal and all directions could be explored. In addition, this technique not only obtain the decompression effect similar to open operation, but also could reach the goal of minimally invasive spinal surgery. In other words, this method is an appropriate supplement to the existing endoscopic technology.

Thanks to the rapid development of spinal endoscopy technology, UBE could be used treat LDH. In light of that posterolateral transforaminal approach through unscarred tissue could prevent further damages to paraspinal posterior spinal structure and prevent nerve injury, UBE technique has some advantages for LDH. Recent research has confirmed that with satisfactory early follow-up outcomes, UBE technique is a safe and effective surgery for sufficient decompression of LDH. However, no comparative research has hitherto assessed the clinical efficacy of OLDM and UBE in treating LDH. This study aimed to exam the clinical outcome of OLDM and compare it with conventional UBE for LDH.

2. Patients and methods

2.1. Subjects and grouping

A total of 76 patients diagnosed with L4/5 or L5/S1 LDH, who underwent OLDM and UBE at the Affiliated Hospital of Nantong University and Affiliated Mental Health Center of Nantong University from February 2019 to February 2022, were included and classified into OLDM and UBE groups, respectively. The surgery of OLDM or UBE for a patient was depended on whether an adequate decompression was needed necessarily. If so, OLDM would be picked. Otherwise, UBE would be chose. This research was approved by Human Subjects Institutional Review Board at University. Written informed consent was obtained from all participants. The OLDM group (n = 42) included 24 men and 18 women, aged 38 to 65 years, with an average of 49.4 years. In addition, the UBE group (n = 34) contained 20 men and 14 women, aged 42 to 63 years, with an average of 48.2 years. Preoperative signs and symptoms were related to the imaging information, and the responsible intervertebral space was identified as L4/5 or L5/S1 in all the concluded patients. The same surgical team from our hospital performed the operations. The decision of surgical method is made by fully consideration depended on the patients and their families following the doctors thoroughly explains the advantages and disadvantages, operational details, total cost, risks and complications of the various surgical methods.

The inclusion criteria were:

1. Back and radiating pain related to LDH;
2. Imaging examination (magnetic resonance imaging) confirmed LDH and the responsible segment was single;
3. Despite conservative treatment, the clinical symptoms persist for >4 weeks;
4. All the patients conducted could follow up for at least 6 months regularly;
5. No evidence of contraindication to surgery.

The exclusion criteria were as follows:

1. Met the criteria for enrollment, however, patients were receiving another treatment;
2. Lumbar spondylolisthesis more than Meyerding grade II;
3. Patients had quite a few lumbar spinal stenosis;
4. Patients with additional spinal disorders, such as fracture, tumor, or idiopathic scoliosis;
5. Cauda equine syndrome;
6. Prior relevant surgical history.

2.2. Surgical techniques

2.2.1. OLDM. Surgeons made a posterior median incision over the spinous process with paravertebral muscles dissected under fluoroscopy, and then the medial part of the articular process and the upper and lower edge of the adjacent lamina were removed for fenestration, meanwhile, the doctors removed the lateral semi articular process. At the same time, the 3 dimensions (3D) microscope was employed, the surgical field of view was magnified by this 3D microscope, while surgeons completed operations by watching the high definition screen. The compressed tissue of nerve root and dura mater and the thickened ligamentum was fully removed to decompress the nerve root and dura mater. With 3D microscope, when required, contralateral decompression was conducted until the contralateral nerve roots were decompressed by using the same approach. In the end, a drainage tube was placed and the incision was closed with adequate hemostasis (Fig. 1A).

2.2.2. UBE. All the patients underwent general anesthesia and were placed in a prone position with the chest raised. Through placing the arch bridge cushion on the ventral side, the abdomen is suspended. The target segment was checked by C-arm fluoroscopy. Taking a right-side approach as an example, the incision design was 5 mm aside the posterior midline, and the working and viewing portals were located 1 cm distal and proximal to the intersection point of the horizontal line of the midline of the lateral mass and the intervertebral space on an anteroposterior view. The endoscopic trochar and cannula are docked over the superior lamina through the endoscopic portal. And then, the irrigation fluid is

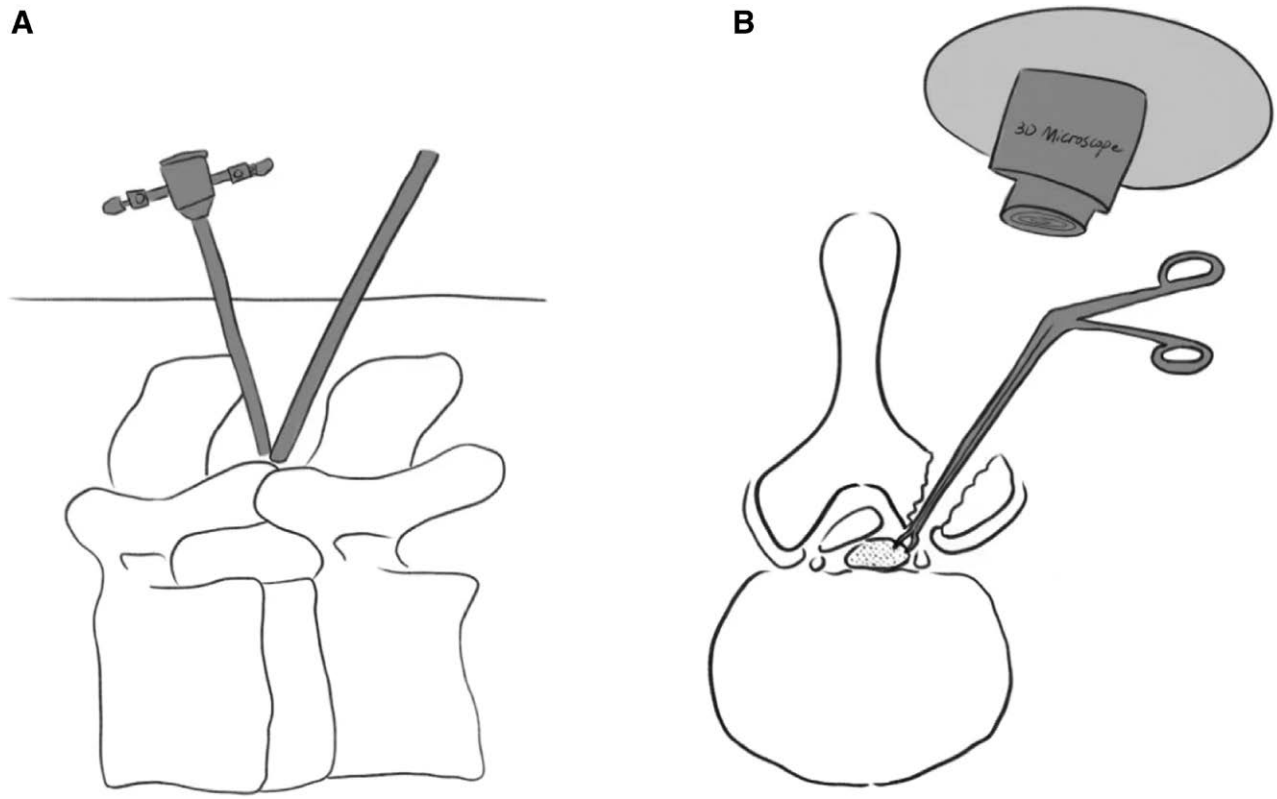

Figure 1. Illustration of (A) OLDM and (B) UBE. OLDM = open lumbar discectomy with 3D microscope, UBE = unilateral biportal endoscopic discectomy.

initiated and the endoscope with 30° lens is drew through the cannula, the trochar is removed to clean out the blood. The radiofrequency probe is took to wash out the remaining muscles or other soft tissues over the ligamentum flavum and limina. The isotonic saline is used as a kind of irrigation fluid to avoid tissue edema. The arthroscopic burr is used to thin out ispilayeral lamina, while the inferior edge of the superior lamina and the ligamentum flavum of the target interlaminar space are completely exposed. The ligament is removed by the Kerrison punch and is peeled down in caucal direction, following ensuring the plane between dura and ligamentum flavum is free from adhesion. The shoulder and axillary regions of the nerve root were explored completely, after that, the herniated disc was removed. The pulsation and color of the nerve roots could return to normal. A Kirschner wire could be put into the intervertebral space with an auxiliary portal, in cases with severe stenosis to pull and protect the nerve root. To prevent hematoma, a drainage tube was placed in all patients by the working portal following by wound closure (Fig. 1B).

Typical cases are presented in the manuscript (Fig. 2A through L and Fig. 3A through L).

2.3. Outcome measures

The demographic data, hospital stay, fluoroscopy times, operation time, and complications were recorded and analyzed. All the patients must be followed up for at least 6 months after operation in the outpatient department. Leg pain (visual analog scale [VAS]-Back) and back pain (VAS-Back) were assessed by the 10-point VAS. And then, we recorded them at 3 days, 3 months, 12 months after the operation and on 3-days before surgery. Besides, as functional evaluation methods, modified MacNab criteria and Oswestry Disability Index (ODI) were adopted in this study.

2.4. Statistical analysis

SPSS statistic software (version 14.0K) was used to finish all the statistical analyses. We used Wilcoxon signed rank test and paired sample *t* test to compare the difference of pre and postoperative parameters on radiological and clinical outcomes in each group. And then Chi-square test, Mann–Whitney *U* test, Fisher exact test and independent *t* test were performed to compare the differences of the radiological and clinical outcomes between the 2 groups. A P value of <0.05 was of great significant.

3. Results

3.1. Preoperative information of the patients

The preoperative information of the patients, including demographic data (numbers, age, sex, symptom duration, BMI, L45, or L5S1 intervertebral space) and the perioperative data, such as intraoperative hemorrhage, surgical time, complications and postoperative hospital stay were collected and tested (Table 1). All of the patients received OLDM or UBE, and then all of them were followed up within 12 months.

3.2. Postoperative outcomes and complications

Clinical information was evaluated by improvement of leg and back pain, the level of disability and the rate of clinical satisfaction (Table 2). Compared with OLDM group, UBE group was associated with transparent less intraoperative hemorrhage, shorter surgical tine and shorter postoperative hospital stay. Four patients (9.52%) occurred complications in OLDM group and 2 patients (5.88%) in UBE group. Three patients in OLDM group occurred slight headache following operation, and then alleviated by plenty of rest after operation. Another patient in OLDM group experienced cerebrospinal fluid leakage and then

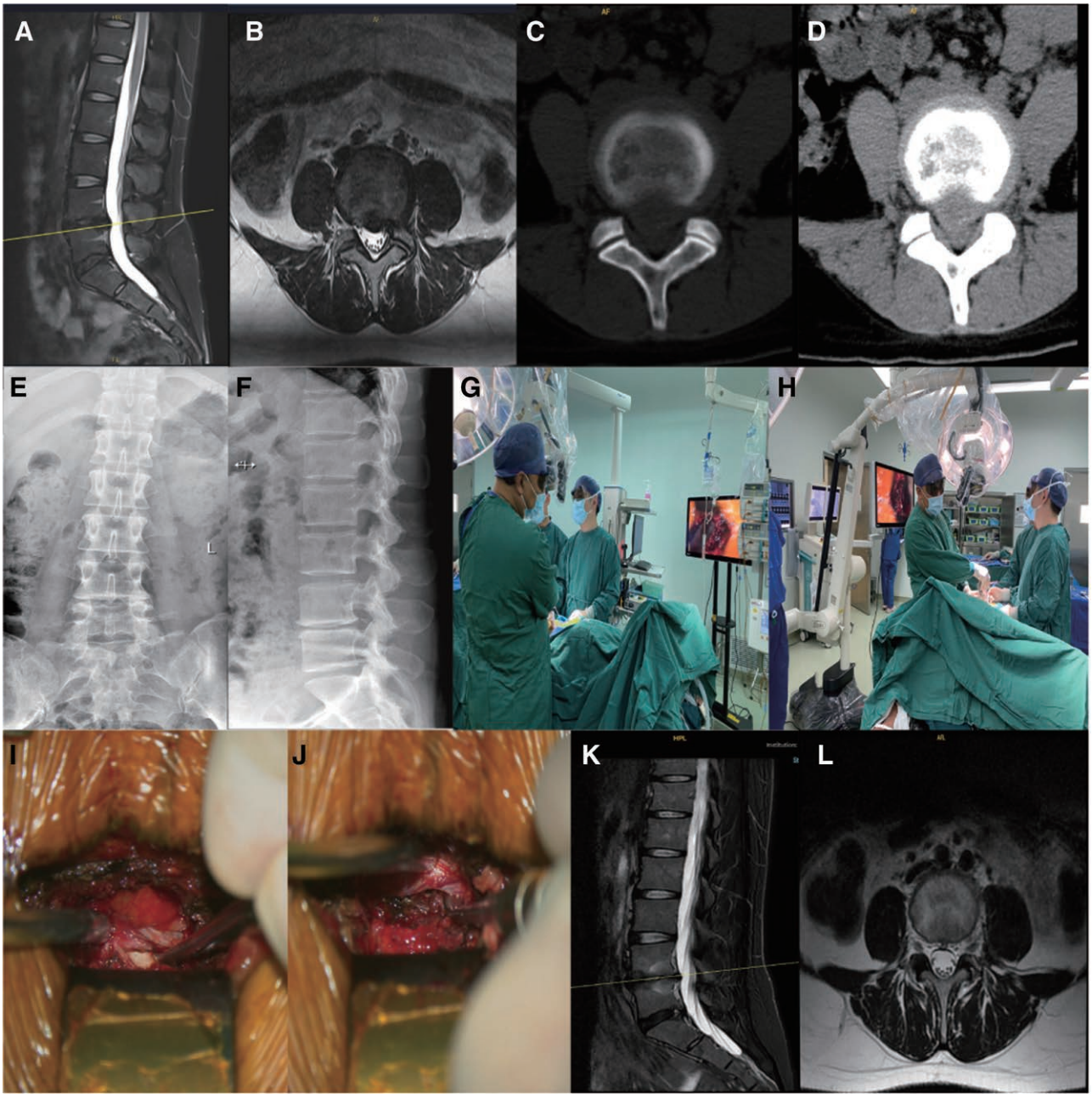

Figure 2. Lumbar disc herniation at the L5/S1 level. Intraoperative imaging of a 39-year-old male with severe back and left leg pain during OLDM. MR shows intervertebral disc protruding from the spinal canal. Axial MR reveals S1 traversing nerve root was compressed (A and B). CT exhibits patacentral disc herniation (C and D). Frontal and lateral X-ray images reveals normal lumbar spine sequence (E and F). Two mature doctors were undergoing surgery with microscope (G and H). Exposing nerve root and protruding intervertebral discs fully (I). Cutting open the intervertebral disc with a blade and remove it completely (J and K). Adequate decompression of nerve root (L). CT = computed tomography, MR = magnetic resonance, OLDM = open lumbar discectomy with 3D microscope.

relieved by increasing drainage time. Two patients in UBE group complained of residual numbness in the lower limbs, which relieved by neurotrophic drugs in a week.

3.3. Clinical outcomes

We used the VASs to estimate the intensity of leg and back pain before operation and at 3 days, 3 months, and 12 months postoperative. Similarly, we also used ODI to evaluate disability before operation and at 3 days, 3months, and 12 months following operation (Table 3). We could find that, there was no obviously difference between the 2 groups in the ODI or VAS scores for leg and back pain at 3 days, 3months, and 12 months following operation ($P < .05$). It is worth noting that, VAS scores for leg and back pain, the same as the ODI scores, were observed higher in OLDM group than that in UBE group at the same group follow-up ($P < .05$). In addition, the MacNab criteria was used to evaluate clinical satisfaction by an independent surgeon at 12 months following surgery. As is well known that, no pain or no restriction of activities of daily was considered as an excellent result. According to the MacNab criteria, we could find that, satisfactory (good or excellent) results were exhibited in 38 (90.48%) of the patients from the OLDM group, and 32 (94.12%) from the UBE group. Therefore, there was no obvious different between the 2 groups in the rate of satisfaction.

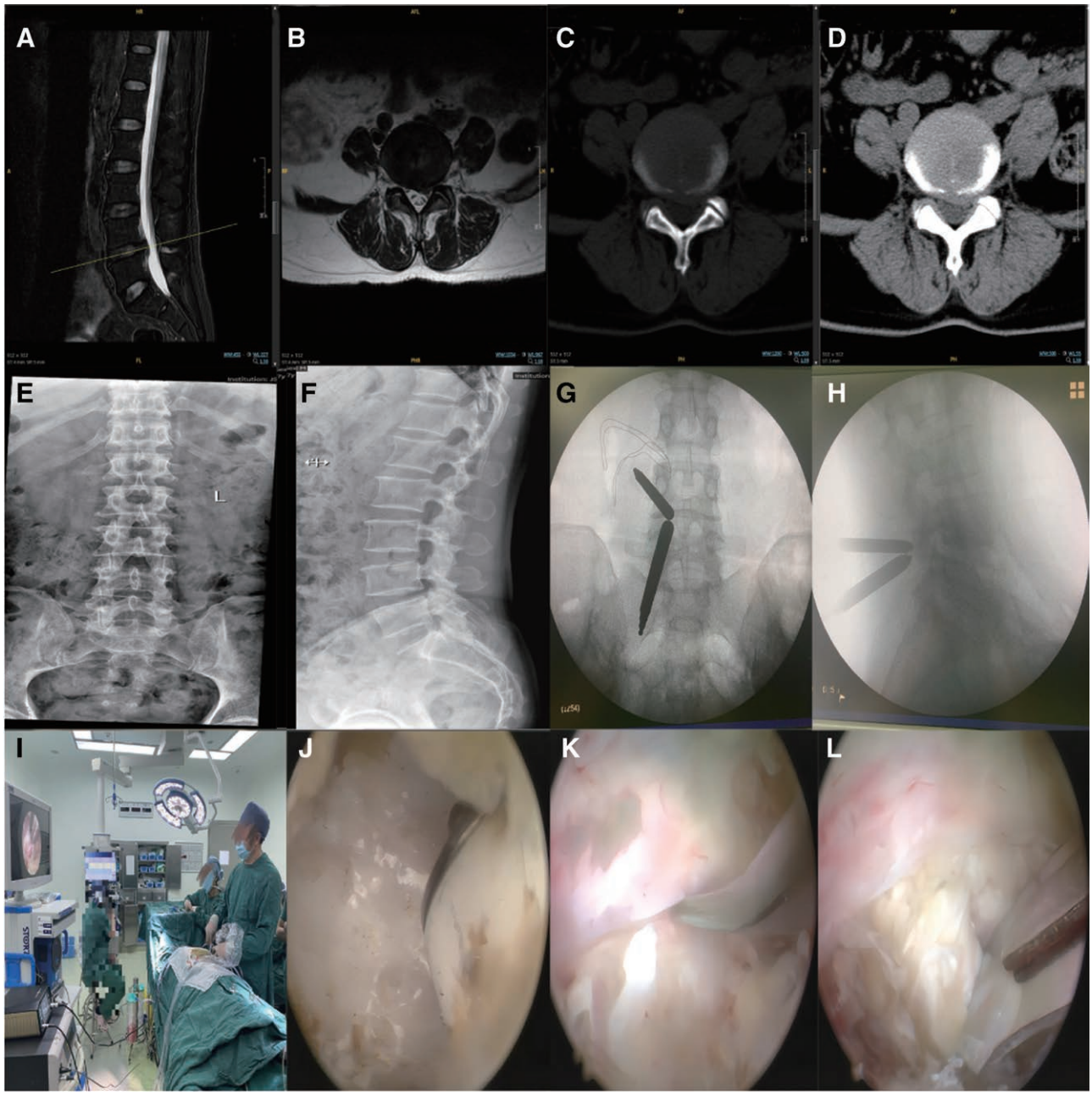

Figure 3. Lumbar disc herniation at the L4/5 level. Intraoperative imaging of a 28-year-old female with back and left leg pain during UBE. T2-weighted parasagittal MR and CT revealing down migrated disc herniation at L4/5 level (A through D). Frontal and lateral X-ray images reveals physiological anterior curvature of the lumbar spine (E and F). Two operation channels located on the targeted intervertebral lacunae by X-ray images (G and H). The surgeon was reducing compression (I). Exposing the vertebral plate, shake off part of the medial aspect of the lower articular process, and expose the nerve root and protruding intervertebral disc fully, and remove it completely (J through L). CT = computed tomography, MR = magnetic resonance, UBE = unilateral biportal endoscopic discectomy.

4. Discussion

In recent years, an increasing body of evidence has indicated that many cases of lumbar stenosis can be effectively managed using UBE. This approach has gained attention since its introduction by Kambin et al in 1996.[12] Kambin et al were the first to report the use of unilateral and bilateral double-channel procedures for the treatment of lumbar degeneration.[13] The conventional technique of open lumbar discectomy has long been regarded as the standard approach for decompression, supported by well-established clinical outcomes.[14,15] Nowadays, 3D microscope has been used in the standard method of open lumbar discectomy, which could take more advantages to this kind of operation. It is worth noting that OLDM enables the removal of abnormal and hyperplastic tissues under direct visualization, ensuring the compressed nerve and dural sac are clearly revealed. Compared with other open surgical methods, this technique maximally preserves the spine's natural anatomical integrity.[16–18] Nevertheless, the OLDM procedure demands sustained force to retract the paraspinal muscle and involves significant removal of paraspinal muscle tissue to expand the surgical field, leading to scar formation and ischemic damage in the surrounding area.[19] An increasing amount of research indicates that paraspinal muscle injury can lead to muscle atrophy, which may accelerate spinal degeneration, causing postoperative pain, reduced rotational stability, and dysfunction.[20]

As minimally invasive techniques continue to advance rapidly, the use of minimally invasive spinal procedures in clinical diagnosis and treatment has steadily grown in prevalence,

Table 1

Preoperative data of OLDM and UBE groups.

Preoperative data	OLDM group	UBE group	*P* value
Numbers	42	34	
Age (yr)	48.3 ± 9.4	51.2 ± 10.2	.001
Sex (%)			
F	24	18	
M	18	16	
BMI (kg/m^2)	27.44 ± 1.67	26.35 ± 2.63	.001
L4/5	14	20	
L5/S1	28	14	
Symptom duration (mo)	40.2 ± 10.3	37.7 ± 15.2	.001

BMI = body mass index, F = female, M = male, OLDM = open lumbar discectomy with 3D microscope, UBE = unilateral biportal endoscopic.

Table 2

Comparison of clinical of OLDM and UBE groups.

	OLDM group	UBE group	*P* value
Operation Time (min)	115.38 ± 20.14	87.34 ± 40.12	.001
Intraoperative hemorrhage (mL)	55.84 ± 10.16	43.21 ± 13.42	.000
Postoperatine hospital stay (d)	8.33 ± 0.52	5.38 ± 1.41	.001
Complications, n (%)	4 (9.52)	2 (5.88)	.001

mL = milliliter, OLDM = open lumbar discectomy with 3D microscope, UBE = unilateral biportal endoscopic.

Table 3

Clinical outcomes of OLDM and UBE groups.

Clinical outcomes	OLDM	UBE	*P* value
VAS of leg pain			
Preoperative	7.37 ± 0.73	7.48 ± 0.83	.047
3 d after operation	3.15 ± 0.42	2.18 ± 0.34	.002
3 mo after operation	1.95 ± 0.63	1.82 ± 0.52	.035
12 mo after operation	1.50 ± 0.41	1.41 ± 0.23	.134
VAS of back pain			
Preoperative	7.07 ± .048	7.17 ± 0.63	.143
3 d after operation	2.89 ± 0.64	2.55 ± 0.72	.044
3 mo after operation	1.91 ± 0.61	1.76 ± 0.42	.032
12 mo after operation	1.13 ± 0.41	1.01 ± 0.15	.146
ODI			
Preoperative	70.34 ± 4.22	70.52 ± 3.89	.003
3 d after operation	30.31 ± 5.01	29.93 ± 4.83	.109
3 mo after operation	17.41 ± 7.51	18.44 ± 3.36	.156
12 mo after operation	10.56 ± 1.73	11.63 ± 1.04	.221
Clinically satisfactory, n (%)	38 (90.48)	32 (94.12)	.001

ODI = Oswestry Disability Index, OLDM = open lumbar discectomy with 3D microscope, UBE = unilateral biportal endoscopic, VAS = visual analog scale.

eventually establishing itself as the dominant approach. This method effectively provides adequate neurologic decompression and alleviation of symptoms without compromising the stability of the lumbar spine, ultimately enhancing the patient's overall well-being.[21,22] Moreover, the UBE technique can accomplish complete nerve root decompression through a posterior approach between the laminae, a method that follows a similar approach to the extended interlaminar fenestration procedure.[23] Two portals were employed to perform the decompression. The viewing portal was used to position the endoscope, ensuring continuous fluid flow, while the operative portal enabled the execution of the decompression procedure.[24] The distinctive dual-channel design enables both the endoscope and surgical instruments to be maneuvered independently within the body, eliminating the constraints of a single channel. This, in turn, significantly reduces the surgeon's workload.[25] The intraoperative approach of the UBE method closely mirrors that of conventional open surgical procedures, with a comparable surgical field. Consequently, for surgeons experienced with the triangulation technique, adopting the UBE method involves a relatively simple learning process.[26–28] Because the UBE technique is performed under direct visualization, it helps minimize the risk of complications, including injury to the dural sac and nerves. In addition, the method allows the use of standard spinal instruments, which can be maneuvered freely through the operating channel.[29] In the UBE technique, an arthroscope is used as the endoscope, allowing structures beneath the opposite lamina to be clearly visualized through the endoscopic lens. The spinal decompression achieved with UBE is both effective and comprehensive. Compared with other endoscopic techniques, it offers unique benefits, particularly in the treatment of lumbar spinal stenosis.[30] In addition, the constant flow of irrigation maintains a clear surgical field, and the pressure from the fluid helps minimize bleeding in the epidural space.[31] In the UBE technique, 2 portals are utilized to carry out the decompression, effectively addressing the limitations of conventional open procedures. These limitations include spinal instability, excessive blood loss, significant surgical trauma, and the potential for postoperative complications.[32] This study primarily focused on evaluating the effectiveness and feasibility of UBE decompression for treating L4-5 or L5-S1 LDH. All the patients received adequate neural decompression successfully. The VAS scores for leg and low back pain significantly improved after surgery and continued to be excellent throughout the postsurgical observation period. In addition, ODI scores also showed improvement. These findings indicate that the unilateral biportal endoscopic technique can produce significant clinical outcomes in the treatment of LDH.

Moreover, intraoperative injury to the paravertebral muscles causes muscle cell necrosis, triggered by the onset of initial inflammation, which leads to an increase in creatine kinase concentrations in the bloodstream following surgery.[33] A considerable amount of evidence suggests that atrophic fibrosis and fat degeneration may occur in the paraspinal muscles following lower back surgery, which can be assessed using magnetic resonance imaging. Studies have now shown that early serum creatine kinase levels are significantly lower after UBE surgery.[34] The results indicate that the UBE procedure can effectively minimize damage to the muscles surrounding the spine, thereby lowering the risk of degeneration in adjacent spinal segments and the development of failed back surgery syndrome. In addition, in case of concomitant foraminal stenosis, necessary bone removal could be assessed.[35] The treatment of an intraforaminal lesion is often considered challenging, with microscopic surgery being difficult to perform. In contrast, the UBE technique allows for accurate assessment of the necessary extent of facet removal, thereby reducing the risk of spinal instability or persistent stenosis.[36] Endoscopic spine operation seems little difficult in literature which has its own learning curve. The triangulation was needed in the biportal endoscopic technique due to a separate viewing portal and working portal just like arthroscopy.[37] Therefore, those doctors who are familiar with arthroscopy could adapt more easily. The UBE approach also requires the use of 1-handed surgical instruments, which can make the procedure more complex and increase the likelihood of delicate maneuvers. This may result in issues such as nerve root damage and dural tears, especially for surgeons with limited experience.

In fact, the UBE technique merges the benefits of both endoscopic and open spinal surgery. It represents an appropriate application of arthroscopic methods in spinal procedures, especially for the less invasive treatment of LDH.[38] This approach has several limitations, such as a confined working area and a restricted visual field. Furthermore, specialized instruments for accessing the intervertebral space are necessary to overcome the limited visibility, achieved through the use of a fluid medium within the operating channel.[39]

In this study, the data demonstrated that both OLDM and UBE contributed to significant improvements in the visual analogue scale scores for back and leg pain after 12 months, as well as a decrease in ODI scores. Furthermore, a significant number of individuals from both groups expressed high levels of satisfaction with the outcomes, suggesting that both treatment methods are similarly effective in managing LDH. However, we observed that the ODI and VAS scores for back and leg pain in the OLDM group showed a slower decline compared with those in the UBE group 3 days postoperatively. This implies that the UBE method may facilitate more rapid recovery and enhanced patient well-being. Moreover, both surgical approaches were distinguished by minimal retraction of nerve structures and less damage to the muscles surrounding the spine, in contrast to spinal fusion procedures. In addition, the UBE group experienced reduced intraoperative blood loss, briefer postoperative recovery times, and a faster surgical duration compared with the OLDM group. Our results align with earlier research. The reduced surgical time in the UBE group may be attributed to a broader field of vision and fewer procedural stages compared to the OLDM technique. Furthermore, the decreased surgical blood loss and reduced recovery time after surgery in the UBE group may be due to less damage to the muscles and bones, as well as a shorter procedure duration. In a word, UBE could give a quickly recovery to patients. This study may impact the patients' recovery time, mental well-being, and their trust and adherence to the treatment plan prescribed by their surgeons.

However, there are some constraints in our study. First, it is a retrospective analysis and lacks a randomized controlled group. Second, this study is limited by its single-center design and small sample size. Future studies with larger sample sizes should be conducted to obtain a comparable control group and validate the findings of this research. Finally, extended follow-up is necessary to assess the sustained clinical outcomes more thoroughly.

5. Conclusion

The UBE operation gives an effective option to achieve nerve decompression. Our research revealed that, compared to the conventional OLDM, UBE had a great better leg and back pain VAS scores and ODI reduction in short-term follow up and a comparable long-term outcome. Consequently, UBE could be regarded as the next future standard in treating degenerative lumbar spine conditions with further improvement.

Author contributions

Writing – original draft: Jie Hao, Ruilin Chen.
Data curation: Jian Zheng, Shaohu Xu.
Investigation: Huawei Xue.
Validation: Huawei Xue.
Writing – review & editing: Yu Yao.

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