

Surgical Outcomes of Minimally Invasive Transforaminal Lumbar Interbody Fusion for Highly Migrated Lumbar Disc Herniation

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Objective: To describe minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) for highly migrated lumbar disc herniation (LDH) and assess its clinical outcomes.

Patients and Methods: This research retrospectively assessed 25 patients who were diagnosed with one-segmental highly migrated LDH and underwent MIS-TLIF in Peking University First Hospital from June 2015 to September 2019. Demographic data, perioperative parameters, complications, recurrence, and surgical outcomes were assessed.

Results: Twelve males and 13 females, with a mean age of 56.68 years old, were involved and the follow-up period was at least one year. The mean operation time was 222.16 minutes, the mean intraoperative hemorrhage was 250.00 mL, and the mean post-operative hospitalization was 5.76 days. The improvements in visual analog scale (VAS) and Oswestry disability index (ODI) were statistically significant. In addition, based on the MacNab criteria, 22 patients (88.0%) acquired satisfactory (good or excellent) results. One patient underwent post-operative epidural hematoma and recovered after evacuation of the hematoma. No recurrence was found.

Conclusion: MIS-TLIF is safe and effective and it can provide satisfactory clinical outcomes for highly migrated LDH.

Keywords: minimally invasive transforaminal lumbar interbody fusion, highly migrated lumbar disc herniation, clinical outcomes

Introduction

With a reported prevalence of 1–3%, lumbar disc herniation (LDH) is a prevalent spinal degenerative disease leading to surgery.¹ Among LDH cases, migrated disc herniation refers to disc herniation either below the superior endplate level of the lower vertebral body or above the inferior endplate level of the upper vertebral body. As Lee et al.² report, disc migration can be divided into four zones based on the orientation and distance from the disc space (Figure 1). Far-downward and far-upward migrations are defined as highly migrated LDH. Highly migrated LDH is more often associated with severe radicular symptoms or cauda equina syndrome compared with common LDH cases, because of the massive herniated disc pressing on nerve roots or cauda equina, which makes it hard to achieve satisfactory outcomes with conservative treatments.³ Hence, highly migrated LDH is more prone to surgery, and choosing an optimal operation approach is undoubtedly important.

Conventional open lumbar fusion surgery, with the advantages of wide view, easy accessibility to the target fragment, thorough discectomy and attainable vertebral stability, has been confirmed effective for highly migrated LDH.⁴ However, it

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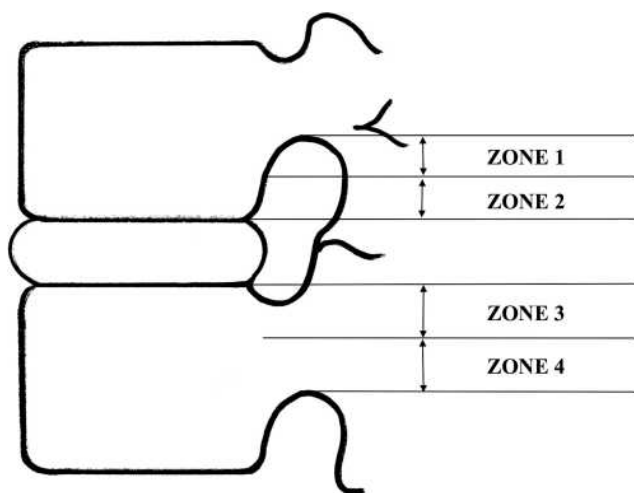


Figure 1 Four anatomic zones and levels of disc herniation: ZONE 1, far-upward: from the inferior margin of upper pedicle to 3 mm underneath the inferior margin of upper pedicle; ZONE 2, near-upward: from 3 mm underneath the inferior margin of upper pedicle to the inferior margin of upper vertebral body; ZONE 3, near-downward: from the superior margin of lower vertebral body to the center of lower pedicle; ZONE 4, far-downward: from the center to the inferior margin of lower pedicle.

requires prolonged paraspinal muscle retraction and extensive subperiosteal dissection, which inevitably results in muscle denervation and atrophy.⁵ First reported by Foley in 2003,⁶ minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) has become an ideal choice for the treatment of LDH; it is better than conventional open fusion surgeries in the aspects of decreased invasion to back muscles and bony structures, providing faster rehabilitation.^{7–14}

Undeniably, highly migrated LDH cases were challenging for minimally invasive spine surgeries because of inadequate exposure and difficulty to touch and grasp the large and separated disc fragments.^{15,16} With the development of surgical equipment and techniques, several previous studies focused on the effectiveness and outcomes of some novel minimally invasive surgical approaches for migrated LDH.^{17–19} However, we are not aware of any previous study evaluating the surgical outcomes of MIS-TLIF for highly migrated LDH. Therefore, the purpose of the current study was to describe MIS-TLIF for a one-segmental highly migrated LDH case series and assess its surgical outcomes.

Patients and Methods

Research Subjects and Grouping

The medical data of 30 patients complaining of back and leg pain resulting from highly migrated LDH who received one-level MIS-TLIF by one surgeon (Y.Z.R.) in Peking University

First Hospital from June 2015 and September 2019 were retrospectively reviewed and enrolled in the study. The surgeon presented a detailed written informed consent to the patients preoperatively. All participants provided informed consent to have their data used in this study. Patient data were collected independently from participants, and data were blindly analyzed. This study was approved by the Human Subjects Institutional Review Board at Peking University First Hospital.

The inclusion criteria were as follows: patients who (1) complained of severe low back pain and lower extremity symptoms associated with the migrated disc; (2) showed hypoesthesia and decreased muscle tone of lower limbs, positive straight-leg raising test and augmentation test; (3) had symptoms agreed with preoperative magnetic resonance imaging (MRI); (4) underwent unsatisfactory conservative treatment for at least 3 months; (5) had one-segmental far-upward/downward migrated disc herniation confirmed by MRI.

The exclusion criteria were as follows: patients who (1) had multi-segmental LDH; (2) had central stenosis or lateral recess stenosis on MRI; (3) had L1/2 or L2/3 disc herniation; (4) had near-upward/downward migrated disc herniation; (5) had lumbar spondylolisthesis and spondylolysis; (6) scoliosis (Cobb's angle >15°); (7) life-threatening medical disease; (8) had undergone lumbar spine surgery before; (9) had deformities requiring correction, fractures, infections, tumors, etc.

Based on these criteria, 25 of the 30 patients were eventually included in the current research. Patients were well informed of the details about optional surgical procedures, complications, as well as the cost of the surgical methods, and the final choice was made by the patients.

Surgical Technique and Post-operative Management

C-arm machine and Quadrant System were prepared, and all the patients received general anesthesia before the surgery. Each patient was placed in the prone position on a radiolucent operating bed. A self-made locator confirmed the targeted level under C-arm fluoroscopy. We marked the pedicle positions (approximately 3.0 cm off midline) and the intervertebral spaces on the patient's body surface according to the spatial relationship. Then we made a 2–3 cm skin incision on the more severe pathology side indicated by preoperative MRI, along the line between the outer portions of ends pedicles. The zygapophysis could be confirmed after splitting and retracting the paravertebral muscles laterally to the outer edge of the facet joint. Quadrant System was placed after inserting

expansion tube. Repeated X-ray examination was necessary to reconfirm the target segments and the location of Quadrant System. Decompression was conducted by removing the inferior portion of the lamina, hypertrophied articular processes, as well as ligamenta flava. Then, the migrated disc was removed with grasping forceps. A suitable bullet-type interbody cage packed with autologous bone was knocked into the center of the intervertebral space the space was enlarged. Following these, under fluoroscopic guidance, we inserted ipsilateral percutaneous pedicle screws through the same skin incision, and contralateral percutaneous pedicle screws were inserted through a mirror incision. Then two titanium rods were symmetrically inserted and tightened on both sides (Figure 2). Finally, closure in layers was performed after adequate hemostasis and placing an incision drainage tube with negative pressure drainage.

Patients were allowed to take off-bed activities with a waist support 24 hours after the operation. The drainage tube could be removed when drainage fluid was less than 30 mL within one day.¹⁰ The patients were permitted to undertake non-manual work 2 weeks after the operation, and then return to full activity 3 months post-operatively. We encourage safe and sufficient rehabilitation activities

with the protection of waist support within 3 months after operation.

Clinical Assessment

The demographic characteristics including age, sex, body mass index (BMI), herniation level, and conservative time from the participants were evaluated.

The perioperative parameters (operation time, intraoperative hemorrhage, and post-operative hospitalization), complication, and recurrence were also assessed.

Surgical outcomes, collected 1, 6, and 12 months post-operatively and compared with preoperative baseline, evaluated the improvement of back and leg pain according to visual analog scale (VAS), and the level of disability assessed with the Oswestry disability index (ODI) version 2.0. Clinical satisfaction was assessed based on the MacNab criteria²⁰ by an independent surgeon at the 12-month post-operative follow-up. Excellent and good outcomes were rated as clinical satisfaction, which means at most occasional paresthesia or pain existed with no need for medication, and no restriction of daily activities.

Statistical Analysis

SPSS Statistics (Version 12, SPSS, Chicago, IL) was used to analyze the collected data. The statistics were illustrated as mean \pm SD. Independent Student's *t*-test and Chi-square test were used to compare the differences between preoperative and postoperative parameters. $P < 0.05$ was regarded as statistically significant.

Results

Demographic Characteristics of the Patients

Twelve males and 13 females, with a mean age of 56.68 (range 42–69) years old and a mean BMI of 25.89 kg/m² were involved. The L4/5 was the most common herniation level (15 cases, 60.0%) followed by L5/S1 (6 cases, 24.0%) and L3/4 (4 cases, 16.0%). The mean conservative time was 7.44 months (Table 1). All the participants underwent one-segmental MIS-TLIF, and then were followed up for at least one year.

Perioperative Outcomes, Complications, and Recurrence Condition

The mean operation time was 222.16 minutes, the mean intraoperative hemorrhage was 250.00 mL, and the mean post-operative hospitalization was 5.76 days (Table 2).

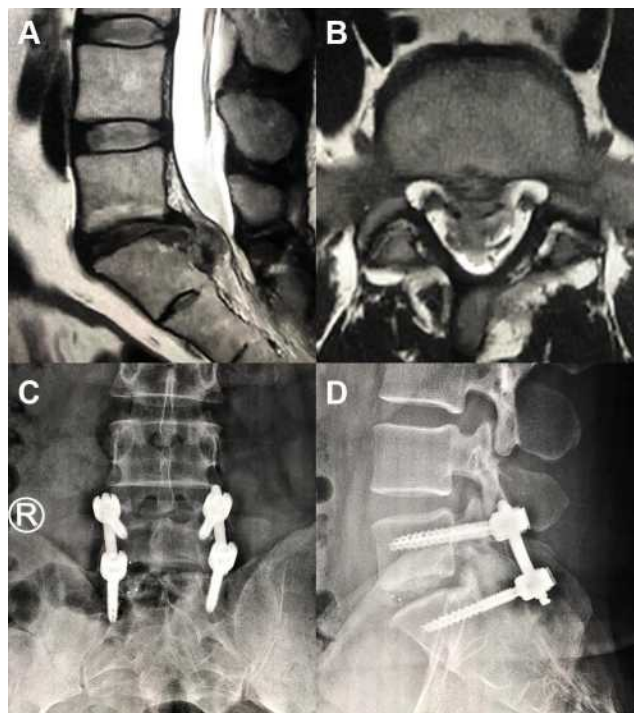


Figure 2 A 43-year-old male diagnosed with L5/S1 highly migrated LDH who underwent MIS-TLIF: (A and B) Preoperative MRI revealed highly downward migrated disc herniation on L5/S1. (C) Anteroposterior and (D) lateral radiographs after MIS-TLIF and percutaneous pedicle screw fixation.

Table 1 Demographic Characteristics (N = 25)

Variables	
Age (years)	56.68±10.13
Sex: male (%)	12 (48.00)
BMI (kg/m ²)	25.89±3.01
Herniation level (n)	
L3/4	4
L4/5	15
L5/S1	6
Conservative time (months)	7.44±1.58

Abbreviation: BMI, body mass index.

Table 2 Perioperative Parameters, Complications, and Recurrence

Variables	
Operation time (minutes)	222.16±42.46
Intraoperative hemorrhage (mL)	250.00±118.05
Postoperative hospitalization (days)	5.76±2.57
Complication, n (%)	1 (4.00)
Recurrence, n (%)	0 (0)

One patient suffered from post-operative complication of epidural hematoma and later recovered after evacuation of the hematoma. No recurrence occurred in 12 months post-operatively (Table 2).

Clinical Outcomes

VAS scores for back and leg pain, and ODI scores were significantly improved at 1, 6 and 12-month follow-ups compared with preoperative baselines ($P<0.01$). Based on the MacNab criteria, surgical satisfaction accounted for 88.0% of the involved patients (Table 3).

Discussion

Highly migrated LDH is still a challenge for minimally invasive spine surgeries due to limited view and accessibility to the target fragment.²¹ With the development of endoscopic surgical equipment, several novel approaches of micro-discectomy were reported.^{3,17,18,21} However, non-fusion surgery resulted in a higher recurrence rate compared with interbody fusion surgery in our clinical practice and according to previous studies.^{22–24} The more aggressive removal of residual intervertebral disc fragments may reduce the risk of reherniation,²⁵ but the

Table 3 Clinical Outcomes

Variables	
VAS of back pain	
Preoperative	7.20±0.76
1 months after operation	3.00±0.65*
6 months after operation	1.80±0.41*
12 months after operation	1.12±0.33*
VAS of leg pain	
Preoperative	7.00±0.71
1 months after operation	2.68±0.63*
6 months after operation	1.96±0.61*
12 months after operation	0.96±0.45*
ODI	
Preoperative	28.12±1.92
1 months after operation	15.20±1.15*
6 months after operation	12.24±0.97*
12 months after operation	10.72±0.68*
Clinically satisfactory, n (%)	22 (88.0)

Note: *Statistically significant difference compared with preoperative baseline.

Abbreviations: VAS, visual analog scale; ODI, Oswestry disability index.

degree of intervertebral disc degeneration in highly migrated cases is often higher than that in general LDH cases, thus residual disc may still exist for recurrence even though the volume of the removed herniation is large. In addition, large damage to the integrity of annulus fibrosus and posterior longitudinal ligament in highly migrated cases might alter the interlaminar shear stress, which makes the residual nucleus pulposus more prone to prolapse. The patients involved in the current study undertook physical labor with strong intensity in daily life and they had high demand for lumbar stability in their future life and work. Besides, to avoid stretch injury of nerve root, bone resection for the wide removal of the large migrated disc almost inevitably involves the articular process during the surgical procedure. The patients were well informed of these details and they preferred fusion surgery, so in this study we selected MIS-TLIF as a fusion surgical approach for highly migrated LDH and no recurrence case was found during postoperative follow-ups.

In this study, the operation time seemed relatively long, this might relate to the intricate operating steps and restricted visual scope of MIS-TLIF. Patients could acquire relatively short post-operative hospitalization and fast recovery of waist strength, due to minimal damage to spinous process ligaments and adjacent vertebral tissues.^{10,26,27}

We found MIS-TLIF improved VAS scores of the back and leg pain, and decreased ODI at 1-, 6- and 12-month follow-ups. Referring to the MacNab criteria, 88.0% of the patients acquired surgical satisfaction, indicating that the MIS-TLIF was effective for highly migrated LDH.

In our study, the unilateral approach for bilateral decompression was performed to one case and this patient suffered from epidural hematoma post-operatively. When dealing with far-migrated disc fragments, iatrogenic injury to adjacent nerve roots, blood vessels or dural sac is more likely.^{15,28} Than et al.¹⁶ reported that the risks of dural laceration and cerebrospinal fluid leak might increase during the unilateral approach for bilateral decompression. Similarly, factors including tissue or scar adhesion around the spinal dural sac, limited intra-operative view, inadequate hemostasis, and obstructed drainage might associate with post-operative epidural hematoma. Additionally, the steep learning curves of the surgeon should be considered,²⁹⁻³¹ experience accumulation and adequate knowledge of spine anatomy are key points to avoid these complications.

The present study has some limitations. First, the sample size is relatively small, and the follow-up period is relatively short. A prospective and multicenter study with more participants is needed to explore the long-term surgical outcomes. Furthermore, some other parameters including lumbar spine and adjacent degeneration stability need to be evaluated. Second, surgical choice in this research is limited and the control group was absent; it would be meaningful to compare the outcomes among more novel approaches such as PELD, micro-endoscopic discectomy (MED), open TLIF, posterior lumbar intervertebral fusion (PLIF) for highly migrated LDH in future studies. Third, there may be a bias resulting from the specific learning curves of the same experienced surgeon who performed all the operations.

Conclusions

MIS-TLIF is a safe and effective surgical choice and it can provide satisfactory clinical outcomes to patients with one-segmental highly migrated LDH.

Ethics

This study complied with the Declaration of Helsinki. All the participants provided informed consent to have their data used in this study.

Disclosure

The authors report no conflicts of interest in this work.

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