Original Article

Application and thinking of minimally invasive transforaminal lumbar interbody fusion in degenerative lumbar diseases

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Background: This study sought to investigate the clinical efficacy and safety of minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) in the treatment of lumbar degenerative diseases.

Methods: The clinical data of 55 patients with lumbar degenerative diseases treated at our hospital from January 2018 to January 2020 were analyzed retrospectively. Of the 55 patients, 35 who underwent MIS-TLIF were included in the MIS-TLIF group, and 20 who underwent posterior lumbar interbody fusion (PLIF) were included in the PLIF group. The visual analogue scale (VAS) score, Oswestry disability index (ODI) score, operation time, incision length, intraoperative bleeding, postoperative drainage, postoperative landing time, postoperative hospital stay, postoperative interbody fusion rate, and complications were compared between the two groups.

Results: The patients in both groups were followed-up for at least 1.5 years (range, 18–30 months; with an average of 27.5±2.6 months). There was no significant difference in the operation time, incision length, intraoperative bleeding, VAS score for low back and leg pain, ODI score, interbody fusion rate, hospitalization expenses, and complication rate between the two groups ($P>0.05$). One patient had nail failure in the MIS-TLIF group, 1 patient in each group had nerve root irritation, and 1 patient in each group had superficial incision infection and local suture dehiscence. The postoperative drainage volume, postoperative landing time, and postoperative hospital stay of the MIS-TLIF group were less than those of the PLIF group ($P<0.05$).

Conclusions: Compared to PLIF, the use of MIS-TLIF in the treatment of lumbar degenerative diseases has a number of advantages, including more complete intraoperative hemostasis, less postoperative drainage, earlier landing, and faster discharge, and also significantly improves postoperative lumbar discomfort.

Keywords: Minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF); posterior lumbar interbody fusion (PLIF); degenerative lumbar disease; vertebral height

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Introduction

Lumbar degenerative disease is a common cause of low back and leg pain, and it is also one of the most common reasons for spinal surgery (1). Surgical treatment is considered for patients for whom formal conservative treatment for 3 months or more has been ineffective (2,3). Minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) is used to treat lumbar degenerative diseases. Through the tubular expander, MIS-TLIF can reach the facet joints of the diseased segments. MIS-TLIF effectively reduces the peeling and traction injury of the multifidus muscle, prevents postoperative muscle atrophy, and reduces

the occurrence of postoperative chronic low back pain (3-5). Posterior lumbar interbody fusion (PLIF) has long been used as a routine spinal operation by spine orthopedics doctors at our hospital because of its early invention; however, the disadvantages of PLIF is that it is necessary to pull the nerve root and dural sac through the midline during the operation, which increases the risk of nerve root and dural sac injury, especially above lumbar segment 3, and the dural sac lacks mobility and traction space (6). From the perspective of serving doctors and patients, this study sought to clarify whether MIS-TLIF could replace PLIF in the treatment of degenerative lumbar diseases, and provide a reference for clinical decision making. We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-401/rc).

Methods

General information

Based on the clinical data, 55 patients with lumbar degenerative diseases treated at our hospital from January 2018 to January 2020 were included in the study. Of these, 35 patients who underwent MIS-TLIF were included in the MIS-TLIF group, which comprised 16 males and 19 females, aged 34–67 years, with an average age of 51.54±10.24 years, and 7 cases of lumbar spondylolisthesis, 8 cases of lumbar spinal stenosis, 18 cases of lumbar disc herniation (LDH), 1 case of degenerative scoliosis, and 1 case of postoperative revision of LDH. While 20 patients who underwent PLIF were included in the PLIF group, which comprised 8 males and 12 females, aged 36–70 years, with an average age of 52.23±11.19 years, and 3 cases of lumbar spondylolisthesis, 6 cases of lumbar spinal stenosis, and 11 cases of LDH. There was no significant difference in terms of age, sex, degeneration type, and lesion segment between the two groups (P>0.05; see *Table 1*). The visual analogue scale (VAS) score (7), Oswestry disability index (ODI) score (8), operation time, incision length, intraoperative bleeding, postoperative drainage, postoperative landing time, postoperative hospital stay, postoperative interbody fusion rate, and complication rate were compared between the two groups.

Inclusion and exclusion criteria

Inclusion criteria

Patients were included in the study if they met the following inclusion criteria: (I) had been clinically diagnosed with LDH, lumbar spinal stenosis, lumbar segmental instability, or Meyerding grade I or II degenerative lumbar spondylolisthesis; (II) continued to have symptoms, including low back pain and/or lower limb pain, numbness, muscle weakness, after 3–6 months of regular conservative treatment, and showed no remission or even experienced aggravation; (III) had complete postoperative follow-up data; (IV) had a Responsible section within 3 sections (including 3 sections); (V) had complete data for bone mineral density examinations and related imaging examinations, and complete follow-up data for 1.5 years; and (VI) they and their families agreed to their participating in the study and signed the informed consent form.

Exclusion criteria

Patients were excluded from the study if they met any of the following exclusion criteria: (I) had another malignant tumor disease/s; (II) had a mental illness; (III) could not be treated surgically for various reasons, and/or had scoliosis and a Cobb angle >10°; (IV) had bleeding, coagulation dysfunction, and abnormal liver and kidney function; (V) had severe osteoporosis (t value ≤3.5SD), or an osteoporotic fracture; and/or (VI) had a congenital spinal deformity.

The study met the ethical requirements of our hospital. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of Yan'an Hospital of Kunming City (No. 2021-001-01) and informed consent was taken from all the patients.

Surgical methods

The MIS-TLIF patients were placed under general anesthesia, in the prone position, with long sponge pillows placed in front of the chest, abdomen, and double ankles. The "C" arm X-ray machine fluoroscopically located the body surface position of the bilateral pedicle of the surgical segment, and marked the surgical incision. A 3.5–4.0 cm incision was cut 2 cm next to the spinous process on the decompression side and the incision entered into the space between the multifidus muscle and longissimus muscle. The facet joint of the responsible segment was touched with the guide needle and the space expanded layer by layer and the Quadrant channel was placed, the expandable channel equipment of 5, 6 and 7 cm was selected according to the physical condition of the patient, and then fixed the operating table. The decompression segment was confirmed by a secondary fluoroscopy using the "C" arm X-ray

Table 1 Comparison of basic data between the two groups

Group	MIS-TLIF	PLIF	χ^2	P value
Number	35	20		
Gender (male/female), n	19/16	8/12	0.002	0.969
Age (years), $\bar{x} \pm s$	51.54±10.24	52.23±11.19	–0.774	0.442
Degeneration type, n			1.184	0.673
Lumbar spondylolisthesis	7	3		
Spinal canal stenosis	8	6		
LDH	18	11		
Degenerative scoliosis	1	0		
LDH postoperative revision	1	0		

MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; PLIF, posterior lumbar interbody fusion; LDH, lumbar disc herniation.

machine. After the decompression of the intervertebral space, the superior and inferior facet joints and upper and lower lamina were exposed under the channel (9,10). The loupe tool was used to assist the surgical operation (the pedicle screws and interbody fusion cage were all products of the Shanghai Sanyou Company, and the Madunquant expandable channel minimally invasive surgery system was a product of the Medtronic Company) (11,12). An osteotome was used to remove the unilateral lower facet joint and the tip of the upper facet, the medial edge of the upper facet was bitten by the lamina biting forceps, and the upper and lower parts of the lamina were bitten to fully expose the intervertebral foramen. A cotton sheet protected the dura mater and the nerve root on the decompression side, and it may be insure fully depressurized the compressed nerve root and dura mater. The intervertebral space was treated routinely, and the bitten autologous bone particles were densely filled in the intervertebral space and intervertebral fusion cage, and then driven into the fusion cage to the appropriate position (see *Figure 1*). After screwing in two universal pedicle screws, fluoroscopic positioning was performed to ensure good internal fixation and the appropriate positioning of the fusion cage (13).

Postoperative rehabilitation

The postoperative treatment methods of the two groups were the same. Antibiotics was administered to prevent infection within 48 hours after the operation. When the postoperative drainage flow was <50 mL/24 h, the drainage tube was pulled out, and the positive and lateral X-ray films of the lumbar spine were rechecked. On the day on which the tube was pulled out and the lumbar support should be worn to gradually move down to the ground. Patients who had no discomfort, normal routine blood results, and no fever were discharged from the hospital (14). All patients moved under the protection of lumbar support within 3 months, and began to gradually increase the rehabilitation exercises for the low back muscle after 1 month (15).

Follow-up and evaluation indexes

Clinical efficacy evaluations, regular outpatient follow-up evaluations after the operation, and telephone records of the observation indexes were kept. X-ray films of the lumbar spine in the anterior and lateral position, hyperextension and flexion position were routinely re-examined at 3 months, 6 months, 1 year, and 1.5 years after surgery, and three-dimensional (3D) computed tomography (CT) and magnetic resonance imaging (MRI) scans of the lumbar spine were re-examined at 1 year and 1.5 years after surgery. Data on the operation time, incision length, intraoperative bleeding, postoperative drainage volume, postoperative time to the ground, postoperative hospital stay, complications, and nerve root irritation were collected. The VAS and ODI scores were collected before the operation, and 7 days, 3 months, 1 year and 1.5 years after the operation.

Imaging evaluations

Based on the follow-up X-ray films at 1 day, 3 months, 6 months, 1 year, and 1.5 years after the operation, internal

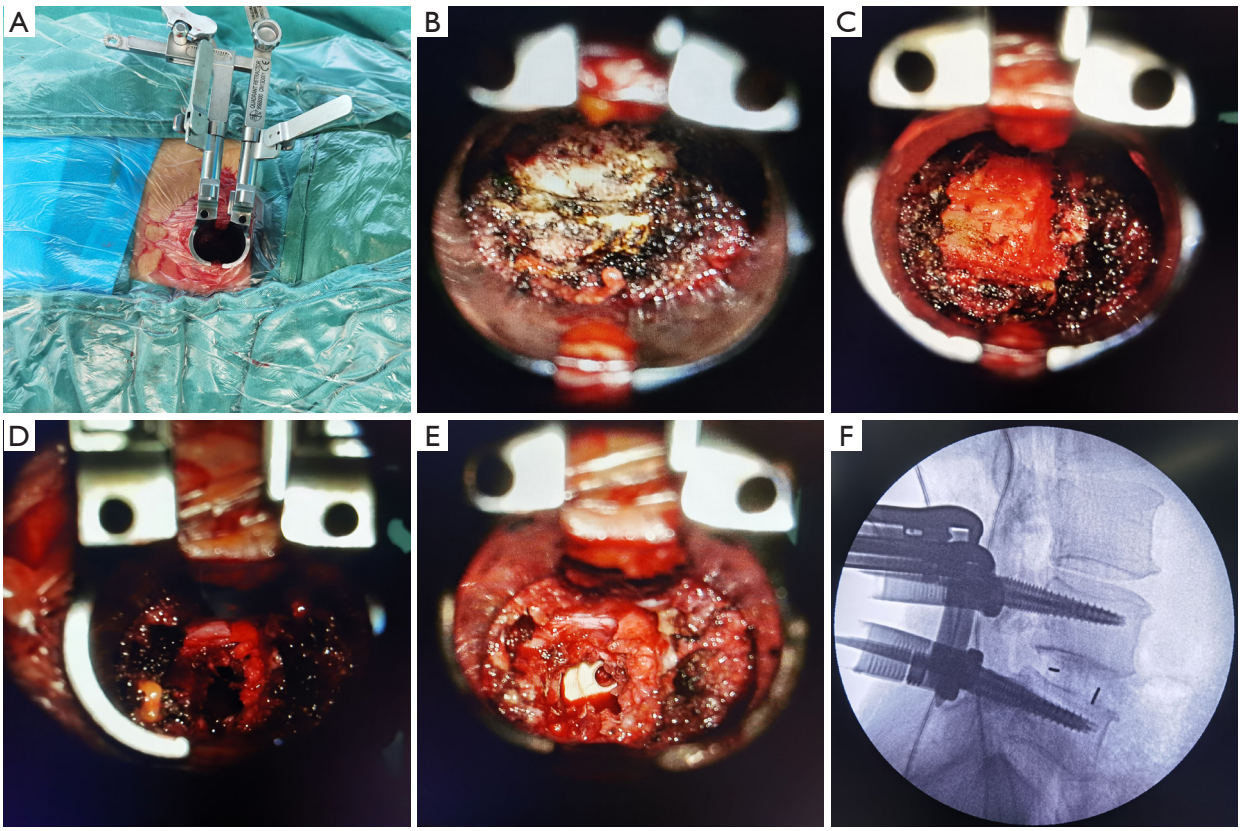

Figure 1 MIS-TLIF operation process. (A) Channel establishment. (B) Expose the articular process. (C) Resection of articular process. (D) Decompression. (E) Intervertebral bone graft and cage insertion. (F) Percutaneous fixation. MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion.

fixation complications, such as a broken screw, a broken rod, screw loosening and fusion cage displacement, were evaluated. At 1 year and 1.5 years after the operation, the fusion rate of the intervertebral bone graft was determined according to the lumbar 3D CT, lumbar MRI scans, and the Bridwell fusion evaluation grade system. Bridwell grades 1 and 2 indicated fusion, and grades 3 and 4 indicated non-fusion.

Statistical analysis

SPSS 20.0 statistical software was used to analyze the data. All the data were tested for normality by the Shapiro-Wilk test, and the measurement data with a normal distribution or with an approximately normal distribution are expressed as mean ± standard deviation ($\bar{x} \pm s$). If the variance was homogeneous, the independent sample *t*-test was used for the inter-group comparisons. If the variance was uneven, the *t*'-test was used for the inter-group comparisons. The VAS scores and ODI at multiple time points were compared by a one-way analysis of variance. The counting data were compared using the χ^2 test. AP value <0.05 was considered statistically significant.

Results

Comparison of clinical efficacy

The operations for patients in both groups were successfully completed, and the patients had complete follow-up data for 1.5 years. The follow-up time ranged from 24 to 36 months, with an average of 27.5±2.6 months. The postoperative drainage volume, postoperative landing time, and postoperative hospital stay in the MIS-TLIF group were significantly lower than those in the PLIF group (all P<0.05), but there was no significant difference in the operation time, incision length, and intraoperative bleeding between the two groups (all P>0.05). The VAS

Table 2 Analysis of the related indexes of the two groups of patients before and after the operation

Group	MIS-TLIF, $\bar{x}$ ± s	PLIF, $\bar{x}$ ± s	t	P value
Number	35	20		
Perioperative observation index				
Operation time (min)	203.3 ±33.6	218.9±42.1	−1.75	0.073
Incision length (cm)	7.9±0.4	7.9±1.1	−0.139	0.85
Intraoperative bleeding (mL)	155.0±90.1	152.8±95.9	0.048	0.934
Postoperative drainage (mL)	48.9±24.4	69.6±52.0	−2.466	0.031
Postoperative landing time (mL)	2.5±0.3	2.4±0.4	−2.776	0.006
Postoperative hospital stay (days)	3.2±0.6	3.9±0.9	−2.274	0.024
Comparison of VAS scores for low back pain before and after surgery				
Preoperative	5.03±1.23	5.60±1.82	−1.583	0.118
7 days after operation	2.21±0.80	2.15±0.95	0.301	0.764
3 months after operation	0.9±0.8	1.2±0.9	−1.806	0.075
12 months after operation	0.33±0.48	0.55±0.55	−1.795	0.077
18 months after operation	0.27±0.45	0.28±0.45	−0.21	0.983
F value	203.208	167.326		
P value	<0.001	<0.001		
Comparison of VAS scores for leg pain before and after surgery				
Preoperative	6.61±0.99	6.08±1.76	1.613	0.13
3 months after operation	1.61±0.89	1.55±1.11	0.244	726
12 months after operation	1.21±0.81	1.13±1.04	0.391	0.697
18 months after operation	0.67±0.74	0.68±0.66	−0.051	0.959
F value	0.39±0.6	0.58±1.2	−0.811	0.42
P value	320.031	147.912		
ODI comparison before and after surgery				
Preoperative	49.52±8.08	49.90±8.69	−0.196	0.845
3 months after operation	25.36±2.28	25.55±2.43	−0.336	0.738
12 months after operation	10.67±3.05	10.85±2.78	−0.269	0.789
18 months after operation	9.09±3.76	9.33±3.22	−0.286	0.775
F value	493.314	568.24		
P value	<0.001	<0.001		

MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; PLIF, posterior lumbar interbody fusion; VAS, visual analogue scale; ODI, Oswestry disability index.

and ODI scores for low back pain and leg pain in the MIS-TLIF group and the PLIF group were significantly lower than those before operation (P<0.05), but there was no significant difference between the two groups (P>0.05; see *Table 2* for details).

There were no complications, such as dural rupture, nerve root injury, fusion cage displacement or subsidence, in either group. One patient in the MIS-TLIF group

Table 3 Comparison of postoperative follow-up curative effects and complications between the two groups

Group	MIS-TLIF, n (%)	PLIF, n (%)	χ^2	P value
Number	35	20		
Interbody fusion (year)				
1 year	34 (97.14)	19 (95.00)	0.178	0.673
1.5 years	35 (100.00)	20 (100.00)	–	1
Postoperative complications (year)				
Nailing failure	1 (2.86)	0 (0.00)	1.299	0.268
Incision infection	1 (2.86)	1 (5.00)	0.019	0.92

MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; PLIF, posterior lumbar interbody fusion.

failed to screw placement and the muscle strength of the patient's lower limbs decreased after the operation, but the patient recovered well after screw placement. After the operation, 1 patient in each group had nerve root stimulation symptoms, which were relieved within 3 days of treatment with non-steroidal drugs for anti-inflammatory, detumescence, and nutritional nerve symptomatic treatment. After the operation, 1 patient in each group had a superficial infection and local suture dehiscence, which healed after the use of antibiotics and regular wound dressing changes. One year after the operation, the fusion rate was 97.14% (34/35) in the MIS-TLIF group and 95.00% (19/20) in the PLIF group. The fusion rate was 100% in both groups 1.5 years after the operation. During the 2-year follow-up period, no complications, such as internal fixation fractures, prolapses, or displacements, were observed (see *Table 3* for details).

Typical cases

Figures 2-8 show some typical cases.

Case 1, a 54-year-old male, was diagnosed with lumbar spinal stenosis (see *Figure 2*).

Case 2, a 48-year-old female, was diagnosed with LDH (see *Figure 3*).

Case 3, a 62-year-old male, was diagnosed with lumbar I° spondylolisthesis and spinal canal stenosis (see *Figure 4*).

Case 4, a 69-year-old male, was diagnosed with multi-segmental lumbar spinal stenosis (see *Figure 5*).

Case 5, an 81-year-old male, was diagnosed with degenerative lumbar spondylolisthesis (see *Figure 6*).

Case 6, a 67-year-old male, was diagnosed with thoracic 11–12 vertebral infection (see *Figure 7*).

Case 7, a 49-year-old male, was diagnosed with lumbar intervertebral disc, which recurred 6 months after the operation, and had an unstable L4 vertebral body (see *Figure 8*).

Discussion

TLIF via the intervertebral foramen approach has quickly become popular because the nerve root does not need to be pulled during the operation (16,17). However, the muscle injury of open posterior TLIF still affects the long-term effect of this fusion technique. In 2021, Sun *et al.* and Wang *et al.* used percutaneous and channel technology to complete MIS-TLIF technology, which solved the problem of the minimally invasive posterior spinal approach by applying the paravertebral approach, reduced the traction and stripping of the paravertebral muscle that occurs in conventional posterior lumbar surgery, and achieved a good clinical effect (18,19). Compared to PLIF, TLIF has a number of obvious advantages, including that it results in complete intraoperative decompression and hemostasis, faster postoperative functional recovery, less postoperative lumbar pain, and fewer postoperative complications (20-22). PLIF requires the removal of supraspinous, interspinous ligaments, spinous processes, and bilateral laminae, the preservation of facet joints, the removal of ligamentum flavum, the removal of epidural fat, the expansion of nerve root canal, nerve extraction, ion protection and separation, the pulling of the dura mater to 1 side with a nerve retractor, the cutting of the fibrous ring with a sharp knife, the removal of the nucleus pulposus, and the cleaning of the upper and lower endplates with a curette. The fusion cage is placed in the vertebral space. As PLIF has long been used in the clinical treatment of degenerative lumbar diseases, it has been largely mastered by clinical orthopedic doctors,

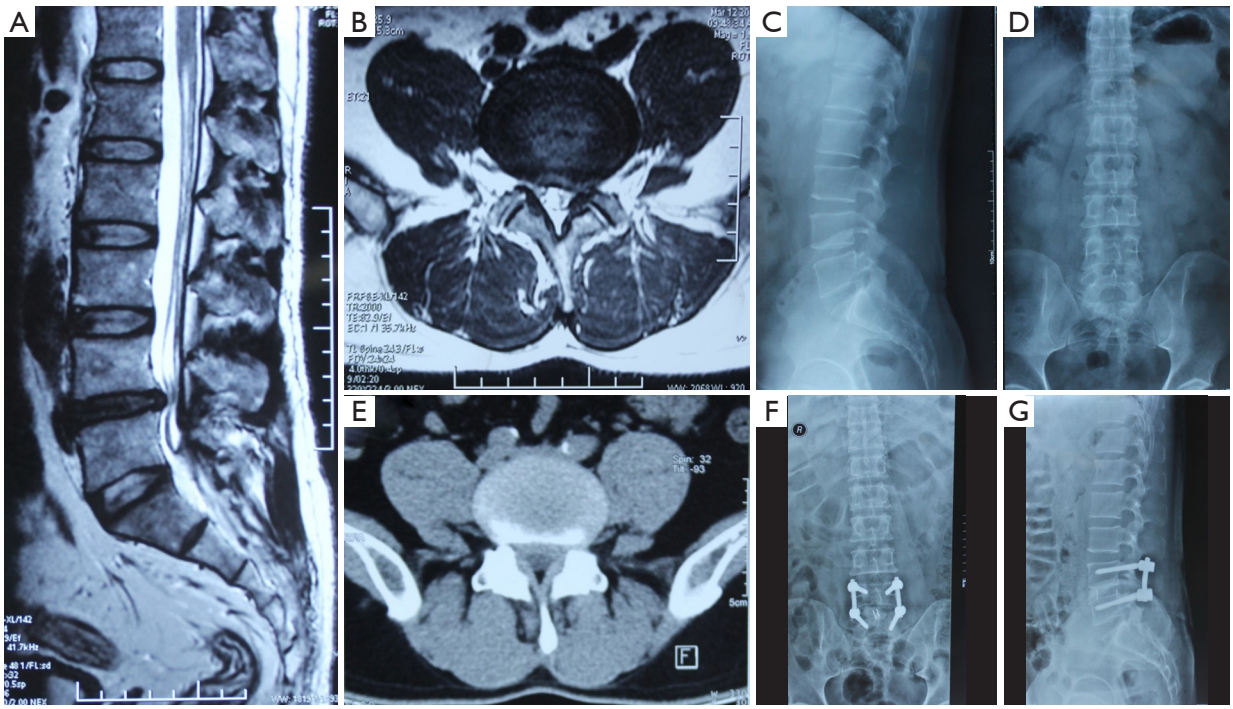

Figure 2 Lumbar spinal stenosis. (A,B) Preoperative MRI. (C,D) Preoperative anteroposterior and lateral position. (E) Preoperative CT. (F,G) After operation. The special symbol "R" in (F) means the right side of the body. MRI, magnetic resonance imaging; CT, computed tomography.

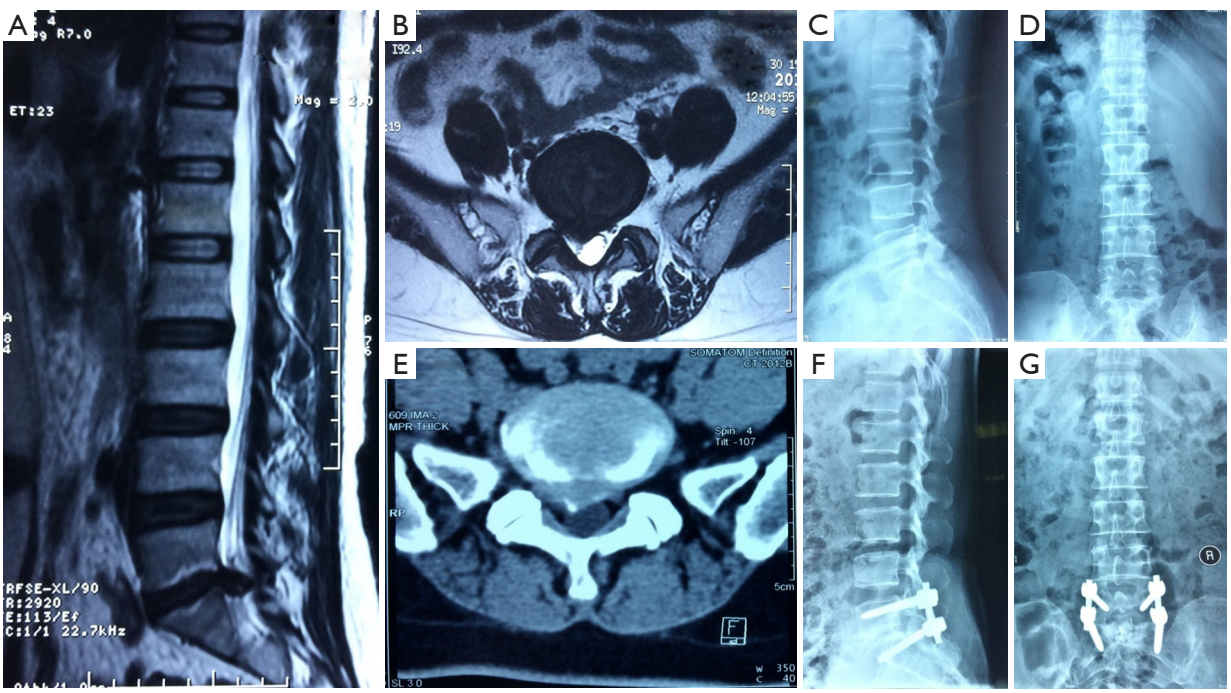

Figure 3 LDH with calcification and endplate inflammation. (A,B) Preoperative lumbar MRI. (C,D) Preoperative lumbar anteroposterior and lateral radiographs. (E) Preoperative lumbar CT. (F,G) Postoperative lumbar anteroposterior and lateral radiographs. The special symbol "R" means the right side of the body. LDH, lumbar disc herniation; MRI, magnetic resonance imaging; CT, computed tomography.

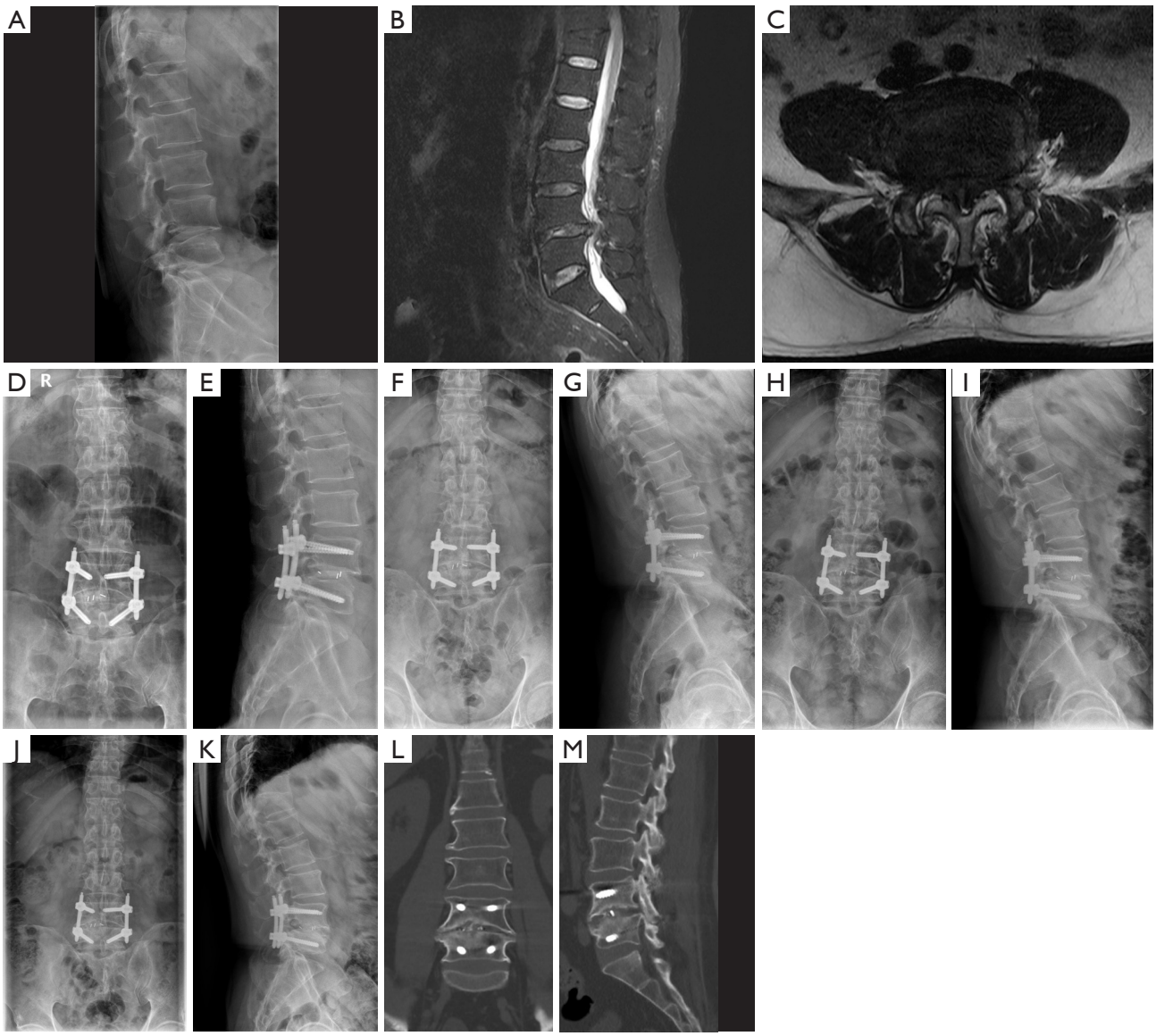

Figure 4 Lumbar I spondylolisthesis and spinal canal stenosis. (A) Preoperative lumbar CT. (B,C) Preoperative lumbar MRI. (D,E) Lumbar anteroposterior and lateral radiographs 3 months after operation. (F,G) Lumbar anteroposterior and lateral radiographs 6 months after operation. (H,I) Lumbar anteroposterior and lateral radiographs 1 year after operation. (J,K) Lumbar anteroposterior and lateral radiographs 1.8 months after operation. (L,M) Lumbar CT 18 months after operation. The special symbol "R" in (D) means the right side of the body. CT, computed tomography; MRI, magnetic resonance imaging.

but the disadvantage of PLIF is that the nerve root and dural sac need to be pulled through the midline during the operation, which increases the risk of nerve root and dural sac injury, especially above the lumbar 3 segment (23-25). Additionally, the lack of mobility of the dural sac and the limited traction space easily lead to nerve injury (23-25).

In addition to providing the same sufficient decompression and a fixation as strong as that of the traditional PLIF operation, TLIF has a number advantages, including less trauma, less blood loss, fewer complications and earlier underground activities, fewer secondary injuries, such as postoperative lower limb venous thrombosis, postoperative infection, and hematoma, and an acceleration of the speed of rehabilitation treatment (26,27). TLIF is characterized

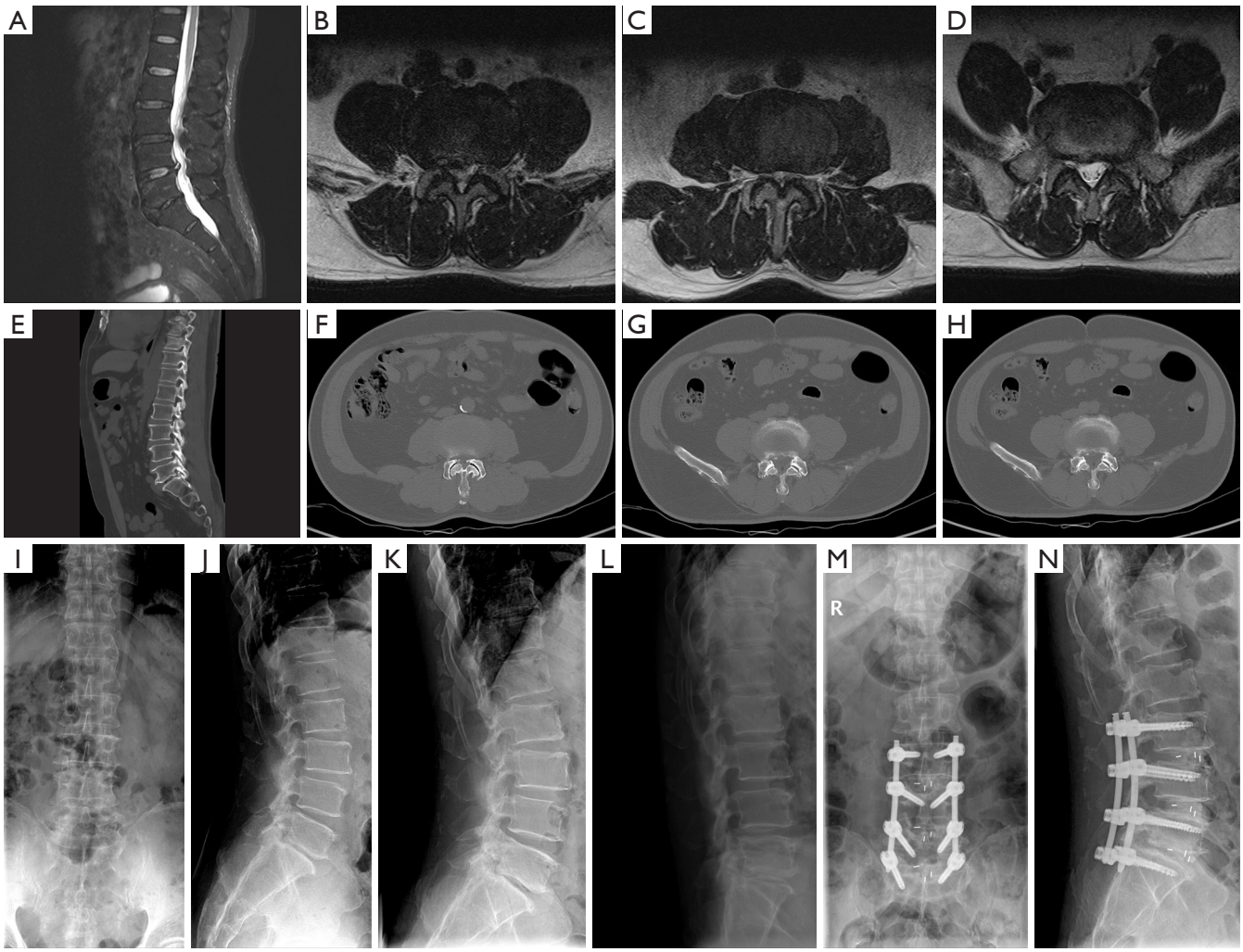

Figure 5 Multi-segmental lumbar spinal stenosis. (A-E) Preoperative lumbar MRI. (F) Preoperative CT, L3/4. (G) Preoperative CT, L4/5. (H) Preoperative CT, L5/S1. (I,J) Preoperative anteroposterior and lateral position. (K,L) Preoperative hyperextension and hyperflexion. (M,N) Postoperative anteroposterior and lateral position. The special symbol "R" in (M) means the right side of the body. MRI, magnetic resonance imaging; CT, computed tomography.

by complete unilateral facet joint resection through the posterior approach. In TILF surgery enters the intervertebral space using the transforaminal approach, retains the supraspinous, interspinous ligaments, and anterior and posterior longitudinal ligaments, and retains the role of the tension band of the spinal ligaments. During the operation, only 1 facet joint is removed, and the lamina and the other facet joint are retained, which causes less damage to the integrity of the spinal bone, making the effect on spinal stability much less than that of PLIF. During the operation, the traction of the nerve root and dural sac are avoided, the risk of injury is reduced, and the risk of dural sac tear and nerve root traction injury are reduced. PLIF is suitable for the treatment of degenerative lumbar diseases, discogenic low back pain, recurrent intervertebral disc herniation, degenerative spinal canal stenosis, grades I and II spondylolisthesis, isthmic lumbar spondylolisthesis, degenerative scoliosis, intervertebral pseudo-joint formation, and unilateral intervertebral disc protrusion, but it is not suitable for the treatment of severe osteoporosis in patients with severe peridural fibrosis and a history of posterior extensive laminectomy decompression (28-30).

Lumbar interbody fusion includes common PLIF, transforaminal lumbar interbody fusion (TLIF), oblique

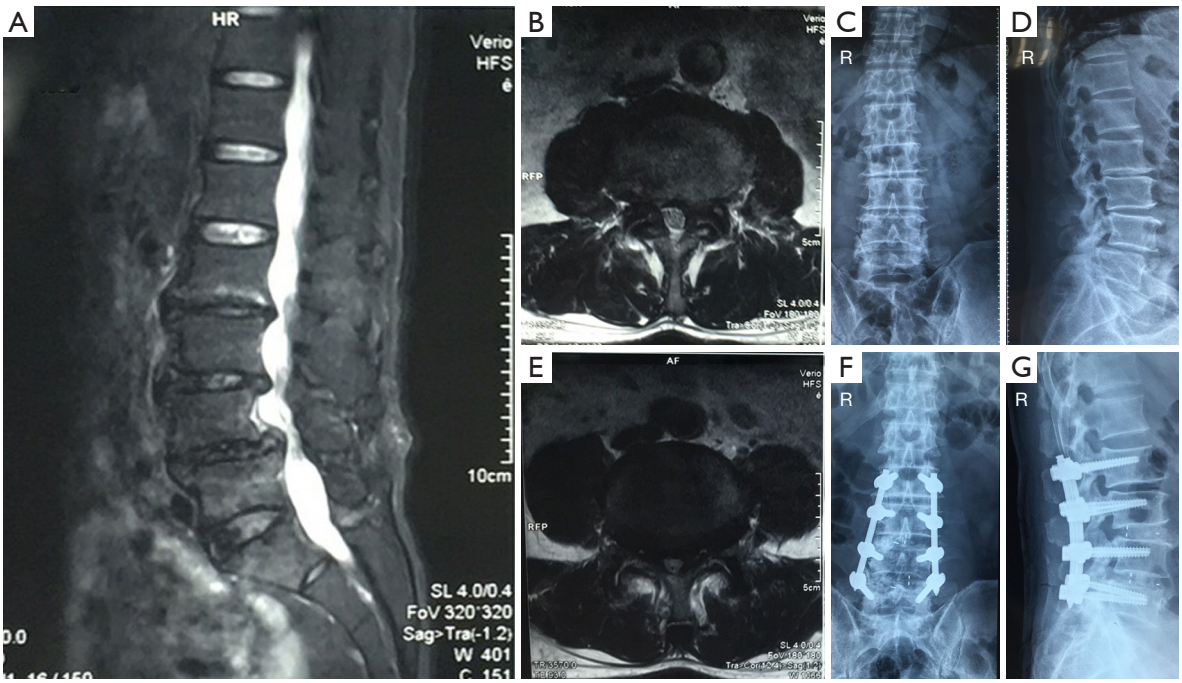

Figure 6 Lumbar spondylolisthesis with multi-level disc herniation and spinal canal stenosis. (A,B,E) Preoperative lumbar MRI. (C,D) Preoperative anteroposterior and lateral position. (F,G) Postoperative anteroposterior and lateral position. The special symbol "R" means the right side of the body. MRI, magnetic resonance imaging.

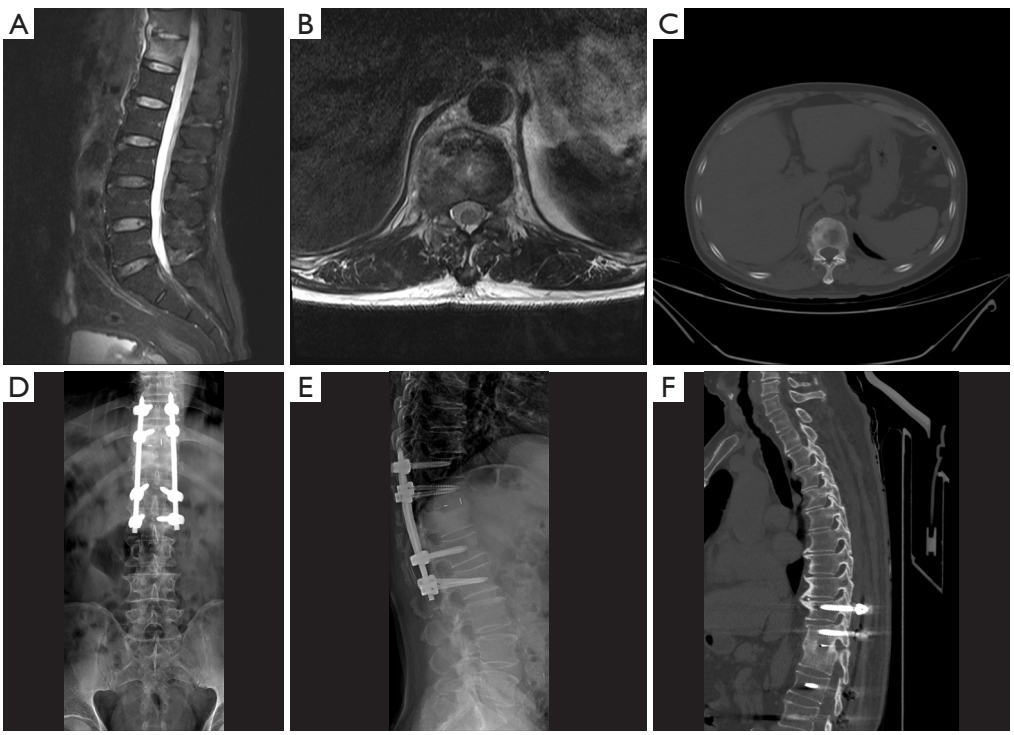

Figure 7 Thoracic 11–12 vertebral infection. (A,B) Preoperative lumbar MRI. (C) Preoperative thoracic CT. (D,E) Postoperative lumbar anteroposterior and lateral radiographs. (F) Postoperative lumbar MRI. MRI, magnetic resonance imaging; CT, computed tomography.

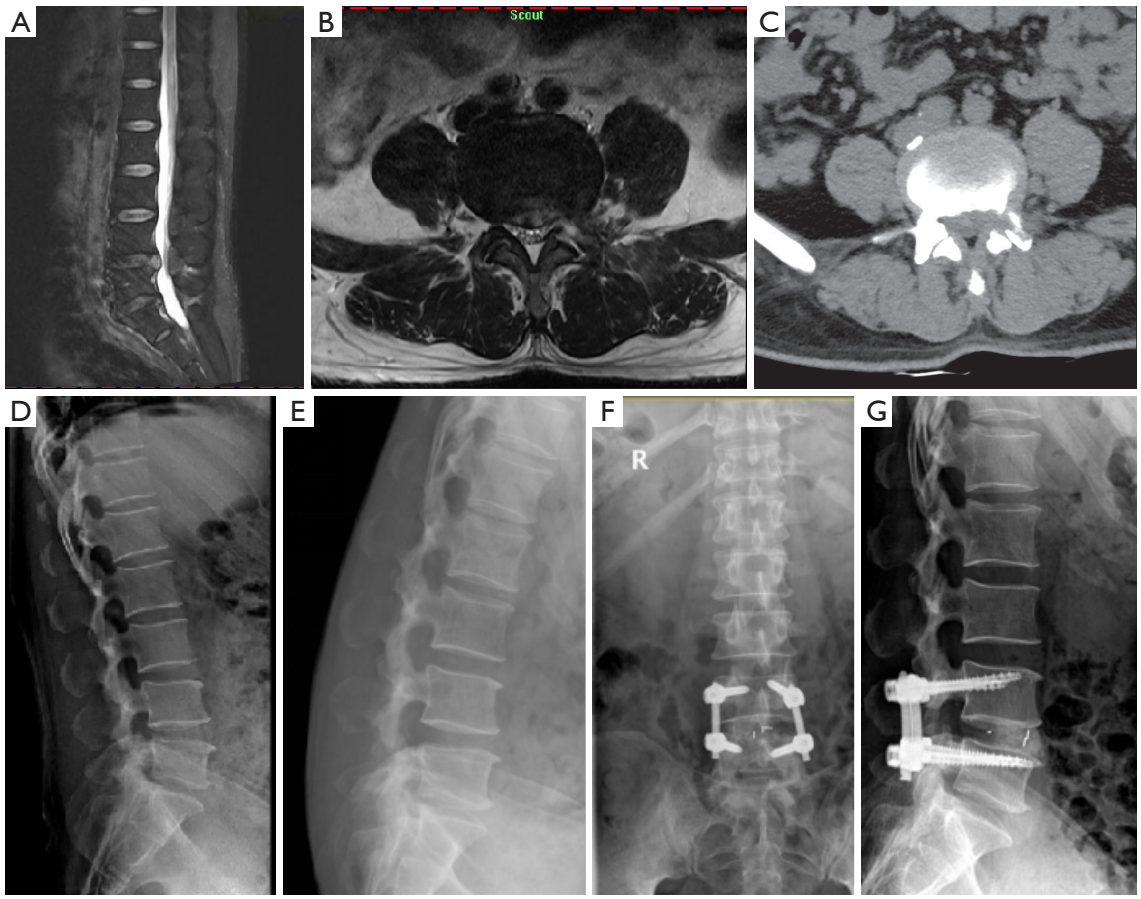

Figure 8 Treatment of LDH recurrence with MIS-TLIF. (A,B) Preoperative lumbar MRI. (C) Preoperative lumbar CT. (D,E) Preoperative lumbar anteroposterior and lateral radiographs. (F,G) Postoperative lumbar anteroposterior and lateral radiographs. The special symbol "R" in (F) means the right side of the body. LDH, lumbar disc herniation; MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; MRI, magnetic resonance imaging; CT, computed tomography.

lateral interbody fusion (OLIF) and anterior lumbar interbody fusion (ALIF), while MIS-TLIF is accepted by most clinicians because of its small trauma and low risk of disability. MIS-TLIF addresses the shortcomings of TLIF, and uses a minimally invasive small incision and expandable channel, which results in minimal surgical trauma, reduced bleeding, and a rapid postoperative recovery. For single segment lumbar spinal stenosis, its level of incision length is ≤4 cm, and it has intraoperative bleeding of about 100–300 mL, postoperative bleeding of 20–250 mL, and an operation time of about 70–120 min. MIS-TLIF interbody fusion through intervertebral foramen has the advantages of less nerve interference, convenient interbody fusion, minimal epidural scar formation, and easy revision surgery (31,32). Compared with open surgery, MIS-TLIF has less trauma, faster recovery and obvious clinical effect.

In this study, MIS-TLIF displayed obvious advantages over PILF, but MIS-TLIF has some inevitable limitations. There are still great technical difficulties and surgical risks in the surgical treatment of multi-level MIS-TLIF, severe spinal stenosis, and lumbar spondylolisthesis above grade II. In addition to the common cardiovascular and cerebrovascular diseases and anesthesia risks, MIS-TLIF has almost no absolute contraindications. Routine nursing can be followed after operation.

The positioning and internal fixation in MIS-TLIF minimally invasive surgery largely depend on the assistance of X-ray fluoroscopy. The number of fluoroscopies required in MIS-TLIF was significantly more than that of traditional open surgery, which is worthy of further discussion. MIS-TLIF technology has a big learning curve. The operator must have certain open operation experience

and be familiar with local anatomy. The operator needs to be strictly trained to master the skills of operating in a narrow space. MIS-TLIF is a minimally invasive technique that uses modern lumbar fusion technology, but we need to clearly understand the limitations and potential risks of this technology. A potential disadvantage of MIS-TLIF is the lack of visualization, which can lead to potential nerve injury risk. Only standardized treatment options can achieve excellent treatment effect, and realize the value of minimally invasive surgery (33,34). The results of this study show that the postoperative drainage volume, postoperative underground time, and postoperative hospital stay of the MIS-TLIF group were significantly less than those of the PLIF group ($P<0.05$), which indicates that MIS-TLIF was better able to stop bleeding during the operation and achieved more accurate hemostasis for some small blood vessels than PLIF. According to our preliminary analysis, the short-term and long-term surgical effects of MIS-TLIF are better than other types of surgery. Through statistical comparison, it has obvious advantages.

In conclusion, the treatment of lumbar degenerative diseases by MIS-TLIF not only shortens the hospitalization time of patients, but also has a number of advantages, including more thorough intraoperative hemostasis, less postoperative drainage, the ability to go to the ground earlier, and a shorter hospital stay. The sample size of this study was small. Studies with greater sample sizes will be conducted in the future. MIS-TLIF is in line with the concept and principle of surgical treatment and accelerating rehabilitation, and is worthy of clinical promotion.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of Yan'an Hospital of Kunming City (No. 2021-001-01) and informed consent was taken from all the patients.

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