



# Trans–Pars Interarticularis Approach for Lumbar Interbody Fusion: An Efficient, Straightforward, and Minimally Invasive Surgery for Lumbar Spondylolisthesis and Stenosis

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## Abstract

**Background** Lumbar interbody fusion is a commonly applied surgical treatment for spondylolisthesis. For this procedure, various minimally invasive (MIS) approaches have been developed, including posterior lumbar interbody fusion, transforaminal lumbar interbody fusion (TLIF), oblique lumbar interbody fusion, and anterior lumbar interbody fusion. In this study, we characterized the features of an MIS trans–pars interarticularis lumbar interbody fusion (TPLIF) and compared its surgical outcomes with those of MIS-TLIF.

## Keywords

- ▶ posterior lumbar interbody fusion
- ▶ trans–pars interarticularis lumbar interbody fusion
- ▶ transforaminal lumbar interbody fusion
- ▶ spondylolisthesis
- ▶ minimally invasive spine surgery

**Methods** This study included 89 and 44 patients who had undergone MIS-TPLIF and MIS-TLIF, respectively, between September 2016 and December 2022. The following clinical outcomes were analyzed: operative time, blood loss, and hospitalization duration.

**Results** The average operative time, blood loss, and hospitalization duration for the MIS-TPLIF and MIS-TLIF groups were, respectively, 98.28 and 191.15 minutes, 41.97 and 101.85 mL, and 5.8 and 6.9 days.

**Conclusion** The MIS-TPLIF approach for lumbar spondylolisthesis or other degenerative diseases involves the use of the commonly available and cost-effective instrument Taylor retractor, thus enabling posterior lumbar interbody fusion to be performed with minimal invasion. This approach also confers the benefits of a short learning curve and an intuitive approach. Our results suggest that although MIS-TPLIF is noninferior to MIS-TLIF, it is easier to learn and perform than MIS-TLIF.

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## Introduction

Posterolateral fusion (PLF) of the lumbar spine was first proposed by Albee and Hibbs in 1911. After Roy-Camille introduced transpedicular screw fixation for lumbar PLF in the 1970s,<sup>1</sup> this technique has been used to treat unstable thoracolumbar junction fractures. Moreover, it is commonly recommended for spinal fractures, spinal deformities, spinal tumors, and degenerative diseases. When transpedicular screw fixation is combined with posterior lumbar interbody fusion (PLIF), it can provide a 360-degree circumferential stability to the spine.<sup>2,3</sup> However, the excessive retraction of the nerve roots may still present risks; specifically, it may lead to neurologic deficits during the preparation of the tract for cage insertion and during the posterolateral insertion of the interbody cage or bone graft. Subsequently, Harms and Jeszenszky developed the open transforaminal lumbar interbody fusion (TLIF) method, which is an alternative method for performing lumbar interbody fusion.<sup>2,3</sup> TLIF requires less retraction of the thecal sac, allows for the intervertebral space to be exposed more laterally, and enables intervertebral preparation to be completed unilaterally.<sup>2</sup> Although open TLIF is a safe and effective method for treating degenerative lumbosacral diseases,<sup>4</sup> this method still requires the stripping of the paravertebral muscles, which may lead to negative postoperative outcomes,<sup>5,6</sup> such as postoperative pain and paraspinal muscle atrophy.<sup>7,8</sup> To address the possible adverse effects associated with open TLIF, Holly (2006)<sup>9</sup> proposed the Wiltse posterolateral spinal approach for conducting minimally invasive (MIS) TLIF. Although this approach essentially preserves the posterior tension band and reduces injury to the paraspinal musculature,<sup>10</sup> it is associated with long learning curves<sup>11</sup> and requires the use of a cylindrical expandable retractor.<sup>12</sup> Herein, we propose an alternative method called trans-pars interarticularis lumbar interbody fusion (TPLIF). This method requires the minimal use of instruments (e.g., Taylor spinal retractor and rubber bands) and can be performed with the aid of a microscope. Our lumbar decompression method employs a midline unilateral approach, which involves ipsilateral hemilaminectomy, facetectomy, and contralateral sublaminar decompression, thereby effectively achieving bilateral adequate decompression and creating space for cage insertion. Subsequently, the spine is fixated using percutaneous transpedicular screws to complete the fusion and fixation process. Because the surgical pathway used in this method is almost identical to that of microdiscectomy, which most spine surgeons are familiar with, we believe that this procedure is a straightforward, effective, and safe procedure for treating lumbar spine degenerative disease.

Our method is particularly suitable for treating multiple-segment lesions because it allows for straightforward and continuous decompression. It is also compatible with hybrid surgery that uses the midline approach (e.g., methods that incorporate the use of an interspinous process device).

## Materials and Methods

This study included 89 patients with symptomatic lumbar disease who had undergone MIS-TPLIF performed using a

single polyether ether ketone (PEEK) cage (Capstone, Medtronic, USA) and through additional percutaneous pedicle screw internal fixation (Sextant, Medtronic, USA) between September 2016 and December 2022; these patients formed the MIS-TPLIF group. In addition, 44 patients who had undergone MIS-TLIF performed using the same single PEEK cage (Capstone, Medtronic) during the same period were included as the MIS-TLIF group.

Patients were eligible for inclusion if they had single-level spondylolisthesis: spondylolysis at the L4–L5 or L5–S1 level. Patients with specific conditions (e.g., trauma, osteoporosis, and multilevel spondylolisthesis) or a history of revision spine surgery were excluded.

The MIS-TPLIF group comprised 33 men and 56 women aged 19 to 80 (mean, 59.86) years, whereas the MIS-TLIF group comprised 20 men and 24 women aged 34 to 79 years (mean, 58.68) years. The two groups were similar in terms of age, body mass index, surgical indications, and comorbidities (► **Table 1**).

We had two different groups of attending surgeons performing the surgeries, and the groups were randomized. The patient decides on the attending physician who will perform the surgery. MIS-TPLIF is performed by Dr. Chang, and MIS-TLIF is performed by Dr. Hsieh.

Independent observers collected relevant data by using standardized data collection forms.

## Surgical Technique

The patients in both groups had undergone unilateral single cage insertion. Surgery was performed after administering general anesthesia and placing the patient in the prone position.

### Minimally Invasive Trans-Pars Interarticularis Lumbar Interbody Fusion

At the start of MIS-TPLIF, a midline incision (~3 cm) was performed in a manner similar to that of a standard lumbar microdiscectomy. On the basis of symptom severity or imaging studies, surgery is typically conducted on the side that exhibited relatively pronounced signs of the affliction. The paraspinal muscle was carefully peeled off along the periosteum to expose the laminae and facet joints of the upper and lower segments. To ensure a clear operating field, a simple Taylor spinal retractor and rubber bands were used (► **Fig. 1**). Thereafter, the patient was repositioned to the opposite side. Next, the spinous process was aligned at a right angle to the surgical field of view (► **Fig. 2A**). This step is performed to facilitate ipsilateral hemilaminectomy, remove the contralateral yellow ligament and perform sublaminar decompression to ultimately achieve bilateral decompression. After hemilaminectomy and facetectomy (performed through trans-pars interarticularis), the hypertrophic flavum ligament was removed to expose the dura sac and exit nerve root for adequate decompression (► **Fig. 2B**). During this step, a crucial and intricate aspect involved the removal of the medial portion of the superior articular process of the

**Table 1** Preoperative data

Category	MIS-TPLIF	MIS-TLIF	p value
Total patients	89	44	
<b>Gender</b>			
Male	33	20	0.17851
Female	56	24	
Mean age (range), y	59.86 (19–80)	58.68 (34–79)	0.55674
BMI	26.65 ± 3.962	27.62 ± 5.014	0.22502
ASA	2.213 ± 0.557	2.071 ± 0.608	0.05666
DM	25	16	0.16733
Usage of antiplatelet or anticoagulation	13	3	0.09836
Smoking	14	8	0.36140
<b>Diagnosis</b>			
Spondylolisthesis	86	38	
Spondylolysis	3	6	

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; DM, diabetes mellitus; MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; MIS-TPLIF, minimally invasive trans-pars interarticularis lumbar interbody fusion.

lower vertebra (► **Fig. 2C**) and maximal removal of the pars interarticularis. This step maximized the available space for cage placement without the risk of excessive nerve root retraction.

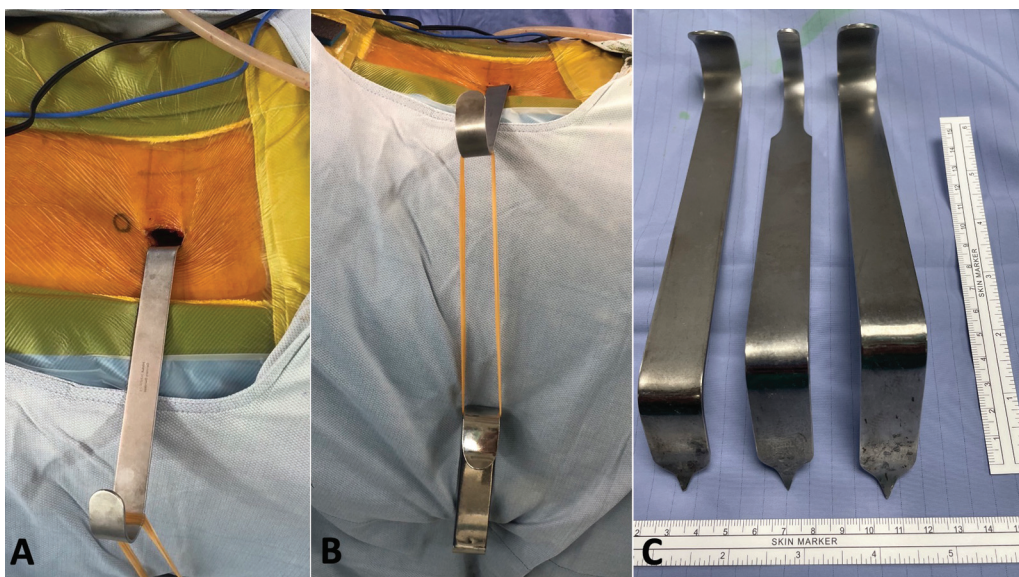
Subsequently, the intervertebral disk was removed, and the endplates of the central portion of the disk spaces were carefully decorticated for successful interbody fusion. The axial views of conventional PLIF and TPLIF are presented in ► **Fig. 2D, E**, clearly highlighting the differences between the two approaches.

An appropriately sized cage filled with morselized bone graft material was placed obliquely into the intervertebral space.

Typically, the cage is placed on the midline of the vertebral body, as close as possible to the anterior edge. This technique was named TPLIF because it differs from the conventional PLIF technique in terms of the number of cage placements and the direction of cage placement. After achieving hemostasis, the wound was sutured without the use of a drainage tube.

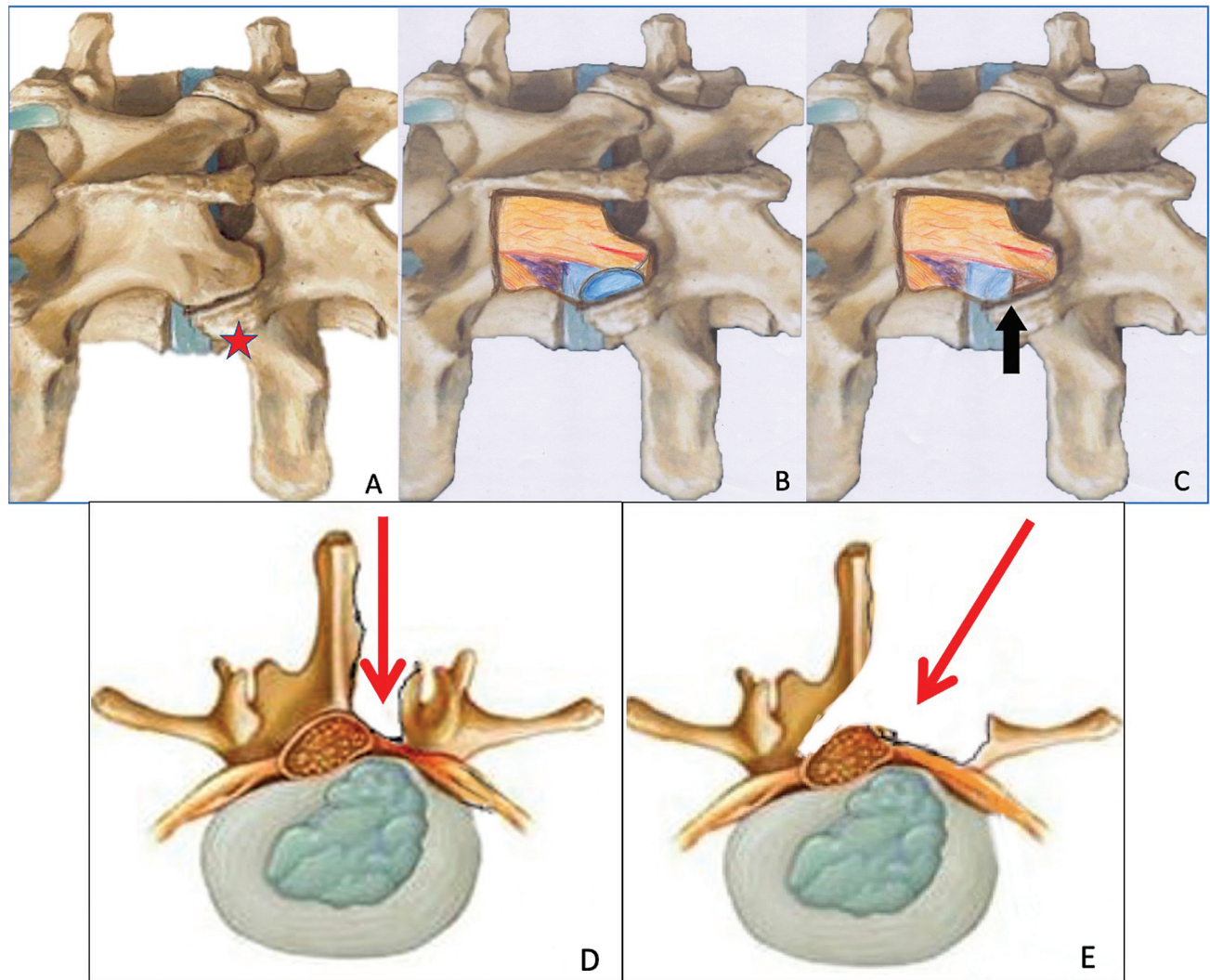
### Minimally Invasive Transforaminal Lumbar Interbody Fusion

For MIS-TLIF, unilateral surgery was performed using the Wiltse technique under a fluoroscope through a paramedian



**Fig. 1** (A) Midline incision (~3 cm) and Taylor retractor. (B) Connection formed using rubber bands. (C) Bladder of the Taylor retractor measured approximately 2 cm in width.





**Fig. 2** Axial views of the surgical procedures. (A) The retractor bladder is hooked to the lateral side of the facet joint (*red star*). (B) Results after laminectomy and medial facetectomy. (C) Maximal removal of the pars interarticular and the medial portion of the superior articular process of the lower vertebra (*black arrow*). (D) Axial view of conventional posterior lumbar interbody fusion (PLIF) and (E) trans-pars interarticularis lumbar interbody fusion (TPLIF). The differences between the two approaches can be clearly observed.

skin incision (3–4 cm lateral to the midline). Once the skin and fascia were incised, a plane developed between the multifidus and longissimus muscles, which enabled us to enlarge the path to the spine by using sequential dilators. The facet and pars were removed using a high-speed drill; thereafter, the nerve roots were identified and fully visualized before laminectomy was performed using a high-speed drill. The local bone graft that had been collected during laminectomy and facetectomy was stored in a bone trap. The interbody space was identified through fluoroscopy, and the endplates were prepared using sequential endplate cutters. An appropriately sized Medtronic PEEK cage (8–12 mm, Capstone) filled with autologous bone graft was placed into the intervertebral space, and local bone was placed anterior to the cage in the intervertebral space. Then, the cage was gently and obliquely inserted into the intervertebral space.

On postoperative day 1, the patients in the MIS-TPLIF and MIS-TLIF groups could get out of bed and walk with the help of a functional waist brace, which they continued to use for at least 1 month.

## Results

### Preoperative Data

The MIS-TPLIF and MIS-TLIF groups comprised 89 and 44 patients, respectively. The MIS-TPLIF group comprised 33 men and 56 women aged 19 to 80 (mean, 59.86) years at the time of surgery, whereas the MIS-TLIF group comprised 20 men and 24 women aged 34 to 79 years (mean, 58.68) years at the time of surgery. The American Society of Anesthesiologists classification scores of the MIS-TPLIF and MIS-TLIF groups were  $2.213 \pm 0.557$  and  $2.071 \pm 0.608$ , respectively. The two groups did not exhibit any significant difference in

**Table 2** Perioperative parameter

Category	MIS-TPLIF	MIS-TLIF	p value
Operative times (min)	100.29 ± 24.77	187.18 ± 44.57	<0.00001
Blood loss (mL)	44.05 ± 54.08	100.13 ± 78.62	<0.00001
Hospital days	5.59 ± 1.50	6.84 ± 3.04	0.00063
Pre-op VAS	7.62 ± 1.10	7.39 ± 1.22	
Post-op 6 mo VAS	2.57 ± 1.20	2.44 ± 1.09	
Follow-up period	25.51 ± 9.10	35.30 ± 26.08	

Abbreviations: MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; MIS-TPLIF, minimally invasive trans-pars interarticularis lumbar interbody fusion; VAS, visual analog scale.

age, sex, body mass index, diabetes mellitus (DM), or smoking habit (►Table 1).

### Perioperative Outcomes

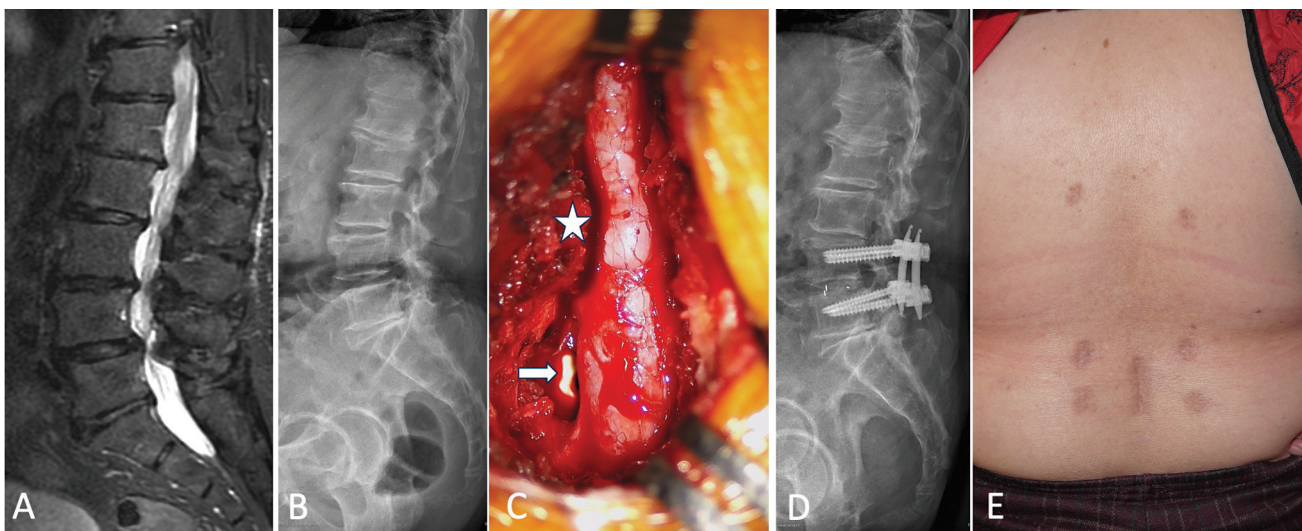
All the patients included in the present study had undergone single-level fusion. For the MIS-TPLIF and MIS-TLIF groups, the average operative time, blood loss, and hospitalization duration were, respectively, 100.29 and 187.18 minutes, 44.05 and 100.13 mL (no patient required blood transfusion), and 5.59 and 6.84 days (►Table 2). MIS-TPLIF led to more favorable perioperative outcomes than did MIS-TLIF; no significant difference was noted between the two techniques in patients' visual analog scale scores before surgery or 6 months after surgery. The average follow-up period was 25.51 months for the MIS-TPLIF group and 35.30 months for the MIS-TLIF group. No major complications (e.g., revision surgery or persistent neurologic deficits) were reported in either group during the follow-up period. In summary, MIS-TPLIF is noninferior to MIS-TLIF.

### Case Sharing

Herein, we present the case of a 74-year-old woman with low back pain and left-sided radiculopathy. An examination of the patient revealed spondylolisthesis and stenosis L4–L5. We performed fusion surgery with TPLIF, after which the patient's low back pain and leg pain improved considerably. Relevant photographs of the operation and postoperative wound are presented in ►Video 1. The next patient presented with L3–L4–L5 lumbar stenosis and L4–L5 spondylolisthesis. Adequate decompression was achieved through TPLIF for L4–L5 and through laminectomy for L3–L4–L5 (►Fig. 3).

#### Video 1

TPLIF for L4-5 spondylolisthesis and stenosis  
Online content including video sequences viewable at:  
<https://www.thieme-connect.com/products/ejournals/html/10.1055/a-2350-7936>.



**Fig. 3** (A) Sagittal T2-weighted magnetic resonance imaging (MRI) of the lumbar spine reveals severe L3–L4–L5 stenosis with L4–L5 spondylolisthesis. (B) Lumbar spine X-ray (lateral view) indicates L4–L5 spondylolisthesis. (C) The operative image obtained using a microscope indicates adequate decompression at L3–L4–L5 with L4–L5 cage insertion (white arrow) through trans-pars interarticularis lumbar interbody fusion (TPLIF) and preservation of the L3–L4 facet joint (white star). (D) Postoperative lumbar spine X-ray. (E) Image of a patient's surgical wound.

(This case is to share the benefits of TPLIF. The patient was not included in our study data; we only included pure L4–L5 decompression with interbody fusion in this study.)

## Discussion

Lumbar interbody fusion is an effective treatment for relieving pain resulting from nerve compression and an unstable spine. This method involves the neural decompression of the symptomatic side, restoration of disk height, maintenance of vertebral alignment, implementation of weight-bearing measures, and reconstruction of segmental stability. PLIF has been reported to achieve a higher rate of intervertebral segment fusion and more favorable clinical outcomes than does posterolateral bone grafting.<sup>13</sup> To date, there were lots of different trajectories for cage insertion such as PLIF, TLIF, oblique lumbar interbody fusion (OLIF), and anterior lumbar interbody fusion (ALIF). What is more, the concept of MIS surgery has also been brought into lumbar interbody surgery.

The conventional PLIF technique involves the insertion of two cages through a bilateral approach in addition to extensive total laminectomy, posterior facetectomy, and bilateral pedicle screw placement for spinal stability. However, Zhao et al<sup>14</sup> reported that the use of a single diagonal cage in PLIF can lead to satisfactory clinical outcomes with minimal invasion of the posterior elements.

Our MIS-TPLIF technique is similar to a modified version of PLIF that entails performing unilateral hemilaminectomy and facetectomy (►Fig. 2), instead of laminectomy and bilateral facetectomy, on the symptomatic side. Bingqian et al<sup>15</sup> demonstrated that a modified version of PLIF can preserve the spinous process, supraspinous and interspinous ligaments, and contralateral vertebral plate and facet joints, all of which are crucial for maintaining lumbar spine stability. Xue et al<sup>16</sup> indicated that the preservation of the posterior tension band structure can help alleviate low back pain, reduce complication rates, and accelerate functional recovery. For our MIS-TPLIF technique, we used a single PEEK cage, which has the same specifications as those used in TLIF and has been demonstrated to have a favorable fusion rate.<sup>17</sup> The MIS-TPLIF destroys the facet joint on only one side and retains the spinous process in the middle; therefore, the overall procedure is more straightforward to learn, more familiar to surgeons, and less time intensive to perform than are conventional methods.

The main difference between MIS-TLIF and MIS-TPLIF is in the approach route, which determines the type of retractor that is used and the medical expenses that are incurred. MIS-TLIF is performed using the Wiltse technique, which usually requires the use of a special tubular or rectangular retractor<sup>18</sup>; however, such retractors tend to be costly. By contrast, MIS-TPLIF involves a midline approach, requiring only a simple Taylor retractor that can effectively grip the outside of the facet joint; this method facilitates the creation of a well-defined surgical space, providing a clear view of the laminae and medial facet joint (►Fig. 2A).

When a surgeon is performing MIS-TPLIF, they can easily locate the pars interarticularis, interlaminar space, and facet

joint by performing a dissection along the bony structure of the spinous process. When the Wiltse technique is applied during MIS-TLIF, the path and direction of operation can occasionally be challenging to verify because of the absence of distinct landmarks. This problem is particularly pertinent in patients with spondylolisthesis because they often have hypertrophic facet joint; specifically, hypertrophic soft tissues can confuse surgeons such that the coagulation of additional muscles is required to accurately determine positioning. Therefore, a primary distinction between MIS-TLIF and MIS-TPLIF is their different learning curves. Between the two methods, MIS-TLIF is more complex and requires a longer period of training and more hands-on experience to achieve proficiency. By contrast, MIS-TPLIF is performed using a midline approach that is similar to that used in microdissection in terms of anatomical principles, thereby reducing the time required to achieve proficiency in this technique. These findings align with the results of our study, in which the MIS-TPLIF group exhibited less blood loss and shorter operative times than did the MIS-TLIF group.

This TPLIF is not intended to replace the most widely used TLIF today. The Wiltse approach TLIF is still one of the best methods. The TPLIF we propose can achieve the same effect through a pathway with clear bony structures in the midline.

Sometimes, the Wiltse approach TLIF takes more time to find the pars interarticularis, especially when the patient has a hypertrophic facet joint. In addition, TLIF decompression also takes time because the medial portion near the midline is blocked by the multifidus, and contralateral decompression is difficult to achieve with TLIF.

Doubts have been raised about using the midline approach for lumbar interbody fusion. Nevertheless, the trans-pars interarticularis midline approach provides several advantages. First, it allows for the easy removal of the contralateral ligamentum flavum through the crossing of the midline.<sup>16</sup> Removal can be achieved even when only unilateral hemilaminectomy is performed. By contrast, MIS-TLIF requires a large slope level adjustment to decompress both sides from one side. If the MIS-TLIF group decides to use bilateral approaches for decompression, more surgical time will be required. Second, when a patient has two-level stenosis with only one-level spondylolisthesis, using a midline approach can lead to the decompression of the adjacent segment without destroying the facet joint. This is achieved by completing unilateral laminectomy at L3–L4–L5 and only TPLIF at L4–L5, similar to the method used in the second case discussed in the present study. Finally, the midline approach may also accommodate the topping-off technique, which may help alleviate adjacent segment disease.<sup>19</sup>

The present study has some limitations. First, because it is a retrospective clinical study, prospective studies should be conducted to produce more relevant results. Second, our patients were all ethnic Chinese individuals, who may differ from other ethnic populations in terms of weight and height. Finally, the length of hospital stay in our MIS-TLIF group was longer than in other published study groups. Since both groups have their own learning curves, we collect data from the beginning. Our data cannot fully represent these



two groups of surgeries, but it can be found that TLIF does require a learning curve.

## Conclusion

Our results indicated that the proposed MIS-TPLIF can achieve lumbar surgery outcomes comparable to those of MIS-TILF, all while avoiding the need for complex retractors and a highly intuitive operational approach. Additionally, because MIS-TPLIF uses a simple surgical pathway, it can reduce the length of the learning curve. Furthermore, the midline approach allows for continuous decompression and the incorporation of other hybrid surgical methods, such as the topping-off technique. Therefore, this surgical approach should be further explored and promoted.

### Funding

None.

### Conflict of Interest

None declared.

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