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Review Article

A retrospective study of MIS-TLIF combined with unilateral or bilateral internal fixation for mono-segmental lumbar vertebra degenerative diseases

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Abstract: Objective: This study aimed to compare the therapeutic effects of Minimally Invasive Surgery Transforaminal Lumbar Interbody Fusion (MIS-TLIF) combined with unilateral internal fixation (UIF); and MIS-TLIF combined with bilateral internal fixation (BIF), for mono-segmental lumbar vertebra degenerative disease. Methods: Patients with mono-segmental lumbar vertebra degenerative diseases were selected for retrospective analysis and grouped into the unilateral group and the bilateral group The clinical observation indexes, VAS (visual analog scale/score), ODI (Oswestry disability index) and JOA (Japanese Orthopaedic Association) of the two groups were recorded and compared. Results: In the unilateral group, the length of operation and hospital stay were significantly shorter than those in the bilateral group, while the intraoperative blood loss and postoperative drainage volume were significantly lower than those in the bilateral group. The VAS scores, ODI scores, and JOA scores of patients in both groups 7 days after operation were significantly improved. Also, compared with the measurements 7 days after the operations, the VAS scores, ODI scores, and JOA scores were significantly improved 3 months after operation. Compared with the measurements 3 months after operation, the VAS scores, ODI scores, and JOA scores were significantly improved 1 year after operation. The fusion rate of the VAS scores, ODI scores, and JOA scores of patients in both groups measured before operation, 7 days after operation, 3 months after operation, and 1 year after the operations were not significantly different. Conclusion: MIS-TLIF combined with UIF and MIS-TLIF combined with BIF are both effective in the treatment of mono-segmental lumbar vertebra degenerative diseases. However, comparatively, MIS-TLIF combined with UIF has a shorter length of operation, less intraoperative blood loss, less damage to paravertebral tissues, and faster recovery.

Keywords: MIS-TLIF, unilateral internal fixation, bilateral internal fixation, mono-segmental lumbar vertebra degenerative disease, X-ray

Introduction

The lumbar vertebra is the pivot point of the human trunk, and it is also the site with the most stress within the vertebral column. With an increase of age, excessive activity and overloaded weight bearing all make the lumbar intervertebral disc, facet joints, and surrounding ligaments gradually degenerate. Severe degenerative lumbar vertebra changes cause pain in the lower back and even nerve damage, affecting the working ability and quality of life of the patients. Lumbar vertebra degenerative diseases are common diseases seen in the Spinal Surgery Department and occur mostly in middle-aged and in seniors. In recent years, the incidence rate of lumbar vertebra degenerative diseases has been increasing annually [1]. At present, the treatment of lumbar vertebra degenerative diseases mainly includes conservative treatment and surgical treatment [2]. For patients with severe conditions, conservative treatment is often unsatisfactory; therefore, they require intervention through surgery. Transforaminal Lumbar Interbody Fusion (TLIF) is a common surgical procedure for the treatment of lumbar vertebra degenerative diseases, which is effective in reducing pressure, resetting, fusion, and internal fixation. The Minimally Invasive Surgery Transforaminal Lumbar Interbody Fusion (MIS-TLIF) is a new type of surgical procedure based on TLIF after the development of minimally invasive techniques. From the perspective of human anatomy, it is said to have

advantages over traditional surgery. In addition, the MIS-TLIF surgical approach has minimal trauma and is suitable for the treatment of most monosegmental lumbar vertebra degenerative diseases [3]. Rahmatullah et al. believed that the percutaneous pedicle technique used in MIS-TLIF surgery could better preserve the function of paravertebral muscles and reduce injury [4]. At present, MIS-TLIF combined with bilateral vertebral arch root screw internal fixation is commonly used in the treatment of lumbar vertebra degenerative diseases. However, the bilateral internal fixation (BIF) brings great damage to soft tissues such as the muscles and ligaments. Moreover, it brings unnecessary damage to patients with unilateral symptoms. Studies have shown that BIF increases the incidence rate of complications such as screw rupture and nerve root injury and raises the risk of postoperative hematoma and infection [5]. Compared with unilateral internal fixation (UIF), BIF has advantages in stability. However, with the deepening of research, some scholars have begun to question it. Cui et al. believed that UIF could provide similar stability to BIF [6]. Therefore, in order to obtain a more effective and less invasive surgical method for the clinical treatment of lumbar vertebra degenerative diseases, it is necessary to explore UIF.

MIS-TLIF combined with BIF has been widely used in the clinical treatment of lumbar vertebra degenerative diseases. A large number of studies have reported its efficacy, but few studies have compared the two treatment methods side by side; i.e., MIS-TLIF combined with UIF and MIS-TLIF combined with BIF. This study included patients with mono-segmental lumbar vertebra degenerative disease to investigate the efficacy of MIS-TLIF combined with unilateral or BIF for the treatment of mono-segmental lumbar vertebra degenerative diseases, providing a reference basis for the clinical treatment of mono-segmental lumbar vertebra degenerative diseases.

Materials and methods

Research subjects

A retrospective analysis was performed on 100 patients diagnosed with mono-segmental lumbar vertebra degenerative disease in our hospital (July 2018 to June 2019), who were divided into the MIS-TLIF combined with UIF treatment group (the unilateral group, 50 patients) and the MIS-TLIF combined with BIF treatment group (the bilateral group, 50 patients). This experiment was approved by the ethics committee of our hospital. All the patients signed an informed consent form.

Inclusion criteria: those who had received more than 3 months of formal conservative treatment without expected effects; those who met the diagnostic criteria for mono-segmental lumbar vertebra degenerative disease; patients aged ≤75 years old; those with their first time receiving mono-segmental lumbar vertebra operations; patients who had no surgical contraindications; patients who could communicate well and had good clinical compliance; patients with complete clinical data.

Exclusion criteria: those with multi-segmental lumbar vertebra degenerative disease; those aged over 75 years old; those with comorbidities such as hemiplegia and mental abnormalities that affected the judgment of therapeutic effects; those with lumbar infection, spinal deformity, and severe osteoporosis; those with coagulation dysfunction; and those with other serious systemic diseases.

Preoperative preparations

Before the operation, the relevant examinations were completed to comprehensively assess the physical conditions of patients and determine the surgical plans. Preoperative interviews with patients and their families were completed for safely regarding the operations. The general conditions of the patients were understood. Patients with common complications such as cardiovascular diseases were actively treated to eliminate surgical contraindications. Meanwhile, according to the actual situations of each of the patients, the surgeons actively communicated with relevant co-workers in the Internal Medicine Department and Anesthesiology Department to fully prepare for the operations and make a good plan for all possible situations during and after the operations.

Surgical method

The operations of the two groups of patients were completed by the same group of senior physicians. The specific steps were as follows:

The unilateral group: All patients were anesthetized by general anesthesia. The patient was placed in a prone position, and a cushion was placed under the chest and the crotch of the patient to make the abdomen hang in the air. A positioner was attached to the midline of the lower back and the lumbar vertebrae were photographed under a C-branch form X-ray machine (Royal Philips, Netherlands). The lesion segment and the vertebral arch root at the decompression side were positioned, and a mark was made 3 cm away from the positioner. The surgical towels were disinfected. The working cannula free arm was installed. A longitudinal incision about 4 cm along the mark was made. The skin, subcutaneous tissue, and deep fascia layer were cut open, the positioning guide needle was inserted and placed on the articular process. Then, the multifidus muscle and the longest muscle gap were bluntly separated to the facet joint. By using the expansion sleeve (Shanghai Reach-med, China), the Quadrant minimally invasive channel was placed. The channel was adjusted and fixed, the surgical field was exposed, the fixed equipment was installed, and two vertebral arch screws were placed on the affected side. The upper and lower articular processes were excised, the ligamenta flava was removed, the annulus fibrosus was cut open, and the nucleus pulposus was bitten off to achieve the purpose of decompression. The upper and lower cartilage endplates were scraped off, and the autologous iliac bone was taken, which was ground with a rongeur and placed in an interbody cage. After the connecting rod was pre-bent, it was placed at the end of the vertebral arch and was pressurized to lock. The position was confirmed through X-ray scanning. The channel was taken out. Finally, the wound was rinsed with saline, hemostasis was strictly performed, a drainage tube was placed, and the incision was sutured.

The bilateral group: All patients were anesthetized by general anesthesia. The patient was placed in a prone position, and a cushion was placed under the chest and the crotch of the patient to make the abdomen hang in the air. A positioner was attached to the midline of the lower back and the lumbar vertebrae were photographed under a C-branchform X-ray machine. The lesion segment and the vertebral arch root at the decompression side were positioned, and a mark was made 3 cm away from the positioner. The surgical towels were disinfected. The working cannula free arm was installed. A longitudinal incision about 4 cm along the mark was made. The skin, subcutaneous tissue, and deep fascia layer were cut open, the positioning guide needle was inserted and placed on the articular process. Then, the multifidus muscle and the longest muscle gap were bluntly separated to the facet joint. By using the expansion sleeve, the Quadrant minimally invasive channel was placed. The channel was adjusted and fixed, the surgical field was exposed, the fixed equipment was installed, and four vertebral arch screws were placed on both sides. The upper and lower articular processes were excised, the ligamenta flava was removed, the annulus fibrosus was cut open, and the nucleus pulposus was bitten off to achieve the purpose of decompression. The upper and lower cartilage endplates were scraped off, and the autologous iliac bone was taken, which was ground with a rongeur and placed in an interbody cage. After the connecting rod was pre-bent, it was placed at the end of the vertebral arch and was pressurized to lock. The position was confirmed through X-ray scanning. The channel was taken out. Finally, the wound was rinsed with saline, hemostasis was strictly performed, the drainage tube was placed, and the incision was sutured.

Postoperative treatment

After the operations, the two groups of patients were routinely given antibiotics for 2 to 3 days. The general conditions of the patients were closely observed. When the drainage volume was ≤50 mL/24 h, the drainage tube was removed. The drainage tube was usually removed 1 to 3 days after the operation and was not retained longer than 7 days. According to the conditions of the incisions, the sutured threads could be removed 7 to 10 days after the operations. If the patient was in good physical condition, progressive exercise for lower back muscles and the straight leg lifting exercise could be performed within 10 days after the operations. After 10 days, a hard waist circumference brace was worn, and was kept on for 3 months. Activities such as bending and weight-bearing were reviewed regularly.

Clinical observation indicators

Clinical observation indicators included the length of operation, hospital stay, intraopera-

tive blood loss, and postoperative drainage volume.

Length of operations: There was a close relationship between the length of operation and the risks of trauma during surgery. In this study, the time from the incision of the skin to the completion of the incision was recorded as the length of operation.

Hospital stays: Hospital stays = total hospitalization days - preoperative hospitalization days.

Intraoperative blood loss: Intraoperative blood loss was an important indicator to measure the size of the wound and the safety of the operation. It had an important impact on the therapeutic effects on the patients. Intraoperative blood loss = drainage volume of the drainage bottle + wet dressing count × 50 - the amount of saline used for flushing.

Postoperative drainage volume: Postoperative drainage was an important indicator to measure the size of the wound and the safety of the operation. Postoperative drainage volume = the sum of the drainage before the tube was removed.

Efficacy evaluation indicators

Efficacy evaluation indicators include the Visual Analogue Scale (VAS), the Oswestry Disability Index (ODI) score, the Japanese Orthopaedic Association (JOA) lumbago score, and the imaging evaluation.

VAS [7]: VAS was sensitive and comparable, allowing pain assessment in patients. VAS had a scale of 0-10, with 0 being painless and 10 being severe pain; the scales between 0 and 10 represented varying degrees of pain. The patients marked the scale based on their pain sensation to indicate the extent of the pain. The degrees of pain in the lower back and legs of the patients were evaluated before the operation, 7 days after the operation, 3 months after the operation, and 1 year after the operation.

ODI score [8]: The ODI score was used to evaluate the lumbar function of the patient. The score was 0 to 50 points. It consisted of 10 questions with 5 points each. The higher the score was, the more obvious the dysfunction was. The degree of dysfunction was assessed before the operation, 7 days after the operation, 3 months after the operation, and 1 year after the operation.

JOA score [9]: The JOA score was mainly used for the evaluation of human functional disorders, with a score of 0 to 29, including subjective symptoms (9 points), clinical signs (6 points), and daily activity limitations (14 points). The lower the score, the more obvious the dysfunction of the patient was. The degree of pain in the lower back and legs of the patients were evaluated before the operation, 7 days after the operation, 3 months after the operation, and 1 year after the operation.

Imaging evaluation: According to the X-ray standard of bone graft fusion [10], the lumbar fusion of the patient was evaluated. If the bone graft gap was completely filled by the trabecular bone, it indicated that it was fused; if the trabecular bone was not seen in the bone graft gap, or the beam was discontinuous and the light transmission line continued to appear, it indicated that it was not fused. The X-ray scanning of the lumbar vertebra was reviewed 1 year after the operation, and the lumbar fusion was evaluated. The fusion rates of the two groups were calculated and compared.

Statistic analysis

SPSS 22.0 statistical software was used for data analysis. The measurement data were expressed as mean number ± standard deviation (x±s). Two-sample means were compared by t-test. The count data were compared by the Chi-square test. The difference was statistically significant at $P<0.05$. The VAS score, ODI score and JOA score of the two groups before and after operation were compared by paired t-test within the group, and independent sample t-test was made between the groups.

Results

General information of the patients in the two groups

The comparison of the general information of the patients in both groups was shown in **Table 1**. It suggests that there were no obvious differences between the two groups regarding all general data, such as age, gender, and admission time ($P>0.05$); thus, the groups were comparable. The distribution of diagnosis and degenerative segments were compared (**Figure 1**), and the diagnosis composition had no great differences between the two groups ($P>0.05$). It can be considered that the diagnosis distribution of the unilateral group was the same as

Table 1. The comparison of general information between patients in the two groups

Clinical observation indicators	The unilateral group	The bilateral group	t values	*P* values
Age (years old)	54.43±7.94	55.29±8.77	1.275	0.244
Male (case/%)	32 (64.00)	33 (66.00)	0.041	0.839
Weight (kg)	57.53±8.42	58.16±8.51	0.784	0.498

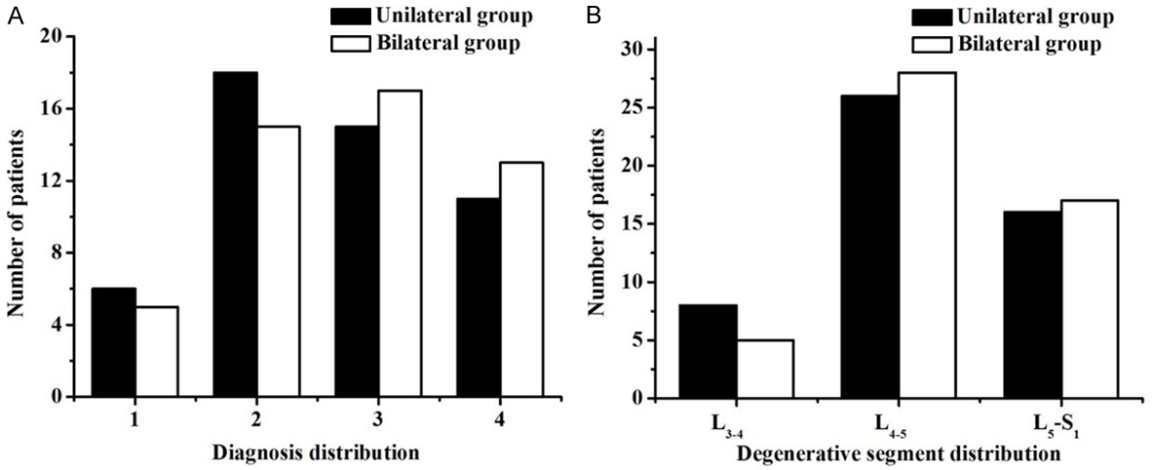

Figure 1. Comparison of diagnosis distribution and degenerative segment distribution between the two groups (A. Diagnosis distribution, in which, 1 refers to discogenic low back pain, 2 indicates lumbar disc herniation and spinal canal stenosis, 3 denotes mild lumbar slip instability, 4 suggests extreme lateral lumbar disc herniation; B. Degenerative segment distribution).

Table 2. The comparison of clinical observation indicators between patients in the two groups

Clinical observation indicators	The unilateral group	The bilateral group	t values	*P* values
Length of operation (min)	131.42±22.18	139.75±22.73	3.083	0.017
Hospital stay (day)	7.04±2.15	10.88±3.78	6.154	0.001
Blood loss during the operations (mL)	187.34±43.56	256.42±68.45	4.710	0.003
Drainage volume after the operations (mL)	109.15±41.69	195.56±77.77	2.769	0.009

that of the bilateral group. The number of cases in each segment of the two groups was not apparently different (P>0.05) and the segment distribution was considered to be the same.

The comparison of clinical observation indicators between patients in the two groups

The comparison of the length of operation, hospital stay, intraoperative blood loss, and postoperative drainage volume was shown in **Table 2** and **Figure 2**. **Table 2** suggests that the length of operation and hospital stay in the unilateral group were significantly shorter, with obvious differences (P<0.05). Meanwhile, the intraoperative blood loss and postoperative drainage volume in the unilateral group were significantly lower, with obvious differences (P<0.05).

The comparison of VAS, ODI and JOA between patients in the two groups

The comparison of the results of VAS, ODI, and JOA between patients in the two groups is shown in **Figure 3** and **Table 3**. In the unilateral group, the VAS scores, ODI scores, and JOA scores of patients 7 days after the operations were significantly improved, with obvious differences (P<0.05). Also, compared with the measurements 7 days after the operation, the VAS, ODI, and JOA were significantly improved 3 months after the operation, with obvious differences (P<0.05). Compared with the measurements 3 months after the operation, the VAS, ODI, and JOA were significantly improved 1 year after the operation, with obvious differences (P<0.05).

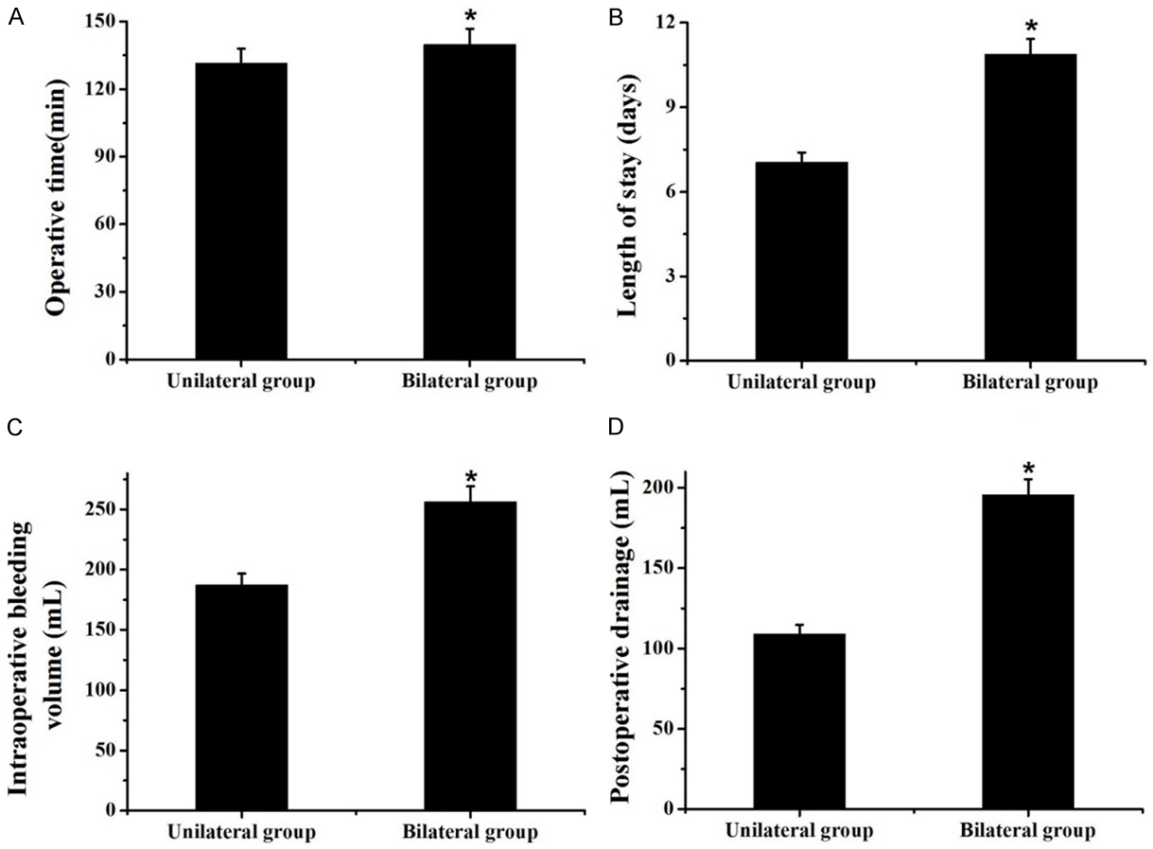

Figure 2. Comparison of clinical observation indexes between the two groups (A. Operation time; B. Hospitalization time; C. Intraoperative bleeding volume; D. Postoperative drainage volume. Compared with unilateral group, *P<0.05).

In the bilateral group, the VAS, ODI, and JOA of patients 7 days after operation were significantly improved, with obvious differences (P<0.05). Also, compared with the measurements 7 days after operation, the VAS, ODI, and JOA were significantly improved 3 months after operation, with obvious differences (P<0.05). Compared with the measurements 3 months after operation, the VAS scores, ODI scores, and JOA scores were significantly improved 1 year after operation, with obvious differences (P<0.05).

The VAS scores, ODI scores, and JOA scores before the operation, 7 days after operation, 3 months after operation, and 1 year after operation were compared between the two groups. The results were not greatly different (P>0.05).

Results of imaging evaluation of patients in the two groups

The X-ray scans of certain cases from both groups were shown in **Figure 4**. In the unilateral group, a patient had $L_{4,5}$ intervertebral disc degeneration (**Figure 4A**). After 1 year post MIS-TLIF combined with UIF, the trabecular bone grew past and through the cage to achieve intervertebral fusion (**Figure 4B**), with excellent therapeutic effects. In the bilateral group, a patient had $L_{4,5}$ intervertebral disc degeneration (**Figure 4C**). After 1 year post MIS-TLIF combined with BIF, the trabecular bone grew past and through the cage to achieve intervertebral fusion (**Figure 4D**), with excellent therapeutic effects. The comparison results of the fusion rate between the two groups were shown in **Table 4**. The fusion rate was 94.00% (47/50) in the unilateral group and 96.00% (48/50) in the bilateral group. The fusion rates of the two groups were compared, but no obvious difference was found (P>0.05).

Discussion

The operation for lumbar degenerative disease is meant to release the compression of spinal nerve roots and implant a cage through partial

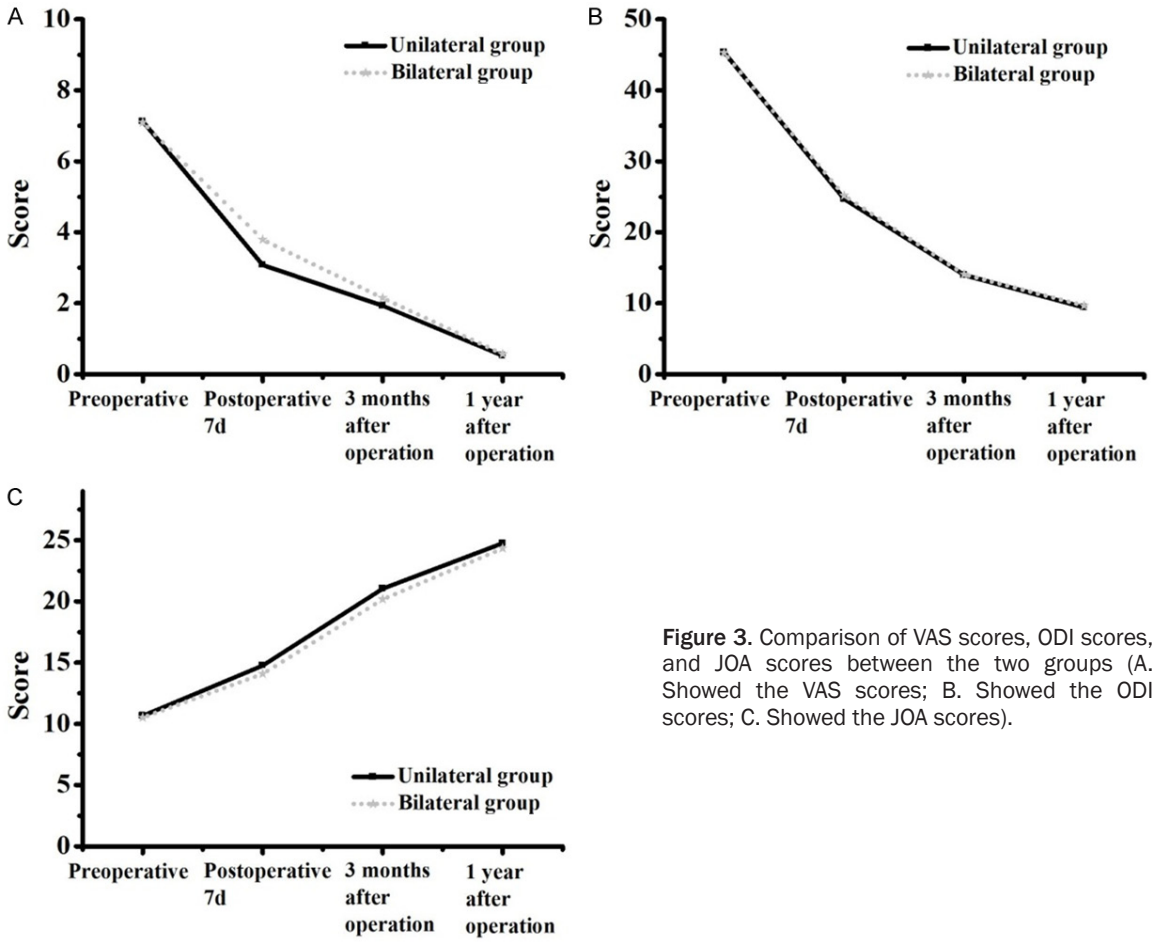

Figure 3. Comparison of VAS scores, ODI scores, and JOA scores between the two groups (A. Showed the VAS scores; B. Showed the ODI scores; C. Showed the JOA scores).

Table 3. Comparison of VAS score, ODI score, and JOA score between the two groups

Score	Time periods	Unilateral group	Bilateral group
VAS	Before operation	7.12±0.85	7.09±0.79
	7 days after operation	3.08±0.67	3.79±0.70
	3 months after operation	1.93±0.52	2.15±0.57
	a year after operation	0.52±0.42	0.57±0.43
ODI	Before operation	45.32±6.32	45.27±6.27
	7 days after operation	24.68±5.73	25.17±5.79
	3 months after operation	13.98±3.34	14.06±3.38
	a year after operation	9.43±2.04	9.65±2.11
JOA	Before operation	10.65±1.88	10.52±1.84
	7 days after operation	14.76±1.95	14.09±1.94
	3 months after operation	21.04±2.10	20.18±2.06
	a year after operation	24.76±2.37	24.34±2.35

removal of lamina and lumbar disc, to help with decompression and thereby maintaining the stability of lumbar spine and achieve fusion, avoiding the formation of pseudarthrosis, relieving the pain, and meeting the requirement of allowing activities. An open posterior approach combined with bilateral pedicle fixation is a traditional surgical method for the treatment of lumbar degenerative diseases. The operation can place the nails in a more intuitive field of vision, remove an increased part of the thickened ligamentum flavum and joint process degeneration, remove the herniated or calcified intervertebral disc, fully decompress the spinal canal, effectively improve the stability of the spine, and significantly relieve back pain, which has been widely used in clinic. This kind of operation easily leads to low back pain, low back flexion stiffness, and low back extension. Although bilateral fixation of the lumbar spine can obtain good fixation, too strong of an internal fixation will lead to the loss of bone mass in the fusion vertebral body and accelerate the degeneration of adjacent segments

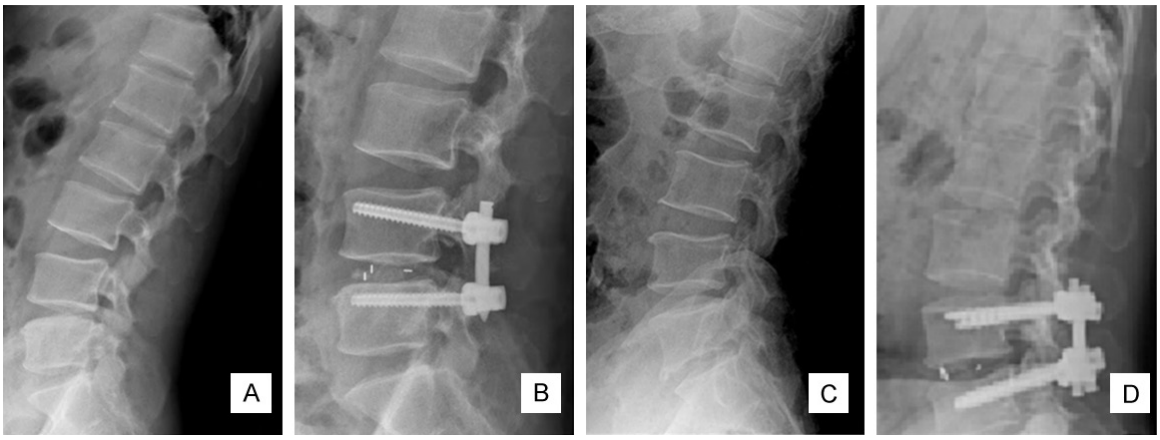

Figure 4. X-ray scans of classic cases in both groups (A. Was the preoperative X-ray scan of a patient in the unilateral group; B. Was the X-ray scan 1 year after the operation of the patient in the unilateral group; C. Was the preoperative X-ray scan of a patient in the bilateral group; D. Was the X-ray scan 1 year after the operation of the patient in the bilateral group).

Table 4. Comparison of fusion rate between the two groups

Groups	Fusion rate (%)
Unilateral group	94.00
Bilateral group	96.00

[20]. Mechanical studies have reported that unilateral surgery cannot fully control the rotation of the sagittal plane and cannot achieve the fixed effect in theory, but there are reports that there is no difference in the success rate between the two surgical methods [21, 22]. As spine surgery technology develops and minimally invasive surgery improves; minimally invasive surgery is more widely used in treating lumbar degenerative diseases. The Wiltse approach was selected for minimally invasive unilateral fixation, through a longitudinal small incision on the affected side, and then the cannula was used for blunt separation step by step, and the operation was performed under the channel. In this way, paravertebral muscles can be protected to the maximum extent, which helps the functional recovery of the patients' back after operation, and can reduce back pain [23].

To compare the therapeutic effects of MIS-TLIF combined with UIF and MIS-TLIF combined with the BIF on mono-segmental lumbar vertebra degenerative diseases, this study included patients with mono-segmental lumbar vertebra degenerative disease as the research subjects. The included patients were divided into the unilateral group and the bilateral group for analysis, that respectively received MIS-TLIF combined with UIF and MIS-TLIF combined with BIF. The clinical observation indicators, such as length of operation, hospital stay, blood loss during operation, and drainage volume after operation of patients in groups, were recorded and compared. Also, the efficacy evaluation indicators, such as VAS, ODI score, JOA score, and imaging results, were recorded and compared. The results showed that in the unilateral group, the length of operation and hospital stay were significantly shorter than those in the bilateral group, while the intraoperative blood loss and postoperative drainage volume were significantly lower than those in the bilateral group. Therefore, compared with MIS-TLIF combined with BIF, MIS-TLIF combined with UIF has a shorter length of operation, less intraoperative blood loss, less damage to paravertebral tissues, and faster recovery. Ortega-Porcayo et al. proposed that compared with BIF, UIF could reduce the amount of intraoperative blood loss and shorten the length of hospital stay, which was consistent with the results of this study [24]. The VAS scores, ODI scores, and JOA scores of patients in both groups 7 days after operation were significantly improved. Also, compared with the measurements 7 days after operation, the VAS scores, ODI scores, and JOA scores were significantly improved 3 months after operation. Compared with the measurements 3 months after operation, the VAS scores, ODI scores, and JOA scores were significantly improved 1 year after operation. Therefore, both MIS-TLIF combined with UIF and MIS-

TLIF combined with BIF are effective in the treatment of mono-segmental lumbar vertebra degenerative diseases. Dai et al. believed that MIS-TLIF combined with unilateral fixation could significantly improve the postoperative VAS scores and ODI scores [25], which was consistent with the results of this study. The VAS scores, ODI scores, JOA scores, and fusion rates before the operation, 7 days after operation, 3 months after operation, and 1 year after operation were compared between the two groups. The results were not significantly different. It indicated that both the treatments could achieve the same therapeutic effects in pain relief, functional recovery, and fusion rate.

In summary, through the study of MIS-TLIF combined with unilateral or BIF treating mono-segmental lumbar vertebra degenerative diseases, it was found that MIS-TLIF combined with UIF and MIS-TLIF combined with BIF are effective in the treatment of mono-segmental lumbar vertebra degenerative diseases. Both treatments have the same therapeutic effects in pain-relieving, functional recovery, and fusion rate. However, comparatively, MIS-TLIF combined with UIF has a shorter length of operation, less intraoperative blood loss, less damage to paravertebral tissues, and faster recovery. The results of this study have provided a reference for the clinical treatment of mono-segmental lumbar vertebra degenerative diseases. However, certain deficiencies were found in the research process; for example, the number of samples was relatively few and that caused the results to be biased to a certain extent. Therefore, data capacity can be further increased in subsequent work to make the obtained results more valuable.

Disclosure of conflict of interest

None.

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