Comparison of the efficacy of MIS-TLIF combined with unilateral or bilateral internal fixation on single-segment lumbar degenerative diseases

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Abstract
In this study, to compare the efficacy of minimally invasive surgery transforaminal lumbar interbody fusion (MIS-TLIF) combined with unilateral or bilateral internal fixation for the treatment of single-segment lumbar degenerative diseases, patients with single-segment lumbar degenerative diseases treated with MIS-TLIF combined with unilateral or bilateral internal fixation in Rehabilitation Center, Gansu Province Hospital from January 2014 to November 2015 were retrospectively enrolled, and the related data of 85 patients with 2-year follow-up were obtained. The patients were divided into unilateral group (40 cases) and bilateral group (45 cases) according to the method of internal fixation, and the Oswestry dysfunction index (ODI), visual analogue scale (VAS), lumbar lordosis angle, surgical segmental lordosis angle, lumbar scoliosis angle, surgical segmental scoliosis angle, lumbar lordosis index (LI), intervertebral height index (IHI), fusion rates, and serum inflammatory factors, including C-reactive protein (CRP), interleukin (IL)-6, and tumor necrosis factor alpha (TNF-α), were calculated to evaluate the efficacy of these two surgical methods. The results showed that the VAS and ODI of the two groups at 1 month, 6 months after surgery, and the last follow-up were significantly improved when compared with those before surgery ($P<0.05$). However, there were no significant differences in VAS and ODI between the two groups at preoperative, 1 month, 6 months after surgery, and the last follow-up ($P>0.05$). The lumbar lordosis and LI decreased at 1 month, 6 months, and the last follow-up ($P<0.05$), while the IHI increased when compared with that before surgery ($P<0.05$). Besides, no significant differences were observed in lumbar lordosis, LI, and IHI between the two groups at preoperative, 1 month, 6 months after surgery, and final follow-up ($P>0.05$). In addition, the fusion rates between these two groups had no significant difference ($P>0.05$). The levels of serum CRP, IL-6, and TNF-α at 12 and 24 h after operation in the two groups were higher than those before operation ($P<0.05$), but there was no significant difference in the levels of serum CRP, IL-6, and TNF-α between the two groups at 12 and 24 h after operation ($P<0.05$). In addition, none of the patients of both groups had permanent nerve injury, incision infection, and other complications. These results showed that MIS-TLIF combined with unilateral or bilateral percutaneous internal fixation technique causes less damage to the body tissues of patients with single-segment lumbar degenerative diseases, and they were considered to have similar clinical effects and imaging.

Keywords
bilateral internal fixation, inflammatory factors, minimally invasive transforaminal lumbar interbody fusion, single-segment lumbar degenerative disease, unilateral internal fixation

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Introduction

Lumbar degenerative disease is a general term for diseases in which the lumbar intervertebral disk, the cartilage part of the facet joint, and its surrounding ligaments degrade with age, leading to waist and leg pain, including mainly degenerative lumbar spinal stenosis, lumbar disk herniation, lumbar instability, spondylolisthesis, and degenerative lumbar scoliosis. Its pathological changes are complicated, including mainly herniation of intervertebral disk, symptomatic osteophyte, spinal canal stenosis, facet joint hyperplastic arthritis, ligamentum flavum hypertrophy, local lumbar instability, slippage, and so on.

There are many surgical intervention methods for lumbar degenerative disease. The open transforaminal lumbar interbody fusion (open TLIF) was first reported by Harms et al. in 1982. It has the advantages of less laminectomy and small nerve root traction, but it has many problems such as soft tissue injury and intraoperative bleeding. To compensate for these deficiencies, minimally invasive surgery transforaminal lumbar interbody fusion (MIS-TLIF) for lumbar degenerative diseases was reported by Foley et al. in 2003 and is widely used to treat spinal diseases. In recent years, MIS-TLIF has been further promoted with the enhancement of minimally invasive concept. For example, soft tissue exfoliation and nerve tissue stretching in a wide range of muscles have been avoided by MIS-TLIF technology, and it has the advantages of reducing intraoperative bleeding, shortening hospital stay, and other advantages, which has attracted more general attention.

The clinical efficacy of MIS-TLIF combined with unilateral internal fixation has been reported in relevant literature. However, the treatment of MIS-TLIF combined with bilateral and unilateral internal fixation is still controversial. Some scholars have found that there is no significant difference in clinical efficacy and imaging parameters between unilateral fixation and bilateral fixation in the treatment of lumbar degenerative diseases. Some showed that the operation time, hospitalization time, and treatment cost of MIS-TLIF combined with bilateral internal fixation for the treatment of single-segment lumbar degenerative diseases were significantly higher than those of the MIS-TLIF combined with unilateral internal fixation. However, few reports focused on imaging and serum markers of patients who underwent MIS-TLIF combined with unilateral and bilateral internal fixation. Will the lumbar spine sequence change after MIS-TLIF combined with unilateral internal fixation? Will there be any collapse in the unfixed lateral intervertebral space? How does it affect the serum inflammatory markers? To clarify the clinical efficacy and imaging of MIS-TLIF combined with unilateral internal fixation and to understand its effect on serum inflammatory factors, we retrospectively compared the related data of patients who underwent MIS-TLIF combined with unilateral or bilateral percutaneous pedicle screw fixation.

Materials and methods

General data

Patients with single-segment lumbar degenerative diseases treated with MIS-TLIF combined with unilateral or bilateral percutaneous pedicle screw fixation in Rehabilitation Center, Gansu Province Hospital from January 2014 to November 2015 were enrolled in this study, and the related data of 85 patients were obtained. There were 47 males and 38 females, aged 40–75 years, with an average age of 58.5 ± 1.4 years. Inclusion criteria are as follows: (1) patients older than 40 years; (2) patients with single-segment lumbar disk degeneration or spinal stenosis at L4, 5 or L5, S1, which had been confirmed by radiographs; (3) patients with severe low back pain and unilateral nerve root symptoms; (4) patients with no significant stenosis in the contralateral crypt; and (5) patients who underwent regular conservative treatment for at least 6 months. Exclusion criteria are as follows: (1) patients with multisegment disorders; (2) patients older than 75 years; (3) patients with a history of surgery, fractures, and infections in the surgical segment; and (4) patients with lumbar spondylolisthesis and lumbar instability in the surgical segment. The patients were divided into unilateral group (40 cases) and bilateral group (45 cases) according to internal fixation. There were no significant differences in general data such as gender and age between the two groups.

Informed consent was obtained from the patients to use the clinical information, and the study was approved by the ethics committee of Gansu Province Hospital.
Surgical method

The unilateral group was treated with MIS-TLIF combined with unilateral internal fixation (Figure 1(a)), and the bilateral group was treated with MIS-TLIF combined with bilateral percutaneous internal fixation (Figure 1(b)). Surgery was performed by the same doctor in both groups.

All patients of unilateral and bilateral groups received general anesthesia, and the prone position was taken. The self-made locator was placed on the lower back and positioned under the perspective of a “C” arm x-ray machine to mark the position of the vertebral pedicle on the lateral side requiring decompression. The incision was taken along the marking line, then the skin and fascia were incised, and the stepwise expanding cannula and the METRX. MDT cannulas were inserted successively to clean up the local residual soft tissue and expose the outer edge of the lamina and the facet joints of the superior and inferior articular processes. The inferior articular process of the upper vertebral body, the partial superior articular process, and ligamentum flavum of the lower vertebral body were excised, and the nerve roots and dural sac were pulled away to remove the intervertebral disk and cartilage end plate. Thereafter, adjust the angle of the channel, bite off the contralateral ligamentum flavum, remove the bone from the inner edge of the contralateral superior articular process, and decompress the contralateral side crypt. One piece of intervertebral cage (Capstone, Medtronic Inc.) with a suitable height was filled with autologous bone, and the remaining bone was implanted into the intervertebral space. After compaction, the cage was placed into the intervertebral space. Next, two universal vertebral arch screws were placed, and titanium rods were fixed and pressed appropriately. After confirming that the internal fixation position is good under the perspective of the “C”-type arm x-ray machine, the incision is closed.

For patients in the bilateral group, the vertebral pedicle screw (Sextant, Medtronic Inc) was placed percutaneously on the contralateral side under the guidance of the guide needle. After confirming that the pedicle screw, the connecting rod, and the fusion cages are in good position under the fluoroscopy of the “C” arm x-ray machine, the incision is closed.

Follow-up and efficacy evaluation indicators

Outpatient visits were performed at 1, 3, and 6 months after surgery, and follow-up was performed once every 6 months in the clinic. All patients were followed up for 2 years.

Evaluation of clinical function. The Oswestry dysfunction index (ODI) was used to evaluate the lumbar spine function of the two groups at preoperative, 1 month, 6 months after surgery, and the last follow-up. The osphyalgia and melosalgia of the two groups of patients were evaluated by visual analogue scale (VAS) at preoperative, 1 month, 6 months, and the last follow-up.
Imaging evaluation. Lumbar lordosis angle, lumbar lordosis index (LI), and intervertebral height index (IHI) were measured on preoperative, postoperative 1 month, postoperative 6 months, and last follow-up x-ray films.

Inflammatory factor levels. Peripheral venous blood was extracted from two groups of patients at preoperative, 12 h, and 24 h after operation. The levels of inflammatory factors including C-reactive protein (CRP), interleukin (IL)-6, and tumor necrosis factor alpha (TNF-α) were measured by enzyme-linked immunosorbent assay (ELISA).

The intervertebral body lumbar fusion was evaluated by at least two experienced spinal surgeons based on the digital upright lateral radiographs according to the Bridwell–Lenke grading criteria: grade 1 was considered as solid fusion, grade 2 was not fully remodeled and incorporated but graft intact, grade 3 had a definite lucency at the top or bottom of the graft but the graft intact, and grade 4 definitely not fused with resorption of bone graft and with collapse.

The postoperative complications of the two groups were observed.

Statistical method

SPSS 21.0 statistical software was used for statistical analysis. The measurement data were represented as $\overline{x} \pm s$. One-way analysis of variance (ANOVA) was used for comparison of each index at different time points in the group, and the two independent samples t-test was used to compare the indicators among the groups. The count data were determined by chi-square test. The test level is $\alpha = 0.05$.

Results

Comparison of VAS and ODI between two groups at each time point

The VAS and ODI of the two groups at 1 month, 6 months after the surgery, and the last follow-up were significantly improved compared with those before surgery ($P < 0.05$). However, there were no significant differences in VAS and ODI between the two groups at preoperative, 1 month, 6 months after the surgery, and the last follow-up ($P > 0.05$; Table 1).

Comparison of imaging parameters in two groups of patients at different time points

The lumbar lordosis and LI decreased at 1 month, 6 months after surgery, and the last follow-up ($P < 0.05$), while the IHI increased when compared with that before the operation ($P < 0.05$). However, there were no significant differences in lumbar lordosis, LI, and IHI between the two groups at preoperative, 1 month, 6 months after surgery, and final follow-up ($P < 0.05$; Table 2).

Comparison of serum inflammatory factors between the two groups

The levels of serum CRP, IL-6, and TNF-α at 12 and 24 h after operation in the two groups were higher than those before operation ($P < 0.05$), but
there was no significant difference in the levels of serum CRP, IL-6, and TNF-α between the two groups at 12 and 24 h after operation ($P < 0.05$; Figure 2).

**Comparison of fusion rating between the two groups**

The fusion rates of grade 1 in the unilateral group were 42.5%, 55.0%, and 95.0% at 1 month, 6 months, and last follow-up. However, it was not significantly different from the fusion rates of the bilateral group, which were 53.3%, 75.6%, and 93.3%, respectively (Supplemental Table S1).

**Comparison of complications between the two groups**

All patients underwent surgery successfully, and antibiotics were routinely used after surgery. No complications such as permanent nerve injury or wound infection occurred. Two patients in the unilateral group and one patient in the bilateral group had cerebrospinal fluid leakage during the operation of the dural sac tear, which improved after 1 week of conservative treatment. One patient in the bilateral group had postoperative fat liquefaction, delayed incision healing, and negative bacterial culture. After 3 weeks of clean dressing, the incision healed. One patient in the unilateral group developed postoperative root pain, and no screws were seen in the spinal canal after computed tomography (CT) examination. The pain was evidently relieved after treatment with hormones and dehydration.

Six months after operation, one patient in the unilateral fixation group did not achieve bone fusion. After the treatment with less activity and waist circumference protection, CT showed bone fusion at 12 months after operation. No loosening or breakage of screws was found in the two groups during the follow-up period.

**Discussion**

In this study, the efficacy of MIS-TLIF combined with bilateral and unilateral internal fixation for the treatment of single-segment lumbar degenerative diseases was compared, which showed that theVAS and ODI of the two groups after surgery were significantly improved when compared with those before surgery, but no significant differences were observed in VAS and ODI between the two groups at any time points before and after surgery. The lumbar lordosis and LI decreased after surgery, and the IHI increased compared with that before surgery. In addition, no significant differences were observed in lumbar lordosis, LI, and IHI between the two groups at any time points before and after surgery. All the above-mentioned results suggested that MIS-TLIF combined with bilateral and unilateral internal fixation for the treatment of single-segment lumbar degenerative diseases can

| Observational index | Groups                      | Preoperative   | 1 month after surgery | 6 months after surgery | Last follow-up |
|---------------------|-----------------------------|----------------|-----------------------|------------------------|----------------|
| LL (°)              | Unilateral group (n = 40)   | 46.33 ± 7.56   | 40.94 ± 8.36          | 39.87 ± 7.64           | 39.02 ± 9.12    | 6.15 0.000     |
|                     | Bilateral group (n = 45)    | 46.79 ± 8.31   | 39.71 ± 9.63          | 40.71 ± 6.85           | 40.35 ± 10.25   | 7.03 0.000     |
|                     | t value                     | 0.833          | 1.098                 | 1.126                  | 1.579          |
|                     | P value                     | 0.276          | 0.369                 | 0.452                  | 0.087          |
| LI                  | Unilateral group (n = 40)   | 0.21 ± 0.05    | 0.24 ± 0.07           | 0.27 ± 0.09            | 0.25 ± 0.03    | 6.08 0.000     |
|                     | Bilateral group (n = 45)    | 0.22 ± 0.03    | 0.25 ± 0.06           | 0.28 ± 0.08            | 0.25 ± 0.07    | 6.01 0.000     |
|                     | t value                     | 0.918          | 0.983                 | 0.446                  | 0.799          |
|                     | P value                     | 0.206          | 0.416                 | 0.315                  | 0.503          |
| DI                  | Unilateral group (n = 40)   | 48.27 ± 11.26  | 43.25 ± 9.34          | 43.54 ± 9.65           | 43.98 ± 11.25  | 7.12 0.000     |
|                     | Bilateral group (n = 45)    | 47.86 ± 12.35  | 43.71 ± 10.68         | 44.46 ± 8.79           | 45.01 ± 12.17  | 8.45 0.000     |
|                     | t value                     | 1.042          | 0.926                 | 1.005                  | 1.643          |
|                     | P value                     | 0.197          | 0.156                 | 0.094                  | 0.073          |

DI: dysfunction index; LI: lumbar lordosis index; LL: lumbar lordosis.
Effectively improve lumbar function in patients with lumbar degenerative diseases, which is consistent with the relevant research reported.9

Systemic inflammatory status is closely related to the long-term effects of patients undergoing lumbar surgery. CRP levels are related to the size of surgical trauma and are sensitive indicators of early tissue trauma. The pro-inflammatory factor TNF-α is the most important promoter of systemic inflammatory response, which can attract the aggregation of neutrophils. IL-6 can stimulate the differentiation of B cell and synthesis of acute phase protein.10,11 In this study, the serum levels of inflammatory factors were compared before and after surgery. The results verified that the serum levels of CRP, IL-6, and TNF-α at 12 and 24 h after operation in the two groups were higher than those before operation, but no significant difference was

Figure 2. Alteration of the levels of serum CRP, IL-6, and TNF-α in unilateral and bilateral groups: the levels of serum CRP (a), IL-6 (b), and TNF-α (c) at 12 and 24 h after operation in both groups were higher than those before operation; there was no significant difference in the levels of serum CRP (d), IL-6 (e), and TNF-α (f) between the two groups at 12 and 24 h after operation. N.S.: not significant. *P < 0.05.
observed in the serum levels of CRP, IL-6, and TNF-α between the two groups at 12 and 24 h after operation. These results suggested that MIS-TLIF combined with bilateral and unilateral internal fixation has the advantage of small trauma in patients, which might be helpful for early recovery and functional rehabilitation training.

In addition, none of the patients with unilateral internal fixation had permanent nerve injury, incision infection, and other complications, and there was no significant change in the lordosis and scoliosis sequence of the lumbar spine during the follow-up period. Besides, no loosening or fracture of the internal fixation was found. Therefore, we can easily draw a conclusion that MIS-TLIF combined with unilateral or bilateral internal fixation is considered to have similar clinical effects and imaging. The shortcoming of this study is the lack of long-term follow-up results, and thus, subsequent follow-up observations need to be further completed.

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