Comparison of Minimally Invasive and Open Transforaminal Lumbar Interbody Fusion for Lumbar Disc Herniation: A Retrospective Cohort Study

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Background: This cohort study compared the efficacy and safety of minimally invasive versus open transforaminal lumbar interbody fusion (Mis-TLIF versus Open-TLIF) for lumbar disc herniation with radiculopathy.

Material/Methods: From July 2016 to September 2017, we recruited 37 patients suffering from lumbar disc herniation with radiculopathy. Seventeen patients underwent Mis-TLIF (Mis group) and 20 patients underwent Open-TLIF (Open group). Baseline characteristics were similar between the 2 groups before surgery. We compared postoperative clinical and radiological outcomes between the 2 groups.

Results: Compared to patients in the Open group, patients in the Mis group has significantly less intraoperative hemorrhage, drainage fluid, time to go, and hospital stay after surgery, but had longer operation times (P<0.05). These 2 groups had similar postoperative hemoglobin reduction and drain removal time. In addition, the postoperative back and leg pain and intervertebral height reduction at 3 months after surgery in the Mis group were remarkably lower than those in the Open group. There was no significant difference in postoperative Oswestry disability index (ODI) or intervertebral height change immediately after surgery and at 1 month postoperatively between the 2 groups.

Conclusions: Mis-TLIF shows some benefits in lumbar disc herniation compared to Open-TLIF in terms of intraoperative hemorrhage, drainage fluid, time to go, hospital stay after surgery, and postoperative back and leg pain.

MeSH Keywords: Cohort Studies • Lumbar Disc Herniation • Surgical Procedures, Minimally Invasive • Transforaminal Lumbar Interbody Fusion

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Background

Transforaminal lumbar interbody fusion (TLIF) has been widely used for degenerative lumbar disease (e.g., lumbar disc herniation and spondylolisthesis), and aims to provide spinal fusion, restore disc height, and maintain the normal lordosis of the lumbar spine [1–3]. TLIF is well known as an effective technique, but extensive paravertebral muscle stripping and retraction is needed to obtain an adequate surgical field [4–6]. This serious soft tissue injury may increase back pain and the atrophy of the paraspinal muscles [7,8].

Minimally invasive TLIF (Mis-TLIF) was first reported by Foley in 2003 [9]. Mis-TLIF has gained great popularity with the advancement of techniques and instruments specialized for minimally invasive spine surgery (e.g., tubular retractors and percutaneous pedicle screw fixation) [6,10–13]. Mis-TLIF results in decreased trauma to back muscles, less intraoperative blood loss, and less damage to bony structures compared to traditional Open-TLIF [14–18]. However, some clinical studies have reported that compared to Open-TLIF patients, patients with Mis-TLIF have comparable intraoperative blood loss and operation time and even longer duration of hospital stay [19–21]. Considering these inconsistent effects, we therefore conducted the present retrospective cohort study to compare the efficacy and safety of Mis-TLIF versus Open-TLIF.

Material and Methods

This study was approved by the Committee of Medical Ethics and the Institutional Review Board of our institution. Patient outcomes were collected independently from patients with informed consent, and data were analyzed blindly.

Table 1. Demographic data and clinical characteristics.

|                | Mis group | Open group | P value |
|----------------|-----------|------------|---------|
| Number         | 17        | 20         |         |
| Age, years     | 46.12±13.88 | 52.15±10.5 | 0.14    |
| Sex, Male/Female | 9/8      | 8/12       | 0.43    |
| Weight, kg     | 62.53±10.58 | 62.93±10.82 | 0.91    |
| Height, cm     | 163.76±7.73 | 162.8±6.01 | 0.68    |
| Leg pain [left/right] | 8/10     | 10/10      | 0.86    |
| Symptom duration, months | 46.52±62.74 | 38.95±48.81 | 0.62    |
| Level fusion   |           |            |         |
| L2/3           | 1         | 0          |         |
| L3/4           | 1         | 1          |         |
| L4/5           | 7         | 8          |         |
| L5/S1          | 8         | 11         |         |
insertion of the cage. Final placement of the cage was confirmed fluoroscopically.

The ipsilateral pedicle screws were placed under direct visualization after complete decompression and fusion. On the contralateral side, 1 incision approximately 5 cm long was made on the skin and lumbodorsal fascia between the longissimus and multifidus muscles to expose the facet joint of the corresponding level, and then pedicle screws were placed under direct visualization. Rods of an adequate size were fitted. The wounds were copiously irrigated, drainage catheters were placed, and the wounds were closed layer by layer.

A midline open approach was used for Open-TLIF, and details of the procedures were previously described [15,22].

**Outcome measures**

We collected data on operation time, intraoperative hemorrhage, hemoglobin, drain removal time, drainage fluid, time to go, and hospital stay after surgery. The drain removal was conducted when the drainage fluid for 24 h was less than 30 ml.

Back and leg pain were evaluated using visual analog scores (VAS) preoperatively and 5 days postoperatively. Intravenous flurbiprofen axetil (50 mg) was used in all patients for 3 days postoperatively, and no patients received painkillers. We used the Oswestry disability index (ODI) version 2.0 before and 5 days after surgery to assess ability to perform activities of daily living. Radiographs were performed to calculate the intervertebral height preoperatively, immediately postoperatively, and 1 month and 3 months postoperatively.

**Statistical analysis**

Statistical analysis was performed using the *t* test for continuous variables or the chi-square test for dichotomous variables. These 2 tests were used to compare the demographic parameters and perioperative and postoperative parameters between the 2 groups. Statistical significance was defined as *P*<0.05.

**Table 1**

|                         | Mis group         | Open group       | P value  |
|-------------------------|-------------------|------------------|----------|
| Operation time, min     | 124.29±21.44      | 106.8±19.24      | 0.01     |
| Intraoperative hemorrhage, ml | 70.59±25.36   | 101.5±38.29      | 0.003    |
| Preoperative hemoglobin, g/L  | 137.24±14.54 | 133.45±16.57     | 0.46     |
| Hemoglobin reduction 1 day after surgery, g/L | 16.00±13.52       | 9.43±9.94       | 0.18     |
| Drain removal time, day  | 2.71±0.47        | 3.10±0.72        | 0.05     |
| Drainage fluid, ml      | 106.18±49.42      | 156.25±63.74     | 0.0004   |

Table 1 demonstrates the baseline characteristics between the Mis group and Open group. There were no significant differences in terms of age, sex, weight, height, leg pain (left/right), and symptom duration between the 2 groups (*p*>0.05). Seventeen patients were recruited in the Mis group, with 1 case in L2/3, 1 case in L3/4, 7 cases in L4/5, and 8 cases in L5/S1. Twenty patients were recruited in the Open group, with 1 case in L3/4, 8 cases in L4/5, and 11 cases in L5/S1.

Significant differences were found in operating time (124.29±21.44 min in Mis group versus 106.8±19.24 in Open group) between the 2 groups (*p*=0.01). Intraoperative hemorrhage was significantly less for Mis group (70.59±25.36 ml) than in the Open group (101.5±38.29 ml, *p*=0.003). However, there was no substantial difference in preoperative hemoglobin, hemoglobin reduction 1 day after surgery, and drain removal time between these 2 groups. Drainage fluid after the surgery was significantly less in the Mis group (106.18±49.42 ml) compared to the Open group (156.25±63.74 ml, *p*=0.0004, Table 2).

Furthermore, patients in the Mis group had shorter time to go (2.35±0.49 days versus 3.15±0.99 days) and hospital stay (3.82±0.73 days versus 4.90±1.07 days) after surgery compared to patients in the Open group (*p*<0.05, Figure 1). None of the patients in the 2 groups require blood transfusions.

Preoperative back VAS was higher in the Mis group than in the Open group (7.06±0.75 versus 6.55±0.76, *p*=0.04). No significant difference was found in terms of preoperative leg VAS between the 2 groups (*p*>0.05). However, on postoperative 3 day, Mis-TLIF patients had significantly lower back pain VAS (2.88±0.33 versus 3.45±0.69, *p*=0.001) and leg pain VAS (2.06±0.66 versus 2.65±0.88, *p*=0.02) compared to the Open-TLIF patients. No significant difference was found in preoperative and postoperative ODI between the 2 groups (*p*>0.05, Table 3).

Patients in the 2 groups had similar preoperative intervertebral heights (9.34±0.94 cm in Mis group and 9.54±1.39 cm in Open group, *p*=0.60). After the TLIF surgery, intervertebral...
height was significantly improved, with no significant difference between the 2 groups (12.38±0.85 cm versus 12.84±1.06 cm, \(P=0.14\), Figure 2). Patients in the 2 groups had comparable intervertebral height postoperatively (3.04±0.82 cm versus 3.30±1.08 cm) and 1 month after surgery (0.64±0.49 cm versus 0.81±0.59 cm (\(P>0.05\), Table 4). At 3 months after the surgery, patients in the Mis group had less reduction in intervertebral height (0.72±0.51 cm versus 2.15±0.31 cm, \(P<0.05\)) than those in the Open group.

**Complications**

Two patients had constipation (1 in each group). In the Open group, 1 patient had cerebral infarction and 1 patient had hepatic dysfunction, and both recovered after standard treatments. There were no dural tears, wound infections, device-related complications (e.g., hardware loosening and cage migration), or neurological injuries in the 2 groups. The total complication rate was 5.9% in the Mis-TLIF group and 15% in the Open-TLIF group.

**Discussion**

Minimally invasive fusion procedures can significantly reduce iatrogenic tissue trauma, and Mis-TLIF surgery is able to preserve the contralateral ligament and paraspinal muscles through the tubular retraction system [23–26]. Minimal muscle dissection and bone removal is associated with decreases in intraoperative bleeding and tissue fluid accumulation, which subsequently reduces incidence of adverse events (e.g., wound...
infection) [27–30]. Many methods have been developed to reduce the risk of wound infection. For instance, in a study comparing the effects of various lavage techniques for posterior lumbar interbody fusion, pulse lavage and closed drainage had much better postoperative infection prevention than traditional saline lavage [31]. Open-TLIF procedures require extensive dissection of paraspinal muscles, which increases intraoperative blood loss, tissue injury, and the risk of complications (e.g., dural tear, infection, and hematomas) [32–34]. Our results also confirm that patients with Mis-TLIF have less intraoperative hemorrhage compared to those with Open-TLIF (P=0.003). The methods of TLIF show no substantial influence on postoperative hemoglobin reduction (P=0.18).

However, the operation time in the Mis group was longer than in the Open group (P=0.01), possibly because the only surgeon in our study just learned to perform Mis-TLIF a short time before, and was in the initial stage of the learning curve. Mis-TLIF procedures are conducted under limited surgical vision and working space, and a relatively long learning curve may be required. A retrospective study revealed that the operative time decreases as the series progressed in 86 patients with degenerative lumbar disease, and an asymptote is reached after 30 cases [35]. Mis-TLIF may be safe and effective after traversing the initial learning curve, and the surgeon experience is remarkably associated with operation time, intraoperative blood loss, and complication rates [36,37].

Decreased intraoperative blood loss and tissue trauma have important benefits for recovery after surgery. The present study found that time to go and hospital stay after surgery were significantly shorter in the Mis group compared to the Open group (P<0.05). Subsequently, Mis-TLIF may reduce costs to patients. Mis-TLIF is reported to reduce the mean hospital cost compared to Open-TLIF [38]. In addition, our study demonstrates that, compared with Open-TLIF, Mis-TLIF results in decreased drainage fluid, but has no influence on the drain removal time.

Minimized tissue trauma and reduced paraspinal muscle dissection are associated with postoperative back pain and ODI scores in Mis-TLIF surgery. Mis-TLIF results in 0.4 points lower for VAS scores of back pain and 2.2 points lower for ODI scores than Open-TLIF [39]. In addition, a study compared unilateral pedicle screw (UPS) and bilateral pedicle screw (BPS) instrumented TLIF in patients with degenerative lumbar disorders, showing similar clinical outcomes between UPS fixation and BPS procedure, and concluding that the UPS technique is superior to BPS procedure in terms of operative time and blood loss, but results in lower fusion rate [40].

Our results reveal that, compared to patients undergoing Open-TLIF, patients undergoing Mis-TLIF had less postoperative back and leg pain (P<0.05), and demonstrate comparable postoperative ODI. The lower leg pain in the Mis group may be due to less traction of nerve roots during the decompression. In contrast, pain intensity was reported to be worse in patients undergoing Mis-TLIF compared to those receiving Open-TLIF [11]. Better VAS and ODI outcomes result from shorter durations of intramuscular pressures and less tissue injury caused by a more experienced surgeon, but long operation time is associated with poor VAS and ODI scores when surgery is performed by surgeons in the early stage of the learning curve [41]. Our study also reveals that Mis-TLIF can provide sufficient recovery and maintenance of intervertebral height postoperatively and at 1 month after surgery compared Open-TLIF, and Mis-TLIF may have better maintenance of intervertebral height at 3 months postoperatively, which may be associated with reduced trauma to paraspinal muscles.

Some clinical trials have reported that Open-TLIF surgery increases the possibility of adjacent-level revision surgery, and Mis-TLIF surgery can preserve the bony structure and soft tissues for the better spine stabilization [16]. A recent meta-analysis suggests that Mis-TLIF surgery entails more in radiation exposure, possibly affecting its efficacy and safety [39]. However, in the present study, we only found 1 additional radiation exposure was needed to accurately mark the facet joints of the corresponding level preoperatively compared to conventional Open-TLIF.

Limitations

Our study has several limitations. Firstly, the number of enrolled patients is small and overestimation of the treatment effect is more likely in smaller trials compared with larger samples. Secondly, this study mainly focused on the short-term parameters that aim to promote the enhanced recovery after surgery, and longer follow-up time is needed to assess the long-term clinical outcomes between the Mis group and Open group. Thirdly, all operations were performed by a single surgeon who was in the early stage of the learning curve, and the results may be different if many surgeons with varying degrees of experience perform the Mis-TLIF procedures.

Conclusions

Mis-TLIF may provide additional benefits to patients with lumbar disk herniation compared to traditional Open-TLIF.

Conflicts of interest

None.
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