



Minimally invasive surgery for degenerative spondylolisthesis: transforaminal or oblique lumbar interbody fusion

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Aim: To compare the outcomes of minimally invasive surgery (MIS) for degenerative spondylolisthesis transforaminal lumbar interbody fusion (TLIF) and oblique lumbar interbody fusion (OLIF). **Materials & methods:** The clinical and surgical characteristics and outcomes of 38 patients with MIS–OLIF and 55 with MIS–TLIF were retrospectively evaluated. **Results:** Procedures and hospital stay were shorter and blood loss was less, with MIS–OLIF than with MIS–TLIF. The clinical and radiographic outcomes were similar. Postoperative changes in disk height and foraminal dimension were greater and patient satisfaction was better with MIS–OLIF than with MIS–TLIF. **Conclusion:** The clinical findings associated with the two procedures were similar; but patients preferred MIS–OLIF, which is less invasive, to MIS–TLIF. Clinical trial registration number: ChiCTR1800019443.

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The prevalence of degenerative spondylolisthesis (DSL) in the general population has been estimated at 5–7% [1]. It leads to failure of the stabilizing system of the functional spinal unit [2]. The treatment options include nonpharmacological conservative treatment, pharmacotherapy and surgery. The choice of surgical treatment may be complicated by having to choose among the available intersomatic arthrodesis procedures [3–6]. Minimally invasive transforaminal lumbar interbody fusion (TLIF), anterior lumbar interbody fusion (ALIF), transposas lateral lumbar interbody fusion and oblique lumbar interbody fusion (OLIF) are available and widely used for the treatment of DSL [5,7–20]. Each of the four procedures have advantages. Previous studies have compared the clinical and radiographic outcomes of minimally invasive surgery (MIS)–OLIF and MIS–ALIF [21–23], MIS–TLIF and MIS–ALIF [24,25]. Few studies in addition to this one have compared the clinical and radiographic outcomes of MIS–TLIF and MIS–OLIF for the treatment of DSL and evaluated the comparative effectiveness.

Methods

A total of 202 patients with DSL and treated between October 2014 and July 2018 were enrolled and evaluated retrospectively. Four senior chief physicians performed the surgical treatment. Sixty-eight patients were treated with MIS–OLIF (OLIF with posterior bilateral percutaneous pedicle screws) and 134 were treated with MIS–TLIF. The inclusion criteria were DSL at L1–L5, at least 18 years of age, presentation with symptomatic Grade I or II DSL at one or two contiguous lumbar levels, and 12-months follow-up. Baseline data collection included demographics and diagnosis. Patients with previous lumbar fusion surgery, spinal metastases or active spinal tumor

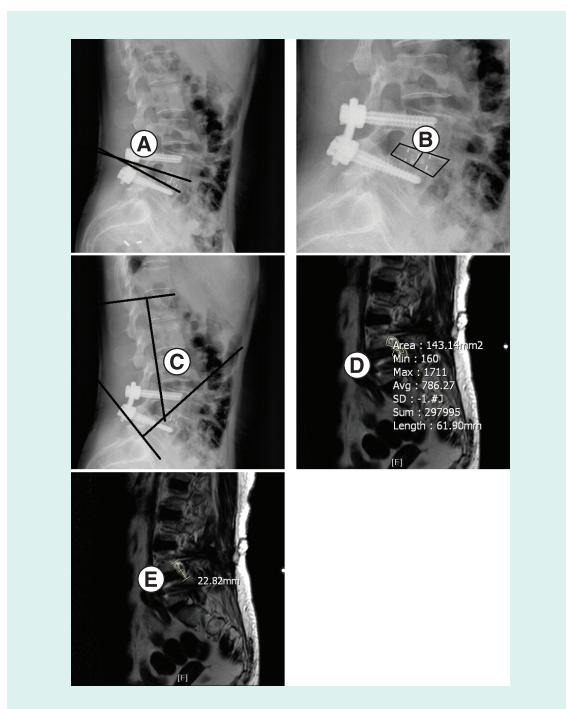


Figure 1. Representative radiographs and magnetic resonance images. (A) Dis angle; (B) dis height; (C) L1-S1 lordosis; (D) foraminal dimension, area; (E) foraminal dimension, height.

malignancy, rheumatoid arthritis or other autoimmune disease, or incomplete follow-up were excluded. Treatment data included the procedure performed, procedure time (including repositioning time), estimated blood loss and length of postoperative hospital stay. Activity levels were collected by patient-completed questionnaires administered preoperatively and postoperatively at 6, 12 and 24 weeks, and 12 months. Patient-reported outcomes were collected at baseline and at each postoperative visit and included the Oswestry Disability Index (ODI), visual analog score (VAS) and patient satisfaction with their outcome. Very satisfied and partially satisfied patients were considered satisfied; very dissatisfied and partially dissatisfied patients were considered dissatisfied. Patients were asked of their willingness to repeat the same surgery with advance knowledge of the clinical outcome. Totally or partially willing patients were considered willing. Totally or partially unwilling patients were considered unwilling [24]. Neurological assessment of motor and sensory function was performed preoperatively and at each postoperative evaluation using a modified American Spinal Injury Association scale. Evidence of restoration, alignment and indirect decompression was collected by radiographs and magnetic resonance imaging at 24 weeks postoperatively (Figure 1). Each measurement was repeated three-times by two independent observers; the mean values were recorded. To reduce error in the estimated size of the intervertebral foramen, differences of the preoperative and postoperative radiographic measurements were divided by the preoperative value (as measurement data).

Statistical analysis

Statistical analysis was performed with SPSS 20.0. Descriptive statistics were calculated and comparative analysis of the MIS-OLIF and MIS-TLIF outcomes was performed using Fisher's exact test and analysis of variance. Paired testing was used to compare the preoperative and postoperative values of the patient variables in the two treatment groups. Statistical significance was defined as $p < 0.05$.

Results

The patient characteristics and treatment outcomes are shown in Table 1. A total of 44 MIS-OLIF levels were treated in the 38 enrolled patients; 32 were single-level and six were two-level cases. Fifty-nine MIS-TLIF levels were treated in 55 patients; 51 were single-level and four were two-level cases. All the patients had DSL with one or more forms of stenosis. Cage height in the MIS-TLIF procedures was 10–12 mm; the width was 25–30 mm. Cage height and width in the MIS-OLIF procedures were 12–14 and 45–55 mm. All cages were from Medtronic Sofamor. There the proportions of patients diagnosed with central, foraminal, of subarticular stenoses in the MIS-OLIF and MIS-TLIF groups were not significantly different. Blood loss, procedure time and hospital stay were all

Table 1. Treatment characteristics and outcomes between MIS OLIF and MIS TLIF.

Treatment characteristics	OLIF (38)	MIS-TLIF (55)	t	p-value
Age (years)	65.29 ± 8.88	60.62 ± 12.37	2.12	0.037
Female	78%	54%	6.866	0.006
N levels treated	2 level:6 1 levels:32	2 level:4 1 levels:51	0.307	0.168
Mean procedure time (min)	90.79 ± 7.93	100.2 ± 14.95	3.935	0.000
Mean hospital stay (day)	5.21 ± 1.26	7.22 ± 1.58	6.523	0.000
Blood loss (ml)	63.95 ± 23.31	186.36 ± 80.19	10.686	0.000
Diagnoses				
Central stenosis	22	17	2.561	0.278
Foraminal stenosis	12	20		
Subarticular stenosis	10	12		
Hip flexion weakness	1	2	1.000	0.637
Distal motor weakness	0	1	1.000	0.591
Sensory deficit (neural)	1	2	1.000	0.637
Patient satisfaction	38	38	14.373	0.000
Willingness to repeat	38	34	18.741	0.000

MIS: Minimally invasive surgery; OLIF: Oblique lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion.

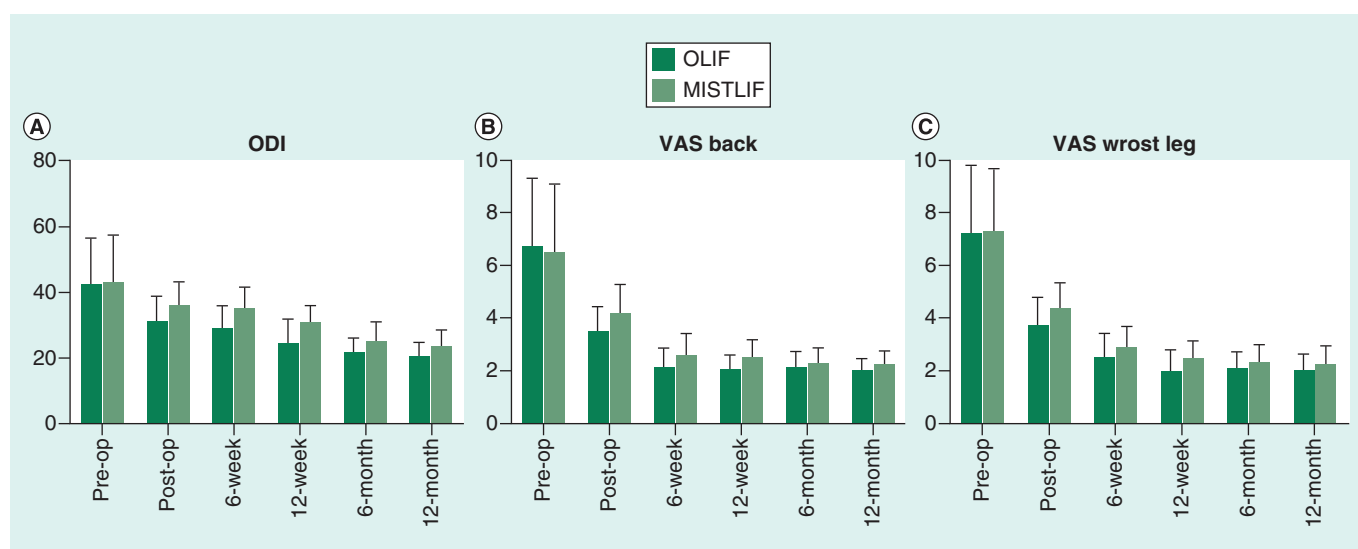


Figure 2. Graphs showing changes over time between the minimally invasive surgery–transforaminal lumbar interbody fusion and OLIF groups. Both groups experienced significant improvements ($p < 0.05$) from baseline to last follow-up and there were no statistically significant differences between the groups ($p > 0.05$).

MIS: Minimally invasive surgery; ODI: Oswestry disability index; OLIF: Oblique lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion; VAS: Visual analog score.

significantly less in the MIS–OLIF than in the MIS–TLIF group ($p < 0.001$). Although the 9-min difference in procedure time was statistically significant, it was not clinically relevant. Procedure-related adverse events included postoperative hip flexion weakness, distal weakness and sensory deficit, and the occurrence was similar in the MIS–OLIF and MIS–TLIF groups. Two patients in the OLIF group experienced hip flexion weakness and one patient experienced sensory deficit that fully resolved by 24 weeks postoperatively. Two patients in the MIS–TLIF group, experienced hip flexion weakness, one experienced distal weakness and two experienced sensory deficit. All the adverse events resolved by 12 months postoperatively. All clinical symptoms, (e.g., back pain, leg pain and OD) were significantly improved in both treatment groups at 12 months after surgery ($p < 0.05$) and the between-group differences were not significant (Figure 2). The radiographic outcomes are shown in Table 2. The

Table 2. Radiographic measures between MIS OLIF and MIS TLIF.

Radiographic measures	MIS-TLIF (32)	OLIF (20)	t	p-value
Dis angle	0.93 ± 1.59	1.55 ± 3.44	0.877	0.385
L1-S1 lordosis	0.05 ± 0.19	0.05 ± 0.21	0.148	0.883
Foraminal dimensions height	0.06 ± 0.25	0.16 ± 0.21	3.763	0.00
Foraminal dimensions area	0.33 ± 0.23	0.59 ± 0.37	2.866	0.007
Dis height	0.13 ± 0.27	0.31 ± 0.57	2.939	0.009*

MIS: Minimally invasive surgery; OLIF: Oblique lumbar interbody fusion; TLIF: transforaminal lumbar interbody fusion.

mean operative level disk height and foraminal dimension were greater in the MIS-OLIF than in the MIS-group. The disk angle and lumbar lordosis (L1–S1 angle) were in the two groups were similar. At 6 weeks after surgery, the patient satisfaction and willingness to undergo the same procedure differed significantly, with patients preferring MIS-OLIF to MIS-TLIF.

Discussion

Previous studies have found that lumbar arthrodesis for the treatment of spondylolisthesis was associated with increased complication rates and that nerve root injury and postoperative nerve adhesions could not be completely prevented [4,26]. OLIF, which involves an oblique channel between the prevertebral venous structures and the psoas muscle was first reported in 2012 [27,28]. In this study, the mean operative blood loss during OLIF was 64 ml, which was similar to that reported by Silvestre [27]. Consistent with previous studies, the mean operative blood loss in MIS-OLIF was less than reported in MIS-TLIF, and can be attributed to indirect decompression and not entering the spinal canal [10,20,29]. Hospital stay was shorter in OLIF than in MIS-TLIF patients because complete resection of the paraspinal and psoas muscles can be achieved in OLIF without disturbing the articular process and allowing more rapid resumption of activity [13]. Restoring sagittal balance and correcting lumbar lordosis are essential for the treatment of lumbar fusion and depend on recovery disk height and angle lumbar lordosis [22,30]. Some studies reported that MIS-TLIF was not effective for the correction of lumbar lordosis, others found that the effect of TLIF on lordosis depended on the degree of shortening of the posterior column [11,12,22,31]. In this study, both MIS-OLIF and MIS-TLIF corrected lumbar lordosis and disk angle because of the large cage that was used with posterior fixation [12,31]. In addition, most patients had single-stage spondylolisthesis. Larger cages were used with MIS-OLIF (width up to 55 mm and height up to 14 mm) than with MIS-TLIF (width of 25–30 mm and height up to 10–12 mm). The wide cage was mounted on the hard epiphyseal ring around the vertebral body rather than the relatively weak area of bone cortex in the central depression of the endplate. Consequently, the disk height, foraminal dimension and area change were all larger in MIS-OLIF than in MIS-TLIF. Disability (ODI) scores and back and leg pain in both MIS-OLIF and MIS-TLIF patients improved significantly from baseline to 24 weeks postoperatively. MIS-OLIF patients experienced 71% improvements in leg and in back pain and 55% improvement in ODI. MIS-TLIF patients experienced 65, 62 and 52% improvements in leg and back pain and ODI, respectively. The study results are consistent with those of Ohtori *et al.*, who reported that MIS-OLIF significantly reduced leg pain from a preoperative VAS of 8.2 ± 2.7 to a postoperative VAS of 1.5 ± 0.80 ($p = 0.005$) and back pain from 9.5 ± 3.5 to 2.3 ± 1.7 ($p = 0.005$) at 1 year.

Hip flexor and distal motor weakness result from psoas muscle function and sensory deficit results from retraction of the associated sensory nerves [23]. In this study, the incidence of hip flexion weakness was 2%, distal motor weakness was not reported and sensory deficit occurred in 2% of MIS-OLIF patients. Hynes reported thigh numbness in 16% and weakness of the hips and quadriceps in 6.5% of patients [32]. Silvestre *et al.* reported lower-extremity sympathetic chain disruption symptoms in 1.7% [27]. Fujibayashi *et al.* reported transient leg weakness in 7.1% and transient numbness in 21.4%, which can be attributed to the small sample size [33]. At present, significant attention has been focused on the surgical experience of the patients, as good surgical experiences provide excellent postoperative clinical results [34–36]. The patients MIS-OLIF patients had 100% satisfaction, significantly better than the MIS-TLIF patients, and were willing to undergo a repeat procedure.

The study limitations included its retrospective single-center design and radiographic follow-up at 24 weeks only. In addition, some radiographic evaluations such as spondylolisthesis, flexion/extension and translation and fusion were not included.

Conclusion

The disk height and foraminal dimension change of the MIS–OLIF group were better than that of the MIS–TLIF group. Disk angle and lumbar lordosis were similar between the two groups. Despite similar clinical findings, the MIS–OLIF group had less blood loss and hospital stay than the MIS–TLIF group. These results suggest that both MIS–OLIF and MIS–TLIF are effective approaches for the treatment of lumbar DSL with stenosis. However, the patients preferred MIS–OLIF (more minimally invasive) to MIS–TLIF.

Future perspective

MIS–OLIF and MIS–TLIF are effective approaches for the treatment of lumbar DSL with stenosis. However, MIS–OLIF (more minimally invasive) will be more popular.

Summary points

- Few studies have compared the clinical and radiographic outcomes of minimally invasive surgery (MIS)–transforaminal lumbar interbody fusion (TLIF) and MIS–oblique lumbar interbody fusion (OLIF) for treatment of degenerative spondylolisthesis.
- This study compared the clinical and radiographic outcomes of and the effectiveness of MIS–TLIF and MIS–OLIF for treatment of degenerative spondylolisthesis.
- Patient and treatment characteristics, patient-reported outcomes, and radiographic outcomes were compared.
- This was a retrospective study.
- Procedure time, blood loss and length of hospital stay were significantly reduced in MIS–OLIF compared with MIS–TLIF patients. Patient-reported outcomes were similar.
- Changes in disc height and foraminal dimension were greater in MIS–OLIF than in the MIS–TLIF patients.
- Patient satisfaction was greater in MIS–OLIF than in MIS–TLIF patients.
- The clinical findings in the two treatment groups were similar, but patients preferred MIS–OLIF (less invasive) to MIS–TLIF.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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Ethical conduct of research

The authors state that they have obtained appropriate institutional review board approval or have followed the principles outlined in the Declaration of Helsinki for all human or animal experimental investigations. In addition, for investigations involving human subjects, informed consent has been obtained from the participants involved.

Data sharing statement

The authors certify that this manuscript reports original clinical trial data. All data are provided in the manuscript.

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