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Original Article

Comparison of short-term efficacy of minimally invasive surgery transforaminal lumbar interbody fusion and posterior lumbar interbody fusion for treating single-segment degenerative lumbar diseases

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Abstract: Objective: To compare the efficiency of Luxor channel-assisted minimally invasive surgery transforaminal lumbar interbody fusion (MIS-TLIF) and posterior lumbar interbody fusion (PLIF) for treating single-segment degenerative lumbar diseases. Methods: Clinical data of 34 patients with single-segment degenerative lumbar disease underwent MIS-TLIF in our hospital were retrospectively analyzed. The operation time, intraoperative blood loss, postoperative drainage volume, postoperative bedtime were recorded and compared with those of 30 patients with the same disease undergoing conventional open PLIF. The low back pain visual analogue score (VAS), Oswestry disability index (ODI) and imaging examination were evaluated before operation and during follow up. Results: There was no significant difference in gender, age, clinical diagnosis, lesion location, and VAS and ODI before operation between the two groups (P>0.05). The operation time was longer in MIS-TLIF group than that in PLIF group (P<0.05), and the intraoperative blood loss, postoperative drainage volume and postoperative bedtime were lower in MIS-TLIF group than those in PLIF group (P<0.01). Both VAS and ODI were lower in MIS-TLIF group than those in PLIF group at month 3 and month 6 after surgery, respectively (P<0.01). The fluoroscopy of lumbar vertebrae during follow-up showed the bony fusion of target level was satisfactory within half a year after surgery in all patients. Conclusion: MIS-TLIF is superior to conventional open PLIF for treating single-segment degenerative lumbar disease at the terms of less intraoperative blood loss, milder muscle damage and low back pain.

Keywords: Spinal diseases, lumbar vertebrae, minimally invasive

Introduction

Posterior lumbar interbody fusion (PLIF) procedure has been widely used for the treatment of degenerative lumbar diseases in the past decades [1, 2]. The procedure was initially popularized by Ralph Cloward for treating lumbar disc herniation [3]. Nowadays, technical challenges have been reported for PLIF and the procedure is reported to be associated with a high risk of complications such as graft dislodgement and pseudarthrosis [4]. Besides, conventional PLIF involves extensive tissue dissection and longtime traction of paraspinal muscles during surgical treatment, coupled with destruction of stability of partial vertebral column, commonly resulting in postoperative chronic low back pain in partial patients, even counteracting the effectiveness of PLIF [5].

Transforaminal lumbar interbody fusion (TLIF), initially described in 1982, offered the same biomechanical results as the PLIF [6]. However, it gains more popularity as it involves less manipulation of neural structures in the graft placement. Recently, various minimally invasive surgeries of spine have been developed and these techniques are reported to show potential advantages [7, 8]. Luxor channel-assisted minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) is one of the minimally invasive surgical approaches. In this study, we investigated the efficiency of MIS-TLIF compared with PLIF for treating patients with single-segment degenerative lumbar diseases by ana-

Table 1. Comparison of demographic and clinical data of patients between PLIF group and MIS-TLIF groups

Variable	PLIF (n=30)	MIS-TLIF (n=34)
Gender (Male/female)	15/15	19/15
Age (year)	57.2±12.1 (39.3~86.0)	53.6±10.3 (30.5~79.5)
Clinical diagnosis		
Lumbar spondylolisthesis	14	20
Lumbar spinal stenosis	8	5
Lumbar intervertebral disc protrusion	8	9
Lesion location (n)		
L3-L4	6	5
L4-L5	15	22
L5-S1	9	7

lyzing the perioperative data, clinical outcome, and radiographic result.

Methods

Patients

Sixty-four patients with single-segment degenerative lumbar disease underwent surgery in our hospital from September 2013 to September 2014 were enrolled in this study. Among these patients, 30 received PLIF (PLIF group), and 34 received Luxor channel-assisted MIS-TLIF (MIS-TLIF group). The patients' demographic and clinical data were shown in **Table 1**. No statistical differentiation was observed between PLIF group and MIS-TLIF group (P>0.05).

The inclusion criteria in this study were as follows: (i) those presented severe low back pain, pain in low back and leg with or without intermittent claudication; (ii) imaging results showed typical single-segment lumbar spondylolisthesis (Grade I or II), lumbar spinal canal stenosis or lumbar disc protrusion (**Figure 1**); and (iii) those showed no obvious improvement after conservative treatment (3-6 months). The exclusion criteria were as follows: (i) those with clinical symptom not completely consistent with the image findings; (ii) patients with multi-segment lumbar disease; (iii) patients with a history of lumbar surgery, bone fracture, tumor or infection; and (iv) patients with other severe systemic disease.

All the surgical operations were performed by sophisticated physicians. Written informed consent was obtained from each patient and their family. The study protocols were proved by the Ethical Committee of Fujian Medical University Union Hospital.

Surgical protocols

Luxor channel-assisted MIS-TLIF: Upon general anesthesia, the patients were asked to lie in the prone position. Anesthesia was performed using midazolam, propofol, cisatracurium and sufentanil. The pedicles of affected lumbar vertebrae were confirmed via preoperative fluoroscopy and the anatomical landmarks were made on the body surface to mark the position of the pedicles. A 3.5 cm-long paramedian incision was made beside the posterior median line. The skin, subcutaneous tissue and lumbodorsae fascia were dissected along the midline of upper and lower pedicles. Afterwards, the guiding needle was inserted to the lateral lamina of vertebra along the space of longissimus and multifidi (**Figure 2**). The cannulation was performed along the guiding needle, and blunt dissection was carried out around the guiding needle. Expansible mini-invasive channel was placed and connected to the free arm for fixation. Subsequently, cold light source was set. After clearance of residual soft tissues, the lamina exterior margin, superior and inferior articular process joints of affected lumbar segment were exposed. Two pedicle screws were placed into the upper and lower vertebral bodies. Briefly, complete decompression was performed after removal of part of the lamina of vertebra, internal margin of articular process, and ligamenta flava. Then the nerve roots and the dural sac were pulled to the internal side, followed by complete removal of intervertebral

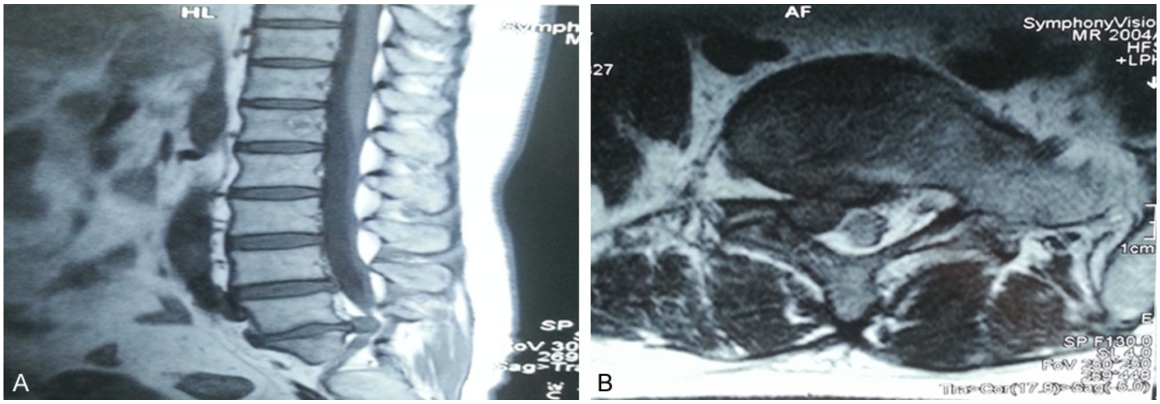

Figure 1. Preoperative MR image (A: Sagittal view; B: Cross section) of a patient with lumbar intervertebral disc protrusion.

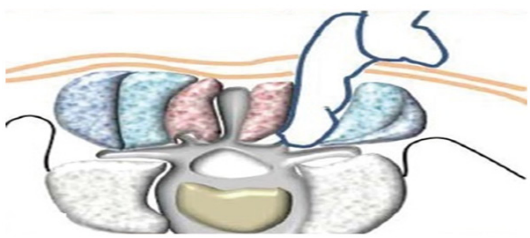

Figure 2. Illustration of the surgical approach of MIS-TLIF.

discs and cartilage end plates. Afterwards, a cage with appropriate height was inserted into the intervertebral space. For the patients with bilateral lesions, decompression was performed at the opposite side. For patients with lesions in single side, only internal fixation was performed using screws. The zygapophysial joints should be relaxed at first for the patients with lumbar spondylolisthesis, followed by insertion of cages to expand the intervertebral space. If no reposition occurred, long-arm pedicles were used. Finally, the nails were connected using the titanium bar for the fixation.

Conventional PLIF: The procedures of PLIF were similar like that of MIS-TLIF except few aspects. PLIF was performed as previously described [5]. Briefly, after anesthesia, fluoroscopy was used to check the appropriate level. A median incision was made to expose the affected segments after separation of muscular tissues. Subsequently, complete decompression was performed after removal of the spinous process, part of the lamina of vertebra, hypertrophic ligamenta flava in the superior vertebral bodies in the intervertebral space and inner margins of the superior articular process in the inferior vertebral bodies.

Evaluation parameters

The operation time, intraoperative blood loss, postoperative drainage volume, and postoperative bedtime were recorded and compared between the patients in PLIF group and MIS-TLIF group. The visual analogue score (VAS) and the Oswestry disability index (ODI) were assessed before surgery and at month 3 and 6 after surgery. The follow-up time was 6-15 months (mean 10.3 months). The fluoroscopy of lumbar vertebrae was performed for each patient during follow-up.

Statistical analysis

SPSS software 16.0 (Chicago, IL, USA) was used for statistical analysis. Data were expressed by mean ± standard deviation. Comparison between groups was carried out based on Student's t test. An analysis of variance was done for the comparison among different time points in each group. Chi square test was performed for ratio comparison. $P<0.05$ was considered statistically significant.

Results

Comparison of perioperative parameters in PLIF group and MIS-TLIF group

Compared with the PLIF group, remarkable increase was noticed in the operation time in the MIS-TLIF group (153±22 min vs. 130±21 min, $P<0.01$). The intraoperative bleeding vol-

Table 2. Comparison of VAS and ODI between PLIF group and MIS-TLIF group before and after operation

	Variable	PLIF (n=30)	MIS-TLIF (n=34)
VAS	Before surgery	6.6±1.2	6.6±1.0
	Month 3 after surgery	3.0±0.7☆	2.2±0.9☆,Δ
	Month 6 after surgery	1.7±0.9☆	2.7±0.8☆,Δ
ODI	Before surgery	59.3±11.4	59.6±9.5
	Month 3 after surgery	30.3±7.4☆	20.5±9.0☆,Δ
	Month 6 after surgery	28.5±6.6☆	19.2±8.3☆,Δ

☆P<0.01, compared with preoperative results within group; ΔP<0.01, compared with the PLIF group in the same period.

ume in the MIS-TLIF group was obviously decreased compared with that of the PLIF group (199±145 mL vs 356±214 mL, P<0.01). Moreover, postoperative drainage volume and postoperative bedtime were significantly lower in MIS-TLIF group than those in PLIF group (drainage volume, 74±63 mL vs 530±174 mL, P<0.01; bedtime, 4.1±1.1 d vs 7.0±1.0 d, P<0.01).

Comparison of VAS and ODI in PLIF group and MIS-TLIF group

No statistical significance was observed in the VAS and ODI between MIS-TLIF group and PLIF group at the baseline levels (P>0.05). Whereas, significant decrease was noticed in the VAS and ODI at month 3 and 6 compared with those of the baseline levels in the PLIF group (P<0.01) and MIS-TLIF group (P<0.01), respectively. Compared with the VAS and ODI in the PLIF group, obvious decrease was noted in the MIS-TLIF group at month 3 and month 6 after surgery, respectively (P<0.01, **Table 2**).

Fusion comparison in the PLIF group and MIS-TLIF group

The bony fusion of target level was satisfactory within half a year after the surgery in all patients (**Figure 3**). No remarkable difference was noticed in the fusion in the PLIF group compared with that of MIS-TLIF group.

Discussion

PLIF with pedicle screw has recently been commonly used as an effective surgical method for treating lumbar pathologies such as spondylolisthesis and lubar intervertebral disc protrusion [9]. However, such procedure is also reported to trigger surgery related complications named failed back surgery syndrome manifested as chronic pain in muscles in lumbar and low back, fatigue and tardive destabilization [10]. These conditions were reported to be related to the excessive exposure of parasinal muscle in the surgery. To overcome such challenge, extensive efforts have been made, among which MIS-TLIF is a common procedure served as an effective method. During the MIS-TLIF, the space between longissimus and mulifidi was expanded via the paraspinal muscle space to avoid the excessive separation and traction in the surgery. In this study, we investigated the efficiency of PLIF and MIS-TLIF for treating single-segment lumbar degenerative disc disease at the terms of operation time, blood loss, and outcomes.

Operation time is an important parameter in the MIS-TLIF and PLIF. Nowadays, no consensus have been achieved on the effects of operation time on the treatment efficiency in both procedures [11]. Previously, TLIF has been considered to show excellent exposure with satisfactory outcome in 24 patients [12]. In this study, expansive channel was placed through the space between longissimus and multifidi in the MIS-TLIF group, and the affected lumbar segment was quickly exposed with blunt dissection. Thus, the exposure time of surgical field should be theoretically much shorter in MIS-TLIF compared with that in traditional PLIF. However, the results showed that MIS-TLIF spent more operation time. This may be related with the smaller surgical field during spinal decompression and fusion, limited visual field of assistant, and difficult co-operation of surgeon and assistant. In the future, we believe that the operation time would be shorter along with the increased surgical experience and improved technique. In addition, computer guidance system can be used to assist the minimally invasive surgery in order to make up the disadvantage of limited surgical field in MIS-TLIF. Besides, the complications will be decreased with shortening of operation time [13].

Indeed, PLIF contributed to the increase of fusion rate in patients, however, this technique was fraught with complications related to intraoperative blood loss [5, 14]. In our study, the intraoperative blood loss and postoperative drainage volume were significantly lower in

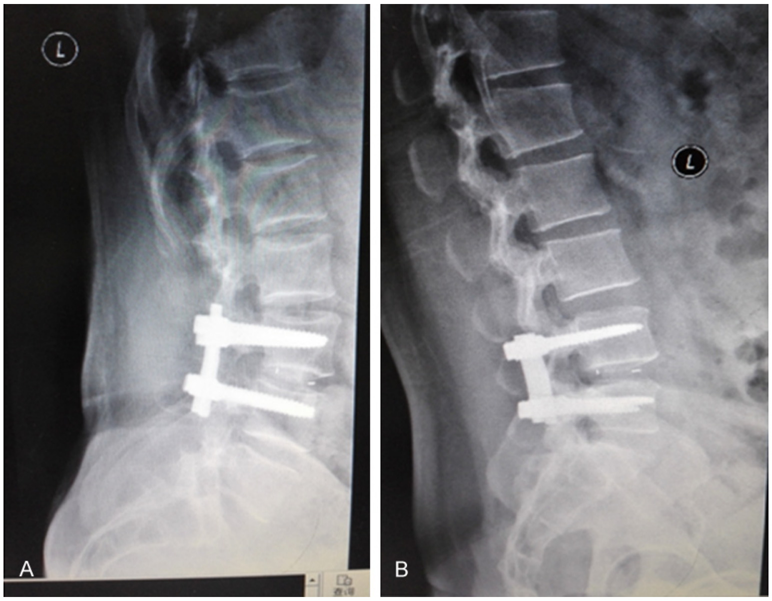

Figure 3. Imaging findings of lateral projection of lumbar vertebrae at 6 months after PLIF (A) and MIS-TLIF (B). The surgery was performed at L4-L5 which showed satisfactory fusion in both procedures.

MIS-TLIF group compared with that in PLIF group. The speculative reasons were as follows: MIS-TLIF avoided the extensive dissection of paraspinal muscle, and the arrangement of muscle fiber was not significantly changed when bracing the spatium intermusculare using minimally invasive channel. The decreased muscle damages contributed to the reduction of the intraoperative blood loss. In addition, the trauma sites could nearly be closed without extra treatment with the postoperative reposition of paraspinal muscle, and the postoperative exudation volume was reduced in would surface. Moreover, the soft tissue injury beside the lumbar vertebrae was mild in MIS-TLIF. Therefore, the postoperative drainage volume was less in MIS-TLIF group compared with that of the PLIF group.

Nowadays, there is no consensus on whether there is any difference in the VAS and ODI in patients received TLIF or PLIF. In a meta analysis [15], Yin et al revealed no statistical difference was observed in the VAS and ODI in patients underwent PLIF and TLIF. However, in another Meta-analysis, Khan et al indicated a decrease in late VAS-back scores MIS-TLIF ($P < .001$), but no differences were found in early VAS-back, early ODI, and late ODI [16]. Our study demonstrated that both VAS and ODI were obviously lower in MIS-TLIF group than those in PLIF group at month 3 and month 6 after surgery, respectively. Also, the postoperative ambulation was earlier in MIS-TLIF group. These results hinted that MIS-TLIF could protect the vulnerable lumbar stability, reduce the low back pain at early stage after surgery, and improve the lumbar function.

It was difficult to avoid the damage of posterior column instruction, such as spinous process, supraspinal ligament and interspinal ligament during PLIF. Multifidi, transversospinales and interspinales were important muscles for the lumbar stability. However, the extensive dissection of these paraspinal muscles was necessary in PLIF. Besides, the continuous traction of paraspinal muscles during surgery might damage the branch of lumbar nerve, resulting in postoperative myoedema, necrosis and denervation of paraspinal muscle. Furthermore, this procedure may lead to dysfunction of low back at early stage after surgery or permanent dysfunction. Whereas, MIS-TLIF preserved the integrity of paraspinal muscles and posterior column, and the possibility of injuring lumbar nerve was rare, which was beneficial for the early functional rehabilitation of lumbar vertebrae after surgery [17-19]. Taken together, it is reasonable to conclude that MIS-TLIF is superior to PLIF at the terms of protecting the anatomical structure of lumbar vertebrae and nerve system.

Compared with PLIF, MIS-TLIF are technically demanding and also requires a long learning curve for mastering the technique. At early stage of learning MIS-TLIF, some complications may present, such as rupture of dural sac and nervous damage [20]. Otherwise, surgical indication should be strictly controlled. Degenerative lumbar diseases associated with 3 lumbar segments or more should be treated with traditional open approach. When combines with central lumbar spinal stenosis, MIS-TLIF is also not recommended. Further more, it is inadvisable to pursuit small incision although MIS-TLIF is minimally invasive. If the skin incision was too small, the extensive stretch strength of subcutaneous tissue and muscles was developed by expander of minimally invasive channel, which was apt to result in necrosis of skin incisal margin and muscle damage.

In conclusion, compared with conventional PLIF, MIS-TLIF technique contributed to reliable clinical efficacy with less damage, less bleeding, quicker recovery and better function after surgery. In future, further studies are needed to confirm the long-term efficacy with large-sample study and long-term clinical follow up.

Disclosure of conflict of interest

None.

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