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Comparison of clinical outcomes and spino-pelvic sagittal balance in degenerative lumbar spondylolisthesis

Minimally invasive oblique lumbar interbody fusion (OLIF) versus transforaminal lumbar interbody fusion (TLIF)

Renjie Li, MD, Xiaofeng Shao, MD, Xuefeng Li, PhD, Yijie Liu, MD, Weimin Jiang, PhD*

Abstract

Spino-pelvic sagittal parameters are closely related to the lumbar degenerative diseases. The present study aims to compare clinical results and spino-pelvic sagittal balance treated with oblique lumbar interbody fusion (OLIF) and transforaminal lumbar interbody fusion (TLIF) in patients with degenerative lumbar spondylolisthesis at single segment.

We retrospectively reviewed and compared 28 patients who underwent OLIF (OLIF group) and 35 who underwent TLIF (TLIF group). Radiological results were evaluated with disc height (DH), foraminal height (FH), fused segment lordosis (FSL), lumbar lordosis (LL), pelvic tilt (PT), pelvic incidence (PI), and sacral slope (SS). Clinical results were evaluated with the Oswestry Disability Index (ODI) and VAS for back and leg pain.

The OLIF group showed higher improvement of DH and FH than the TLIF group at all time points after surgery ($P<.05$). No significant differences were found in PT, PI, and SS between the 2 groups ($P>.05$). Significant restoration of spino-pelvic sagittal balance was observed in the 2 groups after surgery. Significant differences in postoperative lumbar lordosis and fused segment lordosis were found between the 2 groups ($P<.05$). Significant difference in the improvement of symptoms was observed between the 2 groups. The OLIF group had lower VAS scores for back pain and ODI compared after surgery ($P<.05$).

It can be concluded that there are exactly differences in improvement of radiographic parameters between 2 approaches, which confirmed that OLIF is better in restoring spinal alignment. Besides, due to the unique minimally invasive approach, OLIF did exhibit a greater advantage in early recovery after surgery.

Abbreviations: BP = back pain, CSF = cerebrospinal fluid, DH = disc height, FH = foraminal height, FSL = fused segment lordosis, LL = lumbar lordosis, LP = leg pain, ODI = Oswestry Disability Index, OLIF = oblique lumbar interbody fusion, PLIF = posterior lumbar interbody fusion, TLIF = transforaminal lumbar interbody fusion.

Keywords: chronic low back pain, lumbar spondylolisthesis, oblique lumbar interbody fusion, sagittal alignment, transforaminal lumbar interbody fusion

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The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Department of Orthopaedics, The First Affiliated Hospital of Soochow University, 188 Shizi Street, Suzhou, Jiangsu Province 215006, China.

** Correspondence: Weimin Jiang, Department of Orthopaedics, The First Affiliated Hospital of Soochow University, 188 Shizi Street, Suzhou, Jiangsu Province 215006, China (e-mail: jwmspine2@sina.com).*

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Key Points

- We retrospectively compared the spino-pelvic sagittal parameters between OLIF group and TLIF group for treatment of spondylolisthesis with single segment.
- No difference was found in long-term clinical outcomes between the OLIF and TLIF group.
- Differences were did exist in improvement of radiographic parameters between 2 surgery approaches.

1. Introduction

Lumbar spondylolisthesis is a common pathology accompanied with lumbar canal stenosis, displaying a certain degenerative imbalance and thus presenting risk factor for degenerative scoliosis in later life. Symptoms of lumbar spondylolisthesis may include intermittent neurogenic claudication, lumbar radiculopathy, and back pain.[25] The primary treatment for lumbar spondylolisthesis is non-surgical. When unsuccessful, surgery can be considered in order to decompress neural structures and stabilize the spine. This is due to conservative treatment options being relatively inferior, thus indicating that surgical treatments offer a more meaningful approach.[5] Lumbar fusion has become an accepted treatment to treat degenerative diseases of the lumbar spine.[29] There is a growing body of evidence that consistently demonstrates improved clinical outcomes with lumbar fusions for patients who fail conservative care.[2] Transforaminal lumbar interbody fusion (TLIF) is a variant of the posterior lumbar interbody fusion (PLIF) technique described by Cloward in the 1950s,[4] which is one of the widely used techniques for spinal fusion. It is usually performed by unilateral approach preserving the contralateral lamina, which can be used as a site for additional fusion. Compared with PLIF, TLIF retains ligamentous complex, contralateral lamina, and facet joints, thus maintaining spinal stability.[1,9] The first attempt for TLIF was by Harms and Rolinger, who reported on the use of bone graft packed in titanium mesh that was inserted via a unilateral transforaminal route into the anterior part of the disc space. Harms and Blumes developed the TLIF technique further, and Harms described this in detail together with Jeszensky in 1998.[4,7,8] It is a posterior approach that uses a facetectomy corridor and has benefits of safety, good outcomes, and high fusion rate. Surgeons prefer this approach because they can reduce dural retraction and enable direct neural decompression. However, characteristic complications include posterior spinal muscle injury and cerebrospinal fluid (CSF) leakage.[11,20] The oblique lumbar interbody fusion (OLIF) was first described by Mayer et al in 1997,[16] and the term was later coined by Silvestre et al in 2012. This approach aims to avoid the morbidity of the transpsoas approach by translating the incision anteriorly and dissecting around the psoas.[16,23] It is applicable to degenerative lumbar spine diseases, spinal tuberculosis, revision, etc. OLIF conforms to the current trend of minimally invasive spinal surgery, which has many advantages like less surgical trauma, less surgical bleeding loss, shorter hospital stay, etc.[14,27]

Spino-pelvic sagittal parameters are closely related to the lumbar degenerative diseases. The present study aims to compare clinical results and spino-pelvic sagittal balance treated with OLIF and TLIF in patients with degenerative lumbar spondylolisthesis at single segment.

2. Materials and methods

2.1. Patient population

The study was conducted as a retrospective investigation of 71 patients who underwent TLIF (TLIF group) or OLIF (OLIF group) in First affiliated hospital of Soochow university from January 2018 to October 2019. Informed written consent was obtained from all individual participants. Among the 71 patients, 8 were lost to follow-up. Finally, a total of 63 patients (15 males and 48 females) were included in this study. Among them, 28 patients underwent OLIF (OLIF group) and 35 patients underwent TLIF (TLIF group). All patients were performed for a single lumbar level and they had complaints of low back pain and lower limb pain unresponsive to conservative therapy for over 6 months, radicular symptom, and/or intermittent claudication before the operation. Preoperative examination included a detailed physical examination and radiological imaging. The health records and radiographic data of the 63 patients were summarized and analyzed.

The indications of OLIF were as follows: type I and II lumbar spondylolisthesis, lumbar instability, discogenic low back pain, lumbar degenerative scoliosis, mild-to-moderate spinal stenosis, lumbar tuberculosis, and revision. The indications of transforaminal lumbar interbody fusion include nearly all kinds of lumbar degenerative disease except for extensive epidural scar, arachnoiditis, acute infection, and severe osteoporosis.

The inclusion criteria were as follows:

(1) X-ray and computed tomography (CT) showing lumbar spondylolisthesis (grade I, II) at 1 lumbar level;
(2) symptoms of low back pain and lower limb pain unresponsive to conservative therapy for over 6 months;
(3) the follow-up time over 6 months.

The exclusion criteria were as follows:

(1) degenerative spondylolisthesis with grade II above;
(2) multi-segment lumbar spondylolisthesis;
(3) spinal tumor, severe lumbar spinal stenosis, spinal infections, and acute vertebrae fractures.

This study was reviewed and approved by the Ethics Committee of the First Affiliated Hospital of Soochow University.

2.2. Operative procedure

2.2.1. Oblique lumbar interbody fusion. After induction of general anesthesia, the patient was placed in lateral decubitus position on the right side. The operating segment was marked on the skin via a C-arm machine. A 5 cm skin incision was made on the marked disc level at the left abdomen. Then carry out blunt finger dissection of the abdominal oblique muscles, which includes the external oblique, internal oblique, and transversalis abdominis muscles. The surgeon uses the index finger to confirm the anterior border of the psoas muscle, sliding from the quadratus lumborum muscle to reach there. The retroperitoneal space was accessed by blunt dissection and the peritoneal content was mobilized anteriorly. Place a Kirschner wire into the disc space from the anterolateral corner to confirm the target disc space again. Sequential dilators were placed over the Kirschner wire. After the final tubular retractor was placed over the anterior one-third of the disk under illumination, the entire visualized area was made clearly. A lateral annulotomy was performed followed by a complete discectomy by using pituitary rongeurs and curettes, then removing the focus by using curette. After that, an appropriate-sized cage filled with autologous bone graft was inserted orthogonally in a press-fit fashion into the disc spaces. The above procedures were done step by step under C-arm fluoroscopic guidance. Anterolateral screws were placed into the vertebral bodies (Fig. 1).

2.2.2. Transforaminal lumbar interbody fusion. After induction of general anesthesia, the patient was placed in a prone position on a carbon table. Then mark the target level under the C-arm guidance. A midline incision was made. The skin and subcutaneous tissue were incised layer by layer and the paravertebral muscles were dissected from the spine. Pedicle screw-rod was inserted bilaterally. The facet joint and part of the vertebral lamina were removed by osteotome and the disk was then removed. After resection of ligamentum flavum and osteophyte, a cage filled with autologous bone was inserted in the disc space. The wound was copiously irrigated and closed in layers (Fig. 2).

2.3. Assessment of clinical and radiographic outcomes

The duration of the operation, volume of intraoperative hemorrhage, length of bed rest, length of hospital stay, and

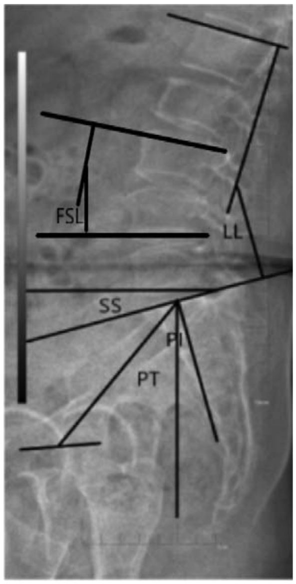

Figure 1. Measurements of radiological parameters. FSL = fused segment lordosis, LL = lumbar lordosis, PI = pelvic incidence, PT = pelvic tilt, SS = sacral slope.

complications were recorded for all patients. Clinical and radiographic outcomes were evaluated preoperatively and at 1 week, 3 months, and 6 months postoperatively. Data of lost to follow-up were excluded. We used the visual analog scale (VAS) for leg pain (VAS-LP) and back pain (VAS-BP) and the Oswestry Disability Index (ODI) to compare clinical outcomes between the 2 groups. Lumbar lordosis (LL), disc height (DH), foraminal height (FH), pelvic tilt (PT), pelvic incidence (PI), and sacral slope (SS) were used to compare radiographic outcomes between the 2 groups. LL was defined as the angle between the upper endplate of the L1 and S1 vertebra using the Cobb method. DH was calculated as the mean value of the anterior and posterior margin heights of the affected disc. FH was measured as the maximal interval between the lower border of the upper pedicle and the upper border of the lower pedicle. Pelvic incidence (PI) was formed by the line vertical to the midpoint of sacral plate and the line between the midpoint of the sacral plate of S1 and the center of the hip joint. Pelvic tilt (PT) was defined as the angle between the line connecting the midpoint of the sacral endplate with the axis of femoral heads and the vertical line. Sacral slope (SS) was defined as the angle formed between the upper endplate of S1 and the horizontal line. Two observations were made at an interval of at least 2 weeks by 2 orthopedic surgeons, and the mean values were used for the study (Fig. 3).

2.4. Statistical analysis

The data analysis was performed by Statistical Package for the Social Sciences (version 19.0 SPSS, Chicage, IL) and Microsfot Excel 2016 (Microsoft, Seattle, WA). All quantitative variables are presented as means ± standard deviations. The differences of demographics between the 2 groups were assessed by using Chi-square test. Student's t test and the Chi-square test were used to compare radiological and clinical outcomes of OLIF and TLIF. $P < .05$ was considered to indicate significant difference.

3. Results

No significant differences were found between the 2 groups in terms of baseline patient characteristics, including age, sex, body mass index, and operated levels (Table 1). The operative duration was shorter and intra-operative hemorrhage was less in the OLIF group compared with the TLIF group (186.44 ± 36.5 vs 199 ± 59.64 min; 55.94 ± 57.37 vs 190 ± 66.33 ml; respectively). The OLIF group had a shorter bed rest time and shorter hospital stay than did the TLIF group ($P < .05$) (Table 1). VAS scores of both groups decreased postoperatively (Table 2). No significant differences in VAS-BP scores were found at preoperative and postoperative 3 months between the 2 groups ($P > .05$). Statistical difference was found at 1 week after surgery ($P < .05$). No significant differences in VAS-LP scores were found at any follow-up time. Preoperative ODI were 54.88 ± 8.13 and 53.93 ± 6.06 points in the OLIF and TLIF groups, respectively ($P > .05$), which both decreased postoperatively. No significant differences in ODI scores were found at preoperative and postoperative 3 months between the 2 groups ($P > .05$). Statistical difference was found at 1 week after surgery ($P < .05$). No significant differences in DH and FH between the 2 groups were seen preoperatively ($P > .05$). The postoperative FH and DH were significantly greater than the preoperative value in each group ($P < .01$). The postoperative DH was significantly greater in the OLIF group than in the TLIF group ($P < .01$). The postoperative FH and DH was significantly greater than the preoperative value in each

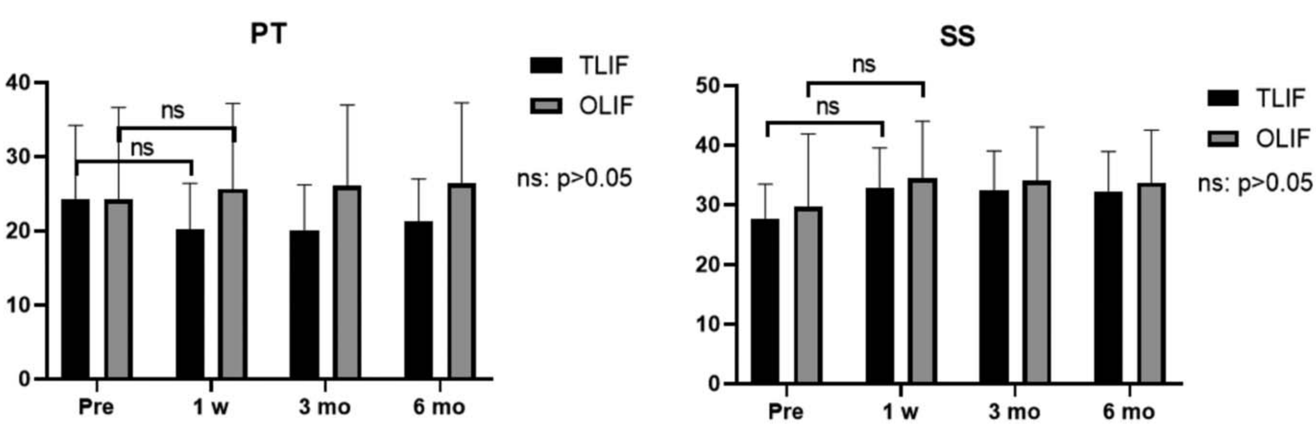

Figure 2. Comparison of spino-pelvic sagittal balance in 2 surgical approaches were shown in the following pictures.

Figure 3. The lateral X-ray radiograph and sagittal-computed tomographic scan (a and b) showed the patient suffered from degenerative spondylolisthesis at the L4 level. The sagittal T2-weighted magnetic resonance image (c) showed the segment of herniation (L4–5) compressed the spinal cord, and the disc signal was changed. The lateral X-ray postoperatively showed oblique lumbar interbody fusion (OLIF) at the target level and the screws were inserted anterolaterally.

group ($P<.05$). The OLIF showed higher DH and FH than the TLIF group at all time points after surgery ($P<.05$) (Table 3). There was no statistical difference found in LL and fused segment lordosis (FSL) between the 2 groups before surgery ($P>.05$), but the recovery of LL and FSL in OLIF group was significantly greater than that in TLIF group ($P>.05$). No significant difference was found in the spino-pelvic sagittal balance parameters between pre- and postoperative in 2 groups ($P>.05$). For patients in TLIF group with a combination of supplemental fixation at a given level, there was 8.6% (3 of 35) rate of cage subsidence. Of the 3 patients with radiographic subsidence, only 1 was symptomatic. Besides, for patients in OLIF group with a combination of anterolateral screws, there was 7.1% (2 of 28) of cage subsidence.

In the OLIF group, 1 patient experienced the postoperative ileus and improved spontaneously in the next several days. One patient experienced thigh and numbness postoperatively, which alleviated within 7 days after surgery. There was no ureteral injury or lesion to sympathetic chain. In the TLIF group, CSF leakage due to thecal sac injury and root injury was confirmed in 3 cases. The drainage tube was removed 7 days after the operation. Superficial incision infection occurred in 3 patients in the TLIF group, which was treated with dressing change and antibiotics.

Table 1

Preoperative patient data and operative details in the 2 groups undergoing different surgical approach.

Demographic	OLIF	TLIF	*P*
Cases	28	35	–
Age (yr)	57.5±10.4	59.3±9.86	.64
Sex (male/female)	7/21	8/27	.44
Blood loss (ml)	55.94±57.37	190±66.33	**$2.53\times10^{-6*}$**
Operative time (min)	186.44±36.5	199±59.64	.496
Bed rest time (d)	2.81±1.24	3.67±0.79	**.036***
LOS (d)	7.06±2.51	12.87±2.60	**$1.18\times10^{-6*}$**
BMI (kg/m^2)	25.29±3.15	23.66±2.38	.128
Smoking	5	4	.469
Diabetes mellitus (n)	2	6	.236
COPD (n)	1	0	.260
CCI	2.3125±0.68	3.07±1.18	**.043***
Slipped segment	L3 (n=3) L4 (n=25)	L3 (n=1) L4 (n=29) L5(n=5)	–
Spondylolisthesis grade	I° (n=12) II° (n=16)	I° (n=19) II° (n=16)	–

CCD=chronic cardiovascular disease, CCI=Charlson comorbidity index, COPD=chronic obstructive pulmonary disease, LOS=length of hospital stay, OLIF=oblique lumbar interbody fusion, TLIF=transforaminal lumbar interbody fusion.

Table 2

The outcomes of clinical parameters measured before and during follow-up.

	OLIF	TLIF	*P*
VAS (back pain)			
Pre-op	7.19±1.56	7.33±1.54	.795
Post-op 1 wk	2.44±0.81	3.87±1.60	**.004***
Post-op 3 mo	0.44±0.51	0.47±0.52	.875
VAS (leg pain)			
Pre-op	6.5±0.97	6.67±1.29	.686
Post-op 1 wk	2.88±0.81	2.93±0.80	.841
Post-op 3 mo	0.38±0.48	0.60±0.49	.224
ODI, %			
Pre-op	54.88±8.13	53.93±6.06	.719
Post-op 1 wk	22.44±2.61	28.13±2.07	**$2.30\times10^{-6*}$**
Post-op 3 mo	17.06±1.29	18.00±1.77	.101

ODI=Oswestry Disability Index, OLIF=oblique lumbar interbody fusion, TLIF=transforaminal lumbar interbody fusion.

Table 3

The outcomes of radiological parameters measured before and during follow-up.

	OLIF	TLIF	*P*
SP%			
Pre-op	26±5.25	26.47±6.08	.826
Post-op 1 wk	14.03±4.47	16.2±4.79	.217
Post-op 3 mo	14.43±4.11	17.13±4.05	.063
Post-op 6 mo	14.49±4.13	17.2±4.02	.064
DH			
Pre-op	8.96±2.11	7.37±2.28	.059
Post-op 1 wk	13.48±1.95	11.50±1.26	**.002***
Post-op 3 mo	12.52±1.95	10.65±12.45	**.006***
Post-op 6 mo	12.45±1.91	10.58±1.26	**.005***
FH			
Pre-op	15.93±2.84	15.84±2.35	.926
Post-op 1 wk	19.75±2.50	17.85±2.36	**.045***
Post-op 3 mo	19.23±2.47	17.37±2.31	**.045***
Post-op 6 mo	19.13±2.38	17.20±2.32	**.035***
Cage subsidence			
Post-op 3 mo	2/28 (7.1%)	3/35 (8.6%)	.84

DH = disc height, FH = foraminal height, OLIF = oblique lumbar interbody fusion, Post = postoperative, Pre = preoperative, SP = slip percentage, TLIF = transforaminal lumbar interbody fusion.

4. Discussion

With the acceleration of population aging process, the number of patients with low back pain caused by lumbar degenerative disease is also increasing. Pelvic sagittal balance plays an important role in maintaining the spinal alignment, which may worsen with the degenerative process. The spino-pelvic sagittal parameters will be changed to compensate for the sagittal imbalance caused by lumbar degenerative disease, resulting in symptoms of low back pain. Recently, surgery approaches of treating spondylolisthesis have increased because of the growing demand for enhanced quality of life and improved surgical techniques. In this study, the mean operative blood loss during OLIF was 57.5±10.4 ml, which was smaller to that recorded in TLIF group. What's more, the mean bed rest time and length of hospital stay in OLIF group were shorter than that in TLIF group because of preservation of the paraspinal muscles can be achieved in OLIF without disturbing the articular process. The ODI scores and back and leg pain in both 2 groups improved significantly after surgery. Statistical difference can be found in clinical outcomes at 1 week after surgery. Compared with the TLIF group, OLIF group experienced 4.75±1.15 improvement in VP and 37.81±7.59 improvement in ODI at 1 week after surgery, respectively.

The statistical data in our study showed that the LL, SS all improved, and PT decreased instead after surgery in both groups, which is conformed to the study reported by Xiao.[25] However, no statistical differences were observed pre- and postoperatively in the 2 groups (Fig. 4). It has been reported that no significant improvement was found in lumbar lordosis in TLIF.[21] However, the lumbar lordosis (LL) recovered significantly in both groups in our study. We noted that the TLIF was effective in restoring normal lumbar lordosis, which is probably because that we place the interbody graft as anterior as possible to maximize the lordotic potential, and it is within the construct in combination with compression from the posterior column. Other studies show that the effect of TLIF in restoring normal lumbar lordosis depends on compression of posterior structure of the lumbar vertebrae.[10] Several literatures demonstrated that LL is restored well in lateral lumbar interbody fusion. Thus far, we expect that OLIF will do better in deformity correction. Luckily, differences were found in LL in 2 groups after surgery. In OLIF group, the mean improved Cobb angle is larger than that of TLIF, demonstrating that the correction in lumbar lordosis is better in OLIF. Kepler et al[12] demonstrated that more lumbar lordosis

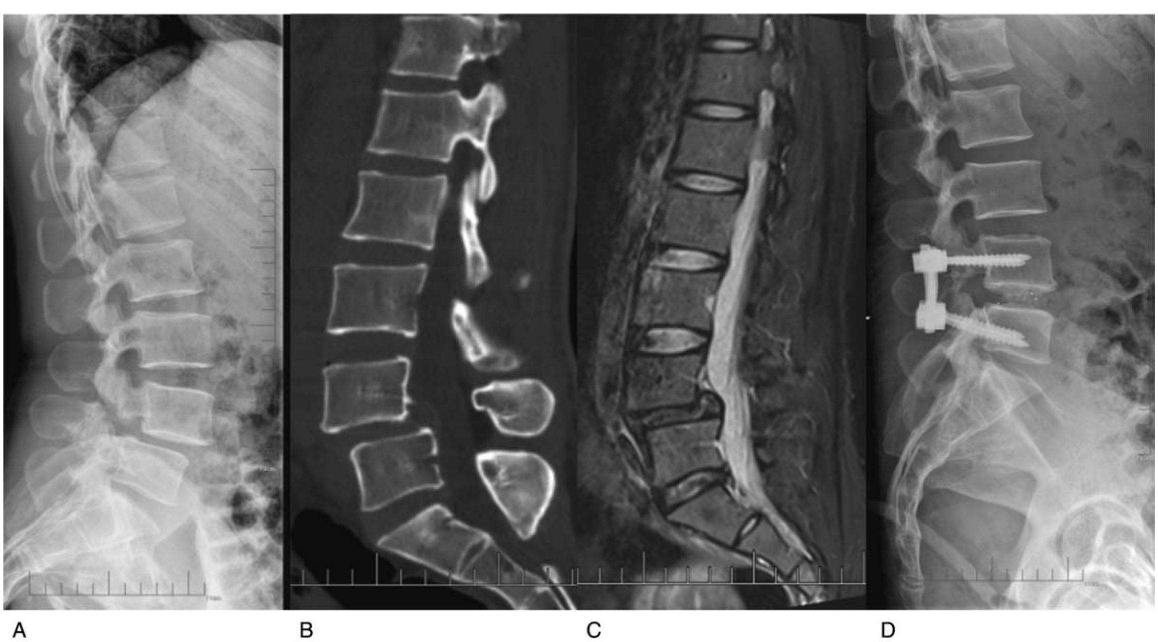

Figure 4. The lateral X-ray radiograph and sagittal-computed tomographic scan (a and b) showed that the patient suffered from degenerative spondylolisthesis at the L4 level. The sagittal T2-weighted magnetic resonance image (c) showed the segment of herniation (L4–5) compressed the spinal cord, and the disc signal was changed. The lateral X-ray postoperatively showed transforminal lumbar interbody fusion (TLIF) at the target level.

Table 4

Comparison of spino-pelvic sagittal balance parameters between 2 groups.

	OLIF	TLIF	P
PI°			
Pre-op	54.67 ± 8.49	53.27 ± 6.36	.817
Post-op 1 wk	56.19 ± 8.94	58.58 ± 7.43	.699
Post-op 3 mo	56.19 ± 8.94	57.93 ± 7.26	.512
Post-op 6 mo	56.19 ± 8.94	57.33 ± 7.27	.402
PT°			
Pre-op	24.25 ± 11.81	24.2 ± 9.38	.99
Post-op 1 wk	21.75 ± 10.86	20.27 ± 5.73	.21
Post-op 3 mo	22.13 ± 10.46	20.13 ± 5.67	.079
Post-op 6 mo	22.44 ± 9.99	21.2 ± 5.39	.11
SS°			
Pre-op	29.69 ± 12.16	27.67 ± 5.39	.564
Post-op 1 wk	34.44 ± 9.56	32.73 ± 6.38	.575
Post-op 3 mo	34.06 ± 9.01	32.33 ± 6.27	.551
Post-op 6 mo	33.75 ± 8.81	32.27 ± 6.23	.619
LL°			
Pre-op	31.93 ± 14.47	31.13 ± 10.74	.869
Post-op 1 wk	44.47 ± 13.10	35.07 ± 7.47	**.028***
Post-op 3 mo	43.0 ± 13.44	34.47 ± 7.09	**.046***
Post-op 6 mo	42.4 ± 13.26	34.07 ± 7.14	**.049***
FSL°			
Pre-op	8.06 ± 4.99	6.2 ± 3.27	.248
Post-op 1 wk	13.31 ± 5.54	7.27 ± 4.12	**.002***
Post-op 3 mo	12.56 ± 5.26	7.33 ± 4.01	**.006***
Post-op 6 mo	12.38 ± 4.99	7.2 ± 4.02	**.005***

FSL = fused segment lordosis, LL = lumbar lordosis, OLIF = oblique lumbar interbody fusion, PI = pelvic incidence, PT = pelvic tilt, SS = sacral slope, TLIF = transforaminal lumbar interbody fusion.

was associated with more back and leg pain as assessed by VAS. Fujibayashi demonstrated that clinical results are related more to the effect of deformity correction than to indirect neural decompression.[5] This may be explained that why the VAS scores are less in OLIF group after the surgery (Tables 2 and 4). In addition, restoration of DH in the fusion segment significantly improved the compression of nerve canal by reduction of disc bulging and elongation of the hypertrophied ligamentum flavum. Both surgical procedures increase DH of the diseased segment. Moreover, the OLIF group showed higher restoration of DH and FH than TLIF group postoperatively. This is reasonable, because we inserted a relatively larger cage into the target disc in OLIF. The height and width of OLIF cage are 8 to 14 mm and 55 mm, respectively while the cage in TLIF is 8 to 12 mm in height and 30 mm in width.[2] The height of intervertebral can be increased by using larger and wider cage, the same as intervertebral foramen height and vertebral canal area. The wide cage allows it to rest on the hard epiphyseal ring around the vertebral body, rather than on the relatively weak area of the cortical bone in the central depression of the endplate. For patients in TLIF group with a combination of supplemental fixation at a given level, there was 8.6% (3 of 35) rate of cage subsidence. Of the 3 patients with radiographic subsidence, only 1 was symptomatic. Besides, for patients in OLIF group with a combination of unilateral fixation, there was 7.1% (2 of 28) of cage sedimentation. It may prove that the effect on avoiding subsidence in unilateral fixation is good enough. Besides, as mentioned by Le, the inferior endplate is 40% stronger than the superior endplate.[13] In 5 cases of our study, the cage was inserted superior endplate, which did consistent the theory mentioned above.

In the current reports, the complication rates of TLIF range from 7.1% to 21.6%,[3,15,24,26,28] including rod-broken and cage migration. The complication incidences of OLIF were varied in the literatures, ranging from 3.7% to 58.3%.[5,6,17,18,19,22] Ohtori et al[19] demonstrated that segmental artery injury occurred in 1 patient and the surgery was converted to open surgery. Zeng et al[30] reported that the complication incidence of OLIF was 13.62%, such as cerebral infraction and reoperation, both of which were only 1 case. Except for several serious complications mentioned above, the rest are all transient symptoms. In the OLIF group, the incidence of complications was 7.14% (2/28), which is less than that recorded in the TLIF group (17.14%, 6/35).

A limitation of the study was that it was a retrospective study with a relatively small sample size. Moreover, the inclusion criteria were rather restrictive and may have contributed to a selection bias that may have led to an underestimation of incidence rates for nonunion, subsidence, and surgical approach-related complications. The intention is to follow-up this study in the future to obtain further information aimed at improving the deficiencies identified in this article. In addition, increase the number of follow-up cases in an attempt to reduce the error of follow-up data to further improve the accuracy of this study.

5. Conclusion

It can be concluded that there are exactly differences in improvement of radiographic parameters between 2 approaches, which confirmed that OLIF is better in restoring spinal alignment. Besides, due to the unique minimally invasive approach, OLIF did exhibit a greater advantage in early recovery after surgery, attracting more and more attention in surgeons.

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Author contributions

Renjie Li assisted with care of the patient and wrote majority of the manuscript.
Xiaofeng Shao helped literature review and writing assistance.
Weimin Jiang performed the surgery and approved the manuscript.
Data curation: Renjie Li, Xiaofeng Shao, Xuefeng Li, Yijie Liu.
Investigation: Renjie Li, Xiaofeng Shao.
Methodology: Weimin Jiang.
Resources: Weimin Jiang.
Writing – original draft: Renjie Li.
Writing – review & editing: Weimin Jiang.

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