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Oblique lateral interbody fusion combined with lateral plate fixation for the treatment of degenerative diseases of the lumbar spine

A retrospective study

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Abstract

Oblique lateral interbody fusion (OLIF) is a minimally invasive decompression technique used in the treatment of lumbar degenerative diseases (LDDs). It is usually combined with posterior pedicle screw fixation to decrease perioperative complications. Few studies have reported the efficacy of OLIF combined with lateral plate instrumentation (OLIF-LP) for the treatment of LDDs.

The purpose of this retrospective study was to evaluate the clinical efficacy of OLIF combined with lateral plate instrumentation for the treatment of LDDs.

From May 2020 to September 2020, the clinical data of 52 patients who underwent OLIF-LP were analyzed. The operation time, blood loss, and complications were recorded. The radiological parameters, visual analog scale score, and Oswestry Disability Index were evaluated.

The average operation time, blood loss, and length of hospital stay were 75.41 ± 11.53 minutes, 39.57 ± 9.22 mL, and 7.22 ± 1.85 days, respectively. The visual analog scale score and Oswestry Disability Index both improved significantly after surgery (7.23 ± 1.26 vs 2.15 ± 0.87; 60.27 ± 7.91 vs 21.80 ± 6.32, $P < .01$). The postoperative disk height was 13.02 ± 8.83 mm, which was much greater than the preoperative value. The postoperative foraminal height improved significantly (16.18 ± 3.49 vs 21.54 ± 2.12 mm, $P < .01$), and the cross-sectional area improved from 88.95 ± 14.79 to 126.53 ± 8.83 mm^2 ($P < .001$). The radiological fusion rate was 88% at the last follow-up. No major complications, such as ureteral injury, vascular injury, or vertebral body fracture, occurred.

Use of the OLIF-LP technique can help avoid lumbar posterior surgery and minimize the operative time and blood loss. OLIF-LP can achieve 1-stage intervertebral fusion and instrumentation through a single small incision.

Abbreviations: CSA = cross sectional area, DH = disk height, FH = foraminal height, LLIF = lateral lumbar interbody fusion, ODI = Oswestry Disability Index, OLIF = oblique lateral interbody fusion, VAS = visual analog scale.

Keywords: lateral fixation, lumbar degenerative diseases, oblique lateral interbody fusion, plate

1. Introduction

Lumbar degenerative disease is a common and debilitating disease that causes pain and disability in elderly patients and is a burden on our health care system. The prevalence of low back pain due to lumbar spondylosis is estimated to be 3.6% worldwide.[1] Meanwhile, the lumbar surgery rates have increased steadily over time.[2] Posterior lumbar interbody fusion and transforaminal lumbar interbody fusion have become widely

Editor: Guangxun Lin.

H-DL and LZ contributed equally to this work.

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

This study was sponsored by the Medical Health Science and Technology Project of Zhejiang Province (2021KY349) and the Project of Huzhou Science and Technology Bureau (2020GY08).

The authors have no conflicts of interest to disclose.

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

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How to cite this article: Li HD, Zhong L, Min JK, Fang XQ, Jiang LS. Oblique lateral interbody fusion combined with lateral plate fixation for the treatment of degenerative diseases of the lumbar spine: a retrospective study. Medicine 2022;101:7(e28784).

Received: 5 October 2021 / Received in final form: 14 January 2022 / Accepted: 20 January 2022

http://dx.doi.org/10.1097/MD.0000000000028784

used to treat degenerative diseases of the lumbar spine. However, extensive dissection of the paraspinal muscles and prolonged soft tissue retraction are well-known disadvantages of posterior surgery.[3] Many complications, such as perioperative bleeding, dural tears, nerve root injury, and postoperative muscle atrophy, have been reported.[4]

Minimally invasive indirect decompression techniques have been developed to address the morbidity of traditional open surgery. Oblique lateral lumbar interbody fusion (OLIF) was first reported in 2012 by Silvestre et al[5]; it uses the natural space between the left lateral border of the abdominal aorta and the anterior medial border of the left psoas muscle. Compared with direct lateral lumbar interbody fusion, OLIF surgery has a lower nerve injury rate.[6,7] Fujibayashi et al[8] reported that the risks of sensory nerve injury and psoas weakness after OLIF were significantly lower than those after extreme lateral lumbar interbody fusion (XLIF).

The biomechanical stability of OLIF alone is questionable, and it may cause many more complications during the perioperative period. Therefore, OLIF is commonly combined with supplemental posterior pedicle screw fixation.[9] Zeng et al[10] reported that the rate of complications was lower with the use of combined pedicle screw fixation. Ohtori et al[11] used posterior screws in all of their patients and reported good outcomes. However, these procedures require 2 different incisions, increasing surgical risks and economic expenses. To the best of our knowledge, few studies have reported OLIF combined with lateral plate instrumentation (OLIF-LP) for the treatment of diseases of the lumbar spine. The purpose of this study was to analyze the clinical and radiographic efficacy of OLIF-LP in the treatment of single-level degenerative disease of the lumbar spine.

2. Materials and methods

2.1. Patient population

This retrospective study was approved by the Ethics Committee of the authors' affiliated institutions (approval number No. 202101-05). The need for individual consent was waived by the committee because of the retrospective nature of the study. From May 2020 to September 2020, 52 patients who underwent single-segment OLIF combined with lateral plate fixation (OLIF-LF) were identified and included in this retrospective study. The inclusion criteria were the presence of single-segment degenerative diseases of the lumbar spine as follows: degenerative disc diseases of the lumbar spine; degenerative spondylolisthesis within Meyerding grade I; spinal stenosis with degenerative instability; and lack of clinical improvement after >3 months of conservative treatment. The exclusion criteria were as follows: severe osteoporosis (T score <2.5), multisegment degenerative diseases of the lumbar spine, <6 months of available follow-up data, severe degenerative spondylolisthesis (classified as more than Meyerding grade II), and severe lumbar spinal canal stenosis that required direct posterior decompression of the spinal canal.

2.2. Surgical procedure

The general OLIF technique has been described previously.[12] Under general anesthesia, the patient was positioned in a lateral decubitus manner with the left hip on the top. X-rays were taken to identify the target vertebral levels. A skin incision of 3 to 4 cm in length was made, and the retroperitoneal space was accessed by blunt dissection along the retroperitoneal fat tissue. The psoas muscle was dissected with the index finger and retracted posteriorly, and the peritoneal sac was mobilized anteriorly. After discectomy, vertebral endplates were prepared, and an intervertebral cage filled with demineralized bone matrix was inserted. After the conventional OLIF procedure, a lateral plate fixation system was placed at the lateral part of the vertebrae. The screws were usually inserted upward and downward along the endplate so that to spare segmental vessels (Fig. 1). No patient received supplementary posterior instrumentation in a second stage. All patients were allowed to ambulate with a Boston brace on the second day postoperatively. Use of the Boston brace was recommended for 3 months.

2.3. Radiographic assessment

Routine X-rays, computed tomography (CT), and MRI were obtained for all patients. As shown in Fig. 2, the radiological parameters, including disk height (DH), foraminal height (FH), and cross-sectional area (CSA), were measured according to the methods reported by Sato et al.[13] All imaging examinations were performed independently by 2 physicians. The intraclass correlation coefficients were >0.85 for all variables. Cage subsidence was defined as a cage sinking into an adjacent vertebral body by >2 mm on CT images.[14] The Bridwell interbody fusion grading system was used for fusion grading.[15] Grades I and II were considered successful.

2.4. Clinical assessment

Standardized and validated questionnaires, including the visual analog scale (VAS) for back pain intensity and the Oswestry Disability Index (ODI), were administered to all the patients. We used a 10-point VAS, where 1 = least pain and 10 = worst pain. Clinical data were obtained preoperatively and at 7 days, 3 months, and 12 months postoperatively. Surgical characteristics and complications were also recorded. All the patients were followed for at least 12 months.

2.5. Statistical analysis

Statistical analysis was performed using SPSS 18.0 for Windows (IBM, Armonk, NY). Continuous data are presented as the means ± standard deviation and were analyzed using Student t test. The level of significance was set at $P < .05$.

3. Results

3.1. Demographic characteristic

A total of 52 patients (24 men and 28 women) were included in the study. The mean patient age was 63.31 ± 10.20 years (range 43–78 years). Twenty-five patients suffered from lumbar spinal stenosis, 20 patients from lumbar instability, and 7 patients from degenerative disc diseases. They were all successfully treated with OLIF-LP. The surgical procedure was performed at L2/3 in 5 patients, L3/4 in 21 patients, and L4/5 in 26 patients. The mean time of hospitalization was 7.22 ± 1.85 days (Table 1).

3.2. Clinical evaluation

The mean operation time in this group was 75.41 ± 11.53 minutes (range 53–110 minutes). The mean blood loss was 39.57 ± 9.22 mL (range 25–73 mL). The VAS score was 7.23 ± 1.26

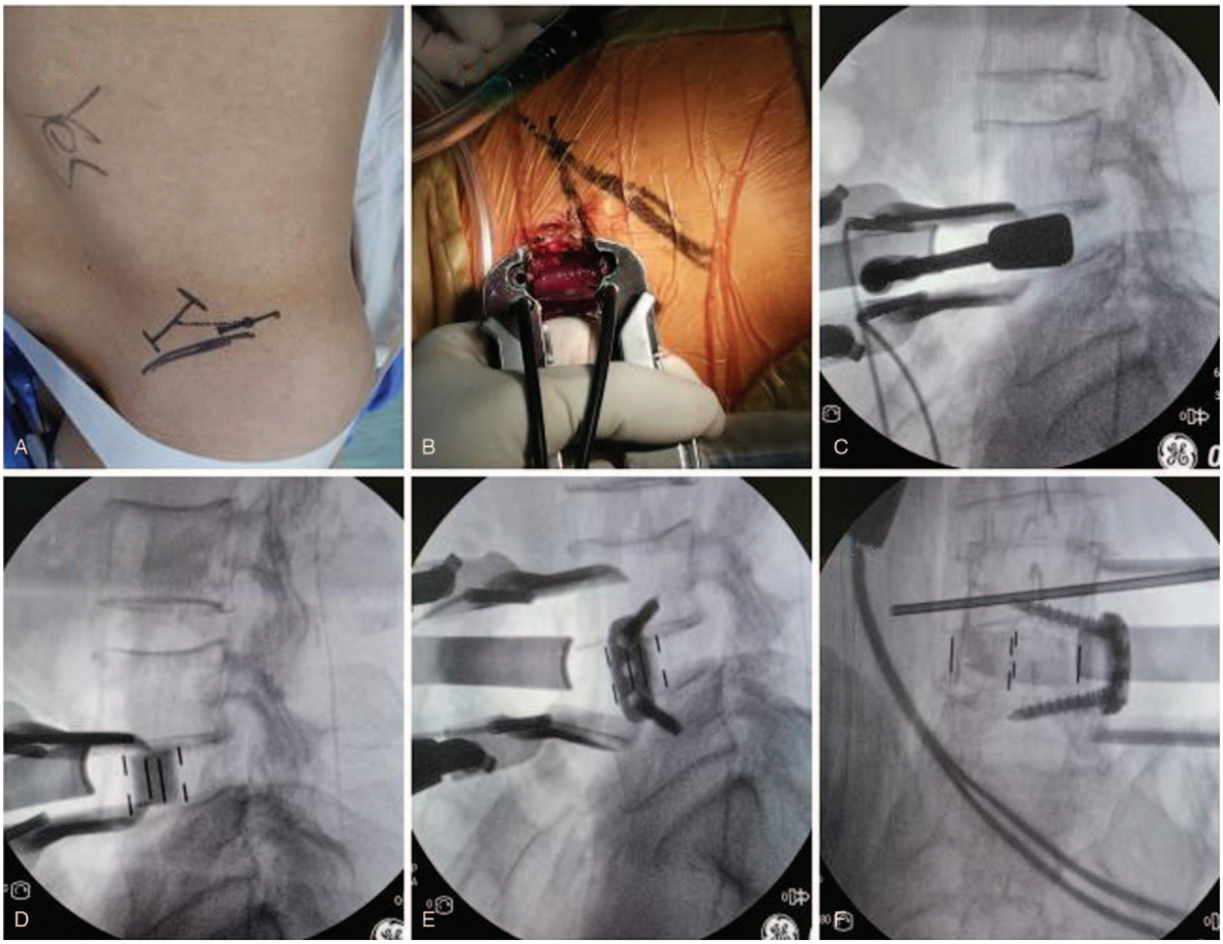

Figure 1. Radiographic images showed the surgical procedures for OLIF with lateral plate fixation. A skin incision was made 4 to 8 cm anterior to the midportion of the disk (A). A retractor was used after dilatation for OLIF (B). The trial position was located in 1/3 of the vertebral body (C). The interbody fusion cage was inserted (D). The lateral plate instrumentation was fixed (E and F). OLIF = oblique lateral interbody fusion.

preoperatively and 2.15 ± 0.87 after OLIF-LP ($P < .05$). The ODI decreased from 60.27 ± 7.91 preoperatively to 21.80 ± 6.32 ($P < .05$) (Table 2).

3.3. Radiographic evaluation

As shown in Fig. 3, the DH, FH, and CSA were 8.96 ± 1.23, 16.18 ± 3.49 mm, and 88.95 ± 14.79 mm^2, respectively, before the surgery, and all had improved significantly by 7 days after the surgery ($P_{DH} = .006$, $P_{FH} = .012$, $P_{CSA} = .010$). Two cases of cage subsidence were identified; however, no case of cage retropulsion occurred during the follow-up. The fusion rate was 88% (46/52) at 12 months. Images of representative cases are shown in Figs. 4 and 5.

3.4. Complications

Two cases of lumbosacral injury were observed in our study. These 2 patients both had hip flexion weakness. Fortunately, they recovered within 3 months postoperatively. No major vessel injury or ureteral injury occurred. No intervertebral space infections, cerebrospinal fluid leakage, vertebral body fracture, or instrument failure were observed during the follow-up.

4. Discussion

Lateral plate instrumentation constitutes an internal fixation system tailored for lateral and anterior surgical approaches. It increases stability immediately after OLIF and theoretically increases the fusion rate after surgery. Moreover, the use of a single lateral incision can help avoid muscle injury in the posterior structures, decrease the potential risk of nerve damage and shorten the operation time. In this retrospective study, the CSA, FH, and DH all improved significantly after OLIF+LP. Additionally, the ODI and VAS scores of the patients both decreased significantly after the operation. No major vascular or nerve damage, vertebral body fracture or instrument failure occurred.

OLIF was first reported in 2012 as a relatively safe procedure, allowing psoas preservation and avoiding the lumbar plexus.[5] It has been reported to result in a 30.2% median increase in the cross-sectional area of the dural sac and a 30.0% average increase in the neural foramen area.[12,13] However, the occurrence of complications is inevitable, and the incidence of complications has been reported to range from 3.7% to 66.7%.[16] In a study directed by Abe et al,[7] intraoperative complications occurred in 44.5% of the patients, while only 4.7% of postoperative complications occurred with OLIF. The most common compli-

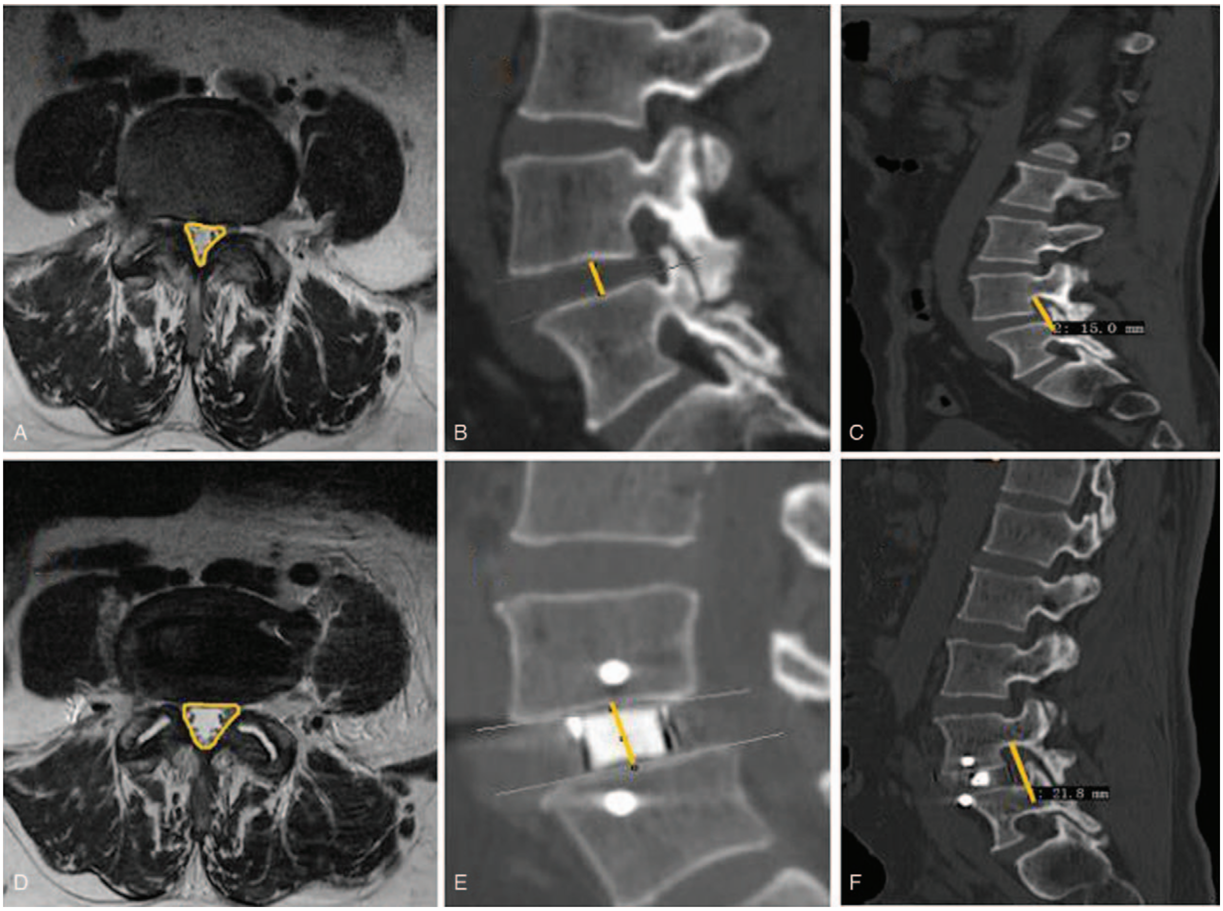

Figure 2. A 65-year-old woman with a diagnosis of degenerative spondylolisthesis of L4 (Meyerding grade I) was treated with oblique lateral lumbar interbody fusion combined with lateral plate fixation. The cross-sectional area (CSA) of the thecal sac was evaluated using magnetic resonance imaging (A) before and (D) 7 days after surgery. Three-dimensional computed tomography scans were used to evaluate the disk height (DH) and foraminal height (FH) (B, C) before and (E, F) 7 days after surgery.

cation was endplate fracture followed by transitory weakness of the psoas muscle and transient neurological symptoms. Zeng et al[10] also reported that endplate damage and cage sedimentation were the most common complications of OLIF. In their study, the complication rate in the OLIF alone group was 36.26%, which was much higher than that in the OLIF combined with pedicle screw group (29.86%). At present, pedicle screws and rod systems are usually applied for stabilization after OLIF because they are considered to provide the most rigid fixation of the spine.[17]

Lateral pedicle screw instrumentation after anterior lumbar interbody fusion or lateral lumbar interbody fusion (LLIF) has been previously reported to avoid the complications of posterior pedicle screw fixation.[18,19] In a retrospective study of 65 patients with degenerative disc disease (DDD) of the lumbar spine, Xie et al[20] reported that lateral pedicle screw combined with OLIF is a safe and effective surgical option that results in less blood loss and a shorter operation time. Additionally, Liu and Feng[21] combined OLIF with supplemental anterolateral screw and rod instrumentation to achieve good clinical results, and a fusion rate of approximately 95% was reported in their study. Wang et al[22] reported that a combination of OLIF and lateral

Table 1

General data of the cohort (n=52).

Parameter	Mean ± SD (range)
Age, y	63.31 ± 10.20 (43–78)
Sex	Male, 24; female, 28
L2–3/L3–4/L4–5 (n)	5/21/26
Diagnosis (n)	
Lumbar spinal stenosis	25
Lumbar instability	20
Degenerative disc diseases	7
Operative time, min	75.41 ± 11.53 (53–110)
Blood loss, mL	39.57 ± 9.22 (25–73)
Hospitalization, d	7.22 ± 1.85 (3–12)
Follow-up time, mo	12.73 ± 2.24 (12–14)

Table 2

The comparison of the clinical data before and after OLIF-LP surgery.

	Preoperative	Postoperative	*t*	*P*
VAS	7.23 ± 1.26	2.15 ± 0.87	11.37	<.001
ODI	60.27 ± 7.91	21.80 ± 6.32	16.21	<.001

ODI = Oswestry Disability Index, OLIF = oblique lateral interbody fusion, VAS = visual analog scale.

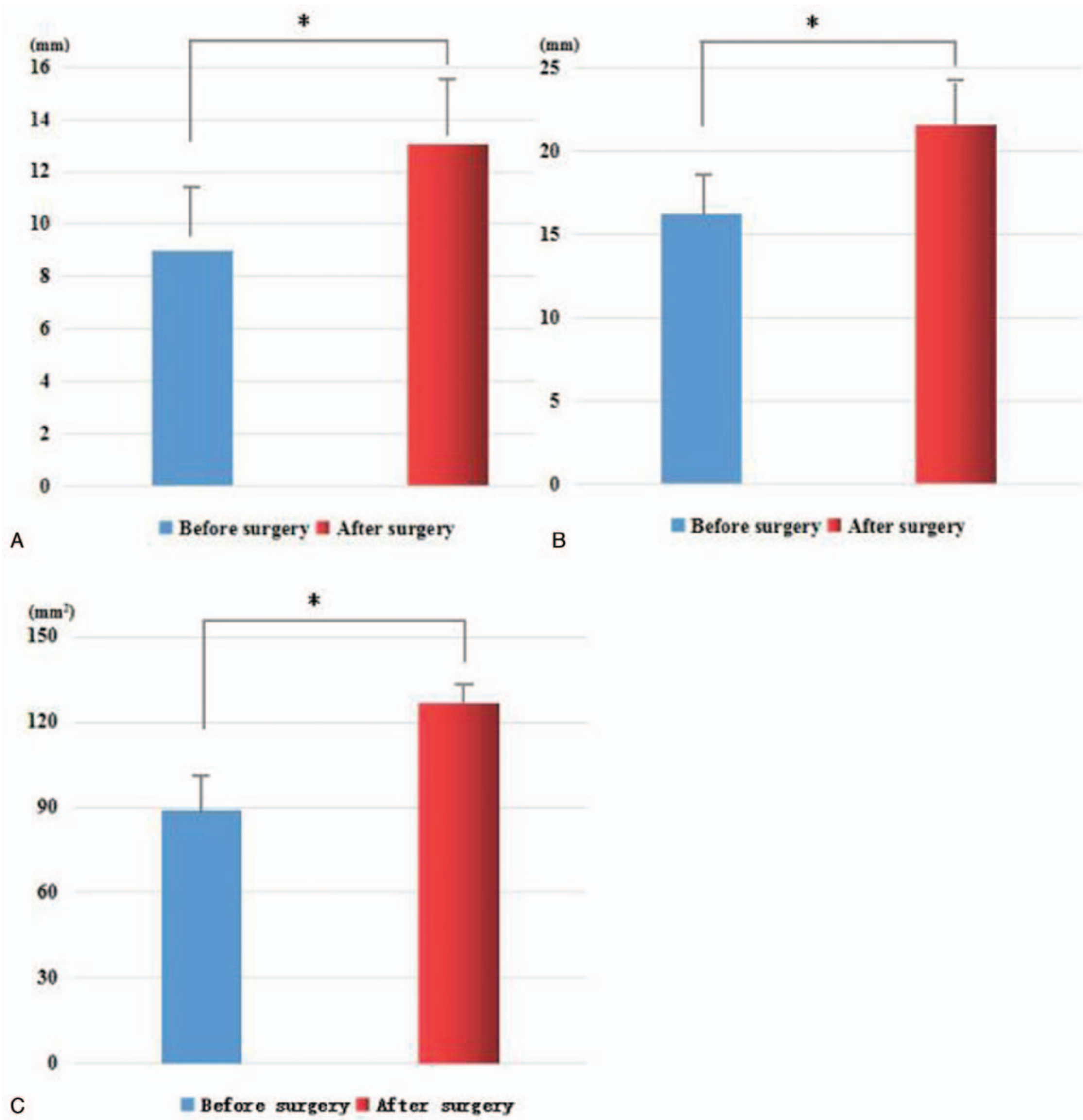

Figure 3. Changes in disk height (DH) (A), foraminal height (FH) (B), and cross-sectional area (CSA) (C) are shown. Significant improvement was seen in all 3 parameters 7 days after surgery compared with before surgery.

instrumentation for the treatment of moderate degenerative spine deformities can correct both coronal and sagittal deformities and improve quality of life. However, there are few reports about the usage of lateral plate fixation systems in OLIF. In the current study, conventional lateral plate instrumentation allowed for one-stage intervertebral fusion and instrumentation through a single small incision.

A major concern regarding the use of anterolateral instrumentation is that it may not be strong enough to maintain stability and prevent subsidence of the interbody cages. The biomechanical strength of the lateral plate fixation system should be considered. Fogel et al[23] reported that compared with the stand-alone technique, lateral plate instrumentation significantly decreased lateral bending and axial rotation ROM, although it did not alter the ROM in flexion-extension. The cage supplemented with a lateral plate was not significantly different from the cage combined with bilateral pedicle screws in lateral bending. In another biomechanical study, it was reported that 2-hole lateral plate and bilateral pedicle screw fixation both significantly limited ROM in all loading planes relative to the stand-alone condition, and they are recommended when used in 2-level lumbar fusion with laterally placed cages.[24] Bilateral pedicle screw rod fixation yields the greatest reduction in ROM and may be a preferable fusion approach when rigid, motion-eliminating stabilization is required. Guo et al[25] suggested that the bilateral pedicle screw model provided the best biomechanical stability for OLIF; the stand-alone model could not provide sufficient stability. In a three-dimensional finite element study, Liu et al[26] suggested that lateral plates and screws could not provide favorable biomechanical stability for multilevel lateral interbody fusion. However, in a cadaveric biomechanical study, Lai et al[27] found that less invasive adjunctive fixation methods, such as unilateral pedicle screws and lateral plates, may provide sufficient biomechanical stability for multilevel LLIF. In the present study, we only applied the lateral plate fixation system in patients with degenerative disease of 1 segment of the lumbar

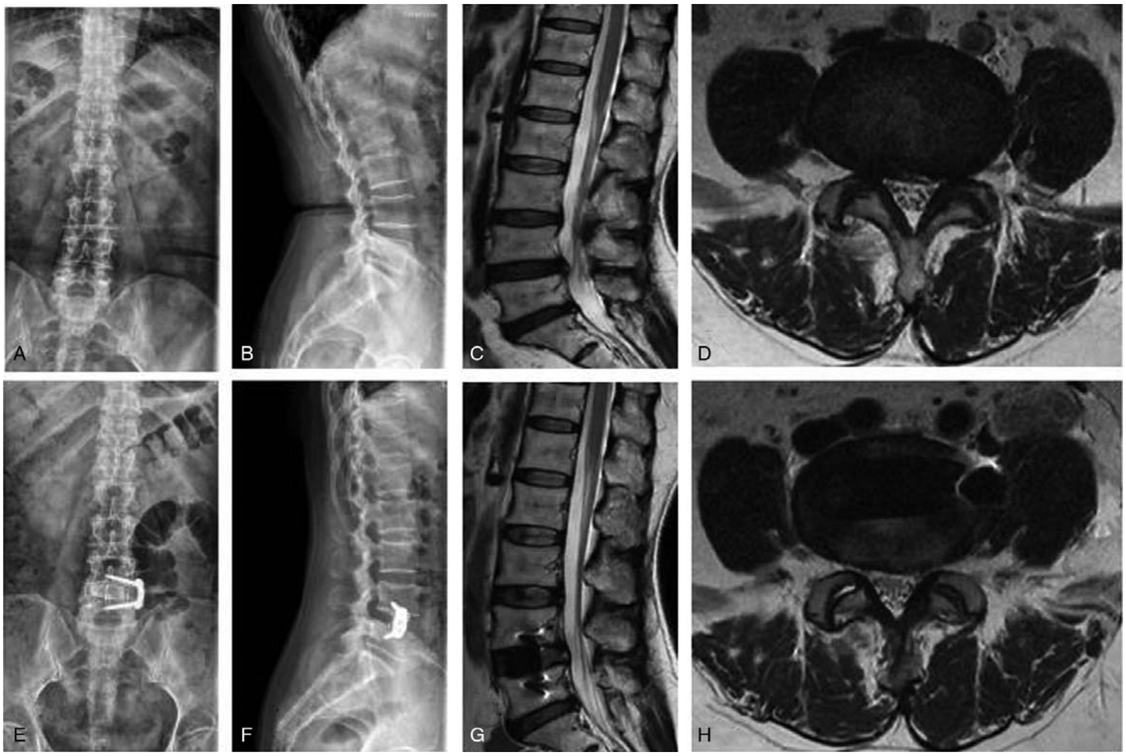

Figure 4. Imaging studies of a representative patient. A 73-year-old man with a diagnosis of lumbar spinal stenosis with degenerative spondylolisthesis of L4 (Meyerding grade I) underwent oblique lateral lumbar interbody fusion combined with lateral plate fixation. Preoperative anteroposterior and lateral radiographs (A, B). Preoperative magnetic resonance imaging scans (C, D). Anteroposterior and lateral radiographs 12 months postoperatively (E, F). Magnetic resonance imaging scans 12 months postoperatively (G, H).

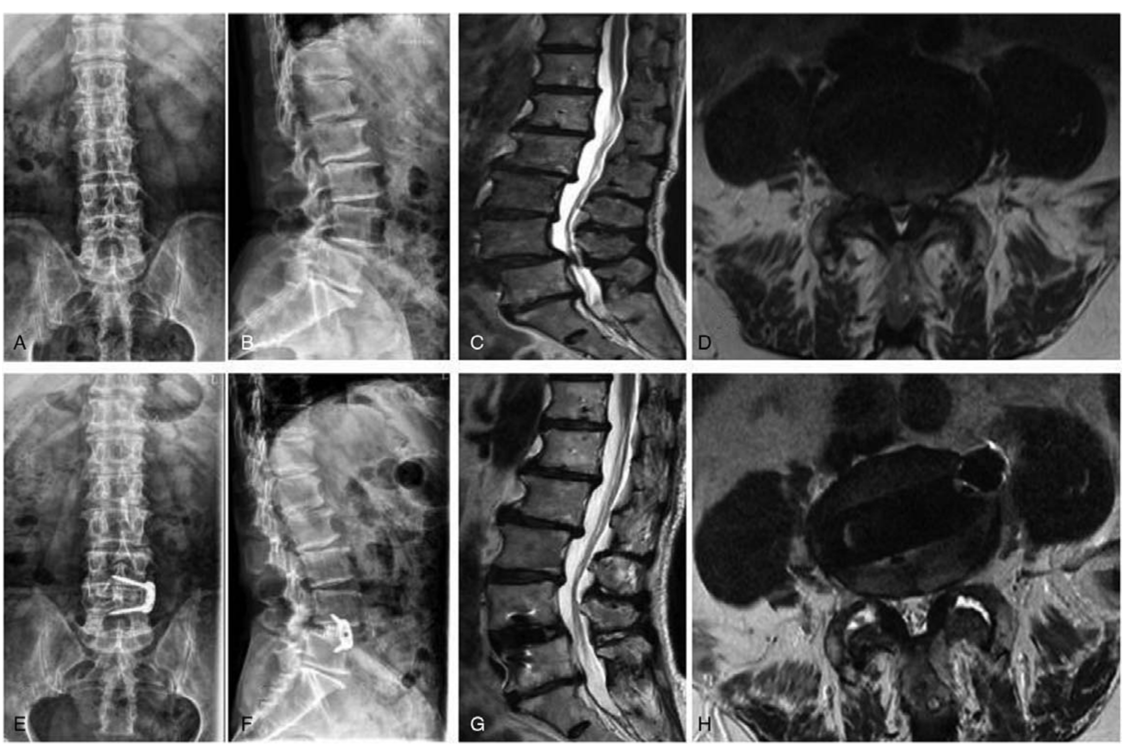

Figure 5. Imaging studies of a representative patient. A 65-year-old woman with a diagnosis of mild lumbar spinal stenosis underwent oblique lateral lumbar interbody fusion combined with lateral plate fixation. Preoperative anteroposterior and lateral radiographs (A, B). Preoperative magnetic resonance imaging scans (C, D). Anteroposterior and lateral radiographs 12 months postoperatively (E, F). Magnetic resonance imaging scans 12 months postoperatively (G, H).

spine, and grade II or more serious lumbar spondylolisthesis patients were excluded. No instrumentation failure occurred in our study.

The difference between lateral plate fixation and anterolateral screw rod fixation also needs to be mentioned. The lateral plate system and the anterolateral screw system can both significantly reduce the ROM compared with the stand-alone lateral interbody fusion technique. However, which one can provide better stability is still controversial. One problem of lateral pedicle screw fixation is that it does not conform to the inherent curvature of the lumbar spine, and the long rod may interfere with adjacent segmental degeneration. Moreover, as the rod is much higher than the lateral side of the vertebral body, the psoas muscle cannot fully return to the original position after the surgery, and it may cause twisting injury to the lumbar plexus and ureter. Nevertheless, similar to the anterior cervical plate system, the lumbar lateral plate system fits the side of the vertebral body more easily and causes less interference to the psoas muscle. Furthermore, the usage of plates can reduce the probability of adjacent segment degeneration. Until now, there have been few studies about OLIF surgery combined with lateral plate fixation, and the long-term efficacy should be further confirmed.

Recently, vertebral body fractures in patients who received supplemental lateral plating or pedicle screw fixation during LLIF were reported.[28,29] The reason might be that a fracture propagates through the screw hole from the fixed-angle anterolateral plate, resulting in a coronal plane fracture pattern as the cage subsides in osteoporotic cases. Coronal plane vertebral fracture also occurred in osteoporotic patients who underwent extreme lateral interbody fusion (XLIF) combined with extreme lateral plate (XLP), and unilateral pedicle screw instrumentation did not prevent this complication.[30] Brier-Jones et al[31] speculated that violation of the epiphyseal ring or subchondral bone by plate-anchoring screws may contribute to coronal vertebral body fractures. Kepler et al[28] suggested that vertebral fractures occur when compressive forces are unevenly distributed by a subsided cage into the bone surrounding plate-anchoring screws. In the present study, there were no complications related to the lateral plate fixation system. Several factors may explain this. First, all patients suffered from degenerative diseases in a single segment of the lumbar spine; second, the cages used for OLIF were much larger, located in the area II–III of the vertebral body, and the stress distribution of the whole vertebral body was even. Third, use of a spine brace was advised for the first 3 months after surgery.

5. Limitations

The present study had some limitations. First, we performed a retrospective study with a small sample size, and the duration of follow-up was short. Second, the absence of a control group was another drawback of this study. Third, patients suffering from single-segment lumbar spine disease were included in our study, and whether this technique is suitable for patients with multisegment degenerative disease of the lumbar spine is unknown. Randomized control trials with large samples are needed to verify its pros and cons.

6. Conclusions

OLIF combined with lateral plate instrumentation seems to be a valuable surgical option for degenerative disease in a single segment of the lumbar spine. It is a minimally invasive, 1-stage surgical procedure that achieves good radiographic and clinical results without any major complications.

Author contributions

Conceptualization: Hai-Dong Li, Li Zhong.
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Software: Li Zhong.
Supervision: Hai-Dong Li.
Validation: Hai-Dong Li, Ji-Kang Min.
Visualization: Hai-Dong Li, Ji-Kang Min.
Writing – original draft: Hai-Dong Li.
Writing – review & editing: Hai-Dong Li, Li Zhong.

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