Oblique Lateral Interbody Fusion Combined With Lateral Plate Fixation for the Treatment of Lumbar Degenerative Diseases: a Preliminary Clinical Study

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Research article

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

Posted Date: August 30th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-836768/v1>

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Abstract

Background The oblique lateral interbody fusion (OLIF) is a minimally invasive indirect decompression technique for the treatment of lumbar spine disease. The OLIF has usually combined with supplemental posterior pedicle screw fixation for decreasing the perioperative complications. The purpose of this study was to evaluate clinical efficacy and complications of oblique lateral interbody fusion (OLIF) combined with lateral plate instrumentation for the treatment of lumbar degenerative diseases.

Methods From May 2020 to August 2020, the clinical data of 20 patients who underwent OLIF combined with lateral plate instrumentation were retrospectively analyzed. The operation time, blood loss, and the complications were recorded. Also, the radiological parameters, Visual Analog Scale (VAS) score and Oswestry Disability Index (ODI) were evaluated before and after surgery.

Results The average operation time, blood loss, and length of hospital stay were 75.41 ± 11.53 min, 39.57 ± 9.22 ml, and 7.22 ± 1.85 days, respectively. The VAS and ODI had both significantly improved after surgery (7.23 ± 1.26 VS 2.15 ± 0.87 ; 60.27 ± 7.91 VS 21.80 ± 6.32 , $P < 0.001$). The postoperative disk height (DH) was 13.02 ± 8.83 mm, which is much higher than before ($P < 0.001$); The postoperative foraminal height (FH) improved significantly (16.18 ± 3.49 VS 21.54 ± 2.12 mm, $P < 0.01$), and the cross-sectional area (CSA) had improved from 88.95 ± 14.79 mm² to 126.53 ± 8.83 mm² ($P < 0.001$). The radiological fusion rate was 95% at the last follow-up, while cage subsidence was found in one case. No major complications, such as ureteral injury, vascular injury and vertebral body fracture occurred.

Conclusions OLIF combined with lateral plate fixation can avoid the lumbar posterior surgery, minimize the operation time, blood loss and the posterior ligament complex disruption. It can realize one-stage intervertebral fusion and instrumentation through a single small incision.

Background

Lumbar degenerative disease is a common and debilitating disease, causing pain and disability in elderly patients and burdening our healthcare system. The low-back pain rate due to lumbar spondylosis is estimated at 3.6% worldwide [1]. Meantime, the lumbar surgery rates have increased steadily over time [2]. Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) have become widely used as a gold treatment for lumbar degenerative disease. However, extensive dissection of the paraspinal muscles as well as prolonged soft tissue retraction was the common criticism for the posterior surgery [3]. Many complications such as peri-operative bleeding, dural tear, nerve root injury and postoperative muscular atrophy were reported [4].

Minimally invasive indirect decompression techniques have been developed to avoid the morbidity of traditional open surgery. Oblique lateral lumbar interbody fusion (OLIF) was first reported in 2012 by Silvestre, it use the natural space between the left lateral border of the abdominal aorta and the anterior medial border of the left psoas muscle [5]. Different from the direct lateral lumbar interbody fusion (DLIF), the OLIF surgery has less nerve injury rate [6–7]. Fujibayashi et al reported that the risks of sensory nerve

injury and psoas weakness after OLIF were significantly lower than the risk after extreme lateral lumbar interbody fusion (XLIF) [8].

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

Methods

Patient population

This study was approved by the Ethics Committee of the authors' affiliated institutions, and all the patients signed an informed consent document. From May 2020 to August 2020, 20 patients who underwent one-segmental OLIF combined with lateral plate fixation (OLIF-LF) were identified and included in this retrospective study. The inclusion criteria were the presence of single-segmental lumbar degenerative diseases as follows: (1) lumbar degenerative disc diseases; (2) degenerative spondylolisthesis within Meyerding grade I (3) spinal stenosis with degenerative instability; (4) failure to > 6 months of conservative treatment. The exclusion criteria were as follows: (1) severe osteoporosis (T score < 2.5) (2) multi-segmental lumbar degenerative diseases (3) availability of follow-up < 6 months (4) severe degenerative spondylolisthesis (classified as more than Meyerding grade II) (5) severe lumbar spinal canal stenosis which required direct posterior decompression of the spinal canal

Surgical procedure

The general technique of OLIF has been previously described [12]. Under general anesthesia, the patient was positioned in a lateral decubitus manner with left hip on the top. X-ray was made to identify the targeting vertebral levels. A skin incision of 3-4cm in length was made and 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 inserted the intervertebral cage (Medtronic, Memphis, TN, USA) filled with demineralized bone matrix DBM (Wright Medical Technology Inc., TN, USA). After the conventional OLIF procedure, lateral plate fixation system (PIVOX™ Oblique lateral spinal system, Medtronic, USA) was placed at the lateral part of vertebrae. The screws were usually inserted upward and downward along the endplate so that segmental vessels would be spared (Fig. 1). No patient received a supplementary posterior instrumentation in a second stage. All patients were allowed to ambulate by Boston brace on the second postoperative day. The Boston brace was recommended for 3 months.

Radiographic assessment

The routine X-ray, computed tomography (CT) and MRI were allowed for all the patients. As shown in the 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 [13]. All the imaging examinations were read independently by two experience physicians. The calculated intra-class correlation coefficients were all > 0.85 for all variables. Based on CT images, cage subsidence was defined as a cage sinking into an adjacent vertebral body by > 2 mm [14]. The Bridwell interbody fusion grading system was used for the fusion grading criteria [15]. Grades I and II were considered as successful.

Clinical assessment

A standardized and validated questionnaires that included a VAS score for back pain intensity and the Oswestry Disability Index (ODI) were allowed for all the patients. We used a 10-point VAS, where 1 = least pain and 10 = worst pain. Clinical data were obtained preoperatively, 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.

Statistical analysis

Statistical analysis was performed using SPSS 18.0 for Windows (IBM, Armonk, NY, USA). Continuous data are presented as means $\pm$ standard deviation, and were analyzed using the Student t test. The level of significance was set at $P < 0.05$.

Results

Demographic characteristic

A total of 20 patients (8 men and 12 women) were included in the study. The mean patient age was 63.31 ± 10.20 years (range 43–78 years). Ten patients had a diagnosis of lumbar spinal stenosis, eight patients with lumbar instability and two patients with degenerative disc diseases. They were all successfully treated with OLIF-LP surgery. The surgical procedure was performed at L2/3 in 3, L3/4 in 8 and L4/5 in 9 patients. Demographic and operative characteristics of the patients were shown in Table 1.

Table 1
General data of the cohort (n = 20)

Parameter	Mean $\pm$ SD (Range)
Age (years)	63.31 $\pm$ 10.20 (43–78)
Sex	Male, 8; Female, 12
L2–3/L3–4/L4–5 (n)	3/8/9
Diagnosis (n)	
lumbar spinal stenosis	10
lumbar instability	8
degenerative disc diseases	2
Operative time (min)	75.41 $\pm$ 11.53 (53–110)
Blood loss (ml)	39.57 $\pm$ 9.22 (25–73)
Hospitalization (day)	7.22 $\pm$ 1.85 (3–12)
Follow-up time (months)	12.73 $\pm$ 2.24 (12–14)

Clinical evaluation

The mean operation time in this group was 75.41 $\pm$ 11.53 min (range 53–110 min). The mean blood loss was 39.57 $\pm$ 9.22 ml (range 25–73 ml). The preoperative VAS scores was 7.23 $\pm$ 1.26, and that was 2.15 $\pm$ 0.87 after the OLIF-LP surgery ($P < 0.05$). The ODI decreased from 60.27 $\pm$ 7.91 preoperatively to 21.80 $\pm$ 6.32 ($P < 0.05$) (Table 2).

Table 2
The comparison of the clinical data before and after OLIF-LP surgery

	Preoperative	Postoperative	t	P
VAS	7.23 $\pm$ 1.26	2.15 $\pm$ 0.87	11.37	< 0.001
ODI	60.27 $\pm$ 7.91	21.80 $\pm$ 6.32	16.21	< 0.001

Radiographic evaluation

As shown in the Fig. 3, the DH, FH, and CSA were 8.96 $\pm$ 1.23 mm, 16.18 $\pm$ 3.49 mm and 88.95 $\pm$ 14.79 mm² respectively before the surgery, and were all significantly improved at the 7 days after the surgery ($P < 0.05$). One case of cage subsidence was identified, however no case of cage retropulsion happened

during the follow-up. The fusion rate was 95%(19/20) at 12 months. Images of typical cases are shown in Fig. 4 and Fig. 5.

Complications

One case of lumbosacral injury was recorded in our study. This patient had hip flexion weakness. Fortunately, he had recovered within 2 months postoperatively. There were no occurrences of major vessel injury or nerve root injury. No intervertebral space infections, cerebrospinal fluid leakage, vertebral body fracture or instrument failure was observed during the follow-up.

Discussion

The lateral spinal fixation system (PIVOX) was an internal fixation system tailored for lateral and anterior surgical approaches. It increased the immediate stability after OLIF, and theoretically increased the fusion rate after surgery. Moreover, single lateral incision can avoid the muscle injury of posterior structures, decrease the potential risk of nerve damage and shorten the operation time. In this retrospective study, the CSA, FH and DH were all significantly improved after the OLIF + LP surgery. Also, the ODI and VAS scores of the patients both decreased significantly than before. No major vascular and nerve damage, vertebral body fracture or instrument failure had occurred.

OLIF was first reported in 2012 as an relatively safe procedure, allowing for psoas preservation, and avoids the lumbar plexus [5]. It has been found 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, the incidence of complications after surgery fluctuates was reported from 3.7–66.7% [16]. In a study directed by Abe et al, intraoperative complications were reported in 44.5% of the cases, while only 4.7% of postoperative complications occurred [7]. The most common complication was the endplate fracture followed by the transitory weakness of the psoas muscle and transient neurological symptoms. Zeng et al also reported that the endplate damage and cage sedimentation were the most common complications of OLIF [10]. In their study, the complication rate in the OLIF stand-alone group was 36.26%, much higher than the OLIF combined pedicle screw group (29.86%). Up to date, the pedicle screws and rod systems were usually applied for stabilization after OLIF because they were considered as the standard method of instrumentation to provide the most rigid fixation of the spine [17].

Lateral pedicle screw instrumentation after anterior lumbar interbody fusion (ALIF) or lateral lumbar interbody fusion (LLIF) has been previously reported to avoid posterior pedicle screw fixation [18–19]. In a retrospective study of 65 lumbar DDD patients, Xie et al reported that the lateral pedicle screw combined OLIF is a safe and effective surgical option with less blood loss and less operative time [20]. Also, Liu et al suggested the OLIF with supplemental anterolateral screw and rod instrumentation can achieve good clinical result, and about 95% fusion rate was reported in their study [21]. Wang et al reported a combination of OLIF and lateral instrumentation for the treatment of moderate degenerative spine deformity, it can correct both coronal and sagittal deformity and improve the quality of life [22].

However, there was few report about the usage of lateral plate fixation system in OLIF. In the current study, the PIVOX oblique lateral spinal system was used in the OLIF procedure, which was a very convenient and safe method of fixation, realizing one-stage intervertebral fusion and instrumentation through a single small incision.

A major concern regarding the use of anterolateral instrumentation is that the construct may not be strong enough to maintain stability, prevent the interbody cages from subsidence and promote fusion. The biomechanical strength of lateral plate fixation system should be considered. Forge et al reported that compared with the stand-alone condition, lateral plate instrumentation significantly decreased lateral bending and axial rotation ROM, though not altering the ROM in flexion-extension [23]. The cage supplemented with a lateral plate was not statistically different from bilateral pedicle screws in lateral bending. In another biomenchanical study, it was reported that the two-hole lateral plate and bilateral pedicle screw fixation both significantly limit ROM in all loading planes relative to the stand-alone condition, and they are recommended when used in two-level lumbar fusion with laterally placed cages [24]. Bilateral pedicle screw rod fixation can provide the greatest reduction in ROM and may be a preferable fusion construct when rigid, motion-eliminating stabilization is required. Guo et al suggested that the ilateral pedicle screws model provided the best biomechanical stability for OLIF; the stand-alone model could not provide sufficient stability [25]. In a three dimensional finite element study, Liu et al suggested the lateral plate and screws can not provide the favorable biomechanical stability for the multilevel lateral interbody fusion [26]. However, In an cadaveric biomechanical study, Lai et al suggested that less invasive adjunctive fixation methods such as unilateral pedicle screw and lateral plate may provide sufficient biomechanical stability for multilevel LLIF [27]. In present study, we apply the lateral plate fixation system only to the one-segmental lumbar degenerative disease patients, and the grade II or more serious lumbar spondylolisthesis patients were excluded. No instrumentation failure case occurred in our study .

The difference between lateral plate fixation and anterolateral screw rod fixation also needs to be mentioned. The lateral plates system and the anterolateral screw system can both significantly reduce the ROM, compared with the stand-alone lateral interbody fusion construct. However, which one can support the better stability was unknown. One problem of lateral pedicle screw fixation is that it dose not conform to the inherent curvature of lumbar spine, and the long rod may be interfere with adjacent segmental degeneration. Moreover, the rod is much higher than the side of vertebral body, and the psoas muscle can not fully return to the original position after the surgery, also it may cause twisting injury of the lumbar plexus and ureter. Like the anterior cervical plate, the lumbar lateral plate system can fit the side of vertebral body more easily, and make less interference to the psoas muscle. Furthermore, the length of plate was much shorter than rod, it can decreased the rate of ASD theoretically. However, as we known there was few studies about the application of lateral plate fixation on the OLIF surgery, the long-term efficacy should be further confirmed.

Recent reports address vertebral body fractures on the patients who received supplemental lateral plating or pedicle screw fixation during the LLIF [28–29]. The reason might be that a fracture propagated through

the screw hole from the fixed-angle anterolateral plate, resulting the coronal plane fracture pattern as the cage subsided in osteoporotic cases. The coronal plane vertebral fracture also occurred in osteoporotic patients who underwent XLIF combined with XLP lateral instrumentation, the unilateral pedicle screw instrumentation does not prevent this complication [30]. Brier-Jones et al speculate that violation of the epiphyseal ring or subchondral bone by plate-anchoring screws may contribute to the coronal vertebral body fractures [31]. Kepler et al suggested that vertebral fractures occur when compressive forces are unevenly distributed by a subsided cage into the bone surrounding plate-anchoring screws [28]. In present study, there was none complication related to the lateral plate fixation system. Several factors as follows may be able to explained it. Firstly, all patients admitted were single-segmental lumbar degenerative disease; secondly, the cages used by OLIF were much larger, which located in the II-III area of the vertebral body, and the stress distribution of the whole vertebral body is even. Thirdly, the spine brace is advised for the first three months after surgery.

Limitations

The present study had some limitations. Firstly, We performed a retrospective study with a small sample size, and the duration of follow-up was short. Secondly, the absence of control group was another drawback of this study. Thirdly, OLIF-LP surgery only conducted in the single-segmental lumbar spine disease in our study, whether it suitable for the multi-segmental lumbar degenerative disease is unknown. Further random control trials with large samples are needed to verify its pros and cons.

Conclusions

OLIF combined with lateral plate instrumentation seems to be a valuable surgical option for single-segmental lumbar degenerative disease. It is a minimal invasive one-stage surgical procedure to achieve good radiographic and clinic results without any major complications.

List Of Abbreviations

OLIF, Oblique Lateral Interbody Fusion; ODI, Oswestry Disability Index; VAS, Visual Analog Scale; PLIF, Posterior Lumbar Interbody Fusion; TLIF, Transforaminal Lumbar Interbody Fusion; DLIF, Direct Lateral Lumbar Interbody Fusion; ALIF, Anterior Lumbar Interbody Fusin; LLIF, Lateral Lumbar Interbody Fusion; DH, Disk Height; FH, Foraminal Height; CSA, Cross Sectional Area;

Declarations

Ethics approval and consent to participate

This study had been approved by Ethics Committee of the authors' affiliated institutions, and the informed consent to participate in the study should be obtained from all the patients.

Consent for publication

All patients provided written informed consent to use their clinical data for publication purposes.

Availability of data and material

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

Competing interests

The authors declare that they have no conflict of interest.

Funding

This study was sponsored by the Medical Health Science and Technology Project of Zhejiang Province (2021421708) and Project of Huzhou Science and Technology Bureau(2020GY08).

Authors' contributions

HDL had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. All authors meet all three of the requirements for authorship. STX and JKM were highly involved in the planning and execution of this study. Furthermore, XFF and SWF were highly involved in the acquisition of data and in the process of data interpretation. All authors read and approved the final manuscript.

Acknowledgements

We express deep thanks to Dr. Xiang-Qian Fang and Shun-Wu Fan for their technical support.

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Figures

Figure 1

Radiographic images showed the surgical process of OLIF with lateral plate fixation. The skin incision was made 4-8cm anterior to the midportion of the disk (A). Retractor for OLIF used after dilatation (B). The trial position is located in the 1/3 of the vertebral body (C). Insert the interbody fusion cage (D). Fix the lateral plate instrumentation (E-F).

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), foraminal height (FH) (B,C) before and (E,F) 7 days after surgery.

Figure 3

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

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) had undergone oblique lateral lumbar interbody fusion combined with lateral plates fixation. Preoperative anteroposterior and lateral radiographs (A,B). Preoperative magnetic resonance imaging scans (C,D). Anteroposterior and lateral radiographs as 12 months postoperatively (E,F). Magnetic resonance imaging scans as 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 had undergone oblique lateral lumbar interbody fusion combined with lateral plates fixation. Preoperative anteroposterior and lateral radiographs (A,B). Preoperative magnetic resonance imaging scans (C,D). Anteroposterior and lateral radiographs as 12 months postoperatively (E,F). Magnetic resonance imaging scans as 12 months postoperatively (G,H).