Percutaneous Delta Endoscopic Decompression versus Oblique Lateral Interbody Fusion for Lumbar Spinal Stenosis

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Research article

Keywords: Delta endoscopic technology, oblique lateral interbody fusion, lumbar spinal stenosis, outcomes, safety

DOI: https://doi.org/10.21203/rs.3.rs-75405/v1
Abstract

Background: Oblique lateral interbody fusion (OLIF) expands the inner volume of the spinal canal by indirect decompression. However, there were few studies to assess OLIF for LSS. The aim of this study was to evaluate outcomes and safety after percutaneous delta endoscopic decompression (PED) and OLIF.

Methods: Ninety-four patients with lumbar spinal stenosis (LSS) underwent PED or OLIF with percutaneous pedicle screw fixation (PPS) between January 2016 and December 2018 were retrospectively studied. Patients were assessed by estimated blood loss (EBL), operative time, hospital stay, cost, reoperation, complications, the Visual Analogue Scale (VAS), the Oswestry Disability Index (ODI), Japanese Orthopaedic Association score (JOA) and Short Form-36 (SF-36).

Results: Compared with OLIF group, the OLIF group was with longer operation time and hospital stay, more blood loss and more cost (p=0.001, 0.005, 0.001 and 0.001, respectively). Compared with preoperative data, VAS and ODI were significantly reduced and JOA and SF-36 increased significantly with the statistically significant difference (all p <0.05). There was no significant difference in postoperative main outcomes except VAS (lumbar) and ODI between the two groups (all p >0.05). But patients in the PED group were with lower VAS (lumbar) and ODI (p=0.012 and 0.042, respectively). In addition, the PED group was with SF-36 physical-component summary score (p=0. 0.036). The PED group was with lower all complication rate (2.4% PED vs 9.8% OLIF), intra-operative complication rate (2.4% PED vs 3.9% OLIF) and post-operative complication rate (0.0% PED vs 5.9% OLIF), but the difference was not statistically significant (p=0.336, 0.517 and 0.402, respectively). And there was no statistical difference in and reoperation rate (2.4% PED vs 3.8% OLIF) (p= 0.715).

Conclusions: PED and OLIF had satisfactory results for LSS. In general, PED was superior to OLIF in relieving patients with low back pain and improving function without any obvious shortcomings. Therefore, we recommend PED for LSS.

Level of Evidence: 3

Introduction

Lumbar spinal stenosis (LSS) is caused by the progressive narrowing of the lumbar spinal canal [1]. LSS patients usually present with low back pain and leg pain, especially when walking. It severely limits function, walking ability and quality of life. LSS has become the most common indication for spinal surgery [2–4]. Surgery is not a first-line treatment for symptomatic LSS which is a slowly degenerative disease [5, 6]. However, when conservative treatments are ineffective, surgical treatment, such as decompression with or without fusion, can be a reasonable treatment option[7].

With endoscopic spinal surgery gradually entering the mainstream, the debate about its clinical results and recommended indicators may intensify [8–12]. The surgical indications for endoscopic spine surgery
are still expanding due to the practical and reliable clinical results [13]. Spinal endoscopy has expanded from the treatment of disc herniation to LSS [14]. Previously, a key obstacle was to remove enough bone and the ligamentum flavum under continuous visualization to achieve the purpose of decompression [15]. Advances in technology have made it possible to treat LSS with percutaneous Delta endoscopic decompression (PED) [13, 15, 16]. And oblique lateral interbody fusion (OLIF) as another minimally invasive surgery technique is considered to be an extension and alternative of spinal surgery [17, 18]. OLIF expands the inner volume of the spinal canal by indirect decompression with little soft tissue and muscle damage [19, 20]. However, there were few studies to assess endoscopic surgery and OLIF for LSS [21–25]. So a retrospective cohort study was conducted to evaluate the efficacy and safety between PED and OLIF for LSS.

Materials And Methods

1. Patient Selection

This was a retrospective cohort study. And the study was approved by the hospital ethics committee. Between January 2016 and December 2018, 94 patients diagnosed with LSS who underwent PED and OLIF surgery were included in the study. Inclusion criteria: 1. Patients with LSS due to neurogenic claudication; 2. Patients with surgical indications; 3. Patient’s imaging findings consistent with symptoms. Exclusion criteria: Patients with trauma, active infection, malignant tumor, spinal deformity, previous lumbar fusion.

2. Surgical Procedure

2.1 PED

The patients were treated with Delta endoscopic technique. The PED operation was performed bilateral decompression through a unilateral approach. After general anesthesia, the patient took the prone position, and then the operating table was adjusted to expand the lumbar lamina space. The positioning point is located at the midpoint of the interlaminar space of the facet joint under X-ray. Then, a 15 mm incision was made at the positioning point; the skin and fascia was cut; it was expand step by step with a 3rd grade cannula, and the depth of the expansion cannula was confirmed under fluoroscopy without breaking through the ligament flavum. After the position of the cannula was satisfactory, the working cannula was inserted and the expansion cannula was removed; the spinal endoscope was connected and inserted. First, the soft tissues on the lamina and ligamentum flavum were cleaned endoscopically. The bony dispiration was performed by grinding drill and then intervertebral disc was removed the ipsilateral decompression. Then the cannula was tilted to remove the contralateral ligamentum flavum and part of the medial bone of the upper articular process to complete contralateral decompression. After the exploration showed that the decompression was sufficient, the working sleeve was pulled out, and finally the wound was sutured.

2.2 OLIF
53 patients underwent OLIF surgery [26, 27]. The patient was placed in the right lying position after induction of general anesthesia. 1. External oblique muscle, internal oblique muscle and transverse abdominal muscle were cut according to the fiber direction. 2. In the retroperitoneal space, we performed blunt dissection through the plane between the retroperitoneum fat and lumbar muscle to enter the lumbar spine, protecting the lumbar muscle and the lumbar plexus. 3. After the target disc was exposed, subtotal discectomy was performed to prepare the vertebral endplate. 4. A cage wide enough to prevent sinking was chosen. Subsequently, a cage filled with allogeneic bone is placed and its position confirmed by fluoroscopy. 5. Four percutaneous pedicle screws were inserted into the vertebral body and bilateral rods were used for fixation. 6. The rubber drainage tube was placed and the incision was closed in layers.

2.3 Outcome Measures

Patients were assessed by estimated blood loss, operative time, hospital stay, cost, reoperations and complications including dural tear, nerve injury and vascular injury, deep tissue infection, instrumentation failure, etc. The Visual Analogue Scale (VAS), the Oswestry Disability Index (ODI), Japanese Orthopaedic Association score (JOA) and Short Form-36 (SF-36) of patients were recorded before surgery and at the last follow-up.

2.4 Statistical Analysis

The statistical analyses were performed by SPSS (version 23.0; IBM, Chicago, IL). The independent t-test was utilized to compare continuous data between PED and OLIF groups. The paired t-test was utilized to compare continuous data between preoperative and postoperative values. Categorical variables were assessed using chi-square test. The significance of all analyses was defined as \( p < 0.05 \).

Results

94 patients were included this study, including 44 males and 50 females. The process of patient screening was shown in Fig. 1. Mean follow-up was 20.29 ± 4.63 in the PED group and 25.81 ± 6.06 in the OLIF group \((p = 0.001)\). There were 41 patients with mean age 56.76 ± 13.35 years in the PED group. And there were 53 patients with mean age 58.42 ± 9.98 years in the OLIF group without significant difference. There were 71 segments in the OLIF group and 45 segments in the OLIF group. And there were no significant difference in clinical characteristics between the PED group and the OLIF group (Table 1). Compared with the PED group, the OLIF group was with longer operation time and hospital stay, more blood loss and more cost \((p = 0.001, 0.005, 0.001 \text{ and } 0.001, \text{ respectively, Table 1})\). Two typical PED and OLIF cases were shown in Figs. 2 and 3.
Table 1
Clinical characteristics of included patients

| Variables            | OLIF (N = 53) | PED (N = 41) | Difference (95% CI) | P value |
|----------------------|---------------|--------------|---------------------|---------|
| Age                  | 58.42 ± 9.98  | 56.76 ± 13.35| NA                  | 0.492   |
| Gender               | NA            | 0.451        |                     |         |
| Male                 | 23 (43.4%)    | 21 (51.2%)   |                     |         |
| Female               | 30 (56.6%)    | 20 (48.8%)   |                     |         |
| BMI                  | 23.74 ± 2.77  | 25.34 ± 3.10 | NA                  | 0.010   |
| Operative segments   | NA            | 0.062        |                     |         |
| 1                    | 38 (67.9%)    | 37 (90.2%)   |                     |         |
| 2                    | 12 (22.6%)    | 4 (9.8%)     |                     |         |
| 3                    | 3 (9.4%)      | 0 (0.0%)     |                     |         |
| Operative time (min) | 144.26 ± 30.94| 113.41 ± 28.69| -27.40 (-44.65 to -10.15) | 0.001* |
| Blood loss (mL)      | 176.23 ± 68.45| 121.78 ± 82.03| -185.61 (-223.93 to -147.28) | 0.001* |
| Hospital stay        | 12.26 ± 3.49  | 10.34 ± 2.84 | -2.80 (-5.02 to -0.60) | 0.005* |
| Cost                 | 11.38 ± 2.88  | 3.57 ± 0.45  | 3.27 (2.37 to 4.18)  | 0.001* |

*Statistically significant (P < 0.05); Plus–minus values are means ± SD; NA denotes not applicable.

As shown in Table 2, there was no significant difference in baseline preoperative of main outcomes including VAS, JOA, ODI and SF-36 between the PED group and the OLIF group. Compared with preoperative data, VAS and ODI were significantly reduced and JOA and SF-36 increased significantly with the statistically significant difference (all p < 0.05, Fig. 4). And there was no significant difference in postoperative main outcomes except VAS (lumbar) and ODI between the two groups (all p > 0.05, Table 3). Patients in the PED group were with lower VAS (lumbar) and ODI (p = 0.012 and 0.042, respectively, Table 3). In addition, the PED group was with SF-36 physical-component summary score (p = 0. 0.036, Table 3).
Table 2
Preoperative estimation of mean values of main outcomes

| Outcome   | OLIF       | PED       | P value |
|-----------|------------|-----------|---------|
| VAS(lumbar) | 5.64 ± 2.30 | 5.05 ± 2.33 | 0.221   |
| VAS(leg)   | 5.13 ± 2.74 | 5.51 ± 2.82 | 0.512   |
| JOA        | 11.62 ± 4.42 | 11.73 ± 4.99 | 0.911   |
| ODI        | 47.22 ± 19.22 | 52.80 ± 20.41 | 0.177   |
| SF-36      |            |           |         |
| PF         | 36.60 ± 20.42 | 35.12 ± 21.75 | 0.735   |
| RP         | 6.13 ± 16.19 | 4.27 ± 14.69 | 0.566   |
| BP         | 25.49 ± 15.21 | 27.98 ± 15.52 | 0.438   |
| GH         | 46.34 ± 13.97 | 45.85 ± 12.10 | 0.860   |
| VT         | 42.83 ± 16.42 | 42.43 ± 15.93 | 0.908   |
| SF         | 54.72 ± 23.28 | 50.00 ± 20.92 | 0.312   |
| RE         | 6.29 ± 16.09 | 5.69 ± 14.72 | 0.853   |
| MH         | 58.26 ± 18.41 | 55.41 ± 19.91 | 0.474   |

*Statistically significant (P < 0.05); Plus–minus values are means ± SD.
Table 3
Postoperative estimation of mean values of main outcomes

| Outcome          | OLIF       | PED       | Difference(95%CI)          | P value |
|------------------|------------|-----------|---------------------------|---------|
| VAS(lumbar)      | 0.91 ± 1.08| 0.41 ± 0.67| -0.60 (-1.09 to -0.12)    | 0.012   |
| VAS(leg)         | 0.85 ± 1.54| 0.49 ± 0.68| -0.36 (-0.43 to 0.30)     | 0.164   |
| JOA              | 25.36 ± 4.38| 26.44 ± 2.12| 0.90 (-0.69 to 2.50)     | 0.150   |
| ODI              | 8.62 ± 12.79| 4.35 ± 3.89| -4.83 (-10.01 to 0.36)    | 0.042   |
| SF-36            |            |           |                           |         |
| PF               | 86.69 ± 18.50| 93.29 ± 8.03| 5.88 (-1.23 to 12.98)   | 0.036   |
| RP               | 87.26 ± 24.81| 87.19 ± 26.88| 0.67 (-1.55 to 3.10)   | 0.990   |
| BP               | 85.04 ± 19.54| 88.10 ± 15.39| 4.88 (-2.96 to 12.72)   | 0.412   |
| GH               | 70.16 ± 14.20| 70.37 ± 12.92| 0.21 (-1.15 to 11.15)  | 0.945   |
| VT               | 76.69 ± 14.73| 77.80 ± 14.14| -0.28 (-6.44 to 5.88)  | 0.714   |
| SF               | 103.30 ± 16.10| 97.56 ± 23.58| -5.74 (-11.39 to 0.00)  | 0.165   |
| RE               | 85.53 ± 27.35| 86.99 ± 31.52| 1.44 (-11.09 to 13.96)  | 0.811   |
| MH               | 85.43 ± 10.52| 82.63 ± 14.74| -2.37 (-8.04 to 3.31)  | 0.286   |

*Statistically significant (P < 0.05); Plus–minus values are means ± SD.

As shown in Table 4, the PED group was with lower all complication rate (2.4% PED vs 9.8% OLIF) and intraoperative complication rate (2.4% PED vs 3.9% OLIF), but the difference was not statistically significant (p = 0.336 and 0.517, respectively, Table 4). And there was no statistical difference in postoperative complication rate (0.0% PED vs 5.9% OLIF) and reoperation rate (2.4% PED vs 3.8% OLIF) (p = 0.402 and 0.715, respectively, Table 4).

Table 4
Complication and reoperation of included patients

| Outcome            | OLIF       | PED       | P value |
|--------------------|------------|-----------|---------|
| All complications  | 5 (9.8%)   | 1 (2.4%)  | 0.336   |
| Intra-complication | 2 (3.9%)   | 1 (2.4%)  | 0.517   |
| Post-complication  | 3 (5.9%)   | 0 (0.0%)  | 0.402   |
| Reoperation        | 2 (3.8%)   | 1 (2.4%)  | 0.715   |

*Statistically significant (P < 0.05).
This study showed that PED and OLIF had similar therapeutic effects for LSS. However, PED was superior to OLIF in relieving patients with low back pain and improving function, which implied that direct decompression was better than indirect decompression. But the magnitude of the between-group difference was small. Because it was reported that the surgical effect decreased over time [28]. In complication and reoperation rates, there were no statistical difference between the PED and OLIF group.

Conventional laminectomy decompression is a common surgical method for LSS [29, 30]. The posterior column structure was severely damaged during laminectomy and related facet joint resection, and postoperative complications such as lumbar instability can occur [31, 32]. Lumbar interbody fusion is a common method for the treatment of LSS, which can prevent lumbar spine instability [33]. OLIF is commonly used approach [25]. It is required to resect of joint and soft-tissue structures for conventional decompression of LSS. It is possible to achieve decompression without destroying these structures with the help of endoscopic technology [34, 35]. However, there were few studies to assess endoscopic surgery and OLIF for LSS. Therefore, we conducted this study to compare outcomes after PED and OLIF surgery.

OLIF as an indirect neural decompression had a satisfactory clinical outcome for degenerative spine disease [19, 27, 36]. The current study had similar results with previous studies. But PED was with lower VAS (lumbar) and ODI. This might be because direct decompression is more thorough and endoscopic decompression was with less damage to soft tissues and better recovery. And compared with the PED group, the OLIF group was with longer operation time and hospital stay, more blood loss and more cost. This was consistent with previous studies [21, 37]. OLIF was conducted through the window between abdominal major vessels and anterior border of the psoas muscle [38], which was reported in 2012 [39]. Silvestre et al. showed that only 7 patients (3.9%) had complications related to lumbar plexus injury or psoas muscle weakness, and all those patients recovered completely after a period of time [39]. There was no patient with complications related to the major vessel injury in our study, which was consistent with previous study [38]. In current study, 2 patients (3.8%) were with intraoperative complications (1 with thigh numbness and 1 with hematomcus). The patient with hematomcus received surgery. 3 patients (5.9%) were with postoperative complications. Two patients were with poor fusion and one patient was with cage subsidence who received posterior instrumentation in OLIF group.

Due to the revolutionary advances in technology and equipment, the model of percutaneous endoscopic spinal surgery is shifting from the treatment of disc herniation to the treatment of lumbar spinal stenosis [14]. In current study, 1 patients (2.4%) received second surgery. And there was one patient (2.4%) with dural tear which was sutured with satisfactory result. Bao et al. showed that two patients (3.6%) treated by PED needed a second surgery [40]. The PED group was with lower complications rate at 2.4% than that in the OLIF group. The reduction of operation time, blood loss and operation-related complications in the PED group can also be found in comparisons of the literature related to discectomies [41, 42]. The physical components of SF-36 has been proven to be an effective, responsive and reliable tool for assessing degenerative lumbar spine conditions [43]. The results showed similar outcomes in SF-36. The hospitalization cost of lumbar fusion surgery is higher, which may indicate that the comprehensive value assessment may be more inclined to perform decompression surgery alone [44].
So far, there is still much controversy about the indications of decompression plus fusion. Some experts have pointed out that patients with predominantly leg symptoms and no signs of segmental instability and deformities should use stability-preserving decompression techniques to avoid fusion [37]. Our study revealed that patients who were with or without mild degenerative spondylolisthesis all achieved satisfactory results in the PED group. This results were consistent with previous studies [4, 44].

There were some limitations in this study. First of all, this was a retrospective study. The follow-up period was relatively short and the sample size was small which was unable to evaluate the long-term difference in efficacy and safety between the two groups. Finally, the diameter of the spinal canal was not measured. The efficacy of surgery will be evaluated by measuring the postoperative diameter of the spinal canal in future research.

In conclusion, PED and OLIF had satisfactory results for LSS. In general, PED was superior to OLIF in relieving patients with low back pain and improving function without any obvious shortcomings. Therefore, we recommend PED for LSS. However, further studies are needed to evaluate the long-term maintenance of the efficacy of PED surgery. There is an urgent need to identify indications that decompression requires additional fusion. Future economic analyses may include the loss of productivity, reoperations, and the use of outpatient health resources to compare these surgical methods over a longer period of time.

**Abbreviations**

OLIF: Oblique lateral interbody fusion; PED: Percutaneous delta endoscopic decompression PPS: Percutaneous pedicle screw fixation; EBL: Estimated blood loss; VAS: Visual Analogue Scale; JOA: Japanese Orthopaedic Association score; ODI: Oswestry Disability Index; SF-36: Short Form-36; LSS: Lumbar spinal stenosis.

**Declarations**

**Acknowledgements**

We thank Dr. Lei Liu (Department of Gastroenterology, Tangdu Hospital, Fourth Military Medical University, China) for the help in statistical analysis.

**Authors’ contributions**

F-L W, C-P Z, X-D Y and J-X Q conceptualized and designed the study. F-L W drafted the initial manuscript, and reviewed and revised the manuscript. M-R D, K-L Z, and H-R G designed the data collection instruments. F-L W, Y-F Y, S-D W and B A collected data. F-L W, C-P Z carried out the initial analyses, and reviewed and revised the manuscript. F-L W, H W and Y-L Z coordinated and supervised data collection,
and critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

**Funding**

This work was supported by grants from the National Natural Science Foundation of China (No. 81871818). Sponsors were not involved in study design or implementation plans.

**Ethics approval and consent to participate**

This investigation was approved by the Clinical Research Ethics Committee of the Tangdu Hospital. All subjects signed informed consent by each patient. All clinical investigations had been conducted according to the principles expressed in the Declaration of Helsinki.

**Availability of data and materials**

Not applicable.

** Consent for publication**

Consent for publication was obtained from every individual whose data are included in this manuscript.

**Conflict of interest statement**

Authors have no conflicts of interests to clear.

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**Figures**

![Diagram](image)

**Figure 1**

The process of patient screening.
Figure 2

A 39-year-old male presented with low back pain and right lower extremity radiculopathy with PED (L5/S1). (A-B) Preoperative anteroposterior and lateral fluoroscopy (C-D) Preoperative sagittal and axial MRI (E-F) Preoperative sagittal and axial CT (E-F) Postoperative sagittal and axial CT.
A 46-year-old female presented with low back pain and left lower extremity radiculopathy with MIS-TLIF (L4/5). (A-B) Pre-operative anteroposterior and lateral fluoroscopy (C-D) Preoperative sagittal and axial MRI (E-F) Pre-operative sagittal and axial CT (E-F) Postoperative anteroposterior and lateral fluoroscopy
Figure 4

(A-B) The changes of VAS (leg), VAS (lumbar), JOA and ODI between before and after surgery in OLIF and MIS-TLIF groups. (C-D) The changes of SF-36 between before and after surgery in OLIF and MIS-TLIF groups.