

Original Article

Comparasion of PLIF combined with different intervertebral fusion methods in the treatment of single-segmental degenerative lumbar spondylolisthesis with spinal stenosis

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Abstract: Objective: This study aim to investigate the efficacy of different intervertebral fusion methods in the treatment of single-segmental degenerative lumbar spondylolisthesis (DLS) with lumbar spinal stenosis (LSS). Methods: We retrospectively reviewed 62 patients with DLS associated with LSS who were divided into an observation group (31 cases, PEEK cage + autograft bone) and control group (autograft bone). The operation time, intraoperative blood loss, postoperative drainage, postoperative duration for bed rest were recorded. Visual analogue score (VAS), Oswestry dysfunction index (ODI), the degree of spondylolisthesis, slip angle of spondylolisthesis, posterior intervertebral height, and angle of lumbar lordosis were recorded before, after and during postoperative follow-up. Result: All the patients were followed up for 12 months. The difference in the posterior intervertebral height, the angle of lumbar lordosis, and the low back VAS were statistically significant post-3/12 months ($P < 0.05$). The difference in the degree of spondylolisthesis was statistically significant post-12 months ($P < 0.05$). Bone healing was achieved in all patients. Conclusion: PLIF combined with PEEK cage + autograft bone transplant group maintains the slip angle, the lumbar anterior convex angle, the posterior edge height of the vertebral space, and the long-term effect is better than the simple autograft bone transplant group.

Keywords: PLIF, intervertebral fusion, degenerative lumbar spondylolisthesis, spinal stenosis

Introduction

Degenerative lumbar spondylolisthesis (DLS) associated with lumbar spinal stenosis (LSS) is a common spinal disease with an incidence of 0.53% [1]. At present, there are many clinical treatments for this disease, and conservative treatment can be used for patients whose disease does not progress [2]. Decompression and fusion are the criteria for surgical treatment, fusion surgery is superior to simple decompression operation [3, 4]. Now, posterior lumbar interbody fusion (PLIF) is often used in the treatment of DLS associated with LSS [5]. In this paper, a retrospective study of PLIF with autogenous bone (control group) or polyetheretherketone (PEEK) cage + autogenous bone (observation group) in the treat-

ment of DLS associated with LSS was conducted to compare the curative effects. A total of 62 patients who met the inclusion criteria were treated in our hospital from July 2013 to June 2017, and a 12-month retrospective study was conducted to evaluate the clinical efficacy of different intervertebral fusion methods.

Methods and materials

Baseline data

Inclusion criteria: (1) DLS associated with LSS within Meyerding Grade II; (2) Imaging examination was in accordance with the diagnostic criteria of spondylolisthesis; (3) Single segment spondylolisthesis; (4) Primary spinal open sur-

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Table 1. Comparison of age, height and body mass index (BMI), sex and surgical segment between the two groups ($\bar{x} \pm s$)

	experimental group (n=31)	control group (n=31)	t/ χ^2	p
Age (years)	55.48±7.99	55.65±7.74	0.081	0.936
BMI (kg/m ²)	26.84±1.29	26.97±1.21	0.415	0.679
Gender (male/female)	6/25	8/23	0.369	0.544
Surgical segment (L4-5/L5-S1)	19/12	21/10	0.282	0.596

gery; (5) One intervertebral fusion cage was used in the observation group.

Exclusion criteria: (1) Cardiovascular and respiratory diseases; (2) Severe dysfunction of liver and kidney; (3) Lumbar trauma; (4) Lumbar tumors; (5) Lumbar infectious diseases, etc.

From July 2013 to June 2017, 62 patients with DLS associated with LSS were treated with PLIF in the First Affiliated Hospital of Bengbu Medical College. There were 31 patients in the observation group, including 6 males, 25 females; 19 patients with L4, and 12 patients with L5. All of them were treated with PEEK cage + autogenous bone (peek material cage provided by Shandong Weigao Company). Meanwhile, 31 patients in the control group were treated autogenous bone, including 8 males and 23 females; 21 patients with L4 and 10 patients with L5.

Surgical methods

The patient was placed in the supine position and underwent tracheal intubation for general anesthesia. A median incision was made in the diseased intervertebral space, and the paravertebral muscle was separated bluntly from spinous process and vertebral plate, and a pedicle nail was placed in the space of the sliding vertebral body by the herringbone crest positioning method, and the slippage was restored, the spinous process was removed by the occlusor forceps, the lamina and ligament were cut off on both sides, the medial edge of the yellow ligament and articular process was removed according to the specific situation of the lesion, the nerve root canal and the lateral recess were enlarged, and the dural capsule and nerve root was protected during the operation. Then, the fibrous ring was cut out, the nucleus was removed, the upper and lower cartilage endplate was removed. The observation group was implanted with autologous bone granules and a peek cage. The dural capsule and nerve root

were examined, and the incision was sutured after placing a negative pressure drainage tube.

Outcome measurement

(1) For all patients we recorded the operation time, intraoperative blood loss, postoperative drainage, and postoperative duration for bed rest. (2) The degree of spondylolisthesis, slip angle of spondylolisthesis, posterior intervertebral height, and angle of lumbar lordosis were recorded before, after and during postoperative follow-up. (3) Visual Analogue Score (VAS) were used to evaluate the degree of pain in the leg and lower back, and the Oswestry dysfunction index (ODI) was used to evaluate the improvement of symptom function. (4) Postoperative complications: cerebrospinal fluid leakage caused by rupture of dural sac, numbness of lower limbs caused by nerve root injury, pain, decreased muscle strength, infection, screw loosening and displacement of intervertebral fusion cage, etc.

Statistical methods

SPSS 19.0 statistical software was used for analysis, the measurement data were expressed by mean \pm standard deviation, repeated measures analysis of variance was used to compare each time points in the group, pairwise sample t test was used for pairwise comparison, independent sample t test was used for comparison between groups, and counting data were used χ^2 test; test level $P=0.05$.

Results

Baseline data

Comparison of the general situation of the two groups of patients. There were no statistically significant differences in age, height, body mass index, gender and surgical segment between the two groups ($P>0.05$) (**Table 1**).

Table 2. Comparison of operation time, intraoperative bleeding volume, postoperative drainage volume and postoperative bed rest time ($\bar{x} \pm s$)

	Operation time (minutes)	Intraoperative bleeding volume (ml)	Postoperative drainage (ml)	Post-operation bedridden time (weeks)
experimental group	108.65±5.20	150.97±21.19	162.58±20.00	6.06±0.854
control group	110.19±5.34	149.35±18.96	167.10±19.01	6.00±0.775
t	0.964	0.316	0.911	0.312
P	0.339	0.753	0.366	0.756

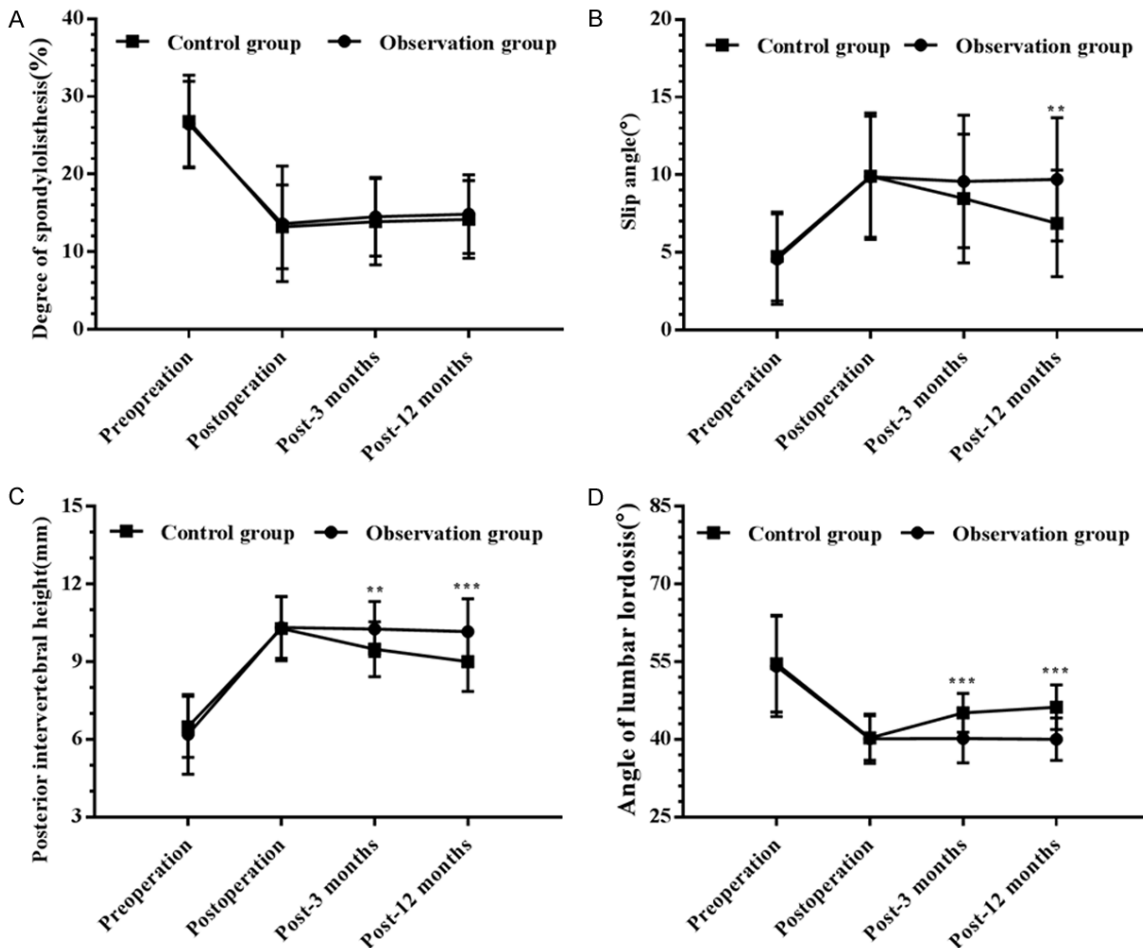


Figure 1. Degree of spondylolisthesis, slip angle of spondylolisthesis, posterior intervertebral height and angle of lumbar lordosis are presented as mean \pm SD. A. $P > 0.05$ control group vs. observation group pre-operation, post-operation, 3 months and 12 months after operation. B. $P > 0.05$ control group vs. observation group pre-operation, post-operation, 3 months after operation. $**P < 0.01$ control group vs. observation group 12 months after operation. C. $P > 0.05$ control group vs. observation group pre-operation, post-operation. $**P < 0.01$ control group vs. observation group 3 months after operation, $***P < 0.001$ control group vs. observation group 12 months after operation. D. $P > 0.05$ control group vs. observation group pre-operation, post-operation. $***P < 0.001$ control group vs. observation group 3 months and 12 months after operation.

There were no statistically significant differences in operation time, intraoperative bleeding volume, postoperative drainage and post-operation bedridden time between the two groups ($P > 0.05$) (Table 2).

Comparison of degree of spondylolisthesis between two groups

There was no statistically significant difference in the degree of spondylolisthesis, pre-opera-

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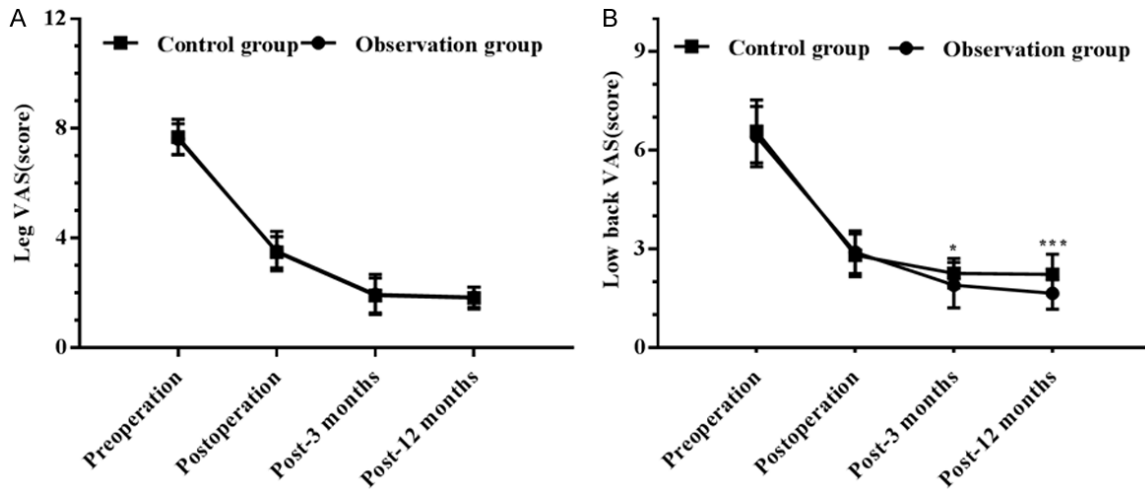


Figure 2. Leg VAS and low back VAS are presented as mean \pm SD. A. $P > 0.05$ control group vs. observation group pre-operation, postoperation, 3 months and 12 months after operation. B. $P > 0.05$ control group vs. observation group pre-operation, post-operation. * $P < 0.05$ control group vs. experimental group 3 months after operation, *** $P < 0.001$ control group vs. experimental group 12 months after operation.

tion, post-operation, post-3 months and post-12 months between the two groups ($P > 0.05$) (**Figure 1A**).

Comparison of slip angle of spondylolisthesis between two groups

There was no statistically significant difference in the slip angle of spondylolisthesis, pre-operation, post-operation and post-3 months between the two groups ($P > 0.05$). However, the difference was statistically significant post-12 months ($t = 3.009$, $P = 0.004$) (**Figure 1B**).

Comparison of posterior intervertebral height between two groups

There was no statistically significant difference in the posterior intervertebral height pre-operation, post-operation between the two groups ($P > 0.05$). However, the difference was statistically significant post-3 months ($t = 2.870$, $P = 0.006$) and post-12 months ($t = 3.771$, $P < 0.001$) (**Figure 1C**).

Comparison of angle of lumbar lordosis between two groups

There was no statistically significant difference in the angle of lumbar lordosis pre-operation, post-operation between the two groups ($P > 0.05$). However, the difference was statistically significant post-3 months ($t = 4.557$, $P = 0.001$)

and post-12 months ($t = 5.817$, $P < 0.001$) (**Figure 1D**).

Comparison of leg VAS between two groups

There was no statistically significant difference in the leg VAS pre-operation, post-operation, post-3 months and post-12 months between the two groups ($P > 0.05$) (**Figure 2A**).

Comparison of low back VAS between two groups

There was no statistically significant difference in the low back VAS pre-operation, post-operation between the two groups ($P > 0.05$). However, the difference was statistically significant post-3 months ($t = 2.382$, $P = 0.020$) and post-12 months ($t = 4.115$, $P < 0.001$) (**Figure 2B**).

Comparison of ODI between two groups

There was no statistically significant difference in the ODI pre-operation, post-operation, post-3 months and post-12 months between the two groups ($P > 0.05$) (**Figure 3A**).

Comparison of postoperative complications in two groups

At the follow-up, bone healing was achieved in both groups, infection, nor displacement of cage was found (**Supplemental Figure 1**). In the control group, there was pain (one case), screw

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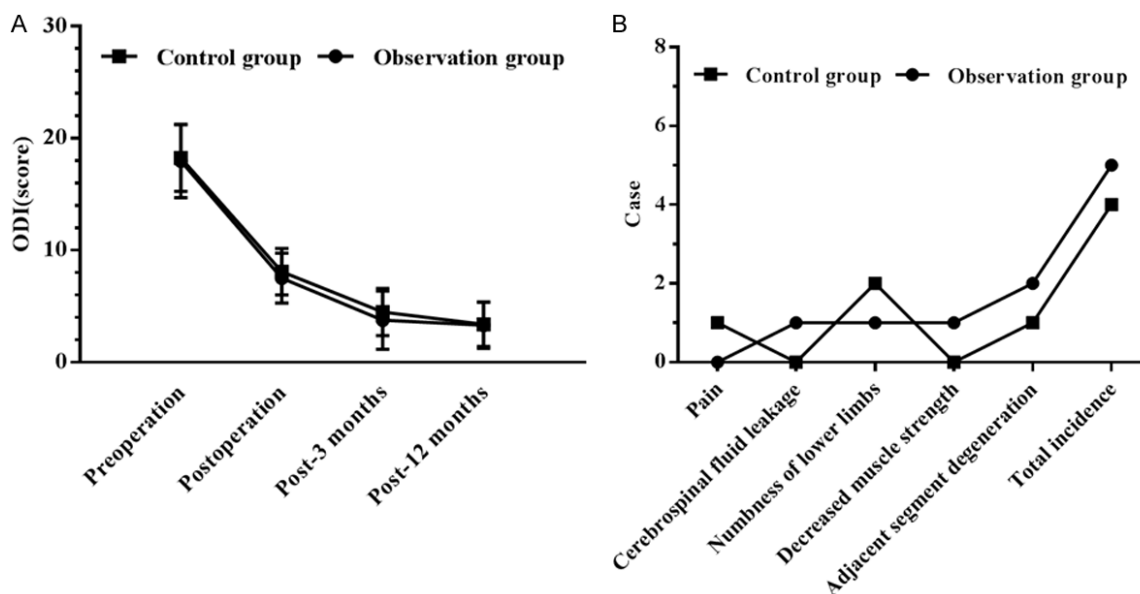


Figure 3. A. ODI are presented as mean \pm SD, $P > 0.05$ control group vs. observation group pre-operation, postoperation, 3 months and 12 months after operation. B. Four patients in the control group had postoperative complications, and 5 patients in the observation group showed postoperative complications, $P > 0.05$.

loosing (one case) and numbness of lower limbs (two cases). The incidence of adverse reactions was 12.9%. In the observation group, there were cerebrospinal fluid leakage (one case), numbness of lower limbs (two cases), loss of appetite (one case) and decreased muscle strength (one case), and the incidence of adverse reactions was 16.1%. There was no significant difference in the incidence of adverse reactions between the two groups ($\chi^2 = 0.00$, $P > 0.05$, continuously correcting) (Figure 3B).

Discussion

Degenerative low degree lumbar spondylolisthesis is the most common form of lumbar spondylolisthesis, which is more common in females than in males, and is most likely to occur at the L4/5 segment [6, 7]. The main clinical manifestations of the patients are low back pain, nerve root disease and/or neurogenic claudication. If non-surgical measures fail, surgery is needed, and the current surgical treatment of spondylolisthesis has a good long-term effect in most patients [8-10]. The common fusion method is intervertebral fusion, which is an effective method for the treatment of unstable degenerative spondylolisthesis [11, 12].

Before fusion surgery, imaging evaluation is needed. As a consensus, lumbar dynamic radiography is a common way to evaluate the stability of lumbar vertebrae, and combined with lumbar MRI is more helpful to judge the segmental stability of patients with lumbar spondylolisthesis [13, 14]. Of course, CT examination of lumbar vertebrae is also indispensable [15]. In this study, all patients were examined by anterior and lateral lumbar radiography, lumbar dynamic radiography, lumbar CT plain scan three-dimensional reconstruction, lumbar MRI and so on.

Chumnanvej et al. found that lumbar interbody fusion can significantly change vertebral body parameters, and can effectively correct disc height [16]. Kong LD et al. conducted a retrospective study and found that posterior interbody fusion and posterior internal fixation for degenerative lumbar spondylolisthesis can reduce low back pain, which may be related to the improvement of sagittal position, surgeons should consider deformity parameters in the treatment of degenerative spondylolisthesis, especially slip angle [17]. In this study, degree of spondylolisthesis, slip angle of spondylolisthesis, posterior intervertebral height, and angle of lumbar lordosis were measured in both groups, and significant improvement was found in both groups. During the 2-year follow-up peri-

od, the effect of the observation group was better.

Bokov A et al. found that screw loosening rate was positively correlated with fusion degree and decreased bone mineral density by a retrospective cohort study. Spondylolisthesis, bilateral facet joint resection and laminectomy without anterior support are risk factors for the development of pedicle screw loosening [18]. Patients with lumbar spondylolisthesis should fully understand the risk of posterior movement of fusion cage before operation, and spinal surgeons should choose larger cage, operate it carefully, especially for newer surgeons with less than 3 years of fusion experience [19]. Wang G et al. followed up lumbar spondylolisthesis patients treated with PLIF for 24 months, and found that there was no difference in clinical efficacy and imaging improvement in autogenous bone transplantation and PEEK cage + autogenous bone transplantation [20]. Lin B et al. conducted a 2-year follow-up on the degenerative lumbar disease patients treated by PLIF, and found that peek cage was as effective as interbody autogenous bone grafting [21]. Tally WC et al. found that if CT scan showed bone bridge at the fusion site 12 months after operation, and was without movement on flexion and extension film, the spinal segment is considered to be fused [22]. In this study, PEEK cage + autogenous bone was compared with autogenous bone, and it was found that bone healing was achieved in both groups and no screw loosening was found.

At present, bilateral pedicle screw fixation is mainly used in clinical practice. Schroeder GD et al. found that for patients with lumbar fusion, the use of bilateral pedicle screws can improve the fusion rate [23]. Kumar P et al. found that it is necessary to select appropriate cases, and in the cases of obesity and osteoporosis, bilateral pedicle fixation is preferred [24]. In this study, bilateral traditional pedicle screw technique was used, the fixation was effective.

Chan A K et al. found that there were some differences between patients with the highest satisfaction and those with the lowest; patients who were less satisfied were usually accompanied with coronary heart disease or were obese, and women were more satisfied [25]. Radovanovic et al. found that the efficacy of patients after lumbar surgery was affected by

sagittal balance [26]. The efficacy of both groups was satisfactory, and there was no statistically significant difference between VAS and ODI scores.

Okuda S et al. found that adjacent segment degeneration after L4 spondylolisthesis was more likely to occur at the headend [27]. Moreau P E et al. found that 29% of the patients with lumbar spondylolisthesis had adjacent segment degeneration, and the rate of surgical revision was 10%. The risk factors of adjacent segment degeneration included fixed segment and preoperative sagittal imbalance [28]. In this study, there were 2 cases of adjacent segment degeneration in the observation group and 1 case of adjacent segment degeneration in control group.

Strömqvist F et al. found that the overall incidence of dural rupture was 5%, spinal canal stenosis and degenerative spondylolisthesis were higher, and disc herniation was lower [29]. The incidence of complications after lumbar fusion was closely related to blood loss and operation time [30]. In this study, there was one case of dural rupture in the observation group and no other complications in both groups.

In summary, PLIF combined with PEEK cage + autograft bone transplant or simple autograft bone transplant, are the current common surgical methods for the treatment of degenerative lumbar spondylolisthesis, and the clinical effect is satisfactory. The PEEK cage + autograft bone transplant group maintains the slip angle, the lumbar anterior convex angle, posterior intervertebral height, the long-term effect is better than the simple autograft bone transplant group, PLIF combined with PEEK cage + autograft bone transplant is a recommended fusion method.

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Disclosure of conflict of interest

None.

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Supplemental Figure 1. Control group: (A) Lumbar lateral X-ray of one case of DLS associated with LSS. (B) Lumbar lateral X-ray of one case of DLS associated with LSS 12 months after operation. (C) Sagittal plane CT. Observation group: (D) Lumbar lateral X-ray of one case of DLS associated with LSS. (E) Lumbar lateral X-ray of one case of DLS associated with LSS 12 months after operation. (F) Sagittal plane CT.