

Outcome of posterior lumbar interbody fusion for L4-L5 degenerative spondylolisthesis

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ABSTRACT

Background: Posterior lumbar interbody fusion (PLIF) has become the standard in the treatment for degenerative spondylolisthesis since improvement of spinal instrumentation. However, few published studies have reported long term outcomes of PLIF using a same surgical procedure. The purpose of this study is to evaluate a long term outcome of PLIF using a same surgical procedure for L4-L5 degenerative spondylolisthesis.

Materials and Methods: Out of 45 patients who underwent L4-L5 PLIF for degenerative spondylolisthesis between 1995 and 2003, 37 patients (16 males and 21 females) were evaluated in this study. Mean age was 61.8 years. The average followup period was 121 months. We evaluated % slip, lordosis at L4/L5, lumbar lordosis, Japanese Orthopedic Association's (JOA) score and adjacent segment degeneration.

Results: The % slip significantly improved from an average of 17.0% before surgery to 9.7% at the last followup. Lordosis at L4/L5 averaged 3.6° before surgery, 8.2° after surgery and 6.9° at the last followup. Although patients experienced some loss of correction at last followup, their lordosis at L4/L5 at last followup still was significantly different from their lordosis at L4/L5 before surgery. Lumbar lordosis did not significantly change. Mean JOA score was 13.4 before surgery and 24.5 at the last followup; mean recovery ratio was 71.2%. Adjacent segment degeneration occurred in 40.5% of patients, almost all of which occurred in the cranial adjacent segment. Three patients (8.1%) required reoperation due to adjacent segment degeneration, at an average of 76 months after their initial surgery.

Conclusions: With more than 10-year followup after L4-L5 PLIF for degenerative spondylolisthesis, the adjacent segment degeneration occurred in 40.5% and reoperation was required in 8.1%.

Key words: Degenerative spondylolisthesis, posterior lumbar interbody fusion, adjacent segment degeneration, spinal instrumentation

MeSH terms: Spine, spondylolisthesis, instrumentation, lumbar region

INTRODUCTION

Posterior lumbar interbody fusion (PLIF) is one of the various methods to surgically manage degenerative spondylolisthesis.¹⁻³ Cloward¹ was first to describe original technique. Several surgeons have modified the original PLIF technique described.¹⁻³ However; it had been associated with a high incidence of fusion complications

such as a graft collapse and nonunion.^{2,3} Hence PLIF is not a standard surgical procedure. Since the development and improvement of spinal instrumentation, however, PLIF is not a standard treatment for progressive degenerative spondylolisthesis. While PLIF with pedicle screw fixation and interbody devices has shown satisfactory clinical results, a solid fusion using spinal instrumentation has been reported to accelerate the degenerative changes at the adjacent levels.²⁻⁷ However, in almost all of them, the surgeons used several surgical procedures such as PLIF with or without cage. The purpose of this study was to evaluate the long term outcome of PLIF using the same surgical procedure in patients with L4-L5 degenerative spondylolisthesis.

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MATERIALS AND METHODS

45 patients underwent a single level PLIF at L4-L5 for degenerative spondylolisthesis between 1995 and 2003. Eight of these patients were excluded because their postoperative followup period was <60 months. The remaining 37 patients (16 male and 21 female) were included in the study. The followup rate in this study was

82.2%. The mean age of the patients at the time of surgery was 61.8 years (range 26-77 years) and the mean followup period was 121 months (range 66-175 months). This study was approved by the ethics committee of our University. Written informed consent was obtained from all patients.

Operative procedure

A routine posterior midline incision was used for, thus exposing the L4 and L5 vertebrae. Laminectomy was performed, for almost all the caudal two-thirds of the L4 spinous process and lamina, including both inferior articular processes of L4. These procedures enable total resection of the ligamentum flavum and exposure of the neural elements. The pedicle screws were then inserted in L4 and L5 bilaterally. The reduction was initiated by distraction at the L4 pedicle screws using the distraction device. After the L4-L5 disc was resected as much as possible, the anterior part of the disc space was packed with cancellous iliac bone, and titanium cages (Harms cage, Depuy Spine, Raynham, MA) packed with grafted bone chips were inserted. Finally, compression was applied at the L5 pedicle screws using the compression device.

Radiologic assessment was performed using plain lateral view radiographs before surgery, immediately after surgery, and at the last followup examination. We evaluated the % slip, the lordosis at L4-L5, the lumbar lordosis and the adjacent segment degeneration. The % slip was measured using the Taillard method.⁸ The lordosis at L4-L5 was defined as the angle subtended by the superior end plate of L5 and the inferior end plate of L4. Lumbar lordosis was measured from the superior end plate of L1 to the inferior end plate of L5 using the Cobb method.⁹ The adjacent segment degeneration was defined as imaging evidence of one or more of the following lesions adjacent to a fused segment that was not present preoperatively: (1) Posterior opening $>5^\circ$; (2) narrowing of the disc height <3 mm; (3) progression of the slippage >3 mm.

The Japanese Orthopedic Association's (JOA) evaluation system for low back pain syndrome (JOA score) was used before surgery and at the last followup examination, to evaluate the outcome of subjective symptoms (low back pain and leg pain), clinical signs (sensory and motor disturbance), and urinary bladder function. A normal score is 29 points and the worst score is 6 points [Table 1]. The recovery rate of the JOA score that indicates the degree of normalization after surgery was calculated at the last followup examination using the formula described by Hirabayashi *et al.*¹⁰

Statistical evaluation was performed using one-way analysis of variance (ANOVA) to compare the radiologic measures before surgery, immediately after surgery, and at the last followup examination. *Post hoc* tests performed were indicated by ANOVA results using Tukey's test for multiple

comparisons. Statistically significant differences were defined as $P < 0.05$. SPSS for Windows (19.0; SPSS Inc., Chicago, IL, USA) was used to perform the statistical analyses.

RESULTS

The % slip decreased from 17.0% before surgery to 9.7% at the last followup examination [Figure 1]. The mean lordosis at L4-L5 was 3.6° before surgery, 8.2° after surgery and 6.9° at the last followup examination [Figure 2]. The

Table 1: Japanese Orthopedic Association's evaluation system for low back pain

Symptoms and signs	Score
Subjective symptoms (nine points)	
Low back pain	
None	3
Occasional mild pain	2
Frequent mild or occasional severe pain	1
Frequent or continuous severe pain	0
Leg pain and/or tingling	
None	3
Occasional mild pain	2
Frequent mild or occasional severe pain	1
Frequent or continuous severe pain	0
Gait	
None	3
Able to walk farther than 500 m, although it results in pain, tingling and/or muscle weakness	2
Unable to walk farther than 500 m	1
Unable to walk farther than 100 m	0
Clinical signs (6 points)	
Straight-leg raising test	
Normal	2
30° - 70°	1
$<30^\circ$	0
Sensory disturbance	
None	2
Slight disturbance	1
Marked disturbance	0
Motor disturbance	
None	2
Slight weakness (MMT 4)	1
Marked weakness (MMT 3-0)	0
Restriction of ADL (14 points)	Severe Moderate None
Turning over while lying	0 1 2
Standing	0 1 2
Washing	0 1 2
Leaning forwards	0 1 2
Sitting (about 1 h)	0 1 2
Lifting or holding heavy objects	0 1 2
Walking	0 1 2
Urinary bladder function (6 points)	
Normal	0
Mild dysuria	3
Severe dysuria	6

MMT=Manual muscle test, ADL=Activities of daily living

lumbar lordosis did not change significantly [Figure 3]. Adjacent segment degeneration occurred at the cephalad

level in 14 patients [Figure 4] and at the caudal level in one patient [Table 2]. No patient had a pseudarthrosis at the last followup examination.

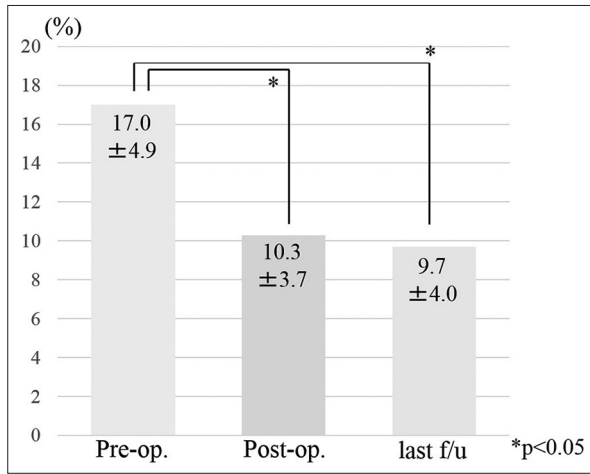


Figure 1: Bar diagram showing the % slip significantly improved from 17.0% before surgery to 9.7% at the last followup (*P < 0.05)

The mean JOA score was 13.4 points (range 4-20 points) before surgery and 24.5 points (range 16-29 points) at the last followup examination. The mean recovery rate was 71.2% (range 44-100%).

There were no serious systemic complications or deep surgical site infections. No immediate postoperative neurological complications were observed, although an incidental dural tear was observed in two patients (5.4%).

Reoperation was required in three patients (8.1%) due to intolerable symptoms in their lower extremities caused by adjacent segment degeneration. The mean period between the first surgery and the revision surgery was 76 months.

DISCUSSION

Anterior column augmentation with PLIF using intervertebral spacers in addition to pedicular screw fixation was found to have superior fusion rate and improved clinical outcomes in spondylolisthesis.¹¹⁻¹⁴ Recently, transforaminal lumbar interbody fusion has also been reported to produce a high fusion rate and excellent clinical outcomes. However, PLIF is more advantageous in achieving solid fusion by removing intervertebral material and cartilaginous endplates through bilateral wide annulotomy and harvesting a greater amount of local autograft.¹⁵ Evaluation of the long term outcomes of PLIF is important. Previously conducted studies had limitations in terms of different diagnoses, different levels and number of fused segments and different fusion techniques. Therefore, we evaluated the long term outcomes of PLIF using the same procedure in patients with degenerative spondylolisthesis.

In this study, the mean recovery rate of the JOA score was 71.2%, and the clinical result was satisfactory. However, we experienced the postoperative course seen in Case 2 on some occasions. Degenerative changes at the levels adjacent to the lumbar spinal fusion have been well recognized.^{5,6} The factors thought to be involved in the

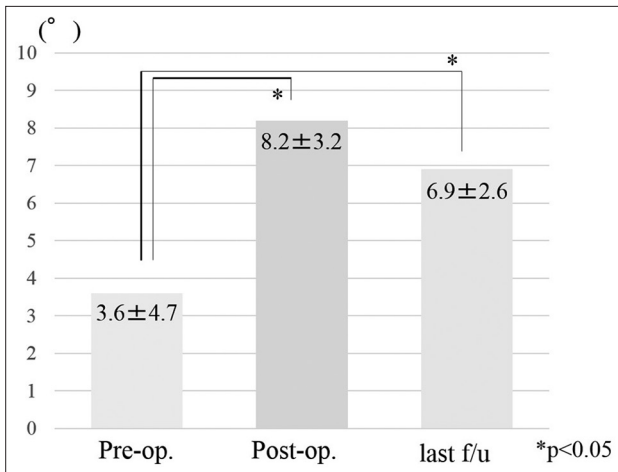


Figure 2: Bar diagram showing the lordosis at L4/L5 significantly improved from 3.6° before surgery to 8.2° after surgery. At the last followup, the lordosis at L4/L5 was restored (*P < 0.05)

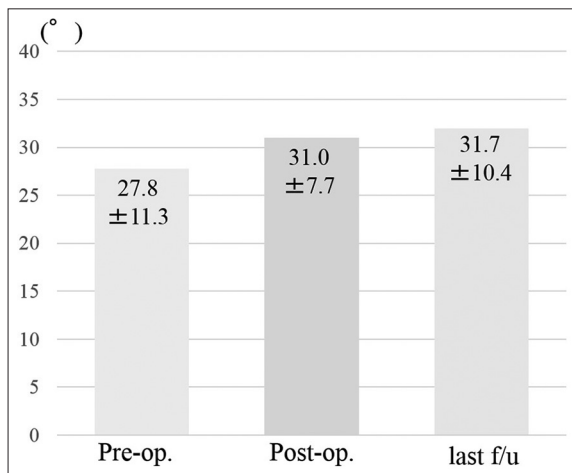


Figure 3: Bar diagram showing that the lumbar lordosis didn't significantly change

Table 2: Details of ASD

ASD	Cases
Posterior opening	4
Narrowing of the disc height	4
Progression of the slippage	2
Posterior opening+narrowing of the disc height	2
Posterior opening+progression of the slippage	1
Posterior opening+narrowing of the disc height+progression of the slippage	2
Total (%)	15/37 (40.5)

ASD=Adjacent segment degeneration

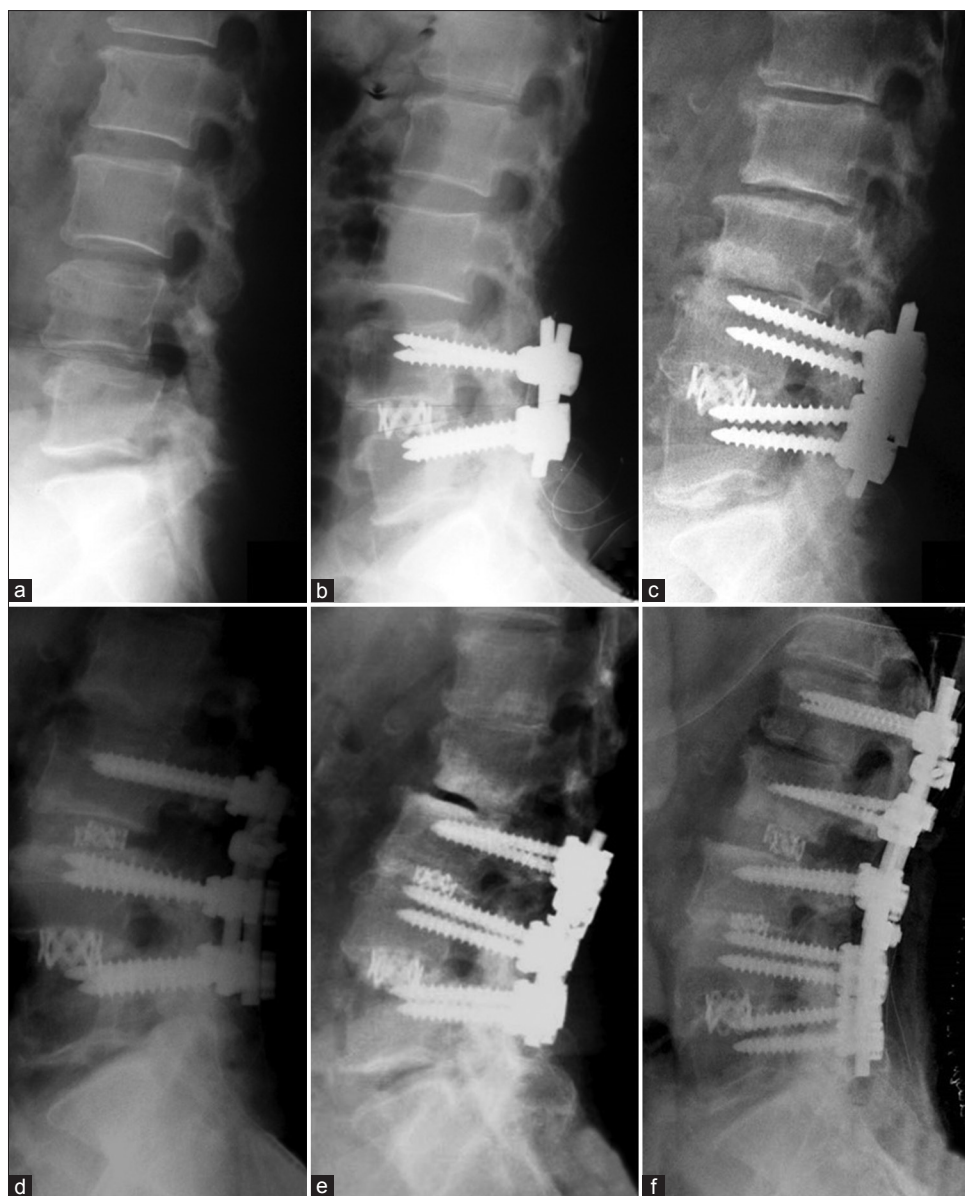


Figure 4: X-ray lumbosacral spine lateral view of a 72 year old male (a) preoperative showing L4-L5 degenerative spondylolisthesis, (b) immediately after the first surgery showing pedicle screws and cage *in situ*. Lordosis improved to 9° at L4L5 (c) 8 years after the first surgery showing adjacent segment degeneration at L3L4 level (d) immediately after the second surgery PLIF showing pedicle screws in L3 and cage between L3L4 also (e) 10 years after the first surgery showing adjacent segment degeneration at L2L3 level (f) After third surgery (at final followup) showing fixation at 2 more proximal levels with PLIF at L2L3 level (JOA score improved 17 to 21 points at final followup)

increase of degeneration at adjacent levels are the stiffness of the fixation, the number of fused levels, the natural course of degeneration at the adjacent level, and any postoperative lumbar sagittal malalignment. The importance of sagittal realignment and maintenance of lordosis during fixation have been documented in clinical studies,^{16,17} and clinical experience suggests that lumbar fusion in a nonanatomic sagittal alignment can cause a deleterious effect at the adjacent level. Akamaru *et al.*¹⁸ in their study have reported the effects of fixing the L4-L5 segment in different sagittal alignments on the adjacent motion segments using human cadavers. Their study showed that sagittal malalignment fusion is considered a risk factor for adjacent segment

degeneration after PLIF.¹⁸ Therefore, we have always ensured adequate lordosis at the fusion site in PLIF.

In this study, the mean lordosis at L4-L5 was 3.6° before surgery, 8.2° after surgery, and 6.9° at the last followup examination. We thought that we achieved good local alignment at the fusion site but adjacent segment degeneration occurred in 15 patients and reoperation was required in three of the 15 patients. Similarly, Ohwada *et al.* performed PLIF both with and without a cage, and reported that adjacent segment degeneration occurred in 57.5% and reoperation was required in 27.5% after a minimum followup period of 10 years.¹⁹ Greiner-Perth *et al.* have reported in

a study of instrumented PLIF that the reoperation rate was 12.9% for mono- or bi-segmental PLIF and 14.4% for multisegmental PLIF after a 5-year followup period.¹³ From our results, the reasons for adjacent segment degeneration occurrence are not understood. Okuda *et al.*²⁰ reported risk factors for adjacent segment degeneration after PLIF. Their study showed that coexistence of horizontalization of the lamina at L3 and facet tropism at L3-L4 may be a risk factor for neurologic deterioration resulting from accelerated L3-L4 degenerative change after L4-L5 PLIF. They used computed tomography and radiographs in their assessment.²⁰ On the other hand, we used only plain lateral view radiographs for our evaluation because our study data was >10 years old and was insufficient. We need to evaluate the risk factors for adjacent segment degeneration using computed tomography in the future.

This study has several limitations. First, we had no control group. Therefore, we could not evaluate the degenerative changes in the discs of nonsurgical patients. Van Horn and Bohnen, in a retrospective matched pair study of 16 patients with a minimum followup period of 16 years after anterior spinal fusion, found radiographic degenerative changes in the adjacent discs at a rate similar to that in the corresponding levels of the control group.²¹ Second, this study was a small case series.

We conclude that at a mean followup period of 10 years outcomes of PLIF using the same surgical procedure for L4-L5 degenerative spondylolisthesis have shown the satisfactory clinical results. The adjacent segment degeneration occurred in 15 patients (40.5%) and reoperation was required in three patients (8.1%).

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