

# What are the Differences in Outcome among Various Fusion Methods of the Lumbar Spine?

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**Objective :** For Posterior lumbar interbody fusion (PLIF) various cages or iliac bone dowels are used with or without pedicle screw fixation (PSF). To evaluate and compare the clinical and radiological results of different fusion methods, we intend to verify the effect of added PSF on PLIF, the effect of bone cages and several factors which are thought to be related with the postoperative prognosis.

**Methods :** One hundred and ninety seven patients with lumbar spinal stenosis and instability or spondylolisthesis underwent various fusion operations from May 1993 to May 2003. The patients were divided into five groups, group A (PLIF with autologous bone dowels, N=24), group B (PLIF with bone cages, N=13), group C (PLIF with bone dowels and PSF, N=37), group D (PLIF with bone cages and PSF, N=30) and group E (PSF with intertransverse bone graft, N=93) for comparison and analyzed for the outcome and fusion rate.

**Results :** Outcome was not significantly different among the five groups. In intervertebral height (IVH) changes between pre- and post-operation, Group B ( $2.42 \pm 2.20\text{mm}$ ) was better than Group A ( $-1.33 \pm 2.05\text{mm}$ ). But in the Group C, D and E, the IVH changes were not different statistically. Fusion rate of group C, D was higher than that of Group A and B. But the intervertebral height (IVH) increased significantly in group B ( $2.42 \pm 2.20\text{mm}$ ). Fusion rate of group C and D were higher than that of group A and B.

**Conclusion :** Intervertebral cages are superior to autologous iliac bone dowels for maintaining intervertebral height in PLIF. The additional pedicle screw fixation seems to stabilize the graft and improve fusion rates.

**KEY WORDS :** Bone dowel · Cage · PLIF (posterior lumbar interbody fusion) · PSF (pedicle screw fixation).

## Introduction

For the patients with chronic low back pain due to spinal stenosis associated with instability or spondylolisthesis, various fusion methods have been developed since Hibbs' first publication of spinal bone fusion in 1911. Pedicle screw fixation (PSF), first reported by King<sup>13)</sup> in 1944, was generalized by Roy-Camille<sup>19)</sup> and Louis<sup>14)</sup>, and became one of the most popular fusion methods in these days. Later on, PLIF introduced by Cloward<sup>4)</sup>, posterolateral bone graft by Watkins<sup>23)</sup>, and various other lumbar fusion methods have been presented and practiced now. As PLIF, PSF and intertransverse fusion (ITF) are the most prevailing lumbar spinal fusion method now in Korea, we intended to evaluate the radiological and clinical outcome of the patients postoperatively.

## Materials and Methods

### Patient population

Between May, 1993 and May, 2003, 197 patients of spinal stenosis with instability or spondylolisthesis were selected and studied. At least one month before the operation, they were confirmed to have had no effect by conservative management. They were divided into five groups; PLIF with bone dowels (Group A, N=24), PLIF with bone cages (Group B, N=13), PLIF with bone dowels plus PSF (Group C, N=37), PLIF with bone cages plus PSF (Group D, N=30), and ITF plus PSF as a control (Group E, N=93).

The criteria of operative indications in every patient of all groups were not different preoperatively.

### Methods

#### Evaluation of clinical and radiological results

We evaluated the clinical outcome at least one year after the operation by using the modified self estimating grading system of Hamby<sup>7)</sup>. Every patient was studied of his or her outcome with the grading system and the highly scored two grades were considered as 'satisfactory group' (Table 1).

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## Differences in Fusion Methods

For the radiologic aspect, we measured the intervertebral height (IVH) and bone fusion rate before and at least one year after the operation to compare the changes between the groups. We defined successful bone fusion as sustained bone density at the fusion site, no mobility on flexion and extension view of the lateral X-ray film, and bone formation between the vertebral body and the bone dowel. In group B and D, no halo around cages and in group E, hour glass shape bone formation between the intertransverse processes were defined as successful fusion.

### Surgical procedure

In group A and C, two pieces of autologous bone dowels were taken from the anterior iliac crest in supine position. Then the patient was turned over to perform the laminectomy. After complete removal of the intervertebral content, two dowels were put into the disc space in series cautiously protecting the nerve root. Then the two dowels were made into a single column with a small screw. In group B and D, the patient was placed prone for the laminectomy and discectomy. The bone cages filled with the cancellous bone chips taken from the posterior iliac crest were put into the intervertebral space. In group C and D, PLIF was followed by PSF. For the group E, PSF was followed by ITF with bone chips taken from the laminar and posterior iliac crest (Fig. 1).

**Table 1.** Modified grading system of Hambly

Outcome	Description
Excellent	My back is normal for my age
Good	I need non-prescription pain relievers occasionally.
Fair	My back was improved by the operation but I often use prescribe pain killers
Poor	My back is not much, if any better. I need constant pain killers
Very poor	My back is worse now than before surgery

### Data analysis

For the statistical analysis, we used paired t-test, one-way ANOVA test and results with p-values less than 0.05 were regard as statistically significant.

## Results

Total 197 patients were evaluated in this study. The patients were between 18 to 76 (mean  $51.2 \pm 12.0$ ) years of age. Seventy one patients were men and 126 patients were women (Table 2, 3).

### Outcome

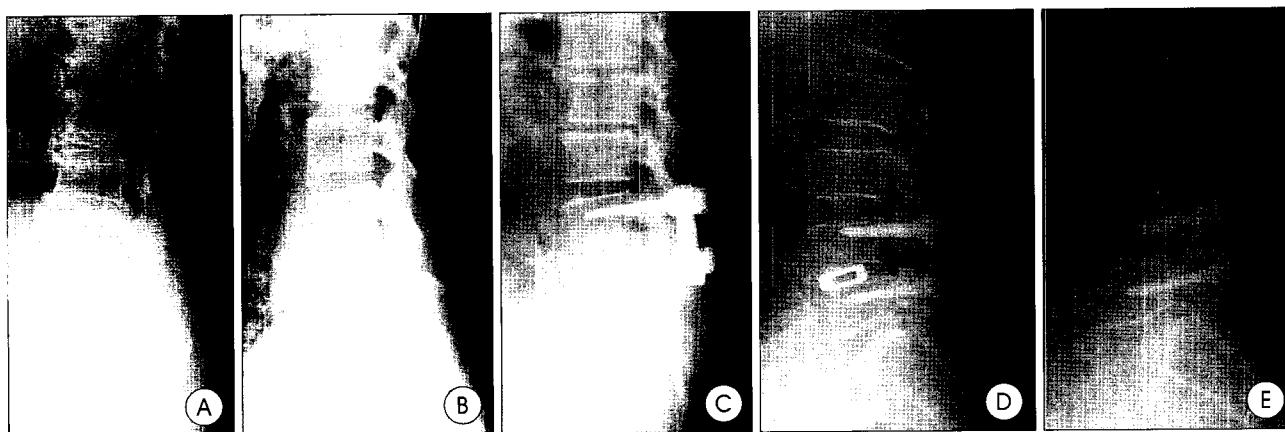
We evaluated the patients at least one year after the operation (mean;  $20.14 \pm 15.11$ mo) with modified grading system by Hambly<sup>7)</sup>.

'Good to Excellent' outcome was 70.8% in Group A, 84.5% in Group B, 62.1% in Group C, 76.6% in Group D, and 73.0% in Group E. The outcome in groups of using bone cages was better than using bone dowels without statistical significance (group A vs. B :  $p=0.417$ , Group C vs. D :  $p=0.075$ ). The groups without PSF showed better result than the groups with PSF, but there was no statistical significance (Group A vs. C :  $p=0.555$ , Group B vs. D :  $p=0.884$ ). The outcome between the Group C and D with PSF and group E with ITF didn't show any difference (Group C and D vs. E :  $p=0.237$ ) (Table 4).

### Radiological results

#### Change of IVH

Group A showed increased IVH than Group B by 2.24mm ( $p<0.001$ ). There was no difference of IVH between Group C and Group D. Group C and D showed increased IVH by 1.49  $\pm$  2.41mm than Group E ( $p<0.001$ ) (Table 4).



**Fig. 1.** 1 (A) Group A: Posterior lumbar interbody fusion (PLIF) with dowels, (B) Group B: PLIF with radiolucent bone cages (polyether ether ketone, PEEK), (C) Group C: PLIF with dowels and pedicle screw fixation (PSF), (D) Group D: PLIF with cages and PSF, (E) Group E: PSF and intertransverse bone graft.

### Bone fusion rates

Group A and Group B showed no difference in fusion rate ( $p=0.835$ ). Group C and D showed significantly higher fusion rate than Group A and B ( $p=0.006$  for A vs C,  $p=0.049$  for B vs D). Group C and D showed higher fusion rate than Group E ( $p=0.026$ ) (Table 4).

### Complications

There were 11 cases of complication. In Group A, one had dowel slippage and the other had continued instability requiring PSF. In Group B, one had instability requiring PSF. In Group C, two required additional decompression and one had epidural hematoma. In Group D, one required screw removal due to persistent postoperative back pain. In Group E, three had hematoma or abscess requiring surgery.

## Discussion

Since the first introduction of PLIF by Briggs in 1944, various modified fusion methods have been developed and practiced<sup>2,4</sup>.

PLIF is indicated for the unstable spine after decompression of the stenotic lumbar spine and has the advantage of preventing foraminal stenosis by maintaining the height of the intervertebral space. Additionally the fusion site can tolerate more loading and keep maximal strength because of its location directly in the center of the rotational axis. It also shows high fusion rate by its wide contact surface<sup>3,9</sup>.

But if fusion is failed, anterior columnar instability can result due to the complete removal of the content in the intervertebral space. As a result of excessive traction of the dura and nerve root, it can result in epidural proliferative fibrosis or root injury. Backward slipping of the grafted bone, pseudoarthrosis and excessive bleeding with transfusion reaction have been reported as the postoperative complications or disadvantages<sup>22,24</sup>.

For PLIF, bone dowels or bone cages are used but Brantigan<sup>1</sup> reported that using bone cages resulted in higher fusion rate than using bone dowels.

Our study showed the same result in terms of maintaining IVH and increased fusion rate but Oh<sup>16</sup> reported that chip bone or bone dowel graft, harvested from the laminectomy procedure or posterior iliac crest showed better result than using metal cages. They explained that the result may possibly be caused by complete discectomy, adequate cortico-cancellous bone insertion, amount of bone chips in the cage, radiologic artifact of the metal cages.

The IVH shortening is thought to be due to enhanced bone absorption by the loading pressure to the grafted bone dowels.

**Table 2.** Pathology of the spine and the level of involvement

	Group A (N=24)	Group B (N=13)	Group C (N=37)	Group D (N=30)	Group E (N=93)
Degenerative spondylolisthesis	12	5	17	12	47
Isthmic spondylolisthesis	5	4	7	8	17
Stenosis with segmental instability	7	4	13	10	29
Level					
L2-3	-	2	-	-	1
L3-4	-	2	4	2	5
L4-5	15	4	27	17	60
L5-S1	5	3	1	4	16
L2-3-4	-	-	-	-	1
L3-4-5	3	-	4	2	4
L4-5-S1	-	-	1	3	5
L3-4-5-S1	1	2	-	2	1

Group A : Posterior lumbar interbody fusion(PLIF) with bone dowels. Group B : PLIF with bone cages. Group C : PLIF with dowels and pedicle screw fixation (PSF). Group D : PLIF with cages and PSF. Group E : PSF and intertransverse fusion

**Table 3.** Clinical characteristics

	Group A	Group B	Group C	Group D	Group E
Age(years)	47±12	45±15	54±11	53±11	51±11
Male : Female	7 : 17	7 : 6	15 : 22	7 : 23	35 : 58
Duration of Sx. (months)	31±51	21±15	62±80	31±64	55±59
Follow-up periods (months)	26±21	21±15	22±16	20±14	20±16

**Table 4.** Clinical and radiological results of each group

	Group A	Group B	Group C	Group D	Group E
Excellent	8(33.3)	6(46.1)	11(29.7)	16(53.3)	22(23.6)
Clinical Good	9(37.5)	5(38.4)	12(32.4)	7(23.3)	46(49.4)
Outcome Fair (%)	6(25)	1( 7.6)	11(29.7)	6(20)	18(19.3)
Poor	1( 4.1)	1( 7.6)	3( 8.1)	1( 3.3)	7( 7.5)
Very poor	0	0	0	0	0
Intervertebral height changes(mm)	-1.3±2.0	2.4±2.2	2.8±1.3	2.0±1.8	-0.1±2.0
Successful bone fusion(%)	58.3	62.5	95.1*	96.7**	89.2***

\*  $p<0.001$  vs. Group A, \*\*  $p=0.003$  vs. Group B, \*\*\*  $p=0.026$  vs. Group C and D

But when bone cage is used, it can possibly resist the loading pressure and maintain the IVH.

Problems of using bone chips taken from the iliac crest may be gradual shortening of the IVH due to insufficient amount of harvested bone.

The advantages of using bone cages are prevention of bone absorption, providing biomechanical stability in early stage, using the bone chip obtained from operation site, early stabilization, less incidence of slipping out and prevention of foraminal stenosis by maintaining IVH.

But the disadvantages are also suggested; neural damage

## Differences in Fusion Methods

during the procedure of cage insertion is relatively high, foreign body reaction may occur, difficulty of radiologic interpretation of fusion, less contact surface between the cage and the vertebral bodies prevents adequate fusion<sup>12)</sup>.

Since King<sup>13)</sup> reported in 1944 internal fixation using pedicle screw, generalized by Roy-Camille<sup>19)</sup> and Louis<sup>14)</sup>, is one of the most common intraspinal fusion methods. Pedicle screw fixation (PSF) makes fusion firmly stable by it pass through anterior · middle · posterior column.

Internal fixation using pedicle screw, introduced by King<sup>13)</sup> in 1944 and later generalized by Roy-Camille and Louis<sup>14)</sup>, became one of the most popular spinal fusion method now. Because pedicle screw penetrates the anterior, middle and posterior columns, vertebral bodies are stabilized early and enables the spine to endure extension, compression and rotation sufficiently. This method can be applied to the total laminar defect state and to the single spinal level that permits normal segmental motion. Concomitant performance with PLIF lessens the loading pressure on the spine to prevent fracture or loosening of the screw and promote fusion<sup>5,6,26)</sup> by theoretically reconstructing the three columns<sup>18,21)</sup>.

The disadvantages of PSF have been presented. Somewhat difficult operative technique, the possibility of neural or facet joint injury due to incorrect direction of the screwing, requirement of normal anatomy of the vertebral body and pedicle. Prolonged operative procedure may result in excessive blood loss and higher risk of infection. Screw fixation may be difficult for the advanced osteoporotic spine<sup>16)</sup>. Biomechanical force may result in 'Fusion transition syndrome'<sup>17)</sup>.

In our study, PLIF with cages showed positive effect on IVH change and high bone fusion rate. PLIF with PSF showed better results than PSF with ITF. In one study of this country, PLIF with PSF showed good results in terms of reduction of spondylolisthesis and fusion rate but PSF with posterolateral bone graft showed low fusion rate and more frequent pathologic fracture induced by unstable anterior column that supported our results<sup>10)</sup>.

Yashiro<sup>25)</sup> also reported that PLIF showed better result for the reduction of spondylolisthesis and its maintenance, reduction of kyphosis than posterolateral bone graft. He also mentioned that fatigue fracture or spinal canal stenosis and instability adjacent to the fusion level occurred more frequently without PLIF.

Theoretically, well fused spine or maintained IVH will improve clinical symptoms by stabilizing the previously unstable spine or by preventing foraminal stenosis but the radiological improvement was not always correlated with the clinical outcome in our study.

## Conclusion

After studying the clinical and radiological results of 197 patients who were operated on by different fusion methods, PLIF with bone cages showed better for maintaining IVH. Addition of PSF was better for bone fusion and maintenance of IVH than PLIF only.

Contrary to the theoretical assumption, radiological results are not always correlated with clinical outcome. Search for other hidden factors that will influence the post-surgical outcome and long term follow up is required.

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