

Comparison of Outcomes for Posterior Lumbar Interbody Fusion (PLIF) between Spinal Block Bullet and Fusion Cages

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Background: Spinal block bullet cages are considered interbody spacers rather than providing a scaffold, into which osteoinductive or osteoconductive materials could be placed. On the other hand, hollow fusion cages provide interbody fusion through osteoinductive or osteoconductive materials placed inside them. While posterior lumbar interbody fusion (PLIF) with spinal block bullet cages is thought to achieve less fusion than that with fusion cages, there are no reports of previous investigation. We compared the PLIF outcomes between the two different cages. **Methods:** A series of patients (n=25) with lumbar disc diseases or degenerative lumbar spondylolisthesis were retrospectively reviewed; Group 1 (n=11) underwent PLIF with bullet cages and Group 2 (n=14) with fusion cages at a single level. Both groups received internal fixation with transpedicular screws and rods at the same level. Rostral adjacent level mobility, segmental motion, ratio of disc height, and foramen area in the fusion level were studied on the follow-up X-ray images. Fusion success was defined as segmental stability and absence of radiolucency at the cage—end plate interface. Visual analogue pain score (VAS) and the SF-8™ health survey (SF-8) were used to access the clinical outcome. **Results:** The duration of follow-up was 25.9 ± 10.65 months in Group 1 and 19.57 ± 13.22 months ($p=0.22$) in Group 2. Group 1 subjects achieved the same results as those in Group 2 in segmental motion (Groups 1, 2= $1.40 \pm 0.71^\circ$, $1.81 \pm 0.94^\circ$; $p=0.28$), ratio of disc height (Groups 1, 2= 0.3 ± 0.03 , 0.29 ± 0.07 ; $p=0.89$), foramen area (Groups 1, 2= $1.30 \pm 0.28\text{cm}^2$, $1.18 \pm 0.33\text{cm}^2$; $p=0.36$), and rostral segmental motion (Groups 1, 2= $6.43 \pm 4.08^\circ$, $8.89 \pm 4.84^\circ$; $p=0.201$). Moreover, there was no statistical difference between both groups in VAS (Group 1, 2= 2.72 ± 1.13 , 3.1 ± 0.96 ; $p=0.44$) and SF-8 (Group 1, 2= 16.54 ± 2.93 , 15.1 ± 2.37 ; $p=0.19$). **Conclusion:** According to our study, the spinal block bullet cages achieved the same radiological parameters and clinical outcomes for PLIF as the fusion cages.

Key words: bullet cage, fusion cage, posterior interbody fusion, segmental motion

INTRODUCTION

Spinal block bullet cages (Bullet cages) (Figure 1) are solid titanium threaded cages that are bullet shaped. They are considered interbody spacers rather than providing a scaffold in which osteoinductive or osteoconductive materials could be placed. On the other hand, the hollow fusion cages allow osteoinductive or osteoconductive materials to be placed inside them and have openings through which bone grafts or bone substitutes can achieve osseous inte-



Fig. 1 The Spinal Block Bullet Cages are titanium threaded cages in bullet-shaped.

gration with adjacent endplates. Accordingly, the fusion cages are thought to have an advantage over the bullet cages in interbody fusion. While posterior lumbar interbody fusion (PLIF) with bullet cages is thought to achieve a lower rate of fusion than that with fusion cages, there are no published reports of evaluation in previous studies. We compared the PLIF outcomes between the two different cages.

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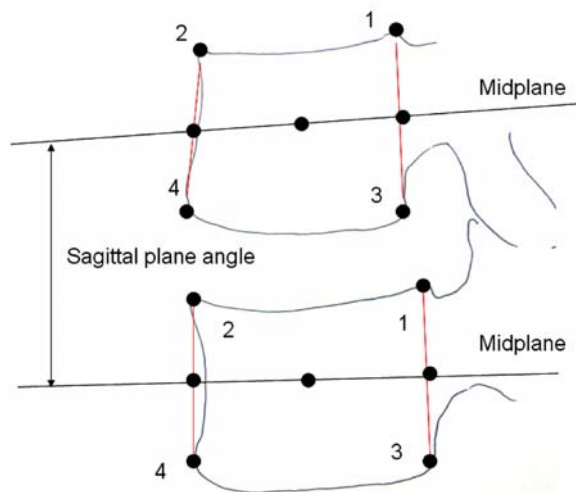


Fig. 2 Radiographs of an instrumented segment taken in extension and flexion. Four circles, 1 to 4, are labeled and shown on the vertebrae of the fusion level and the rostral segment. See the table 2 for definitions of parameters.

MATERIALS AND METHODS

We performed a retrospective study to compare the outcomes of using spinal block bullet cages (A-spine BULLET™ lumbar disc spacer) and fusion cages for PLIF Helix (A-spine helix lumbar cage), Vigor (A-spine VIGOR lumbar disc spacer), and PEEK (A-spine PEEK cage) cages, which are hollow and are considered fusion cages. Bullet cages, which are not hollow, do not provide a scaffold into which osteoconductive or osteoinductive material can be placed.

For comparability, only patients with one-level fusion were enrolled. Twenty-five patients undergoing PLIF at a single level from 2000 to 2005 in our hospital were retrospectively reviewed. All their medical records and follow-up radiographs were reviewed. We ascertained the demographic data by chart review. These patients were divided into two groups: Group 1 (n=11) underwent PLIF with bullet cages and Group 2 (n=14) with fusion cages (Helix ×7, Vigor ×6, PEEK ×1) at a single level. The operative procedure in both groups included muscle dissection through the midline, bilateral hemilaminectomy with removal of the spinal process, and finally discectomy. Both groups received internal fixation with transpedicular screws and rods at the same level. The bone grafts derived from the laminectomy were placed inside the hollow fusion cages,

Table 1 Patients Demographics

	Group 1 Spinal bullet block cages	Group 2 Fusion cages	P value
Case number	11	14	-
Female/Male	6/5	7/7	-
Age(y/o)	67.8 ± 12.4	44.9 ± 13.2	0.0003
Degenerative disc diseases	3	3	-
Spondylolisthesis	8	11	-
Level			
L2-3	0	1	
L3-4	2	0	-
L4-5	9	10	
L5-S1	0	3	
Follow up (months)	25.9 ± 10.65	19.57 ± 13.22	0.22

but no bone grafts were placed around the cages in either group. Posterolateral fusion was not performed in either group.

The segmental rotation angles were determined from the follow-up flexion—extension radiographs using Distortion Compensated Roentgen Analysis (DCRA)¹. The DCRA protocol permits using measurements from all segments imaged on a lateral view and compensates for variations in radiographic magnification and stature as well as for distortion in central projections. In addition, the disc ratio and the foramen area were measured on the lateral flexion radiograph using the Tri-Service General Hospital Uniweb Picture Archiving and Communication System at the fusion level. Table 2 summarizes the definition of the parameters measured, and Figure 2 illustrates these definitions.

Segmental stability is defined as sagittal rotational motion of less than 3°². Fusion success is defined as absence of any dark halo around a cage on both anteroposterior and lateral radiographs³ combined with segmental stability. We did not report bridging bony trabeculation, because the titanium cage obscured reliable assessment of bone formation on plain radiography⁴.

At the time of follow-up, patients were asked to complete a questionnaire regarding a visual analogue pain score (VAS) of backache and an SF-8™ health survey (SF-8). The patients were also asked to answer the following two questions: “Would you be willing to recommend this operation to a friend suffering from the same disease?”; and “Would you be willing to make the same choice if given the chance?”.

For comparison of the radiographic parameters and the clinical outcomes between the two groups, a t test and Chi-squared test were used. The level of significance was set at p=0.05.

Table 2 Definitions of Radiographic Parameters Measured

Radiographic parameters	Definition
Sagittal plane angle	Angle between vertebral midplanes. The vertebral midplane is defined as the line running through midpoints between corners 1 and 3 and 2 and 4, respectively. For vertebrae with an approximately rectangular shape, the midplane angle is identical to the angle of lordosis as measured from the endplates.
Sagittal plane rotational angle in the fusion level	Difference of sagittal plane angle in the extension view minus angle in the flexion view in the fusion level
Sagittal plane rotational angle in the rostral level	Difference of sagittal plane angle in the extension view minus angle in the flexion view in the rostral level
Disc ratio	In the flexion view, the disc ratio is defined as the ratio of the distance between the corner 3 of the rostral level and the corner 1 of the caudal level over the distance between the corner 1 of the rostral level and the corner 1 of the caudal level in the fusion level.
Foramen area	In the flexion view, the area, confined by the lower edge of the rostral pedicle superiorly, inferiorly the upper edge of the caudal pedicle, anteriorly the line between the corner 3 of the rostral level and the corner 1 of the caudal level, and posteriorly the facet joint, is measured using the digital computerized image program (the Tri-Service General Hospital Uniweb Picture Archiving and Communication System).

RESULTS

Three patients in Group 1 and three patients in Group 2 received the operation because of degenerative disc disease, and eight patients in Group 1 and eleven patients in Group 2 because of spondylolisthesis. In Group 1, there were 6 women and 5 men, between the ages of 44 and 89, with a mean age of 67.8 ± 12.4 . In Group 2, there were 7 women and 7 men, between the ages of 23 and 69, with a mean age of 44.9 ± 13.2 . The significant difference in the mean age of patients in the two groups ($p < 0.0003$) was simply because of selection bias. The duration of follow-up was 25.9 ± 10.65 in Group 1 and 19.57 ± 13.22 months ($p = 0.22$) in Group 2. (Table 1).

Sagittal Rotational Motion

The sagittal rotational motion at the fusion level was $1.41 \pm 0.71^\circ$ in Group 1, and $1.81 \pm 0.94^\circ$ in Group 2. All cases in both groups had achieved the segmental stability at the fusion level. The sagittal rotational motion in the rostral level was $6.43 \pm 4.08^\circ$ in Group 1 and $8.89 \pm 4.84^\circ$ in Group 2.

Disc Ratio and Foramen Area

The disc ratios were 0.3 ± 0.03 in Group 1 and $0.29 \pm$

Table 3 Results of Radiographic Parameters

	Group 1 Spinal bullet block cages	Group 2 Fusion cages	P value
Sagittal plane rotational angle in the fusion level	$1.41 \pm 0.71^\circ$	$1.81 \pm 0.94^\circ$	0.26
Sagittal plane rotational angle in the rostral level	$6.43 \pm 4.08^\circ$	$8.89 \pm 4.84^\circ$	0.201
Disc ratio	0.3 ± 0.03	0.29 ± 0.07	0.88
Foramen area(cm^2)	1.3 ± 0.28	1.19 ± 0.33	0.22
Fusion success (%)	90.1% (10/11)	92.8% (13/14)	0.858

0.07 in Group 2. The foramen areas were $1.31 \pm 0.28 \text{cm}^2$ in Group 1 and $1.19 \pm 0.33 \text{cm}^2$ in Group 2. The published mean value of foramen area lies within $1.06\text{--}1.67 \text{cm}^2$ ⁵⁻⁸. According to the published values, foramen area was within the normal limits in both groups.

Fusion Success

Fusion success was achieved in 90.1% (10/11) in Group 1 and 92.8% (13/14) in Group 2. Although two cases presented radiolucency in the cage endplate interface, they had nevertheless achieved segmental stability.

Clinical Outcomes

The VAS were rated as 2.72 ± 1.13 in Group 1, and 3.1 ± 0.96 in Group 2. SF-8 was marked as 16.54 ± 2.93 in Group 1, and 15.1 ± 2.37 in Group 2. When asked “Would you be willing to recommend the operation to a friend suffering from the same disease?”, 72.3% (8/11) of patients in Group 1 and 78.6% (11/14) in Group 2 answered “Yes”. When asked “Would you be willing to make the same choice again if given the chance?”, 81.8% (9/11) in Group 1 and 86.7% in Group 2 answered “Yes”.

Comparison

Group 1 achieved the same results as did the Group 2 in segmental rotational motion (Groups 1, 2= $1.41 \pm 0.71^\circ$, $1.81 \pm 0.94^\circ$, $p = 0.26$), ratio of disc height (Groups 1, 2= 0.3 ± 0.03 , 0.29 ± 0.07 ; $p = 0.88$), foramen area (Groups 1, 2= $1.31 \pm 0.28 \text{cm}^2$, $1.19 \pm 0.33 \text{cm}^2$; $p = 0.22$), and rostral segmental rotational motion (Groups 1, 2= $6.43 \pm 4.08^\circ$, $8.89 \pm 4.84^\circ$; $p = 0.201$). In term of fusion success, Group 1 also achieved the same result as Group 2 (Groups 1, 2=90.1%, 92.8%, $p = 0.858$) (Table 3). Moreover, there was no statistical difference between both groups in VAS (Groups 1, 2= 2.72 ± 1.13 , 3.1 ± 0.96 ; $p = 0.44$) and SF-8 (Groups 1, 2= 16.54 ± 2.93 , 15.1 ± 2.37 ; $p = 0.19$) (Table 4).

Table 4 Results of Clinical Outcomes

	Group 1 Spinal bullet block cages	Group 2 Fusion cages	P value
Visual analogue pain score	2.72 ± 1.13	3.1 ± 0.96	0.44
SF-8™ health survey (SF-8)	16.54 ± 2.93	15.1 ± 2.37	0.19
Percentage of willing to recommend the operation to a friend suffering the same disease (%)	72.3 (8/11)	78.6 (11/14)	0.73
Percentage of willing to make the same choice if given the chance (%)	81.8 (9/11)	86.7 (12/14)	0.79

Complications

Neither group had any incidence of cage migration or instrumentation failure. Only one incidental durotomy occurred during the cage placement in Group 2.

DISCUSSION

Cages are intended to be a spacer that maintains the disc height and the foramen area. In this regard, the bullet cages had maintained the same disc height and the foramen area as the fusion cages did. Moreover, the mean values of the foramen area in both groups were within the published mean value.

In previous reports⁹, adjacent segment disease is rated from 5.2% to 100% depending on the criteria of instability used. It is considered a potential late complication of spinal fusion that can necessitate further surgical intervention and adversely affect outcomes. Rostral segmental hypermobility presented in both groups. In our study, the bullet cages had the same adverse effect on the rostral segmental hypermobility as the fusion cages.

The hollow fusion cages are designed as not only interbody spacers but also as scaffolds. Along with supportive force, they provide scaffolds in which the osteoconductive or osteoinductive material can be placed. Accordingly, osseous integration with adjacent endplates could be achieved by the bridging bony trabeculation through the hollow cages¹⁰. The solid bullet cages, which do not provide a scaffold, have lower fusion rate than the hollow fusion cages do. However, our findings were that the solid bullet cages achieved the same radiographic parameters and clinical outcomes as the hollow fusion cages in patients undergoing PLIF with transpedicular screw and rod fixations.

Shah et al. stated that the interbody fusion with cages is achieved in three ways¹⁰: 1. bridging bony trabeculation through the cages^{11,12}; 2. bridging bony trabeculation outside the cages¹³; and 3. bony anchorage of the cage endplate interface^{12,14}. Obviously, the bullet cages achieved the interbody fusion by only the later two ways. Furthermore, there is a suggestion that bridging bony trabeculation outside the cages and bony anchorage of the cage endplate interface could provide enough strength to achieve the fusion success.

CONCLUSION

According to our study, the spinal block bullet cages achieved the same radiological parameters and clinical outcomes as the fusion cages in PLIF augmented with transpedicular screws and rod fixations. Furthermore, there is a suggestion that bridging bony trabeculation outside the cages and bony anchorage of the cage endplate interface could provide enough strength to achieve successful fusion.

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