Comparative study of posterior lumbar interbody fusion by strut laminar autograft versus cage in degenerative lumbar spine diseases

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Background
Degenerative spondylolisthesis and lumbar disk degeneration are common degenerative diseases of the spine that may lead to lower back pain and radicular leg pain. The perfect surgical treatment remains a point of debate; interbody fusion has been recognized as having a 'golden role' in the treatment of lumbar degenerative diseases, but spinal interbody fusion with polyetheretherketone (PEEK) cage surgery often incurs numerous complications such as cage retropulsion, nonunion, and high cost. We hypothesize that the autologous strut laminar graft will show clinical and radiological results similar to those obtained using a PEEK cage.
Objective
To compare the primary outcome (clinical pain relief) and the secondary outcome (radiological signs of union and rate of fusion) when using strut laminar graft versus PEEK cage in posterior lumbar interbody fusion (PLIF) technique in the surgical management of degenerative lumbar diseases.
Patients and methods
Forty patients with single-level lumbar degenerative disk disease and/or degenerative spondylolisthesis grades 1 or 2 underwent PLIF surgery between November 2017 and December 2020. All patients were randomly divided into two groups according to the method of fusion (group A: laminar strut graft and group B: PEEK cage). Single-level PLIF was performed in all patients. Clinical, radiological, functional, and perioperative data were recorded and compared.
Results
The mean follow-up was 22±6 months. Clinical improvement and radiological fusion were significantly documented in each group (P>0.05). However, no significant difference existed between the two groups regarding demographic, radiological, and functional outcomes.
Conclusions
The results suggest that the laminar strut graft when used instead of the cage seems to be an equally safe and low-priced method of interbody fusion.

Keywords:
degenerative, fusion, lumbar, polyetheretherketone cage, posterior lumbar interbody fusion, strut graft

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Introduction

Low back pain affects about 60–85% of adults at some time in their lives. It has a major socioeconomic burden [1]. Lumbar disk herniation and lumbar instability, a common degenerative disease of the spine, may lead to low back pain and radicular leg pain. Disk degeneration is directly related to increasing patient age with female predominance [2,3]. Initial conservative management plays a major role in most patients. Surgery is indicated if symptoms are disabling and interfere with work or if there is a significant progressive neurological deficit. The perfect surgical treatment remains a point of debate, interbody fusion is recognized as the 'golden role' in the treatment of lumbar degenerative diseases, but spinal fusion surgery often incurs numerous complications including morbidity, adjacent-segment disease, and donor area complications [4]. Theoretical advantages that support posterior lumbar interbody fusion (PLIF) include anterior column stability, restoration of lordosis, maintenance of intervertebral disk height, and indirect foraminal decompression. In the literature, polyetheretherketone (PEEK) cages have been accepted with excellent clinical outcomes [5]. However, the nonresorbable PEEK cage may have some long-term complications such as pseudoarthrosis and the reduction of the available contact area for bony fusion. More than 30% of the surface area of the end

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plate should be in direct contact with the local bone [6]. Another complication is the cage retropulsion, the need for reoperation, and high cost, especially in developing countries. Suk *et al.* [7] reported that the use of bone grafts as interbody spacers and pedicular fixation in the treatment of spondylolisthesis achieved a fully circumferential fusion with good results. we hypothesize that the autologous strut laminar graft will show clinical and radiological results similar to those obtained using a PEEK cage. The purpose of our study is to compare the rate of fusion, clinical pain relief, and radiological signs of union when using strut laminar graft versus PEEK cage in PLIF technique in the surgical management of degenerative lumbar diseases.

Patients and Methods

This prospective comparative randomized study was conducted between November 2017 and December 2020. Forty patients with degenerative lumbar spine diseases consented after obtaining the approval of our local medical ethics committee. All of them were divided into two groups A and B concerning the technique of fusion.

The 40 patients were allocated randomly by simple computer-assisted randomization into two groups. Group A, 20 patients underwent PLIF with autologous laminar strut graft from the site of decompression, and group B underwent PLIF with a PEEK cage.

We included patients with single-level degenerative disk diseases between L3 and S1, patients with degenerative spondylolisthesis grades 1 or 2, not responding to conservative management for 6 months, and the age group between 20 and 60 years. Exclusion criteria included: need for two or more levels of fusion, pathologic conditions such as infection or tumor, revision surgery, obese patients (BMI >30), smokers, patients taking steroids, diabetic patients, and medically unfit patients. Full detailed history, physical examination, radiological workup (plain radiograph including functional radiograph, multi-detector computed tomography in some patients and MRI), and laboratory investigations were performed for all patients.

Clinical parameters before and after surgery included the following: visual analog score (VAS) [8] was assessed for low back pain and functional outcome by Oswestry disability index (ODI), which is valid in the Arabic language [9]. Radiologically, disk space height was measured between the edges of the adjacent vertebral end plate, while the segmental lordotic angle was calculated between the intersection of two lines drawn tangential to the vertebral end plate in the sagittal view (Fig. 1) [10].

The fusion success was assessed by Brantigan–Steffee criteria (BSF) [11].

BSF1: radiographical pseudarthrosis is indicated by collapse of the construct, loss of disk height, vertebral slip, broken screws, displacement of the carbon cage, or significant resorption of the bone graft, or lucency visible around the periphery of the graft or cage.

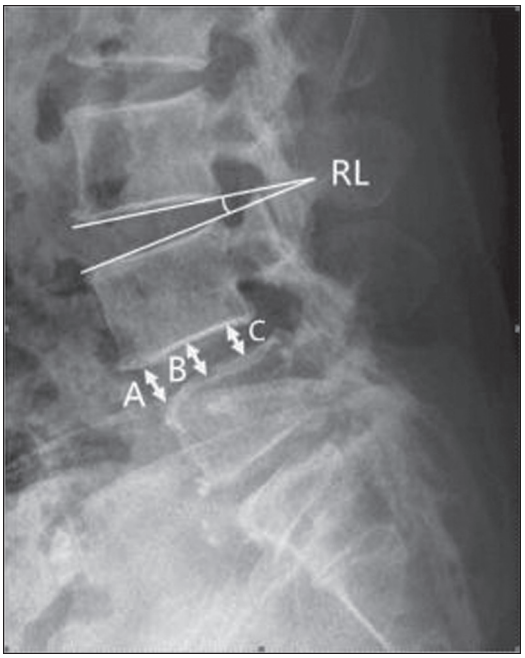
BSF2: radiographical locked pseudarthrosis is indicated by lucency seen in the middle of the cages with solid bone growing into the cage from each vertebral end plate.

BSF3: radiographical fusion: bone bridges at least half of the fusion area with at least the density originally achieved at the surgery. Radiographical fusion through one cage (half of the fusion area) is deemed mechanically solid fusion even if there is lucency on the opposite side.

Surgical technique

All patients were received (third-generation cephalosporin) half an hour before surgery. All patients underwent operation under general anesthesia in the prone position with adequate chest and iliac crests padding, and the abdomen was hanging free. The level was checked by an image intensifier. A midline longitudinal incision was performed, and dissection was

Figure 1

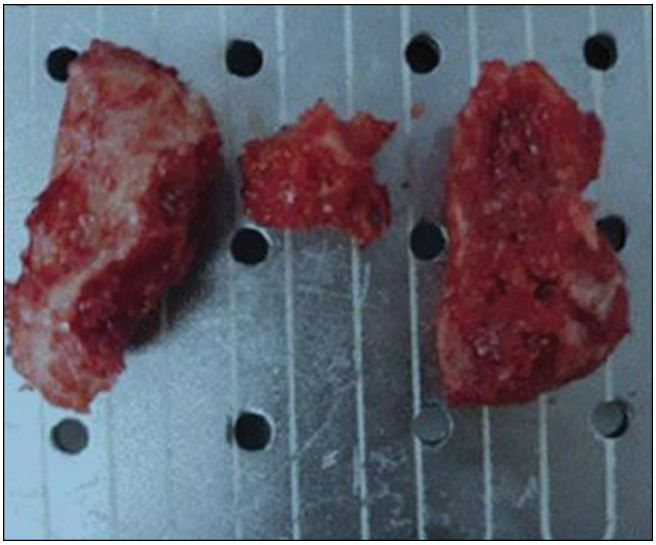


Measurement of disk space height and segmental lordotic angle [10].

done in layers in a sub periosteal manner considering proper hemostasis. The paraspinal muscles were elevated to expose the tips of the transverse processes. Based on anatomical landmarks including the transverse process and facet joint, pedicle screws are then inserted under an image intensifier after carefully fluoroscopically localized drilling and palpating. The pedicular screws were inserted on both sides of the lumbar vertebrae followed by applying the rods and tightening rods over the screws.

Decompression of the neural elements was performed by removing the lamina in one piece by a sharp, small-sized osteotome as it was used later to serve as a source of strut graft material for interbody fusion (Fig. 2).

Figure 2



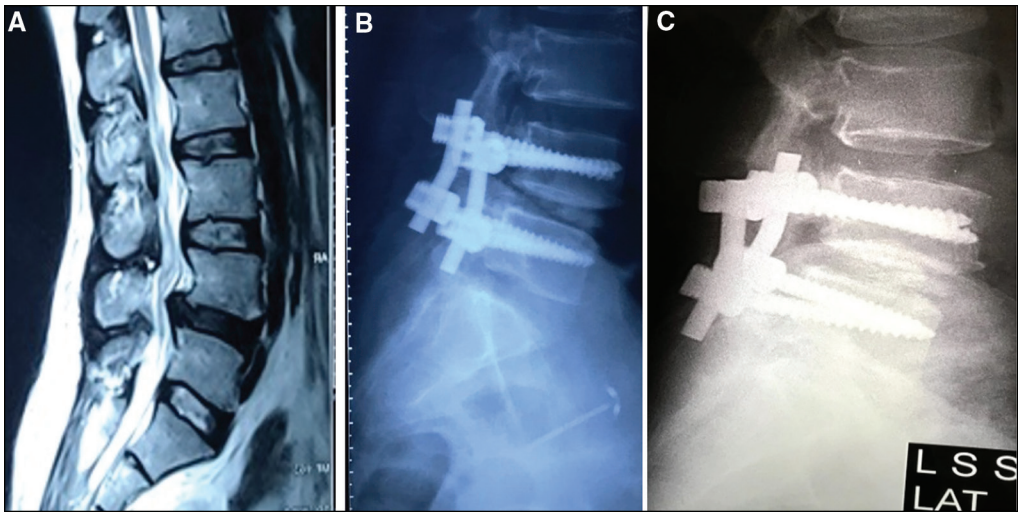
Bone block harvested from the lamina and the spinous process.

This was followed by the removal of the ligamentum flavum, any hypertrophied cartilage, and exposure of the dural sac and nerve roots. Careful hemostasis and control of epidural venous bleeding were performed using bipolar electrocautery. After exposing the disk space by gentle and careful retraction of the dural sac, 11 blades were used to cut the annulus fibrosus, and then removal of the disk material using pituitary rongeurs and microcurettes. Then reamers and curettes were used to remove disk material remnants and cartilage end plate until reaching the subchondral bone making the disk space ready for fusion. Great attention was paid not to violate or destroy the bony endplates to avoid subsidence of the interbody spacer and subsequent loss of structural integrity of the interbody construct.

In group A: a trial instrument was used to determine the size of the graft. Small pieces of bone graft were impacted in the anterior disk space. Then, the excised laminar fragments were prepared, cut into three pieces, and used as strut grafts between the vertebral bodies. Cutting rongeurs were used to make the size of the strut grafts as close to the sizing template as possible. The position of the strut grafts was checked using fluoroscopy (Fig. 3).

In group B: trials were used to reach an appropriate size of cage. Autogenous bone graft from the site of decompression was then packed into the anterior and contralateral portions of the disk space to promote interbody fusion. Then, the cage was inserted in the disk space and the cage position was adapted under the C-arm. Figure 4 illustrates examples of a patient who underwent L4–L5 PLIF with a PEEK cage.

Figure 3



Preoperative MRI (a) showing grade 1 degenerative spondylolisthesis L4–L5 and L4–L5 disk, (b) early postoperative radiograph, (c) 1-year postoperative radiograph.

Gentle compression was then done across the screws to compress the strut grafts or the cage, and then final tightening was performed. A suction drain was then inserted under the fascia after irrigation. The wound was then closed in layers.

Postoperative follow-up regimen

Postoperatively, patients were allowed to ambulate on the night of the operation day, and the drain was removed after 24 h. Intravenous antibiotics were administered during the first 48 h and then the wound stitches were removed. All patients were followed up at 1, 3, 6, 12, and 18 months.

Statistical analysis

All data were expressed as mean±SD or as number (percentage) unless otherwise indicated. χ^2 was used to compare the mean and percentage. One-way analysis of variance will be used to compare quantitative parameters, while Fisher's exact test was used to compare qualitative parameters. Statistical significance was considered at *P* value less than 0.05. SPSS, version 19.0 for Windows (SPSS Inc., Chicago, Illinois, USA) was used for statistical analysis.

Results

The two age groups were almost equally distributed as the mean age±SD (39.1 ± 10) for group A and 41.5 ± 8.1 for group B with no statistically significant difference (*P*=0.409). The current study included 17 males and 23 females. χ^2 was used to detect the difference between both groups regarding their characteristics. There was no statistically significant difference (*P*=0.442).

Indications for surgery were 25 patients of degenerative spondylolisthesis grades 1 or 2 (13 in group A and 12 in group B) and 15 patients of symptomatic degenerative disk disease with stenosis manifestations (seven in group A and eight in group B). There was no statistically significant difference between both groups regarding the indication of surgery.

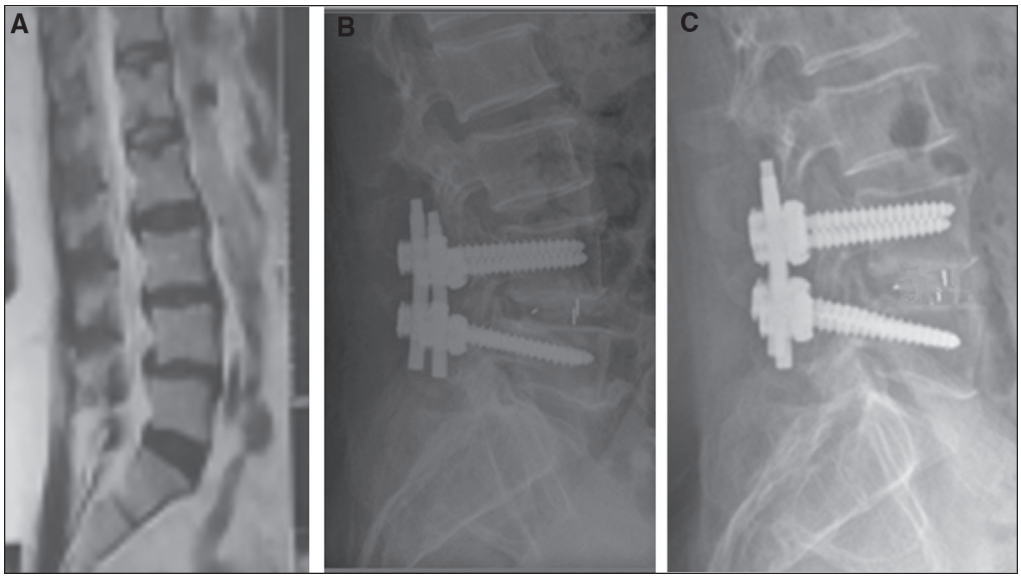
Regarding the operative level, there were two cases at the L3–L4 level in group B. At the L4–L5 level, there were 12 cases in group A, while 10 cases in group B. At L5–S1 there were eight cases in in both groups. There was no statistically significant difference (*P*=0.654).

The mean operative time in group A was 126 ± 13.9 min and in group B it was 133.5 ± 18.1 min with no statistical difference (*P*=0.151). The mean blood loss in group A was 700 ± 113.7 ml, while in group B it was 672.5 ± 139.1 ml with no statistical significance (*P*=0.528).

The range of preoperative VAS was 6–9 with a mean±SD of 7.1 ± 1 in group A and in group B it was 5–9 with a mean of 6.9 ± 1. At 1-year postoperatively in group A, it was 1.9 ± 0.6 and in group B it was 1.8 ± 0.6 with no statistical difference (*P*=0.529, 0.442). There is a statistically significant difference between preoperative and postoperative VAS in both groups.

The preoperative ODI score% was between 50 and 58 in group A with mean±SD of 54.4 ± 3.2 in group A and the mean±SD was 51.4 ± 2 in group B with no statistical significance (*P*=0.236). The postoperative mean±SD ODI was 17.6 ± 5.4 in group A and 20 ± 6.5 in group B with no statistical significance (*P*=0.210).

Figure 4



Preoperative MRI (a) showing degenerative disk disease L4–L5, (b) early postoperative radiograph (c) 1-year postoperative radiograph.

The mean preoperative disk height in group A was 5.9±1.2 mm, and in group B was 6.1±1 mm. The mean 1-year postoperative disk height in group A was 8.4±1 and in group B was 8±1.3 with no statistical significance (*P*=0.299). *P* value for preoperative versus postoperative disk height in each group is significantly different (*P*<0.001).

Table 1: Demographic, clinical, radiological, and functional outcomes

	Group A: strut laminar graft	Group B: PEEK cage	*P* value (A vs. B)
Age (years)			
Range	26–58	30–57	0.409
Mean±SD	39.1±10	41.5±8.1	
Sex [*n* (%)]			
Male	8 (40)	9 (45)	0.749
Female	12 (60)	11 (55)	
Occupation [*n* (%)]			
Housewife	11 (55)	10 (50)	0.442
Worker	3 (15)	7 (35)	
Farmer	3 (15)	1 (5)	
Employee	3 (15)	2 (10)	
Indication of surgery [*n* (%)]			
Spondylolisthesis	13 (65)	12 (60)	0.581
Disk degeneration	7 (35)	8 (40)	
Operated level [*n* (%)]			
L3–L4	0	2 (10)	0.654
L4–L5	12 (60)	10 (50)	
L5–S1	8 (40)	8 (40)	
Operative time (min)			
Range	110–150	110–160	0.151
Mean±SD	126±13.9	133.5±18.1	
Blood loss (ml)			
Range	500–900	500–900	0.528
Mean±SD	700±113.7	672.5±139.1	
VAS for LBP			
Preoperative (mean±SD)	7.1±1	6.9±1	0.529
Postoperative (mean±SD)	1.9±0.6	1.8±0.6	0.442
P value (pre vs. post)	<0.001*	<0.001*	
ODI score%			
Preoperative (mean±SD)	54.4±3.2	53.4±2	0.236
Postoperative (mean±SD)	17.6±5.4	20±6.5*	0.210
P value (pre vs. post)	<0.001*	<0.001	
Disk height (mm)			
Preoperative (mean±SD)	5.9±1.2	6.1±1	0.558
Postoperative (mean±SD)	8.4±1	8±1.3	0.299
P value (pre vs. post)	<0.001*	<0.001*	
Regional lordosis (⁰)			
Preoperative (mean±SD)	12.5±1.3	11.9±1.5	0.491
Postoperative (mean±SD)	21.6±1.4	21.2±2.2	0.153
P value (pre vs. post)	<0.001*	<0.001*	
Fusion of the operated level [*n* (%)]			
	2 (10) BSF1	2 (10) BSF1	
Not fused	18 (90)	18 (90)	
Fused	15 (BSF3)	14 (BSF3)	1
	3 (BSF2)	4 (BSF2)	
Complications [*n* (%)]			
No complications	16 (80)	16 (80)	1
Superficial infection	2 (10)	1 (5)	
Deep infection	1 (5)	0	
Residual radiculopathy	1 (5)	2 (10)	
Cage retropulsion	0	1 (5)	

BSF, Brantigan–Steffee criteria; ODI, Oswestry disability index; PEEK, polyetheretherketone; VAS, visual analog score.

*Means significant difference.

The mean±SD preoperative regional lordosis in group A was 12.5 ± 1.3 and in group B was 11.9 ± 1.5. The mean±SD postoperative 1-year segmental lordosis was 21.6 ± 1.4 in group A and in group B it was 21.2 ± 2.2 with no statistical significance (*P*=0.491). There was a significant statistical difference regarding preoperative versus postoperative values for each group (*P*<0.001).

Fusion was achieved in 18 (90%) patients in each group with 15 cases of solid fusion (BSF3) in group A and 14 in group B. Three patients had locked pseudoarthrosis (BSF2) in group A and four patients in group B with no statistically significant difference.

Superficial infection occurred in three patients (two in group A and one in group B), and it was treated by antibiotic coverage and repeated dressing and finally resolved completely. A deep infection occurred in one patient of group A; the infection needed surgical debridement. Residual radiculopathy was found in three patients (one in group A and two in group B).

A major complication occurred after 2 months of operation in one patient of group B when the patient experienced severe back pain, leg pain, and neurological deficit. We performed another radiograph and discovered a retropulsion of the cage. Another surgery was done; the cage was removed and we did posterolateral fusion. The patient was missed in the follow-up. Thus there was no statistically significant difference between both groups regarding postoperative complications (Table 1).

Discussion

In the 1953s, Cloward [12] elaborated the PLIF using autogenously impacted bone blocks taken from the iliac crest. Since then, PLIF has been widely used for the treatment of degenerative disk disease after failure of conservative treatment.

Over the last decades, continuous adjustment and improvement of surgical techniques, such as minimization of the level of neural retraction required and avoidance of broad dissection of the paraspinal musculature, have contributed to a reduction in the operating time, operative risks, and blood loss during PLIF [13].

Many studies have suggested that successful fusion results in better overall satisfaction and better functional outcomes. Normally, PLIF is performed by the use of synthetic intervertebral cages with autogenous bone or another allograft inserted in the intervertebral space. The surgical goal of PLIF with a cage is to provide an adequate fusion environment, thereby accelerating postoperative rehabilitation and fusion [14].

Some researchers suggest that once the unstable segment is fused successfully, mechanical back pain from a facet arthropathy or pars defect can be reduced, which may add good functional outcomes [15].

To achieve a solid arthrodesis in spinal fusion, a suitable graft material is needed to enhance the formation of the new bone at the surgical site [16]. The ideal graft for PLIF provides maximum efficacy of bone growth by combining osteoconduction, osteoinduction, and osteoblastic characteristics, and will cause the least donor-site morbidity [17].

Ito *et al*. [18] showed that the local autograft was as effective as an autologous iliac bone graft in PLIF. But unfortunately, iliac bone graft has the disadvantage of up to 30% of patients experiencing persistent donor site-associated pain in addition to the possible incidence of infection, sensory loss, and wound dehiscence [19].

Many disk spacers are used for interbody fusion, for instance, titanium cages, PEEK cages, and allografts. Titanium has the best rigidity among interbody devices, which has been reported to be the leading cause of subsidence and loss of disk space height. Femoral head allografts have the benefit of serving as a scaffolding material for bone growth, but subsidence and disk space collapse are also reported. PEEK cages were popularized because of their radiolucency, low rigidity, and less subsidence as compared with titanium and allograft spacers. PEEK cages have a modulus of elasticity near that of cortical bones [20].

Although there are good clinical outcomes using cages, they still have many disadvantages. The insertion of the implant reduces the available contact area for bony fusion. Studies have shown that more than 30% of the surface area of the end plate should be in direct contact with the local bone [6]. The cage is a foreign body and may increase the patient's risk of developing an infection or immunological problem [21], as well as the risk of subsidence and corrosion [22]. In addition, the high cost of cages remains an obstacle, especially in developing countries.

The goal of using an alternative auto-laminar strut graft is to reduce the risk of these complications and as an interbody spacer which achieves better fusion than the cage in the current study.

Lin *et al*. [10] compared the use of the PEEK cage and an autologous cage made from the lumbar spinous

process and laminae in PLIF. They suggested that the autologous cage made from the lumbar spinous process seems to be equally as safe and effective as the PEEK cage.

Fawaz and Abd Elsamad [23] have used a laminar strut graft with transforaminal lumbar interbody fusion. The follow-up radiographs in their study indicated 100% fusion rates, and all patients demonstrated extremely satisfactory recovery of daily activities.

The current study illustrated the clinical and radiological outcomes and a comparison of the two groups using either strut laminar autografts or the PEEK cage in PLIF surgery. Both groups have similar clinical outcome parameters including VAS and ODI. The restoration of normal intervertebral foramen, which is frequently associated with spondylolisthesis, requires the restoration of disk height. Preservation of segmental lumbar lordosis is one of the most important surgical aims in the current era of sagittal balance consideration even during single-level lumbar fusion [24]. Disk height and segmental lumbar lordosis have been restored and preserved in both groups.

Study limitations

As we excluded patients with a BMI of more than 30, our findings may not apply to obese patients, and this study cannot say whether the local bone alone is sufficient in obese patients. In this study, the exclusion criteria included smokers, patients taking steroids and diabetic patients but other risk factors of pseudoathrosis such as vitamin D deficiency, were not assessed, so further studies are needed to assess the effect of these risk factors on the rate of pseudoarthrosis. A sample size of 20 patients in each patient group is another limitation, and we must be cautious with data inference. Furthermore, the follow-up period needs to be increased in future studies, and a multicenter long-term study is highly recommended.

Conclusion

Our results suggest that the use of laminar strut graft is a safe and cost-effective technique in single-level PLIF, especially in developing countries.

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Nil.

Conflicts of interest

Authors have no conflict of interest to disclose.

Abbreviations

BSF, Brantigan–Steffee criteria; ODI, Oswestry disability index; PEEK, polyetheretherketone; PLIF, posterior lumbar interbody fusion.

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