

Cage migration after unilateral instrumented transforaminal lumbar interbody fusion and associated risk factors: a modified measurement method

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Lixia Jin^{1*}, Zixian Chen^{2,*}, Chun Jiang²,
Yuanwu Cao², Zhenzhou Feng² and
Xiaoxing Jiang² 

Abstract

Objective: In this retrospective study, a modified measurement method was used to analyze cage migration during follow-up after unilateral instrumented transforaminal lumbar interbody fusion (TLIF) and identify associated factors.

Methods: We retrospectively evaluated 75 patients who had been treated with unilateral instrumented TLIF. Cage migration was quantitatively defined as anterior–posterior or lateral displacement of the cage.

Results: Five patients had significant cage migration (6.7%), but none developed severe neural symptoms during follow-up or underwent reoperation. The cages tended to migrate posteriorly or toward the side of surgery. The initial cage position and patient age were strongly associated with migration. Migration was less frequent when the cages were initially placed closer to the side of surgery. Patients of advanced age were more likely to develop anterior–posterior migration than were young patients.

Conclusion: Cage migration is related to the initial position of the cage. Particular attention is required when performing unilateral instrumented TLIF in patients of advanced age because they

¹Department of Rehabilitation, Shanghai Zhongshan Hospital, Fudan University, Shanghai, People's Republic of China

²Department of Orthopedics, Shanghai Zhongshan Hospital, Fudan University, Shanghai, People's Republic of China

*These authors contributed equally to this work.

Corresponding author:

Xiaoxing Jiang, Department of Orthopedics, Shanghai Zhongshan Hospital, Fudan University, 180 Fenglin Road, Shanghai 200032, People's Republic of China.
Email: jiang.xiaoxing@zs-hospital.sh.cn



are most likely to develop cage migration. Quantification of cage migration is an effective method of exploring the associated factors.

Keywords

Transforaminal lumbar interbody fusion, unilateral instrumentation, migration, risk factors, measurement method, unilateral fixation

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Introduction

With the increasing prevalence of a sedentary lifestyle among the aging population, it is unsurprising that growing numbers of people are developing degenerative lumbar diseases. Lumbar interbody fusion is a standard procedure with which to relieve these patients' symptoms and improve their quality of life. Initially developed by Harms and Jerszensky¹ in the 1990s, transforaminal lumbar interbody fusion (TLIF) has become a popular procedure for patients with degenerative lumbar diseases because it is safe, effective, and less invasive than other treatments.² Although unilateral instrumented TLIF is less invasive than traditional TLIF, upon which it is based, it has similar clinical outcomes and complication rates.³⁻⁶ Thus, it is a well-accepted surgical technique for the treatment of degenerative lumbar diseases.

However, some controversies remain regarding the use of unilateral instrumented TLIF. One is the increased cage migration rate. Cage migration is usually diagnosed as movement of the cage that exceeds 3 mm or extends beyond the wall of the vertebral body.^{7,8} Cage migration can be further classified as posterior, anterior, or lateral according to the direction in which the cage migrates. The cage can also slide either forward into the retroperitoneum or backward into the vertebral canal, causing failure of fusion or compression of the nerve roots and dura mater. Aoki et al.⁹

and Duncan and Bailey¹⁰ noted that cage migration occurs more commonly in patients treated with unilateral than bilateral fixation. However, several meta-analyses have shown that this difference is not statistically significant.^{5,6} Our previous study of 139 patients treated with unilateral instrumented TLIF showed a cage migration rate of 5.9%,² which is almost identical to the migration rates reported in other studies of bilateral instrumented TLIF. Thus, the available data on cage migration after unilateral instrumented TLIF are still insufficient to either finalize an accurate migration rate or identify the risk factors involved. Moreover, because a large degree of cage movement is rare, sizable samples are required for prospective or retrospective studies to ensure statistically significant results. Therefore, the present study is unique in that we used a modified measurement method to convert the variables tested into continuous variables and to measure cage migration during follow-up to analyze cage migration and identify the related factors.

Materials and methods

Patient selection

All patients included in this study had single-level (L4/5 or L5/S1) lumbar degenerative disc disease or spondylolisthesis and were treated by single-level unilateral

instrumented TLIF with kidney-shaped polyetheretherketone (PEEK) cages by a single doctor from 2009 to 2014. All patients provided written informed consent, and ethical approval for the study was granted by the institutional review board. Before undergoing surgery, all patients were treated conservatively for at least 6 months. Patients were excluded if they had previously undergone spinal instrumentation and/or fusion. Only patients who underwent three complete follow-up examinations at 2 to 3 days, 2 to 3 months, and ≥ 6 months postoperatively were included in the study. The baseline analysis showed no significant differences between the patients in the final sample and the total initial sample (Table 1), indicating that the smaller sample was representative of the whole initial population.

All of the included patients were examined preoperatively and followed up with anterior–posterior (AP) and neutral lateral X-rays taken in a standing position.

Two types of variables were analyzed: demographic variables (age, sex, preoperative diagnosis, level of fusion, cage type, and cage size) and radiographic variables (disc height and cage position).

Surgical technique

All operations were performed by one senior doctor. The patients were placed in the prone position on a radiolucent

operating table. Under fluoroscopic guidance with a C-arm X-ray system, the appropriate surgical level was marked and a lateral incision was made on the symptomatic side, 2 to 3 cm from the midline. The sacrospinalis muscle was split to expose the facet, transverse processes, and vertebral lamina, and two pedicle screws were then inserted through the vertebral pedicles. Consistent with standard TLIF, the facet joint and part of the vertebral lamina were removed with a high-speed drill, osteotome, and Kerrison rongeur; the disc was then exposed as for standard TLIF. The bone graft material was a mixture of autologous bone from the lamina and facet joint and contained 3- to 5-mm sections stripped of all the soft tissue attachments and decorticated. The disc and endplate cartilage were completely and carefully removed to ensure that the subchondral bone was not violated. If the patient developed symptoms of bilateral nerve root compression, the contralateral side was decompressed by resecting the contralateral ligamentum flavum and osteophyte through the same incision. A kidney-shaped cage was inserted into the intervertebral space and filled with autologous bone. Finally, a pre-bent rod was placed and locked. A drain was inserted and the incision was closed. All patients were required to start ambulation early, at 2 to 3 days after surgery, and to wear a brace during ambulation for 8 weeks after surgery.

Radiographic assessment

Plain radiographs of the lumbar spine were obtained four times: preoperatively and at 2 to 3 days, 2 to 3 months, and ≥ 6 months postoperatively.

The anterior disc height was defined as the vertical distance between the anterior edge of the inferior endplate of the superior surgery body and the anterior edge of the superior endplate of the inferior surgery body. The posterior disc height was defined

Table 1. Baseline level analysis.

Variables	t test		Chi-squared test p value (2-sided)
	F	p value	
Age	0.053	0.819	
Sex			0.596
Diagnosis			0.763
Fusion level			0.274
Cage type			0.887

A p value of <0.05 was accepted as significant.

as the vertical distance between the posterior edge of the inferior endplate of the superior surgery body and the posterior edge of the superior endplate of the inferior surgery body. The mean disc height (MDH) was the mean of the anterior disc height and posterior disc height. The value obtained by subtracting the preoperative MDH from the cage size was defined as “cage size – preMDH.” The value obtained by subtracting the postoperative MDH from the cage size was defined as “cage size – postMDH.”

The cage position was identified in terms of its AP position and lateral position, as shown in Figure 1. The AP position was defined as the ratio of the distance between the anterior margin of the inferior endplate of the superior surgery body and the center of the cage to the whole AP length of this endplate (i.e., the distance between the anterior margin of the inferior endplate of the superior surgery body and the center of the cage/the whole AP length of this endplate). The lateral position was defined as the ratio of the distance between the contralateral margin of the endplate of the instrumented side and the center of the cage to the least

lateral length of the superior fusion body. A smaller AP ratio indicated a more anterior position on the sagittal plane, and a smaller lateral ratio indicated a greater distance from the instrumented side on the coronal plane. The initial position of the cage was measured at the first follow-up and modified by the difference between the measured center and the original center according to the inclination angle of the cage. Cage migration was defined as a change in the position of the cage during follow-up on the AP or lateral X-ray. If the cage shifted in the anterior direction or toward the noninstrumented side, the migration was given a negative number. Likewise, if the cage shifted in the posterior direction or toward the instrumented side, the migration was given a positive number. Therefore, movements could differ in direction although their absolute distances were the same. All measurements were made by one of the authors.

To determine the intraobserver consistency, 30 patients were randomly selected and their data were collected again by the same researcher 1 month after the first data

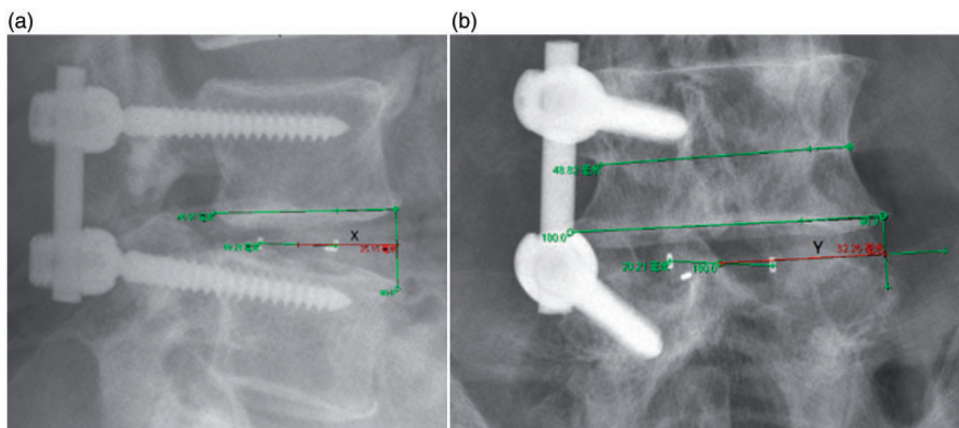


Figure 1. Cage position measurement in anterior–posterior (AP) position and lateral position. (a) The AP position was defined as the ratio of the distance between the anterior margin of the inferior endplate of the superior surgery body and the center of the cage to the whole AP length of this endplate. (b) The lateral position was defined as the ratio of the distance between the contralateral margin of the endplate of the instrumented side and the center of the cage to the least lateral length of the superior fusion body.

collection. To determine the interobserver consistency, the data for these patients were also collected by another two pre-trained researchers using the same process.

Statistical analysis

Data were analyzed with the SPSS 20.0 software package (IBM Corp., Armonk, NY, USA). Descriptive statistics are summarized as frequency and percentage for categorical variables and as mean \pm standard deviation for continuous variables. The preoperative and postoperative indices were compared with a paired *t* test, Pillai's trace, and repeated-measures analysis of variance. The initial position of the cage, disc height, age, sex, and other parameters were analyzed with a general estimating equation to identify the possible risk factors for cage migration. A *p* value of <0.05 was considered statistically significant.

Results

Demographic variables

Of 249 patients who met the inclusion criteria, only 75 patients underwent three complete follow-up examinations (at 2–3 days, 2–3 months, and ≥ 6 months postoperatively) and were therefore included in the study. These 75 patients comprised 30 men and 45 women with a mean age of 57.4 years (range, 34–79 years); 55 patients had a diagnosis of spinal stenosis and 20 had a diagnosis of spondylolisthesis. Fifty-three cages were inserted at the L4.5 level and 22 at the L5.S1 level. All were kidney-shaped PEEK cages made by three manufacturers (Johnson & Johnson, Le Locle, Switzerland; LDR, Sainte-Savine, France; and Stryker, Cestas, France) and varied in size from 7 to 15 mm. The median periods to the three follow-up examinations were 2, 64, and 219 days. The results are presented in Table 2.

Radiographic assessment

Five patients developed significant cage migration (6.7%), but none experienced severe neural symptoms during follow-up or underwent reoperation. The initial position of all cages was marked as (X_0 , Y_0) according to the initially measured AP and lateral position, respectively. The mean X_0 was 0.457 ± 0.083 (0.252, 0.623), and the mean Y_0 was 0.635 ± 0.091 (0.389, 0.826). During follow-up, the cages tended to migrate posteriorly and toward the operative side. A paired *t* test and Pillai's trace showed significant changes in the cage positions at each follow-up (Table 3). The rate of ≥ 3 -mm cage subsidence was 17.9% (14 cages) at the long-term follow-up.

To explore the risk factors for cage migration, a general estimating equation was applied to the repeatedly measured data and revealed that AP migration was related only to age. Patients of advanced

Table 2. Patients' demographic variables.

Variables	n = 75
Sex, n (%)	
Male	30 (40.0)
Female	45 (60.0)
Age, years	
Mean \pm SD	57.40 \pm 10.99
Min, Max	34, 79
Preoperative diagnosis, n (%)	
Spondylolisthesis	20 (26.7)
Stenosis	55 (73.3)
Level of fusion, n (%)	
L4/5	53 (70.7)
L5/S1	22 (29.3)
Cage type, n (%)	
1	22 (29.3)
2	26 (34.7)
3	27 (36.0)
Cage size	
Median (P25, P75)	11 (10, 12)
Min, Max	7, 15

SD, standard deviation; P25, 25th percentile; P75, 75th percentile. Min, minimum; Max, maximum.

age developed more cage migration in the AP position than did younger patients ($p = 0.038$) (Table 4). We examined the relationship between AP migration and age and found that AP migration was more frequent in patients aged >70 years than in younger patients.

Lateral migration was related to the initial lateral position of the cage ($B = -0.219$, $p = 0.009$). When the cage was placed closer to the operative side (i.e., farther from the nonoperative side), less migration occurred. The results are presented in Table 5.

Intraobserver and interobserver reliability

The kappa value for intraobserver agreement regarding measurement of the AP position of the cage was 0.997, and that regarding measurement of the lateral position was 0.929. For interobserver agreement, these kappa values were 0.994 and 0.906, respectively. Thus, all measurements showed excellent agreement.

Discussion

To accommodate the limited samples available for analysis, a classification standard was used to convert the variables tested into continuous variables. To our knowledge, no published clinical study of cage migration and its risk factors has been conducted in this way. In this study, we showed that the cages tended to migrate posteriorly or toward the operative side; this might

have been caused by the pressure exerted on the disc remnants on the anterior or contralateral side. Traditional studies have also shown that cage migration almost always occurs in a posterior direction,^{9,11} which supports the accuracy of our method.

Our study showed that age was a significant risk factor for cage migration because patients of advanced age developed more AP migration, especially those older than 70 years. We presume that older patients have more highly unstable segments. The low bone mineral density (BMD) of older patients may also make the pedicle screw unstable. A previous study showed the same result; i.e., that older age is a risk factor for cage retropulsion.¹² Another study revealed that lower BMD can result in cage migration.⁷ However, this is still only a hypothesis because BMD was not measured in all of the patients in our study. BMD is usually more strongly associated with subsidence. In our study, the rate of ≥ 3 -mm cage subsidence was 17.9% (14 cages) at the long-term follow-up. In 2008, Schleicher et al.¹³ found that TLIF with unilateral pedicle screw fixation was significantly less stable than TLIF with bilateral fixation, particularly in terms of lateral bending and rotation. Therefore, unilateral instrumented TLIF should be performed with caution in patients of advanced age. It may be beneficial to measure the BMD of patients, especially older ones, and to administer anti-osteoporosis drugs to those with osteoporosis.

Table 3. Cage positions during follow-up.

Variables	1st follow-up	2nd follow-up	3rd follow-up	p value			Pillai's trace	
				1st–2nd	1st–3rd	2nd–3rd	F	p
AP position	0.520 ± 0.131	0.540 ± 0.139	0.548 ± 0.136	0.000	0.000	0.000	14.127	0.000
Lateral position	0.609 ± 0.079	0.616 ± 0.101	0.630 ± 0.0086	0.000	0.000	0.000	6.407	0.003

Data are presented as mean ± standard deviation; $P < 0.05$ was accepted as significant. AP, anterior–posterior.

However, further studies are required to determine whether this would reduce the rate of cage migration.

Because the operative window is limited and the cage itself is relatively small, TLIF seems more susceptible to problems of cage position than does posterior lumbar interbody fusion. However, whether the cage position is related to its migration remains controversial. Some studies have shown that anterior positioning confers better sagittal balance¹⁴ but more subsidence, whereas posterior positioning confers better stability.¹⁵ A previous study showed no relationship between the initial position of the cage and cage migration,⁹ whereas other research has shown that cages in a medio-medial position have a greater tendency to migrate after posterior lumbar interbody fusion than those in a posterolateral or posteromedial position.¹⁶ In the present

study, however, the initial position of the cage was unrelated to AP migration; instead, it was associated with lateral migration. Less migration occurred when the cage was placed in a position closer to the operative side, which is probably attributable to the pressure squeezing reaction and stress shielding reaction of the fixation system. In our clinical practice, we tend to place the cage near the middle of the lumbar region, slightly ahead of and away from the operated side. Therefore, the position of the cage is centered, which may reduce the rate of migration. It is commonly reported in retrospective studies that the position of the cage is not chosen randomly but instead according to the surgeon's operative habit. Therefore, we presume that the influence of the initial cage position on its migration is underestimated.

Table 4. Risk factors for anterior–posterior migration.

Variables	Hypothesis test			Model effects	
	B	Wald chi-squared	p value	Wald chi-squared	p value
Age	0.001	4.320	0.038	4.320	0.038
Sex					
Male	0.001	0.008	0.930	0.008	0.930
Female	0.000				
Diagnosis					
Spondylolisthesis	0.001	0.002	0.965	0.002	0.965
Stenosis	0.000				
Fusion level					
L4/5	0.015	1.323	0.250	1.323	0.250
L5/S1	0.000				
Cage type					
1	−0.008	0.436	0.509	2.220	0.330
2	0.012	0.884	0.347		
3	0.000				
Cage size – preMDH	−0.001	0.341	0.559	0.341	0.559
Cage size – postMDH	−0.002	0.597	0.440	0.597	0.440
X0	−0.077	1.251	0.263	1.251	0.263
Y0	−0.032	0.293	0.588	0.293	0.588

A p value of <0.05 was accepted as significant.

preMDH, preoperative mean disc height; postMDH, postoperative mean disc height.

Table 5. Risk factors for lateral migration.

Variables	Hypothesis test			Model effects	
	B	Wald chi-squared	p value	Wald chi-squared	p value
Age	0.000	0.155	0.693	0.155	0.693
Sex					
Male	0.016	0.986	0.321	0.986	0.321
Female	0.000				
Diagnosis					
Spondylolisthesis	-0.032	3.381	0.066	3.381	0.066
Stenosis	0.000				
Fusion level					
L4/5	0.010	0.291	0.590	0.291	0.590
L5/S1	0.000				
Cage type					
1	-0.023	1.499	0.221	2.782	0.249
2	0.010	0.271	0.602		
3	0.000				
Cage size – preMDH	-0.001	0.043	0.836	0.043	0.836
Cage size – postMDH	0.003	0.353	0.552	0.353	0.552
X0	0.039	0.155	0.694	0.155	0.694
Y0	-0.219	6.759	0.009	6.759	0.009

A p value of <0.05 was accepted as significant.

preMDH, preoperative mean disc height; postMDH, postoperative mean disc height.

The type and size of cage did not greatly affect its migration, perhaps because our choice of cage was appropriate. All cages were kidney-shaped and of the most suitable size. Although a bullet-shaped fusion cage can be more easily inserted into a suitable position, fitting well with the concave surface of the normal endplate,¹¹ several studies have shown that the use of a bullet-shaped cage is a possible risk factor for cage migration.^{7-9,17} PEEK is now widely used as the cage material because it offers radiolucency and good fusion and enhances the elastic modulus.^{18,19} Therefore, to minimize the influence of the shape and material of the cage on migration, we only included patients who were treated with kidney-shaped PEEK cages in the present study.

The major problem of migration is that it causes nonfusion and compression of the

nerve roots and dura mater. Of the five patients with significant cage migration, none developed severe neural symptoms during follow-up or required reoperation. We did not collect all relevant data on cage fusion and clinical outcomes because the time assigned for the follow-ups was limited. Further studies are required to investigate the relationships among migration, fusion, and clinical outcomes over a longer follow-up period.

In conclusion, five patients developed significant cage migration (6.7%), but none experienced severe neural symptoms during follow-up or required reoperation. The cages tended to migrate posteriorly or toward the operative side, and less migration occurred when we initially placed the cage closer to the surgical side. Particular attention must be paid when choosing unilateral instrumented TLIF for patients of

advanced age because they are more likely to develop cage migration than younger patients. We propose that this modified method, which includes repeated measurements, is an effective way to analyze cage migration and its risk factors.

Declaration of conflicting interest

The author(s) declare that there is no conflict of interest.

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ORCID iD

Xiaoxing Jiang  <https://orcid.org/0000-0002-4884-2683>

References

- Harms JG and Jerszensky D. The posterior lumbar interbody fusion in unilateral transforaminal technique. *Oper Orthop Traumatol* 1998; 10: 90.
- Liang Y, Shi W, Jiang C, et al. Clinical outcomes and sagittal alignment of single-level unilateral instrumented transforaminal lumbar interbody fusion with a 4 to 5-year follow-up. *Eur Spine J* 2015; 24: 2560.
- Wang L, Wang Y, Li Z, et al. Unilateral versus bilateral pedicle screw fixation of minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF): a meta-analysis of randomized controlled trials. *BMC Surg* 2014; 14: 87.
- Hu XQ, Wu XL, Xu C, et al. A systematic review and meta-analysis of unilateral versus bilateral pedicle screw fixation in transforaminal lumbar interbody fusion. *PLoS One* 2014; 9: e87501.
- Molinari RW, Saleh A, Molinari RJ, et al. Unilateral versus bilateral instrumentation in spinal surgery: a systematic review. *Global Spine J* 2015; 5: 185.
- Xiao SW, Jiang H, Yang LJ, et al. Comparison of unilateral versus bilateral pedicle screw fixation with cage fusion in degenerative lumbar diseases: a meta-analysis. *Eur Spine J* 2015; 24: 764.
- Zhao FD, Yang W, Shan Z, et al. Cage migration after transforaminal lumbar interbody fusion and factors related to it. *Orthop Surg* 2012; 4: 227.
- Kimura H, Shikata J, Odate S, et al. Risk factors for cage retropulsion after posterior lumbar interbody fusion: analysis of 1070 cases. *Spine (Phila Pa 1976)* 2012; 37: 1164.
- Aoki Y, Yamagata M, Nakajima F, et al. Examining risk factors for posterior migration of fusion cages following transforaminal lumbar interbody fusion: a possible limitation of unilateral pedicle screw fixation. *J Neurosurg Spine* 2010; 13: 381.
- Duncan JW and Bailey RA. An analysis of fusion cage migration in unilateral and bilateral fixation with transforaminal lumbar interbody fusion. *Eur Spine J* 2013; 22: 439.
- Aoki Y, Yamagata M, Nakajima F, et al. Posterior migration of fusion cages in degenerative lumbar disease treated with transforaminal lumbar interbody fusion: a report of three patients. *Spine (Phila Pa 1976)* 2009; 34: E54.
- Pan FM, Wang SJ, Yong ZY, et al. Risk factors for cage retropulsion after lumbar interbody fusion surgery: series of cases and literature review. *Int J Surg* 2016; 30: 56.
- Schleicher P, Beth P, Ottenbacher A, et al. Biomechanical evaluation of different asymmetrical posterior stabilization methods for minimally invasive transforaminal lumbar interbody fusion. *J Neurosurg Spine* 2008; 9: 363.
- Kim JT, Shin MH, Lee HJ, et al. Restoration of lumbopelvic sagittal alignment and its maintenance following transforaminal lumbar interbody fusion (TLIF): comparison between straight type versus curvilinear type cage. *Eur Spine J* 2015; 24: 2588.
- Kim MC, Chung HT, Cho JL, et al. Subsidence of polyetheretherketone cage after minimally invasive transforaminal lumbar interbody fusion. *J Spinal Disord Tech* 2013; 26: 87.

16. Abbushi A, Cabraja M, Thomale UW, et al. The influence of cage positioning and cage type on cage migration and fusion rates in patients with monosegmental posterior lumbar interbody fusion and posterior fixation. *Eur Spine J* 2009; 18: 1621.
17. Liu F, Feng Z, Zhou X, et al. Unilateral versus bilateral pedicle screw fixation in transforaminal lumbar interbody fusion: a monocentric study of 215 patients with a minimum of 4-year follow-up. *Clin Spine Surg* 2017; 30: E776–E783.
18. Rousseau MA, Lazenec JY and Saillant G. Circumferential arthrodesis using PEEK cages at the lumbar spine. *J Spinal Disord Tech* 2007; 20: 278.
19. Cutler AR, Siddiqui S, Mohan AL, et al. Comparison of polyetheretherketone cages with femoral cortical bone allograft as a single-piece interbody spacer in transforaminal lumbar interbody fusion. *J Neurosurg Spine* 2006; 5: 534.