

Incidence and risk factors of posterior cage migration following decompression and instrumented fusion for degenerative lumbar disorders

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Abstract

The aim of this study was to explore the incidence and risk factors for posterior cage migration (PCM) following decompression and instrumented fusion for degenerative lumbar disorders, and hope to provide references in decision making and surgical planning for spine surgeons.

By retrieving the medical records from January 2011 to December 2015, 286 patients were retrospectively reviewed. According to the occurrence of PCM, patients were divided into 2 groups: PCM group and non-PCM (N-PCM). To investigate risk values for PCM, 3 categorized factors were analyzed statistically: patient characteristics: age, sex, body mass index, bone mineral density, duration of disease, diagnosis, comorbidity, smoke; surgical variables: surgery time, blood loss, surgical strategy, cage morphology, cage size, surgical segment, fusion number, source of bone graft, surgeon experience; radiographic parameters: preoperative lumbar lordosis, correction of lumbar lordosis, preoperative lumbar mobility, preoperative intervertebral height, change of intervertebral height, Modic changes, paraspinal muscle degeneration.

PCM was detected in 18 of 286 patients (6.3%) at follow-up. There was no statistically significant difference between the 2 groups in patient characteristics, except diagnosis, as lumbar spondylolisthesis was more prevalent in PCM group than that in N-PCM group. There was no difference between the 2 groups in surgical variables, except cage size and surgeon experience, as size of cage was smaller in PCM group than that in N-PCM group, and the surgeons with less experience (less than 3 years) were more prevalent in PCM group than that in N-PCM group. There was no statistically significant difference between 2 groups in radiographic parameters. Logistic regression model revealed that less than 3 years of surgeons' experience, small cage size, and lumbar spondylolisthesis were independently associated with PCM.

For patients with lumbar spondylolisthesis, they should be fully informed about the risk of PCM before operation. While for spinal surgeons, large cage should be preferred, and careful manipulation should be adopted, especially for new learners with less than 3-year experience of fusion surgery.

Abbreviations: BMD = bone mineral density, BMI = body mass index, FIR = fatty infiltration rate, LDH = lumbar disc herniation, LL = lumbar lordosis, LSS = lumbar spinal stenosis, OR = odds ratio, PCM = posterior cage migration, PLIF = posterior lumbar interbody fusion, TLIF = transforaminal lumbar interbody fusion.

Keywords: cage migration, degenerative lumbar disorder, spondylolisthesis

1. Introduction

Application of intervertebral fusion cages in the surgical treatment of degenerative lumbar disorders has many advantages, primarily

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involving improved spinal stability, extensive nerve root decompression, high fusion rate, restoration of disc space height.^[1,2] Deng et al^[3] indicated that cages could promote effective clinical and radiographic outcomes when used for degenerative lumbar diseases. Zhong et al^[4] found that the interbody fusion cages can better preserve the intervertebral space and the foramen height than the autologous bone graft. However, intraoperative and postoperative complications are still encountered, as cage migration into the adjacent vertebral bodies and posterior dislocation into the spinal canal are well-known complications.^[5-9] Aoki et al^[10] followed up 125 patients with TLIF and reported that the incidence of cage migration was 3.2%. Although the incidence is not very high, the adverse effects cannot be underestimated. Cage migration might cause the loss of lumbar lordosis (LL), a narrowing of the disc space and foraminal, a lower fusion rate, and even directly compress the dural sac and nerve root, as well as progressive neurological deterioration. In the event of a cage migration, revision surgery, which is technically challenging, is frequently required for patients with neurological symptoms, while the revision outcome is varied.^[5,6,11]

Although previous reports have alerted spine surgeons about the cage migration subsequent to lumbar decompression and

interbody fusion, very few published reports describing specific risk factors that need to be taken into account to avoid this undesirable event. The aim of this study was therefore to explore the incidence and possible risk factors for posterior cage migration (PCM) following decompression and instrumented fusion for degenerative lumbar disorders, and hope to provide references in decision making and surgical planning for spine surgeons.

2. Methods

2.1. Subjects

A retrospective study was conducted; it was approved by the Institutional Review Board of the Third Hospital of HeBei Medical University before data collection and analysis. The inclusion criteria were diagnosis of lumbar disc herniation (LDH), lumbar spinal stenosis (LSS), and lumbar spondylolisthesis; surgical strategy including posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF); and complete radiological data, including lumbar antero-posterior (A/P) and lateral X-ray at preoperation, early postoperation, and final follow-up, computed tomography, or magnetic resonance imaging at preoperative period and final follow-up. The exclusion criteria were nondegenerative disorders, such as trauma, tumor, infection, inflammation, or isthmic spondylolisthesis; and patients treated by anterior lumbar fusion surgery, minimally invasive lumbar fusion surgery, discectomy, and laminectomy.

By retrieving the medical records from January 2011 to December 2015, 286 patients who met both the inclusion and exclusion criteria were retrospectively reviewed: 156 female and 130 male, with a mean age of 45.2 ± 5.5 years (range from 34 to 68 years). There were 162 cases diagnosed as LDH, 76 cases as LSS, and 48 cases as spondylolisthesis. One hundred sixty-one cases undertook PLIF (108 of them received 1-level PLIF and 53 patients received 2-level PLIF) and 125 cases undertook TLIF (86 of them received 1-level TLIF and 39 patients received 2-level TLIF).

2.2. Clinical and radiological evaluation

Data measurements were done 3 times with 200% magnification for accuracy by the first author, and the mean value was used for analysis. LL was measured from T12 inferior endplate to S1 superior endplate by the Cobb method on lateral X-ray (Fig. 1). Lumbar mobility was calculated as the change of LL between flexion-extension lateral radiographs (Fig. 2). Fatty infiltration rate (FIR) of paraspinal muscles was calculated by subtracting the muscle without the fat value from the total multifidus and erector spinae muscle value in the image processing software (Image J, version 1.48; National Institutes of Health) (Fig. 3). The Modic changes included type I changes that consist of reduced signal intensity (SI) in the vertebral end-plates on T1- and increased SI on T2-weighted sequences. Type II changes consist of increased SI on T1- and either increased SI or isointensity on T2-weighted sequences. Type III changes consist of reduced SI on both T1- and T2-weighted sequences due to subchondral sclerosis (Fig. 4).

PCM was defined as posterior movement of the cage past the posterior wall of the vertebral body. According to the occurrence of PCM at follow-up, patients were divided into 2 groups: PCM group and non-PCM (N-PCM) group. To investigate risk values for the occurrence of PCM, 3 categorized factors were analyzed statistically: patient characteristics: age, gender, body mass index (BMI), bone mineral density (BMD), duration of disease (from first



Figure 1. Lumbar lordosis was measured by the Cobb method.

symptoms to operation), diagnosis, comorbidity (hypertension, diabetes, rheumatism, heart disease), smoke (yes vs no). Surgical variables: surgical strategy (TLIF vs PLIF), cage morphology (bullet-shaped vs box-shaped), size of cage, surgical segment, the number of fusion levels, source of bone graft (autogenous vs allograft bone), surgeon experience (>3 vs <3 years), surgery time, blood loss. Radiographic parameters: preoperative LL, correction of LL, preoperative lumbar mobility, preoperative intervertebral height, change of intervertebral height, Modic changes, preoperative paraspinal muscle degeneration (FIR).

2.3. Statistical analysis

All the data were analyzed using Statistical Product and Service Solutions software (version 13; SPSS, Chicago, IL). The

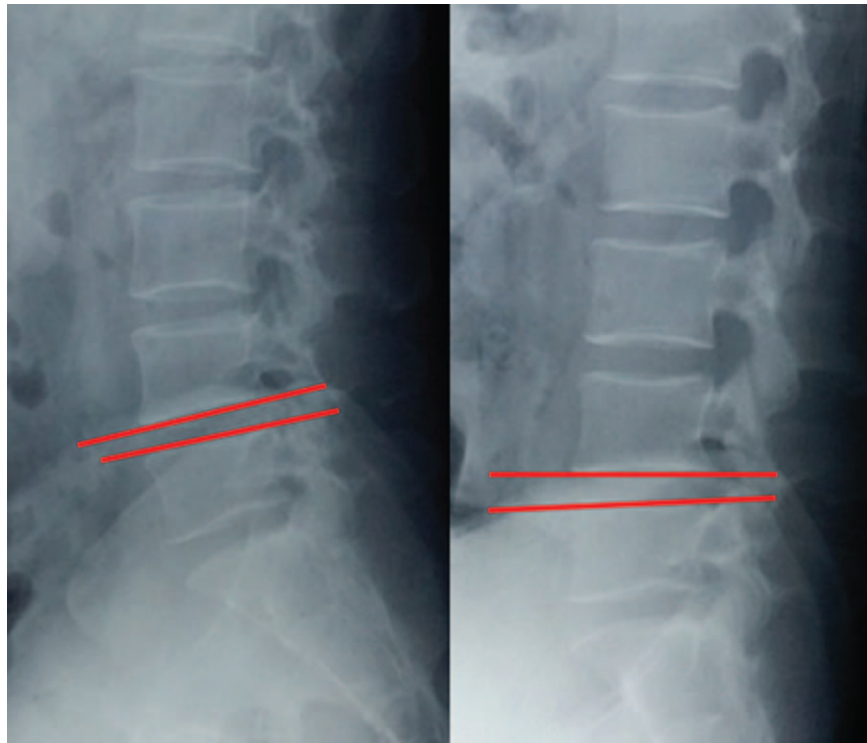


Figure 2. Lumbar mobility was calculated as the difference of LL on flexion and extension lateral radiographs.



Figure 3. The method to evaluate fatty infiltration rate (FIR) of paraspinal muscles (multifidus and erector spinae).



Figure 4. Modic changes were characterized on magnetic resonance imaging.

continuous variables were expressed as mean ± standard deviation; the categorical variables were measured as frequency or percentages. An independent *t* test was performed for the analysis of the difference in continuous variables. A χ^2 analysis or Fisher exact test was used to examine the differences among categorical variables. Variables with *P* values < .05 in the univariate analyses were entered into a multivariate logistic regression model.

3. Results

PCM was developed in 18 of 286 patients (6.3%) at follow-up and were enrolled as the PCM group; the follow-up duration from surgery to this complication range from 2 to 7 months (mean 4.3 months). Three patients experienced <6 mm PCM, 12 patients experienced 6 to 10 mm PCM, and 3 patients experienced >10 mm PCM.

There was no statistically significant difference between the 2 groups in age at operation, gender, BMI, BMD, duration, comorbidity, and smoke. The lumbar spondylolisthesis was more prevalent in PCM group than that in N-PCM group (Table 1). There was no difference between the 2 groups in surgery time, blood loss, surgical strategy, cage morphology, surgical segment, fusion number, or source of bone graft. The size of cage was smaller in PCM group than that in N-PCM group, and the surgeons with less experience (less than 3 years) were more prevalent in PCM group than that in N-PCM group (Table 2). There was no statistically significant difference between the 2 groups in preoperative LL, correction of LL, preoperative lumbar mobility, preoperative intervertebral height, change of intervertebral height, or Modic changes. The FIR was larger in PCM group than that in N-PCM group (Table 3).

The following variables were entered into the multivariate model: age, gender, BMI, BMD, duration, diagnosis, comorbidity, smoke, surgery time, blood loss, surgical strategy, cage size, cage morphology, surgical segment, fusion number, source of bone graft, surgeon experience, preoperative LL, correction of LL, preoperative lumbar mobility, preoperative intervertebral height, change of intervertebral height, Modic changes, and FIR. Multivariate logistic regression model revealed that, less than 3 years of surgeon experience, small cage size, and lumbar spondylolisthesis were independently associated with cage migration (Table 4).

Table 1
Comparison of patient characteristics between PCM group and N-PCM group.

	PCM group (n=18)	N-PCM group (n=268)	P
Age, y	45.4 ± 9.9	46.8 ± 10.4	.580
Sex (F/M)	11/7	145/123	.563
BMI	24.9 ± 1.7	24.6 ± 1.9	.562
BMD	-1.2 ± 0.2	-1.2 ± 0.2	.856
Comorbidity (Y/N)	6/12	43/225	.097
Hypertension	3	16	
Diabetes	1	12	
Rheumatism	0	2	
Heart disease	2	13	
Smoke (Y/N)	3/15	21/247	.183
Duration, mo	13.9 ± 9.6	11.5 ± 7.6	.206
Diagnosis			
Disc herniation	6	156	.009
Spinal stenosis	5	71	
Spondylolisthesis	7	41	

BMD = bone mineral density, BMI = body mass index, PCM = posterior cage migration.

Table 2
Comparison of surgical variables between PCM group and N-PCM group.

	PCM group (n=18)	N-PCM group (n=268)	P
Surgical strategy			
TLIF	8	117	.948
PLIF	10	151	
Number of fusion level			
One	11	183	.528
Two	7	85	
Cage morphology			
Bullet-shaped	16	245	.663
Box-shaped	2	23	
Size of cage (11/12/13 mm)	8/6/4	8/54/206	<.01
Surgical segment			
L4-5	6	102	.817
L5-S1	5	81	
L4-S1	7	85	
Source of bone graft			
Autogenous bone	15	227	.746
Allograft bone	3	41	
Surgeon experience, y			
>3	4	175	<.01
<3	14	93	
Surgery time, min	182.7 ± 30.0	196.7 ± 39.8	.145
Bleeding, mL	708.8 ± 130.7	730.9 ± 90.0	.372

PCM = posterior cage migration, PLIF = posterior lumbar interbody fusion, TLIF = transforaminal lumbar interbody fusion.

Table 3
Comparison of radiographic parameters between PCM group and N-PCM group.

	PCM group (n=18)	N-PCM group (n=268)	P
Preoperative lumbar lordosis, °	12.1 ± 2.8	12.3 ± 6.0	.947
Correction of lumbar lordosis, °	4.4 ± 4.2	5.8 ± 4.8	.231
Preoperative lumbar mobility, °	22.5 ± 5.4	23.7 ± 4.0	.237
Preoperative intervertebral height, mm	7.0 ± 1.3	6.8 ± 1.2	.537
Change of intervertebral height, mm	1.6 ± 0.5	1.4 ± 0.4	.125
Modic changes (Y/N)	4/14	37/231	.304
Preoperative paraspinous muscle degeneration (FIR)	18.8 ± 6.3	15.3 ± 5.7	.011

FIR = fatty infiltration rate, PCM = posterior cage migration.

4. Discussion

In the current study, 6.3% of the patients (18/286) experienced PCM. Instead, we found that less than 3-year surgeon experience and lumbar spondylolisthesis were significantly and independently associated with the PCM. This finding could be assessed before surgery. Moreover, small cage size was also associated with the occurrence of cage migration, and these results were not confounded by other variables that potentially affect PCM.

Table 4
Risk factors for PCM, identified by logistic regression analysis.

Risk factors	Odds ratio [95% CI]	P
Surgeons experience (less than 3 y)	1.589 [1.839–7.884]	<.001
Small cage size	2.201 [3.253–17.537]	<.001
Spondylolisthesis	1.916 [2.587–13.408]	<.001

CI = confidence interval, OR = odds ratio, PCM = posterior cage migration.

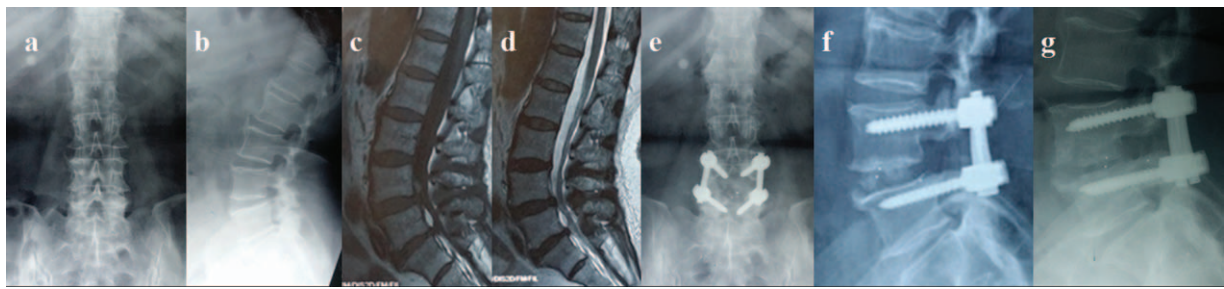


Figure 5. (A–D) Preoperative anteroposterior X-ray and MRI show L4 spondylolisthesis, with compression of spinal cord. (E, F) Postoperatively, PLIF was performed at L4–L5. (G) Three months later, the lateral X-ray showed cage migration posteriorly with appropriate 16mm.

Spine surgeon experience of decompression and instrumented fusion for degenerative lumbar disorders is significantly associated with PCM, as new learners are responsible for the high incidence of PCM in the current study, and we suppose that there are 2 possible explanations may account for it. First, cage packed with cancellous bone is usually inserted into the disc space after meticulous endplate decortication.^[12] The importance of preserving vertebral bone endplates to prevent cage migration has been emphasized by several authors.^[13,14] Endplate preparation before fusion is a very important factor and a high demand technique: too little abrasion could prejudice fusion of the interface between cage-bone and endplates, whereas too much abrasion might damage the bony endplate and result in cage subsidence or posterior migration.^[13] For new learners, appropriate preparation of the endplate needs guidance and practice. Second, care must be taken during cage insertion to decrease the possibility of cage migration. When the surgically treated segment presents bone hyperplasia of posterior vertebrae, removing the hyperplastic bone to provide space for cage insertion may be the priority for most new learners. While for experienced spinal surgeons, the cage should be inserted with the disc space distracted, using a lamina spreading device to avoid destruction of the posterior wall of the vertebral body. Moreover, when the decompression and instrumented fusion are finished, adequate compression needs to be applied by the pedicle screws to prevent PCM.^[12]

It has been shown that smaller cage size is correlated with migration and that larger size cages are recommended to increase the contact area between the cage and endplate to increase the failure load.^[15,16] In the current study, we also found that smaller cage size is a risk factor for PCM, consistent with previous

reports^[15] (Fig. 5). Intervertebral space collapse, facet joint degeneration, nerve root, and dural sac compression are main radiological manifestations in patients with degenerative lumbar disorders. The purpose of the surgical intervention for these patients is not only the nervous decompression but also the restoration of the intervertebral height, which can be achieved by both the pedicle screw-rod distraction and anterior reconstruction of cage. Postoperatively, the vertical transmission of gravity through functional spinal unit contains anterior vertebrae-cage-vertebrae and posterior pedicle screw-rod. Pedicle screw-rod compression should be prohibited due to the potential risk of iatrogenic foraminal stenosis and nerve root compression; if smaller cage is used, the posterior structures may bear more gravity force and anterior part may bear less, respectively. According to the Woff theory, the compressive stress may promote bone fusion, while the tensile stress inhibits bone fusion. As the endplate-cage-endplate stress transmission decrease could influence the intervertebral fusion, the formation of pseudarthrosis around the cage is inevitable, which may lead to PCM finally. Moreover, Kimura et al^[16] recommend that undersized cages should not be used at all.

In the current study, lumbar spondylolisthesis was found to be an independent risk factor for PCM, which has never been addressed in the previous reports (Fig. 6). Spondylolisthesis differs from disc herniation in etiology, pathogenesis, imaging characteristics, clinical presentation, and treatment principle,^[17] which may lead to the high incidence of cage migration. First, endplate sclerosis is common in spondylolisthesis, and is unfavorable to fusion between cage and vertebrae endplates due to the poor blood supply and osteoblast activity. Second, partial reduction, instead of complete reduction of the anterior



Figure 6. (A–F) Preoperative anteroposterior X-ray, CT, and MRI show L5 spondylolisthesis, with compression of spinal cord. (G, H) Postoperatively, PLIF was performed at L5–S1. (I) Three months later, the lateral X-ray showed cage migration posteriorly of 5 mm. (J) Six months later, the lateral X-ray showed cage migration posteriorly, without significant change when compared with postoperative condition. (K) Twelve months later, the lateral X-ray showed cage migration posteriorly, without significant change when compared with postoperative condition.

dislocated vertebral body, is performed in most of the spondylolisthesis patients; this may decrease the interface between cage and endplates. Third, the decompression range for spondylolisthesis always includes laminar and bilateral articular process; both the exiting nerve roots and traversing nerve roots need to be exposed, especially for isthmic spondylolysis. Total facetectomy for decompression and cage insertion purposes always leads to destabilization, which might contribute to the probability of cage migration.^[15] Fourth, decreased intervertebral height is another radiological feature in spondylolisthesis, and it is not easy to insert the cage into narrowed intervertebral space; although small size of cage may be preferred, this may increase the possibility of potential risk of cage migration as mentioned above. However, spondylolisthesis patients should not be excluded from the benefit of surgery, given that their postoperative neurological improvement and pain relief is encouraging. On the basis of above consideration, complete reduction of spondylolisthesis and use of large cage may be of some help to reduce the risk of postoperative cage migration, and should be strived as much as possible.

There are several potential limitations in this study. First, the number of patients is relatively small, and the study may be underpowered to detect the significance of some risk factors. Second, the study was conducted retrospectively by case selection, and was not randomized and controlled. Even with these issues in this study, we find that less than 3 years of surgeons experience, small cage size, and lumbar spondylolisthesis are risk factors for the PCM. For patients with lumbar spondylolisthesis, they should be fully informed about the risk of PCM before operation. While for spinal surgeons, large cage should be preferred, and careful manipulation should be adopted, especially for new learners with less than 3-year experience of fusion surgery.

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