



CLINICAL ARTICLE

Risk Factors and Scoring System of Cage Retropulsion after Posterior Lumbar Interbody Fusion: A Retrospective Observational Study

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Objective: To investigate risk factors of cage retropulsion after posterior lumbar interbody fusion (PLIF) in China and to establish a scoring system of cage retropulsion.

Methods: The retrospective analysis was based on two hospital databases. The medical data records of posterior lumbar interbody fusion with cage retropulsion were selected from August 2009 to August 2019. Inclusion and exclusion criteria were set in advance. Risk factors including patients' baseline demographics (age, gender, operation diagnosis time difference), preoperative neurological symptoms, whether the fusion involves single or double segments, screw type, intraoperative compression, preoperative bone mineral density, whether there are neurological symptoms before surgery, whether there is urine dysfunction before surgery, disease type, complete removal of the endplate, and patient's education level. The research endpoint was the retropulsion of fusion cages. The Kaplan–Meier (K-M) method was used to analyze potential risk factors, and multivariate Cox regression was used to identify independent risk factors ($P < 0.05$). The Statistical Package for the Social Sciences (version 22.0; SPSS, IBM, Chicago, IL, USA) software was used for statistical analysis, and univariate analysis was used to screen out the factors related to cage retropulsion. All independent risk factors were included to predict the survival time of the retropulsion of cage.

Results: This study included a total of 32 patients with PLIF between 2009 to 2019. All patients were residents of China. Univariate analysis showed that there were 13 patients over 60 years old and 19 patients under 60 years old. There were 20 male patients and 12 female patients. The surgical diagnosis time was seven patients within 1 month, 17 patients within 1 to 3 months, and eight patients over 3 months. The disease type was 18 cases of lumbar disc herniation, 10 cases of lumbar spinal stenosis, four cases of lumbar spondylolisthesis. The fusion segment was 18 cases of single segment, 14 cases of double segment. The intraoperative compression was seven cases of compression, 25 cases of no compression. The preoperative bone mineral density was 10 cases of low density, 18 cases of normal, four cases of osteoporosis. The screw type was 27 cases of universal screw, five cases of one-way screw. Preoperative neurological symptoms were found in 25 cases and not in seven cases. Preoperative urination dysfunction occurred in 8 cases, whereas 24 cases did not have this dysfunction. The endplate was completely removed in 10 cases and not in 22 cases. Education level was nine cases of primary school education, 10 cases of secondary school, 13 cases of university level. Cox regression analysis showed that intraoperative pressure (hazard ratio [HR] = 4.604, $P = 0.015$) and complete removal of the endplate ($HR = 0.205$, $P = 0.027$) are associated with the time of cage retropulsion. According to the HR of each factor, the scoring rules were formulated, and the patients were divided into the low-risk group, moderate-risk group, and high-risk group according to the final score. The three median survival times of the three groups were 66 days in the low-risk group, 55 days in the moderate-risk group, and 45 days in the high-risk group, with statistical significance ($P < 0.05$).

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Conclusion: Intraoperative pressure and complete removal of the intraoperative endplate can be helpful to evaluating the expected time of cage retropulsion in patients with PLIF, and this clinical model guided the selection of postoperative prevention and follow-up treatment.

Key words: Cage; Complication; Posterior lumbar interbody fusion; Retropulsion; Surgery

Introduction

Most surgical treatments for degenerative lumbar diseases include segmental spinal fusion. Pedicle screw fixation and interbody fusion cage is the “gold standard” for effective stabilization of lumbar motion segment. The surgical methods of degenerative lumbar diseases include posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), oblique lumbar interbody fusion (OLIF), axial lumbar interbody fusion (ALIF), minimally invasive surgery-transforaminal lumbar interbody fusion (MI-TLIF), and lateral lumbar interbody fusion (LLIF), but PLIF is the mainstream way^{1,2}. For patients with preoperative spinal instability, fusion should be performed to reduce the risk of iatrogenic segmental instability after spinal canal reconstruction^{3,4}. Posterior lumbar interbody fusion (PLIF) is widely used in lumbar degenerative diseases, and the use of interbody fusion cage is gradually increasing⁴⁻⁷. In lumbar interbody fusion (LIF), in order to promote fusion and maintain stability, fusion cage filled with autogenous bone or allogeneic bone is usually implanted into intervertebral space. Interbody fusion cage has the advantages of enhancing spinal stability, high fusion rate, and intervertebral space recovery⁸. Although many studies have reported good clinical results of TLIF or PLIF, there are still some postoperative complications, such as nerve root injury, screw extraction, adjacent segment disease, and spinal instability^{9,10}.

PLIF is a reliable treatment option in patients with degenerative lumbar spinal diseases, and provides spinal stabilization in balanced alignment, disc height restoration, and mechanical decompression of neural elements¹¹, which will not damage the spinal cord and nerve roots. The fusion cage used in the operation is a hollow cage structure, which can reserve sufficient space for the implanted lumbar bone fragments. At the same time, it can be used in the operation in the least segment, with an ideal fixation effect. When surgeons use vertebroplasty to change the connection between the vertebral bodies of the spine, the fusion cage should be packed with autogenous or allogeneic bone and inserted into the intervertebral space where the vertebral endplate was excised¹². LIF with a cage can obtain a firm union and can restore the disc height with normal sagittal and coronal alignment. In addition, the spinal nerve root or compressed dural sac can be secondarily restored by increasing the disc height. Although these procedures have satisfactory clinical outcomes, peri- and postoperative complications remain challenging problems.

After posterior lumbar fusion, the cage retropulsion (CR) increased gradually. CR is defined as a difference of 2 mm between the position on the day 3 after surgery and the position at follow-up. The incidence of cage retropulsion was 0.8%–4.7%, which could compress the spinal cord, reduce the area of intervertebral space and intervertebral foramen, and cause neurological symptoms and abnormal urination^{13,14}. CR with symptoms such as neuralgia, failure of fusion, or low back pain often brings great suffering to patients. In order to prevent this complication, previous studies have evaluated many potential risk factors associated with CR, but they are not fully understood^{9,14,15}. In previous studies, a variety of risk factors that affect cage retropulsion after LIF have been reported^{9,14,15}. Some studies thought that additional posterior instrumentation is essential to preventing cage retropulsion, particularly in terms of flexion-extension torque¹⁴. In the same context, Uzi *et al.* reported that cage retropulsion can occur during flexion movement and thus suggested that this could be prevented by additional posterior instrumentation. In addition, Kimura *et al.*¹⁵ found that the risk factors for cage retropulsion after PLIF were a wide disc space with instability, multilevel fusion surgery, the involvement of L₅S₁, and pear-shaped disc space on lateral radiographs. Other studies have also suggested that higher posterior disc height (PDH), presence of scoliotic curvature at anteroposterior (AP) view, undersized fusion cages, cage positioning, and cage type are possible risk factors for cage retropulsion.

There are few studies^{9,14} on the risk factors and time of cage retropulsion after posterior lumbar fusion. In this study, we explore the factors related to the posterior lumbar fusion cage displacement, and further predict the risk factors of clinical prognosis. However, current reports have variation in terms of patient populations and their findings are controversial. It is difficult to clearly identify which factors are the most significant. Our study used more factors, such as gender, age, surgical diagnosis time difference (from the first discovery of symptoms to the operation time), preoperative neurological symptoms, whether the fusion involves single or double segments, screw type, intraoperative compression (compression with pedicle system), preoperative bone mineral density, whether there is urine dysfunction before surgery, disease type, complete removal of endplate, and patient's education level (primary school level; secondary school level; university level). We comprehensively analyze the potential influencing factors.

In this study, our main research purposes are as follows: (i) to study the time when the cage moves backward;

(ii) to explore the factors affecting the cage displacement; (iii) to provide guidance for clinicians on the time of review after spinal fusion. The study was carried out in an effort to assess the risk factors related to CR following PLIF and was the first to introduce the scoring system of fusion cage retropulsion.

Patients and Method

Inclusion Criteria and Patient Characteristics

Inclusion Criteria

The inclusion criteria are as follows: (i) patients with lumbar degenerative disease, no spinal fracture, tumor, or other diseases; (ii) all patients underwent posterior lumbar interbody fusion. The initial position of the cage and the posterior position of the cage were defined by Abbushi¹⁶ (the initial position and retropulsion position are greater than or equal to 2 mm); X-ray, computed tomography (CT), and magnetic resonance imaging (MRI) were used to determine the patients with posterior lumbar fusion and cage retropulsion, and the posterior position of the cage after posterior lumbar fusion; (iii) this experiment has a separate group of samples for comparison and intra-group comparison; (iv) gender, age, surgical diagnosis time difference (from the first discovery of symptoms to the operation time), whether the fusion involves single or double segments, screw type, intraoperative compression (compressed with pedicle system), preoperative bone mineral density, whether there are neurological symptoms before surgery, whether there is urine dysfunction before surgery, disease type, complete removal of endplate, and patient's education level (primary school level; secondary school level; university level); (v) a retrospective observational study.

Patient Characteristics

Thirty-two patients who met the standards were included in our hospital and affiliated hospital. Three-dimensional reconstruction CT and MRI showed spinal canal stenosis, nerve root compression combined with clinical symptoms. Thirty-two patients were treated with surgery.

There were 20 males and 12 females with an average age of 53 years (range, 44–68 years). Bilateral fixation was performed in 20 cases and unilateral fixation in 12 cases. Data collection: gender, age, surgical diagnosis time difference (from the first discovery of symptoms to the operation time), preoperative neurological symptoms, whether the fusion involves single or double segments, screw type, intraoperative compression (compressed with pedicle system), preoperative bone mineral density, whether there is urine dysfunction before surgery, disease type, complete removal of endplate, and patient's education level (primary school level; secondary school level; university level). This study was approved by the Institutional Review Board of the Eighth Affiliated Hospital of Sun Yat-Sen University in

compliance with the Helsinki Declaration and consent was waived due to its retrospective nature.

Operation Method

All 32 patients were operated on by the same operation team. All patients signed informed consent, which met the requirements of the ethics committee. General anesthesia of the patient in the prone position. Apply routine disinfection with cloth. Expose transverse process, articular process, pedicle isthmus, and other anatomical structures. Conduct intraoperative protection of nerve and spinal cord, incision of annulus fibrosus, removal of nucleus pulposus, and removal of the intervertebral disc, scraping of the endplate, implantation of fusion cage, placement of pedicle and screw, C-arm confirmed as in good placement position. After washing, suture layer by layer, placing drainage tube. The drainage tube was removed 2 days after operation (<25 mL). After the operation, routine orthopaedic nursing and nutritional nerve anti-infection treatment is administered; early lower limb elevation activities and active and passive ankle back joint movement are carried out by the patient to prevent deep vein thrombosis. The patients were able to get out of bed 3–4 days after the operation.

Follow-up

The patients were followed up by WeChat, telephone, and outpatient service, and the follow-up time was up to March 2020. The time from the first lumbar interbody fusion operation to the time when the spinal cage moves backward is called the cage survival time.

Research Index

Surgical Diagnosis Time Difference (SDTD)

SDTD is the time interval between the occurrence of cage displacement-related symptoms and postoperative complications. SDTD was used to evaluate the endurance of the fuser. The time is divided into 1 month and 3 months.

Preoperative Neurological Symptoms (PNS)

Assessment is carried out for preoperative neurological symptoms such as lower extremity sensory motor abnormalities and cauda equina syndrome. PNS was used to evaluate the severity of spinal degenerative diseases.

Intraoperative Compression (IC)

In PLIF operation, the nail rod system (or pedicle system) is used for fixation, which can be pressurized or not according to the specific situation. Whether the operation is pressurized or not depends on the experience of the surgeon. The main purpose is to promote the stability of internal fixation.

Disease Type (DT)

Disease types included lumbar disc herniation and lumbar spinal stenosis and are used to evaluate the relationship between disease and fusion cage retropulsion.

TABLE 1 Univariate analysis of survival time of cage retropulsion in 32 patients with posterior lumbar interbody fusion (bold: the difference is statistically significant)

Factors	Cases	Median fuser backward survival time /days	χ^2	P value
Ages (years)			10.216	0.001
<60	13	55		
≥60	19	42		
Gender			9.300	0.002
Male	20	53		
Female	12	44		
Operation diagnosis time difference			0.555	0.758
≤1 month	7	48		
>1 month and ≤ 3 months	17	49		
>3 months	8	49		
Disease types			19.368	0.001
Lumbar disc herniation	18	50		
Spinal stenosis	10	46		
Lumbar spondylolisthesis	4	38		
Number of fusion segments			20.660	0.001
Single segment	18	57		
Two segments	14	45		
Intraoperative pressure			18.771	0.001
Yes	7	66		
No	25	46		
Preoperative bone mineral density			18.074	0.001
Normal	18	52		
Low	10	46		
Osteoporosis	4	39		
Screw type			0.880	0.348
Universal screw	27	48		
One-way screw	5	49		
Neurological symptoms before operation			10.341	0.001
Yes	25	46		
No	7	61		
Preoperative urination dysfunction			1.585	0.208
Yes	8	46		
No	24	49		
Completely removed the endplate			9.757	0.002
Yes	10	56		
No	22	45		
Education levels			7.482	0.024
Primary school level	9	48		
Secondary school level	10	49		
University level	13	49		

Removal of Endplate (RE)

When we operate, we need to treat the endplate. In the operation mode, complete or partial excavation can be carried out, but the effect between the two is unknown. The main outcome measure was how the operator handled the endplate. What we recorded was the operation procedure of the surgeon.

Patient Education Level (PEL)

A patient's education level is defined as primary school level, secondary school level, and university level. A patient's education level, to a large extent, affects the patient's executive power to the doctor's decision.

Preoperative Bone Mineral Density (PBMD)

According to DXA value, normal BMD was greater than -1SD; low BMD was from -1SD to -2.5SD; osteoporosis was

less than -2.5SD. Bone mineral density reflects the state of bone, which has a key impact on internal fixation and bone transplantation.

Statistical Analysis

The Statistical Package for the Social Sciences (version 22.0; SPSS, IBM, Chicago, IL, USA) software was used for statistical analysis and univariate analysis was used to screen out the factors related to cage retropulsion. In univariate analysis, prognostic factors were included in multivariate analysis. K-M analysis and Log Rank test were used to analyze the binary variables and describe the time curve of the shift of the cage backwards. Cox survival analysis and the Log Rank test were used in multivariate and multivariate survival analyses ($P < 0.05$ with statistical difference). The influencing factors with a statistical significance were screened out in turn.

TABLE 2 Results of multivariate analysis on the time of cage retropulsion after posterior lumbar fusion in 32 cases (bold: the difference is statistically significant)

Factors	P value	HR
Intraoperative pressure	0.015	4.604
Completely removed the endplate	0.027	0.205

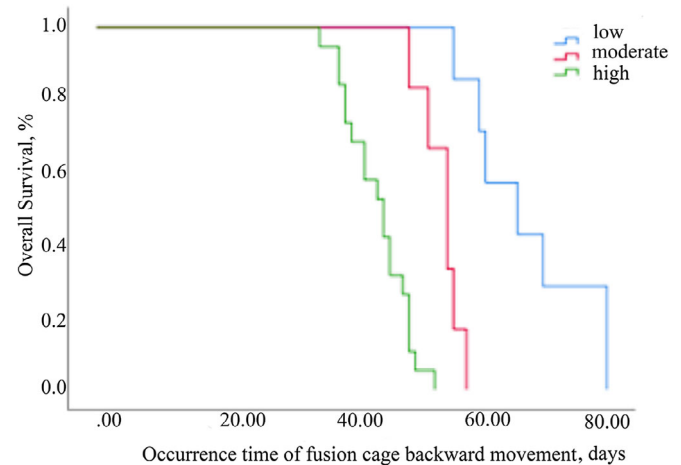
TABLE 3 Risk score of fusion cage backward movement

Factors	Points
Intraoperative pressure	
Yes	0
No	3
Completely removed the endplate	
Yes	0
No	1

Results

General Results and Results of Univariate Analysis of Cage Retropulsion Time

The mean follow-up period was 51 days (range, 35–80 days), and median follow-up was 49 days. Univariate analysis showed that there were 13 patients over 60 years old and 19 patients under 60 years old, $\chi^2 = 10.216$, $P = 0.001$. Gender: 20 male patients and 12 female patients, $\chi^2 = 9.300$, $P = 0.002$. SDTD: seven patients within 1 month, 17 patients within 1 to 3 months, eight patients over 3 months, $\chi^2 = 0.555$, $P = 0.758$. PNS: 25 cases had; seven cases did not, $\chi^2 = 10.341$, $P = 0.001$. IC: seven cases of compression, 25 cases of no compression, $\chi^2 = 18.771$, $P = 0.001$. DT: 18 cases of lumbar disc herniation, 10 cases of lumbar spinal stenosis, four cases of lumbar spondylolisthesis, $\chi^2 = 19.368$, $P = 0.001$. RE: 10 cases had, 22 cases did not, $\chi^2 = 9.757$, $P = 0.002$. PEL: nine cases of primary school education, 10 cases of secondary school, 13 cases of university level, $\chi^2 = 7.482$, $P = 0.024$. FS: 18 cases of single segment, 14 cases of double segment, $\chi^2 = 20.660$, $P = 0.001$. PBMD: 10 cases of low density, 18 cases of normal, four cases of osteoporosis, $\chi^2 = 18.074$, $P = 0.001$. ST: 27 cases of universal screw, five cases of one-way screw, $\chi^2 = 0.880$, $P = 0.348$. Preoperative urination dysfunction: eight cases had, 24 cases did not, $\chi^2 = 1.585$, $P = 0.208$. The median time of cage retropulsion in patients older than 60 years was 42 days than that in patients younger than 60 years. For gender, the time of cage retropulsion in women was shorter than that in men. Different disease types and fusion stages also affect the time of cage retropulsion. Two segments are more likely to cause cage retropulsion. The median time for the cage with complete endplate resection was 56 days, which was longer than that without complete endplate resection. The higher the level of education, the longer the median time of cage

**Fig. 1** Time of cage retropulsion in different risk groups (days).

According to intraoperative pressure and intraoperative endplate being completely removed, patients with posterior lumbar fusion can evaluate the expected time of cage displacement to guide the selection of postoperative prevention and follow-up treatment.

retropulsion, with statistical significance. Operation diagnosis time difference, screw type, and preoperative urination dysfunction are no correlation with the time of cage retropulsion by univariate analysis. The results of the univariate analysis on the time of cage retropulsion are shown in Table 1.

Analysis of Prognostic Factors

Univariate analysis showed that age, gender, disease type, number of fusion segments, compression, preoperative bone mineral density, patient's educational level, and preoperative neurological symptoms were related to the time of cage retropulsion after posterior lumbar disc fusion. Cox regression model was used to analyze the nine factors. The results showed that intraoperative compression and complete endplate removal were independent risk factors for cage displacement ($P = 0.015$, $P = 0.027$; Table 2).

Model Score

Cox regression analysis showed that the hazard ratio of intraoperative compression was 14.604, and complete removal of endplate was 0.205. After understanding the risk ratio of the above factors, the scoring rules are specified: $0.1 < HR < 0.5$, -3 points; $0.5 < HR < 1.0$, -2 points; $1 < HR < 2$, -1 point; $2 < HR < 3$, 1 point; $3 < HR < 4$, 2 points; $4 < HR < 5$, 3 points; the influencing factors were negative, 0 points (Table 3). They were divided into three groups: the low-risk group with 0–1 points, seven cases; the moderate-risk group with 2–3 points, six cases; the high-risk group with 4–5 points, 19 cases. The overall median was 49 days, the median of the low-risk group was 66.0 days, the median of the moderate-risk group was 55 days, and the

median of the high-risk group was 45 days, Cox survival analysis and Log Rank test were performed in the three groups, $P < 0.05$ was statistically significant (Fig. 1).

Discussion

With the development of society, the number of office workers is increasing, and the number of patients with lumbar degenerative diseases is also increasing (including lumbar disc herniation, lumbar spondylolisthesis, lumbar spinal stenosis, and other diseases). Posterior lumbar interbody fusion is more and more widely used in the treatment of lumbar degenerative diseases, which can improve the quality of life of patients. However, the operation also has its complications, including the cage moving backward and the spine moving backward.

Time of Fusion Cage Retropulsion

In this paper, we found that the time of fusion cage retropulsion generally occurred at about 2 months after operation. When the risk factor score was more than 3, the time of fusion cage retropulsion was about 1.5 months. This is the first study that evaluates whether completely removing the endplate and intraoperative compression are associated with the time of cage retropulsion. In this study, we did not study the degree of cage retropulsion. The next step is to study the correlation between the degree of cage retropulsion and the time of posterior displacement, so as to better serve clinical orthopaedic doctors. After posterior lumbar interbody fusion, the cage may compress the nerve, lumbar kyphosis, lumbar intervertebral space narrowing, intervertebral foramen narrowing, serious complications such as paraplegia, and the need for reoperation^{14,17}. There is no relevant study on the prevention and prediction of cage retropulsion in clinical practice. The key point is to select appropriate preventive measures.

Potential Risk Factors of Cage Retropulsion in the Study

The potential risk factors of cage retropulsion included cage size, intervertebral space height, cage material, endplate removal, age, intraoperative compression, and fusion segment^{18,19}. In this paper, we found that insufficient compression of the cage is also an important risk factor for cage retropulsion. Hu *et al.* study showed that 22 patients with cage retropulsion found that the number of patients with intraoperative compression was significantly less than that of patients without compression, and the results were consistent with our research report. During the operation, compression of the cage can better place the cage into the intervertebral space, better adapt to the relative motion environment between the vertebral bodies, and prevent the incidence of posterior displacement. It is found that the removal of endplate is a risk factor for the cage to move backward. Relevant studies have shown that the removal of the endplate is conducive to the placement of fusion cage to better fit the intervertebral space. However, the excessive removal of the endplate leads to the destruction of vertebral bone structure,

which requires certain clinical operation experience and training¹⁷. Relevant studies have shown that the integrity of cartilage layer of intervertebral disc and endplate and the preservation of bony endplate structure can obtain a good biomechanical basis, which is conducive to the combination of bony structure of fusion cage²⁰. This study shows that the complete removal of the endplate is more conducive to the placement of the fuser and reduces the risk rate of the cage moving backward, which is inconsistent with the research of Hu *et al.* Complete removal of the endplate does not increase the difficulty of a fusion cage implant and bone structure healing, nor does it increase the risk coefficient of cage backward movement.

In this study, age and osteoporosis may not be related to the time of cage displacement, which is contrary to previous studies²¹. The possible explanation is that age and osteoporosis are only risk factors for backward migration, but they cannot determine the specific time of occurrence of backward migration. The specific time may be caused by many factors, but age and osteoporosis are not independent risk factors. The type of screw (universal screw and one-way screw) has also been shown to be related to the occurrence of cage backward displacement, but this paper concludes that the type of screw may not be statistically significant in the occurrence of cage backward displacement. A possible explanation is that screw placement is mainly used to fix the anatomical system between the pedicle and the vertebral body, playing the role of support and correction.

Anatomically, the cage is mainly placed in the intervertebral space, while the screw is mainly placed in the pedicle. Therefore, the stability of the cage may not be of sufficient reference value for the selection of screws. In this paper, the patients were divided into groups according to their education level, and there was no statistical significance between the education level and the time of spinal fusion cage backward movement. The difference of educational level is mainly manifested in the self-understanding of surgery and the compliance of follow-up rehabilitation training, and there is no correlation in the backward movement of intraoperative implantation. Preoperative neurological symptoms are one of the surgical indications.

Risk Factors of Cage Retropulsion

The risk factors of cage retropulsion include:

1. Unilateral fixation and bilateral fixation. Duncan thought that the stability of unilateral fixation is worse than that of bilateral fixation, and unilateral is easy to cause the fuser to move backward. There is no detailed description of bilateral or unilateral surgery, but some related studies suggest that unilateral surgery and bilateral surgery have the same stability and fusion rate^{15,22}. There is no final conclusion.
2. The implant was fully implanted (the posterior margin of the cage was greater than 3 mm). Hu *et al.*²³ has shown that the incidence of posterior displacement of the fusion cage is 0.832 times higher than that of insufficient

implantation. The possible reason is that if the implant is fully implanted, there is enough range for movement and less obvious imaging change and related symptoms.

3. Size and type of fuser. The selection principle is basically consistent with the height of intervertebral space and lordosis angle equal to or greater than that before the operation, so as to form a “stretch compression” band with sufficient strength²⁴. If the fuser is too small, it is difficult to produce effective endplate compression^{25,26}. Therefore, the selection of an appropriately large cage is conducive to the expansion of intervertebral space and the formation of a stretch compression state. At present, there are two types of fusion cage, such as double concave, spindle, kidney, rectangle, etc., and the selection of the type depends on the shape, height, and convex angle of the endplate. The main purpose of the selection is to fit the endplate well and maintain good stability.
4. Multilevel segment fusion. Relevant studies have shown that multi-segment fusion cage is more likely to cause backward displacement^{26,27}. But there are other studies that show no correlation^{25,28}, as are consistent with the results of this paper.
5. Body Mass Index (BMI). Pan *et al.* have shown that BMI is one of the risk factors for cage displacement¹⁴. It indicates that the increase of body mass index leads to the posterior displacement of fusion cage, which may be due to the increase of lumbosacral load, which leads to the increase of stress, and the risk of cage backward displacement increases.
6. Gender and age. There are two previous studies on gender, age, and cage migration. Kimura *et al.* studied 1070 cases of lumbar fusion, nine cases of posterior displacement, gender differences, but the sample size is small²⁷. Chinese scholar Zhang *et al.* studied nine patients with backward migration and found that there was no difference in gender ratio (4:5), but the sample size was also small²⁹. There are few studies on age, and there is no relevant special report. The results showed that age had no significant effect on cage retropulsion.
7. Experience and technique of surgeons. Posterior lumbar interbody fusion requires a certain learning curve, good anatomical knowledge, and clinical practice.

Strategy of Cage Retropulsion

The strategy of cage retropulsion processing:

1. The fusion cage is in backward state and oppresses the spinal cord nerve, causing neurological symptoms, which cannot be achieved conservatively. Therefore, revision surgery is needed to solve the spinal stability problem and nerve compression symptoms, so as to avoid the irreversible occurrence of neurological symptoms^{9,30–32}.
2. The posterior displacement of the fusion cage leads to spinal instability, and the cage retropulsion occurs continuously, which may compress the spinal cord nerve. Therefore, early revision surgery is also needed³².
3. The fusion cage moved backward in imaging, but it did not lead to related symptoms^{12,33}. The space of the spinal canal was acceptable. Conservative treatment and imaging review could be performed in time.

Limitations

The limitations of this study are as follows: (i) the sample size is 32 cases, which is a small sample size, so a large sample size is needed; (ii) this study is a retrospective analysis of cases in two affiliated hospitals, and the evidence level is not high, so multi-center, large-sample randomized controlled study should be adopted in the follow-up; (iii) this study does not divide the region of the fusion cage backward, lacking accuracy; (iv) in this study, we did not analyze the related symptoms and follow-up treatment measures after the fusion cage was moved backward, but the relevant content has been described in the discussion; (v) Combined with the current literature, the sample size of this study (32 cases) is large. Whether it is caused by the experience or technology of the surgeon still needs to be considered.

Conclusions

This paper uses survival analysis methodology to predict the time-related risk factors of cage retropulsion after posterior lumbar fusion, which can estimate the time of cage retropulsion; at the same time, it can guide orthopaedic doctors to take relevant measures to prevent the complications of cage backward movement after posterior lumbar fusion. However, more samples are needed for further support in this study. It is suggested that multi-center, large-sample studies should be carried out for higher evidence-level research in the future.

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