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Incidence and Prevention of Intervertebral Cage Overhang With Minimally Invasive Lateral Approach Fusions

Gilad J. Regev, MD,*† Sean Haloman, BS,* Lina Chen, MD,‡ Mallika Dhawan, BSc,* Yu Po Lee, MD,* Steven R. Garfin, MD,* and Choll W. Kim, MD, PhD*§

Study Design. Radiographic review.

Objective. To evaluate the incidence and degree of cage overhang in minimally invasive spinal (MIS) fusions, when using either the direct lateral interbody fusion (DLIF) or extreme lateral interbody fusion (XLIF) techniques.

Summary of Background Data. Among the difficulties surgeons face during a MIS lateral interbody fusion is to assess the proper placement of the cage without the use of direct visualization. Determining the proper length of the cage using AP view fluoroscopy can be misleading. As the axial profile of the vertebral body is oval, inserting the cage anterior or posterior to the maximal width point requires adjustment of the cage's length.

Methods. The incidence and degree of cage overhang were measured using magnetic resonance imaging (MRI) and computed tomography (CT) studies from patients that underwent a MIS lateral interbody fusion. To determine the adjustment needed when the cage is inserted at various sagittal sites, the coronal spans of normal vertebral endplates were measured.

Results. Forty-five percent of the cages were placed in the central portion, 34% were located in the anterior ⅓, and 7% were located in the posterior ⅓ of the disc space. Of the anterior positioned cages, 45% were found to be overhanging outside of the boundaries of the intervertebral disc space. The average measured lateral protrusion was 7.8 ± 3.6 mm, and anterior protrusion was 9.8 ± 3.3 mm. The vertebral body width measured 41.7 ± 6 mm at the anterior ⅓, 50 ± 4 mm at the mid, and 49 ± 1 mm at the posterior ⅓. Compared with the midvertebral width, the vertebral body width at the anterior ⅓ was decreased by 16.5% ± 0.9% ($P < 0.05$).

Conclusion. The risk of placing an excessively long cage, when the insertion site is located in the anterior ⅓ of the disc, is relatively high, when performing MIS lateral approach interbody fusions. When using an anterior entry point for the insertion of the cage, choosing a 15% shorter cage length compared with that measured on the AP should prevent anterolateral protrusion of the cage.

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The minimally invasive (MIS) lateral approach is a relatively new technique for performing interbody spinal fusions.[1–3] This approach allows for a large cage to be placed at the apophyseal ring where the bone is strongest.[4,5] Among the advantages of this approach is avoiding manipulation and retraction of the large retroperitoneal vessels, which has been related to serious vascular complication during the anterior approach.[6–8] However, limited visualization of the surgical field during the MIS lateral approach procedures still exposes the patient to the risk of injury to the ventral nerve roots and intestines during the deployment of the MIS surgical retractor, as well as risk of retroperitoneal vessel injury during the discectomy and cage insertion.[9] Among the difficulties the surgeon faces during this procedure are proper assessment of the length and the placement of the cage because of the lack of direct visualization. Intraoperative fluoroscopy used for guidance during the insertion of the interbody cage, relies on the radio-opaque marker inside the cage to steer it to the proper position.[3] The proper length of the cage is determined by measuring the vertebral body width in the AP view fluoroscopy. However, this technique can be misleading as it represents the maximal width of the vertebral body. Because the oval shape of the vertebral body cannot be evaluated using biplanar fluoroscopy there is a risk of placing the intervertebral cage in a position that will result in it overhanging anteriorly and laterally, within the vicinity of the retroperitoneal vessels or spinal nerves. Although, reports of vascular complication following the MIS lateral approach fusion have not been published to date, we suggest that anterior or lateral protrusion from the disc space during the procedure and placement of the intervertebral cage could potentially increase the risk of complications.

The purpose of this study is to evaluate the incidence and degree of cage overhang following the lateral approach, lumbar interbody fusion, and to establish technical guidelines that would help minimize the risk from this potentially adverse event.

From the *Department of Orthopaedic Surgery, University of California, San Diego, CA; †Spine Surgery Unit, Tel-Aviv Sourasky Medical Center, Tel-Aviv, Israel; ‡Department of Radiology, University of California; and §Center for Minimally Invasive Spine Surgery at Alvarado Hospital, San Diego, CA.
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Address correspondence and reprint requests to Choll W. Kim, MD, PhD, Spine Institute of San Diego, Center for Minimally Invasive Spine Surgery at Alvarado Hospital, 6719 Alvarado Road Suite 308, San Diego, CA 92120; E-mail chollkim@smiss.org

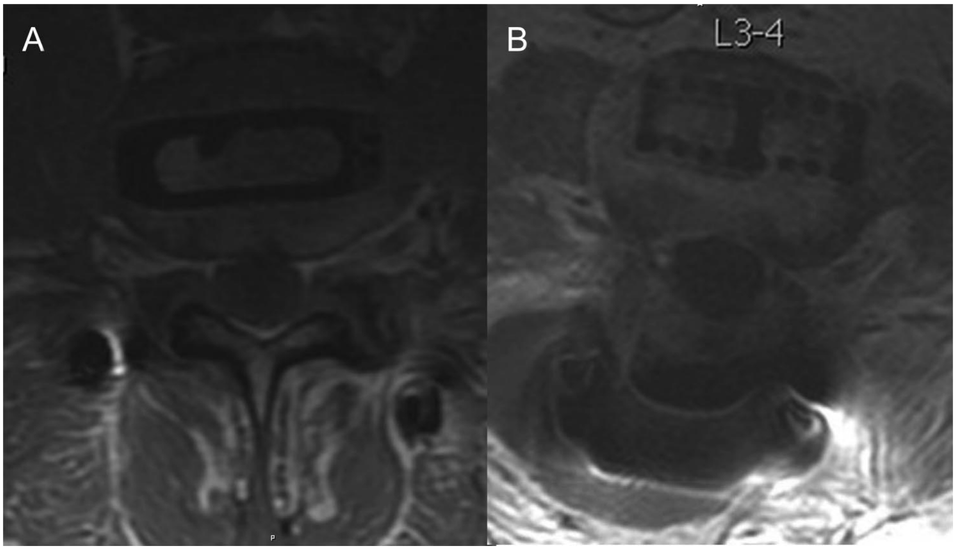

Figure 1. Postoperative axial T1-weighted MRI images showing typical positions and shape of the intervertebral cage following the DLIF (**A**), and the XLIF (**B**) techniques.

■ Materials and Methods

A total of 152 MIS lateral fusion surgeries that were performed at our institution from January 2005 to July 2008 using either the XLIF (NuVasive, Inc., San Diego, CA) or DLIF (Medtronic Sofamor Danek Inc.) techniques (Figure 1). From this group, patients that received postsurgical computed tomography (CT) or magnetic resonance imaging (MRI) were identified. MRI studies were obtained in these patients when the need for an additional posterior decompression following the anterior procedure was considered (*i.e.*, to assess the adequacy of indirect decompression) or to evaluate patients with recurrent back or radicular pain. CT studies were obtained to verify the proper position of the spinal instrumentation in selected patients.

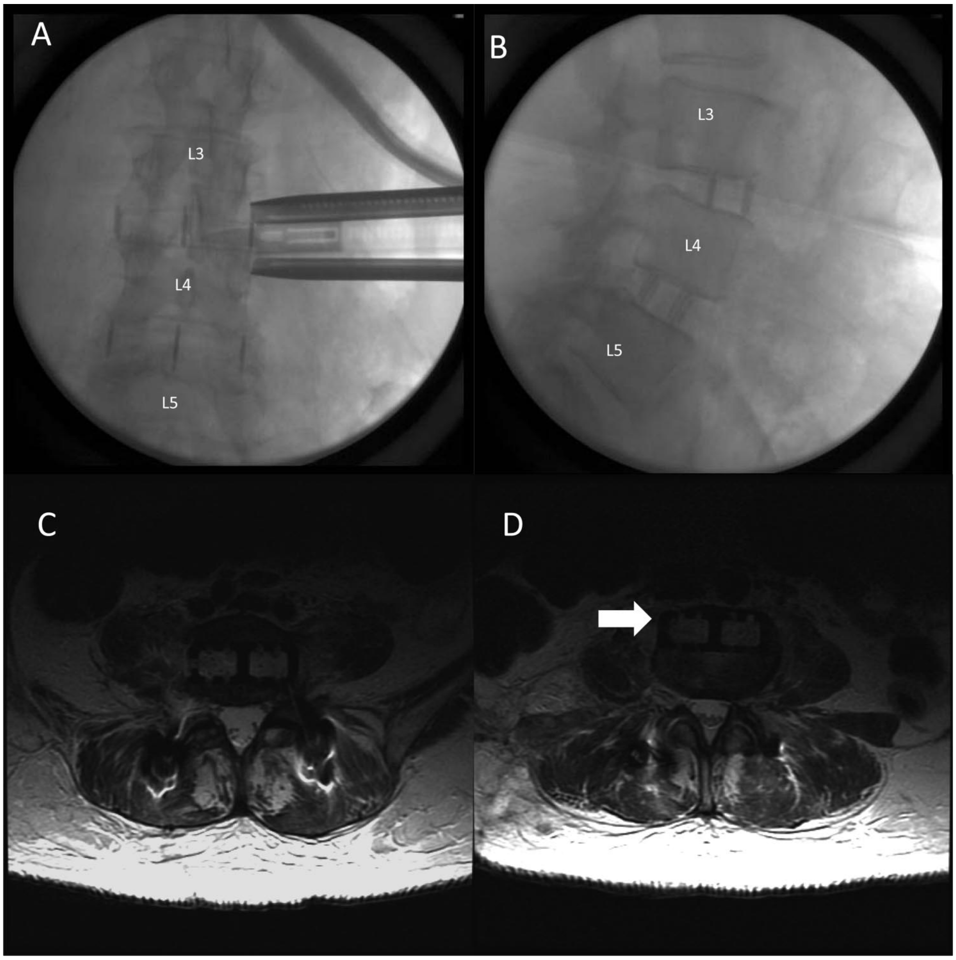

Figure 2. **A** and **B**, Intraoperative fluoroscopic images following the insertion of the intervertebral cages. At L3–4 the fluoroscopic images suggest optimal cage sizing (A) with an entry point at the anterior ⅓ of the disc (B). **C** and **D**, Postoperative, MRI axial images demonstrating: optimal position of the cage (C) within the boundaries of the intervertebral disc space and an oversized cage (D) that is extending over the vertebral margin at the right anterior corner (white arrow) as a result of an anterior discectomy window at that level. This can possibly impinge the nearby blood vessel.

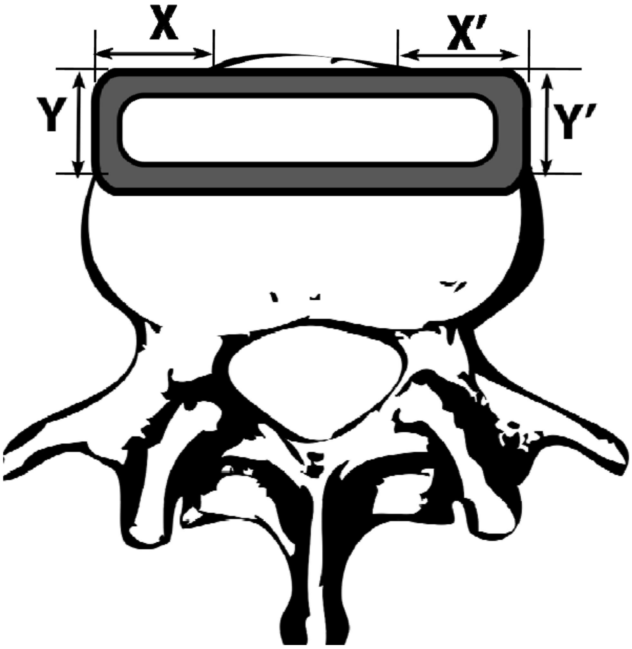

Figure 3. Schematic illustration showing anterior (Y, Y′) and lateral (X, X′) measurements of the degree of cage overhang.

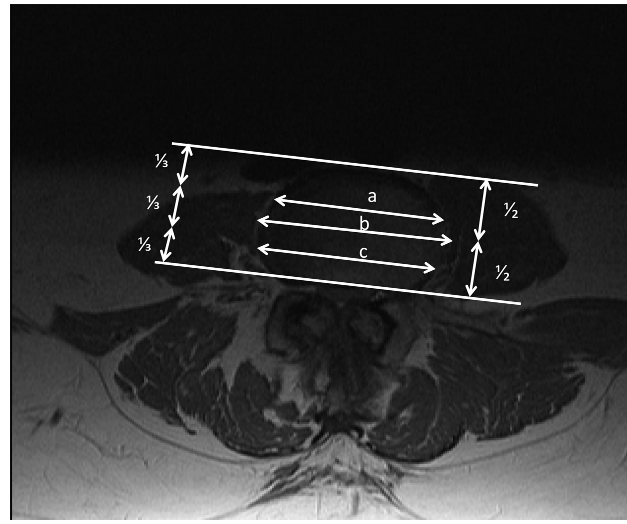

Figure 4. The vertebral body width measurements in the axial plain. a, anterior ⅓ vertebral width; b, central width; c, posterior ⅓ vertebral width.

For each fused segment, the position of the cage in the sagittal plane was determined in the anterior, central, or posterior one third of the disc space in the sagittal plane. The incidence of cage protrusion outside of the vertebral body boundaries was measured in relation to its sagittal position (Figure 2). Additionally, the degree of cage protrusion was measured in the ventral and lateral directions (Figure 3). Measurements were determined using the PACS software computer digitizer (IMPAX 6.3 Agfa Healthcare NV, Mortsel, Belgium).

A second group of patients consisted of spine MRI studies from patients that did not have any spinal deformity or history of previous spinal surgery. This group was used to analyze the normal width variation of the different lumbar vertebrae in order to determine the correction in cage length that is needed when the insertion site is either anterior or posterior. The coronal span of the vertebral body was measured at the anterior one third, the center, and the posterior one third at different levels (Figure 4). The ratios between these measurements were calculated.

Statistical Analysis

Cage protrusion and vertebral body width diameter are reported as means with standard error. Statistical tests were made using SPSS (version 15.0, Chicago, IL) with α values set to 0.05. Pearson χ^2 analysis was used to evaluate the relationship between cage position and overhang with respect to the described surgical variables. One-way repeated analysis of variance (ANOVA) was used to compare differences between vertebral body widths at the different levels.

Results

Intervertebral Cage Position Following MIS Lateral Approached Fusion

Of the patients that underwent a MIS lateral fusion at our institute, 37 were found to have underwent a post-surgical CT or MRI of the lumbar spine. The position of 71 cages from these patients was reviewed. This operated group consisted of 14 DLIF and 23 XLIF patients. Thirty-three of the cages were located at the L4–L5 level, 22 at the L3–L4 level, 14 at L2–L3, and 2 at the L1–L2 level (Table 1). Fifty-nine percent (42 of 71) of the cages were placed in the central portion, 34% (24 of 71) were located in the anterior third, and 7% (5 of 71) were located in the posterior third of the intervertebral space.

A high incidence of protrusion was related to an anterior position of the cage in the sagittal plane ($P < 0.01$). Of all cages that were found to overhang, 73% were positioned in the anterior third of the intervertebral space. When evaluating the anterior cage group, 45% (11 of 24) of cages were found to be overhanging outside of the boundaries of the vertebral body, in the vicinity of the retroperitoneal great vessels. The average extent of cage protrusion in that group measured 7.7 ± 3 mm at the lateral, and 9.8 ± 3 mm at the ventral directions. Of the cages located centrally only 9.5% were found to be overhanging outside the vertebral body. In this group the average lateral protrusion was 4.2 ± 3 mm laterally. Of the cages positioned posteriorly no protrusions outside of the vertebral body borders were observed (Table 1). No relationship was found between the risk for cage overhang and the level of the fusion, the side of the lateral approach or type of procedure that was preformed (XLIF *vs.* DLIF). However, in the more cranial levels the likelihood of placing the cage in the anterior third of the

Table 1. Cage Position and Overhang

		Case Position			
Level	Patients	Anterior	Middle	Posterior	Overhang (%)
L1–L2	2	1	1	0	50
L2–L3	14	4	7	3	14.2
L3–L4	22	8	14	0	13.6
L4–L5	33	11	20	2	18.1
Total	71	24	42	5	16.9

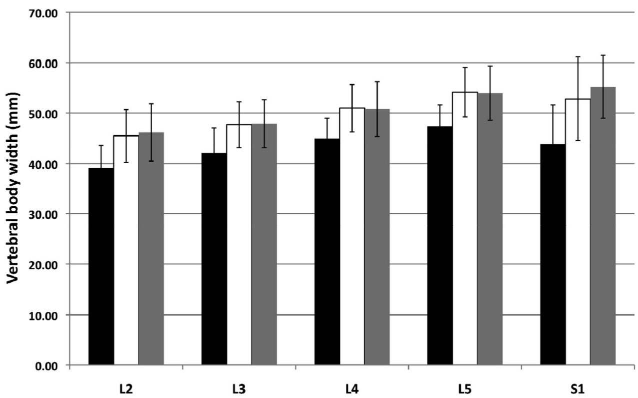

Figure 5. Measured lumbar vertebral widths (mm) at the anterior ⅓ (black), center (white), and posterior ⅓ (grey) of the vertebral bodies.

intervertebral space seemed to be higher, although because of the small sample size it was not statistically significant. Despite the high incidence of cage overhang, no adverse clinical events were seen to date.

Cage Length Adjustments in Off-Centered Lateral Insertion Sites

Two hundred twenty-five segments from 32 women and 30 men were measured using MRI images. The age of the patients ranged from 17 to 87 years (mean 57). For all segments, the lower endplate widths were measured at 3 locations: first the dorsal-ventral diameter of the vertebral body was measured. Then measurements of the vertebral body width were taken at 3 specific points along the vertebral dorsal-ventral axis, the anterior ⅓, the middle, and the posterior ⅓ (Figure 4). When comparing the width at the anterior ⅓ with the center of the vertebral body, the anterior ⅓ was shorter by an average of 8.3 ± 0.9 mm (16.5% ± 1%) for the different levels. The vertebral widths at the posterior ⅓ were similar to those measured at the middle (Figure 5).

■ Discussion

The MIS lateral approach for anterior lumbar fusion enables the surgeon to insert relatively large intervertebral cages without the need to mobilize the retroperitoneal blood vessels, or the neural elements.[1,10,11] Nevertheless, the narrow surgical corridor creates several technical challenges. Meticulous positioning of the patient on the operating table, careful fluoroscopic imaging and neuromonitoring are important for this procedure.[3]

The sagittal entry point during the discectomy and insertion of the intervertebral cage is another variable of the minimally invasive lateral approach. Unlike the anterior approach that enables the surgeon to view the intervertebral space and the vertebral body boundaries during the insertion of the cage, when using the lateral approach technique visualization of the disc space is limited. This limitation requires the use of fluoroscopic guidance during the discectomy and positioning of the intervertebral cage. By failing to take into account the oval shape of the vertebral body in the axial plane, the surgeon may be working outside the boundaries of the intervertebral space, extruding anterior and lateral to it, within the vicinity of the retroperitoneal vessels and the contralateral nerve roots. The risks of injury to the neurovascular structures that lay on the contralateral side of the disc space increase because the contralateral anulus is routinely released during the procedure by a Cobb elevator under fluoroscopic guidance (Figure 6). These risks are further increased in cases of degenerative scoliosis, because of the rotatory deformity of the spine that results in a relatively, anterior position of the nerve root at the convexity and a posterior position of the retroperitoneal vessels at the concavity of the deformity.[9] Conversely, placement of a short cage that does not span the entire vertebral body diameter risks subsidence of the cage into the vertebral body. Biomechanical studies have shown that the vertebral rims are significantly stronger than other areas of the endplate.[4,5]

Our data suggest that relying solely on the fluoroscopic AP image may result in choosing an excessively long cage that protrudes outside of the vertebral rim. This is most likely to occur when the entry point for the insertion of the cage is located in the anterior portion of the disc. Our results indicate that when the sagittal entry

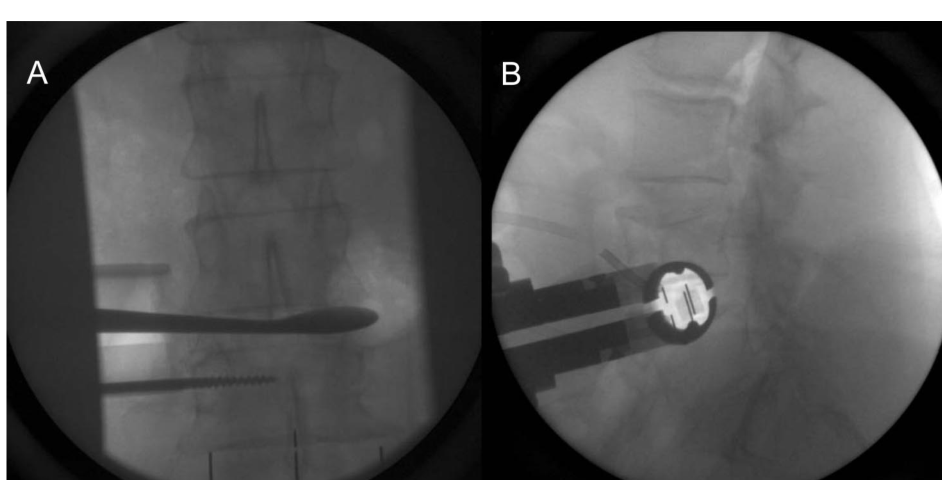

Figure 6. **A**, Fluoroscopic image during the release of the contralateral anulus with a Cobb elevator. The *vena cava* is at risk of injury if the instrument is passed too far laterally or anteriorly. **B**, Fluoroscopic image after the insertion of the cage through the lateral port showing its position in the central ⅓ of the disc space in the sagittal plane.

point is located in the anterior third of the anulus, choosing a 15% shorter cage length compared with that measured on the AP fluoroscopic image should minimize the risk of anterior protrusion of the cage in all of the lumbar segments. However, it must be emphasized that this estimation is relative because the oval shape of the vertebral body results in continuous variation of the width at the anterior third of the body. A few millimeters variation in the dorsal-ventral position of the cage can result in significant change of the vertebral body width. In cases where the vessels are immediately adjacent to the vertebral body, precise measurement of cage diameter should be determined using the axial image from a preoperative MRI or CT scan.

Failure to position the MIS retractors perpendicularly to the vertebral body can also result in incorrect estimation of the proper cage length because of oblique placement of the cage. Technical difficulties in achieving accurate perpendicular positioning of the surgical retractors and intervertebral cage are typical in degenerative scoliosis because of the axial rotation of the vertebrae.[12] This complication can be avoided by meticulous positioning of the patient before the beginning of the procedure such that, the best possible lateral position with the operated spinal segment perpendicular to the floor is achieved.

Cage overhang has not been reported with regards to the anterior lumbar interbody fusion (ALIF) or transforaminal lumbar interbody fusion (TLIF) techniques.[7,13] To the best of our knowledge, none of the documented complications, published to date, following MIS lateral fusion has been related to cage overhang. However, it is a potential injury risk and the incidence and extent of overhang should therefore be reduced as much as possible. Vascular complications, including both bleeding and thrombosis have been reported following cage dislodgement with the ALIF procedure. This was assumed to result from impingement of the retroperitoneal vessels by the cage. Our results demonstrate a significant risk for cage protrusion, when it is positioned in the anterior third of the disc space. This could lead to impingement of the retroperitoneal vessels in a similar fashion to those reported with dislodged ALIF cages. Moreover, protrusion of the cage into the retroperitoneal space can expose the adjacent vessels and nerves to high concentrations of bone morphogenic protein (BMP), which is often placed inside the cage to help obtain a fusion.[14–17] Spillage of BMP outside the confines of the disc space can result in retroperitoneal seromas and hematomas as well as radiculitis of the adjacent nerve roots.[18] As a result, it has been recommended, to minimize the contact of BMP with the structures surrounding the disc space, through copious irrigation and placing the BMP carrier inside the cage.[15]

Conclusion

The risk of placing an excessively long cage, when the insertion site is located in the anterior ⅓ of the disc space, is relatively high, when performing MIS lateral approach fusions. Relying on the AP fluoroscopy can lead to miscalculation of the proper cage length because of the oval profile of the vertebral body. When using an anterior entry point for the insertion of the cage, choosing a shorter cage length compared with that measured on the AP can minimize the chances for anterior-lateral protrusion of the cage. Although the MIS lateral approach is gaining popularity among surgeons, data related to the complications from this procedure are still limited. Future studies are needed to compare the rate of complications from this procedure with that reported for other fusion approaches.

Key Points

- When performing MIS lateral approach fusions relying on the AP fluoroscopy can lead to miscalculation of the proper cage length.
- The risk of placing an excessively long cage, when the insertion site is located in the anterior ⅓ of the disc space, is relatively high.
- In case of an anterior entry point for the insertion of the cage, choosing a 15% shorter cage length compared with that measured on the AP can minimize the chances for anteriolateral protrusion.

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