Revision strategies for AxiaLIF

CHRISTOPH P. HOFSTETTER, M.D., PH.D., ANDREW R. JAMES, M.B.B.S., F.R.C.S., AND ROGER HÄRTL, M.D.

Department of Neurological Surgery and Weill Cornell Medical College, New York–Presbyterian Hospital, New York, New York

Object. Paracoccygeal transsacral fixation is a novel percutaneous technique for arthrodesis of L5–S1 and L4–5 (Axial Lumbar Interbody Fusion [AxiaLIF]). There are no reports on feasible revision strategies. The goal of this paper is to analyze the surgical details of failed AxiaLIF constructs and to describe revision strategies.

Methods. The medical charts, operative records, and imaging studies of 5 patients with failed multisegment instrumentation using the AxiaLIF device were reviewed.

Results. AxiaLIF constructs were revised in 5 patients with a mean age of 58.4 years. All AxiaLIF devices were part of multisegment fusion constructs for revision surgery and were revised an average of 15 months after implantation. Two AxiaLIF devices were percutaneously retrieved; one because of excessive bone resorption around the AxiaLIF screw, and the other because of chronic hardware infection. In these 2 patients, the anterior column was subsequently stabilized via anterior lumbar interbody fusion. In the other 3 patients, the AxiaLIF device was left in situ. In 2 of these patients the anterior column was stabilized with bilateral L5–S1 posterior lumbar interbody fusion, and in the remaining patient with L4–5 instability the posterior instrumentation only was revised. Revision surgeries were well tolerated. One patient suffered from a wound dehiscence of the back wound.

Conclusions. AxiaLIF devices are safely retrieved using percutaneous technique. Both anterior and posterior revision strategies may be used to achieve anterior column fixation. (DOI: 10.3171/2011.8.FOCUS11139)

Keywords: • AxiaLIF • lumbar interbody fusion • pseudarthrosis • minimally invasive spine surgery • revision • complication

Percutaneous paracoccygeal transsacral fixation (AxiaLIF, Trans1, Inc.) has become an increasingly popular method for instrumentation of the lower lumbar spine.4,8,9 The AxialLIF procedure allows for straightforward access to L4–5 and L5–S1 via the presacral space. Therefore, it eliminates muscle detachment, ligamentous disruption, and incision of the anulus, and it minimizes destabilization of the joint.1,13 Biomechanical studies have proposed that the AxialLIF device in combination with posterior fixation offers stability similar to anterior interbody fusion cages augmented with a posterior construct.2,22 The AxialLIF procedure has been reported to be associated with a low risk of complications such as visceral, vascular, or sympathetic injury.5,15 The rate of immediate operative complications of the first 5000 1-2-level AxialLIF procedures was 1.08% (unpublished data).

Known complications of spinal fusion surgery include bony nonunion and instrumentation failure and require revision surgery in 6%–36% of cases.9 Revision surgeries tend to be associated with a poorer functional outcome than initial surgeries, and they also have a higher complication rate.2,10 A recent study reported that ALIF lumbar spine fusions may be revised using either anterior or combined anterior-posterior procedures.15 However, while the authors found that revision surgery was generally performed safely following ALIF procedures, they noted a high rate of early complications (44%). Likewise, revision of TLIFs has been described using posterior,3 anterior, and combined approaches.16 Given its recent introduction, there is a lack of published literature on issues relating to revision strategies of failed AxialLIF instrumentation. Additionally, given the unique access corridor, there is a need for a detailed technical description of removal and revision of the AxialLIF constructs.
In this report, we present the surgical technique for percutaneous removal of the AxiaLIF device and present several revision strategies for revision AxiaLIF surgery.

Methods

Patient Population

Our institutional database was searched to retrieve all patients who had undergone revision surgery involving AxiaLIF devices since 2006. The medical charts, radiological records, and operative reports of 5 patients were reviewed. All initial AxiaLIF surgeries were performed at our institution between January 2008 and November 2009. Basic epidemiological data such as age, sex, and indication for the initial AxiaLIF placement were recorded. Operative reports were reviewed for operative times, estimated blood loss, and type of instrumentation. The length of hospital stay and postoperative complications were recorded. This study was approved by the institutional review board, and written informed consent was obtained from all patients prior to inclusion in the current study.

Surgical Procedure

Initial AxiaLIF procedures were performed according to standard protocol. Silicate-substituted calcium phosphate (Actifuse, Baxter) was used as bone graft. No BMP was used during the index AxiaLIF insertion. Preoperative planning for AxiaLIF removal included pelvic MR imaging to identify possible space-occupying lesions (such as seromas and abscesses), to assess the width of the presacral space, and to look for obvious postoperative adhesions. A CT scan was also obtained to determine bone formation and overgrowth at the AxiaLIF screw head. Consistent with the implantation surgery, all patients were recommended to undergo a full mechanical bowel preparation prior the procedure.

Surgical Removal of the AxiaLIF Device

AxiaLIF removal was performed in 2 of 5 patients. Patient positioning for removal of the AxiaLIF device is identical to positioning for implantation. The original skin incision is reopened, and the pelvic floor muscles are perforated in a blunt fashion using a closed clamp, with care taken to enter the presacral space and develop a working corridor using digital dissection. Under fluoroscopic guidance, a blunt guide pin is advanced while maintaining contact with the presacral fascia covering the sacrum and is carefully advanced (Fig. 1A and B). With bone overgrowth, metal-to-metal contact may not be appreciated when the guide reaches the screw head of the AxiaLIF implant. Once the tip of the blunt guide is precisely centered on the screw head of the AxiaLIF device on anteroposterior and lateral imaging, a 1-level guidewire (3.2 mm in diameter) is impacted into the core of the AxiaLIF device using a mallet (Fig. 1C). After confirmation of the correct insertion of the guidewire, the blunt guide is withdrawn, leaving the guidewire in place. Following a series of blunt dilators, a beveled exchange cannula is brought in place as a working channel (Fig.
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1D and E) and is anchored to the sacrum by using a fixation wire (1.4 mm in diameter). The manufacturer offers 2 main tools for rod extraction: the AxiaLIF Extraction Tool and the Retrieval Expanding Hex Sub-Assembly. The extraction tool is designed to engage the mating threads; however, in our experience this was hampered by local bone ingrowth as well as by suboptimal alignment of the extraction tool and the AxiaLIF device. The expanding hex device is advanced using a mallet and is expanded once in place; in our experience, this tool allowed for secure and efficient removal. Primary attempts at extraction may be best undertaken using the extraction tool as subsequent utilization of the expanding device may deform the screw threading. Prior to closure of the wound, the working corridor and adjacent bowel segments were inspected using a 30°-angled endoscope for possible bowel lacerations.

Statistical Analysis

Continuous variables are shown as means and ranges. All analyses were performed using appropriate statistical software (SPSS version 19.0.0.1, IBM SPSS).

Results

Revisions of AxiaLIF constructs were performed in 5 patients with a mean age of 58.4 years (range 38–73 years). All patients had undergone lumbar spine surgery prior to the AxiaLIF procedure. Moreover, the transsacral rod was part of multisegment constructs in all 5 patients (Table 1). In general, failure of instrumentation presented with exacerbation of low-back pain and radiolucency surrounding the transsacral rod on CT imaging. Revision surgery was performed 15 months (range 6–36 months) after the initial AxiaLIF procedure. In 2 patients the AxiaLIF device was removed, which required an average of 106 minutes (92 and 120 minutes) to perform. Revision of the anterior and posterior instrumentation required on average 511 minutes (range 342–870 minutes) and was associated with 820 ml (range 500–1500 ml) of blood loss. In 2 patients, the AxiaLIF device was removed, and anterior column support was achieved by ALIF. Removal of the device was necessary in 1 patient because of excessive resorption of bone surrounding the axial rod. The anterior approach allowed for placement of a wide spacer extending beyond the bony defect created by the AxiaLIF device and thereby decreasing abnormal postoperative stress distribution between the cage and vertebral endplate. In the other patient, the AxiaLIF device was removed in the setting of chronic hardware infections. In 3 patients, the arthrodesis was revised with the AxiaLIF device left in place. In 2 patients additional stabilization of the anterior column was achieved by bilateral PLIF surgery using expandable PEEK spacers. In the third patient the fusion construct was reinforced by revision of the posterolateral instrumentation. Intervertebral cages were filled with silicate-substituted calcium phosphate (Actifuse) supplemented with BMP. Patients tolerated revision surgeries well and left the hospital after an average of 8 days (range 5–14 days). One patient developed a wound dehiscence that required surgical washout and revision.

Case Reports

Case 1

This 38-year-old woman with a history of an L5–S1 discectomy presented with severe chronic low-back pain that was unresponsive to conservative treatment (Fig. 2A). Initial surgery with placement of an L5–S1 AxiaLIF and an L4–5 TLIF supplemented with unilateral pedicle screws was undertaken (Fig. 2B). The patient experienced partial relief of her low-back pain immediately following the procedure. Approximately 6 months after the procedure, the patient was the victim of a car accident and suffered from severe left lower-extremity pain. Imaging revealed loss of L5–S1 intervertebral disc height and S-1 superior endplate fracture (Fig. 2C and D). The patient underwent revision surgery with bilateral L5–S1 PLIF with placement of PEEK spacers filled with BMP and Actifuse. The posterolateral pedicle-rod constructs were revised and extended to the iliac crests using 3D navigation (Fig. 2E and F). The patient is now 3 years out from her revision surgery and experiences residual back pain. The construct has remained stable.

Case 2

This 66-year-old woman with a history of spine fusion

<p>| TABLE 1: Characteristics in 5 patients undergoing revision of AxiaLIF* |
|--------------------------|------------------|------------------|--------------------------|</p>
<table>
<thead>
<tr>
<th>Age (yrs), Sex</th>
<th>Initial Pathology</th>
<th>AxiaLIF Level</th>
<th>Total Fusion</th>
<th>Revision Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>38, F</td>
<td>DDD</td>
<td>L5–S1</td>
<td>L4–S1</td>
<td>no</td>
</tr>
<tr>
<td>66, F</td>
<td>adjacent-level disease</td>
<td>L4–S1</td>
<td>T5–S1</td>
<td>yes</td>
</tr>
<tr>
<td>67, F</td>
<td>pseudarthrosis</td>
<td>L4–S1</td>
<td>L2–S2</td>
<td>yes</td>
</tr>
<tr>
<td>48, M</td>
<td>postamnionectomy syndrome</td>
<td>L4–S1</td>
<td>L3–S1</td>
<td>no</td>
</tr>
<tr>
<td>73, M</td>
<td>pseudarthrosis</td>
<td>L5–S1</td>
<td>L2–S1</td>
<td>no</td>
</tr>
</tbody>
</table>

* All patients underwent AxiaLIF procedures after previous spine surgery. Abbreviation: DDD = degenerative disc disease.
for thoracolumbar scoliosis (T5–L4 with Harrington rods) presented with low-back pain and bilateral hip and thigh pain. A CT myelogram revealed spinal stenosis at L4–5 (Fig. 3A). The patient underwent lumbar decompression and a 2-level AxiaLIF procedure combined with bilateral posterolateral pedicle screw-rod constructs (Fig. 3B). The patient did well, but 2 years after the procedure exacerbation of her low-back pain prompted an imaging study, revealing radiolucency surrounding the AxiaLIF device in the vertebral body of L-4. The symptoms of low-back pain deteriorated over 12 months, and CT imaging revealed increased radiolucency associated with the AxiaLIF as well as loosening of the L-5 and S-1 pedicle screws (Fig. 3C and D). Because of concerns regarding the degree of bone loss surrounding the AxiaLIF, the implant was removed to allow placement of ALIF cages with a large footprint. The interbody cages were filled with Actifuse supplemented with BMP. Revision of the posterolateral construct and extension to the iliac crest was performed (Fig. 3E and F). The patient had an unremarkable postoperative course and is currently doing well.

**Fig. 2.** Case 1. A: Sagittal STIR MR image of the lumbar spine revealing degenerative endplate changes (arrowheads). B: Instrumentation of L5–S1 using AxiaLIF and of L4–5 by TLIF. C and D: After a car accident, the L5–S1 intervertebral space is collapsed and the superior endplate of S-1 is fractured. Arrowhead indicates radiolucency surrounding the rod in the vertebral body of S-1. E and F: Revision of the L5–S1 fusion with bilateral PLIFs (arrows) results in body fusion.

**Fig. 3.** Case 2. A: Sagittal CT myelogram revealing L4–5 spinal stenosis (arrowhead). B: A 2-level AxiaLIF device on immediate postoperative imaging. C and D: Radiolucency surrounding the transaxial rod (arrowheads). E and F: Removal of the AxiaLIF device and L4–5 and L5–S1 ALIF. The posterolateral screw-rod construct is extended to the iliac crest. The asterisk indicates the cavity of the transsacral rod.
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Case 3

This 67-year-old woman had a history of multiple lumbar spine surgeries complicated by chronic infections and hardware failures. She underwent removal of her hardware (L2–S1) and received an AxiaLIF implant for instrumentation of L4–5 and L5–S1 combined with an L2–S2 pedicle screw-rod construct. Intraoperative cultures grew *Pseudomonas*, and the patient received intravenous antibiotics followed by permanent oral suppression therapy. After 14 months the patient returned with complaints of low-back pain, and a CT scan revealed radiolucency surrounding the left S-2 pedicle screw. The posterolateral pedicle screw-rod construct was revised and extended to the iliac bone using iliac screws. Intraoperative cultures were positive for multidrug-resistant *Klebsiella*, and the antibiotic suppression therapy was adjusted. Nine months later there was failure of both pedicle screw rods at the level of L5–S1, and radiolucency surrounding the axial rod was noted. All implants including the AxiaLIF device were removed, and new posterolateral and anterior instrumentation (ALIF) was implanted using Actifuse graft substitute. The patient tolerated the procedure well and is currently undergoing physical rehabilitation.

Case 4

This 48-year-old man with a previous history of a lumbar laminectomy that led to degenerative changes suffered from low-back pain and left lower-extremity pain. He underwent a 2-level AxiaLIF procedure and posterolateral L3–S1 instrumentation; at L3–4 dynamic instrumentation was chosen without interbody fusion. Initially the patient did well, but 1 year later he experienced low-back pain and tenderness to palpation. A CT scan was obtained and demonstrated radiolucency surrounding the AxiaLIF proximally in the vertebral body of L-4 and pedicle screw at L-3 and S-1. Sixteen months after the initial procedure, the patient underwent surgical revision of the posterolateral pedicle screw-rod construct, and an L3–4 PLIF with Actifuse graft combined with BMP was performed. The patient tolerated the surgery well and is doing well 4 months after the procedure.

Case 5

This 73-year-old man with a history of L3–5 laminectomy and L3–S1 pedicle screw-rod instrumented fusion at another institution presented with adjacent-segment degeneration proximally at L2–3 and nonunion at L5–S1 (Fig. 4A). A transpsoas approach was performed at L2–3 supplemented with a lateral plate, and an AxiaLIF procedure was undertaken at L5–S1 (Fig. 4B). Continued back pain and worsening leg pain associated with radiolucency around the AxiaLIF device led to revision surgery after 8 months (Fig. 4C and D). At this time a posterior approach was undertaken with further clearance of the intervertebral disc space and insertion of bilateral expandable PEEK cages (Spinewave) using Actifuse graft positioned to either side of the retained AxiaLIF device (Fig. 4E and F). Posterior pedicle screw–based instrumentation was extended to the iliac crest. Twelve months later, CT imaging demonstrated a stable construct and early signs of a fusion mass, and the clinical symptoms are similar to the preoperative assessment.

Discussion

In the current study we report our experience with revision of failed AxiaLIF constructs. We provide a step-by-step description of the surgical technique for removal of the device and discuss revision strategies.

Removal of the AxiaLIF Device

Paracoccygeal transsacral fixation is a relatively novel technique. Only 1 case of successful removal of
an AxiaLIF device has been described in the literature. In that case an anterior sacral resection was performed to remove the implant and to stabilize the segment with an ALIF. We describe percutaneous retrieval of the device using the same presacral working corridor as for implantation. The presacral space is bordered anteriorly by visceral fascia that lines the posterior aspect of the mesorectum and posteriorly by parietal fascia that covers the sacrum. Since these planes of dense fascia are not usually violated during initial placement of the device, it is possible to redevelop the surgical corridor for device retrieval by blunt dissection. Moreover, the presacral space is usually devoid of vasculature except for the middle sacral artery, which provides only minor contributions to segmental arteries and may be entirely absent in 15% of cases. However, given the possible increased risk of visceral and vascular injury using the same presacral working corridor, we only recommend removal of the device if clinically necessary. In our 2 cases the removal was straightforward and safe with minimal blood loss and without injury to gastrointestinal structures. Removal was facilitated by 2 intraoperative maneuvers. First, after docking of the blunt guide at the head of the AxiaLIF device, insertion of a guidewire into the hollow core of the device is necessary to maintain position and alignment until the exchange cannula is anchored with a separate guidewire; and second, the AxiaLIF Retrieval Expanding Hex Sub-Assembly was by far the most useful instrument to remove the proximal and distal rod of the AxiaLIF device.

Strategies for Revising AxiaLIF Arthrodesis

Removal of the AxiaLIF device was deemed necessary in 2 patients. Excessive bone resorption around the AxiaLIF device and chronic infection were identified as indications for the removal in our series. In both of these situations we chose to stabilize the anterior column with an ALIF rather than a PLIF because the small footprint of PLIF cages combined with the large bony defect created by the AxiaLIF device would be associated with a high likelihood of graft subsidence. In contrast, the anterior approach allows for the implantation of spacers with a wide contact area decreasing stress concentrations between the cage and the vertebral body, potentially minimizing the risk of graft subsidence. In our series, posterior instrumentation was revised in all failed constructs. When nonunion was evident at the L5–S1 segment, the pedicle screw-rod construct was extended to the iliac crest and the anterior column instrumentation was enhanced by bilateral PLIF at L5–S1. In a case with L4–5 instability we opted for sole revision of the posterior construct. Importantly, we used BMP in combination with Actifuse in all of our revision cases.

How to Avoid Failure of AxiaLIF Constructs

There are lessons to be learned from our revision cases and failed surgeries. We have performed a total of 40 AxiaLIF procedures, and all our failures were observed in multilevel construct and in procedures in which AxiaLIF was part of a revision surgery. Therefore, AxiaLIF may not be an ideal operative approach for revision surgery. In addition, in the setting of a preexisting infection, the AxiaLIF approach may not allow an adequate removal of infected tissue and discectomy, which may be crucial to clear out an infection. Moreover, multisegment fusion constructs may also be more prone to failure. Based on our clinical experience, we believe that 2-level AxiaLIF constructs are biomechanically inferior to ALIF/pedicle screw constructs. Finally, in our initial surgeries bone extender was used for the fusion. Based on the failures we believe that the addition of BMP may facilitate fusion and reduce the rate of nonunions.

Conclusions

In the majority of cases, a posterior approach alone is adequate for revision of failed AxiaLIF constructs. If clinically indicated, the AxiaLIF device may be removed using percutaneous technique followed by ALIF for stabilization of the anterior column. Thus, AxiaLIF appears to be a valuable technique for single-level L5–S1 instrumentation. Safe and effective revision strategies exist.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Härtl, Hofstetter. Acquisition of data: Hofstetter, James. Analysis and interpretation of data: all authors. Drafting the article: Hofstetter, James. Critically revising the article: Härtl, James. Reviewed submitted version of manuscript: Härtl. Approved the final version of the manuscript on behalf of all authors: Härtl. Statistical analysis: Härtl, Hofstetter. Study supervision: Härtl.

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C. P. Hofstetter, A. R. James, and R. Härtl

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Address correspondence to: Roger Härtl, M.D., Weill Cornell Brain and Spine Center, Department of Neurological Surgery, Weill Cornell Medical College, New York–Presbyterian Hospital, 525 East 68th Street, Box 99, New York, New York 10065. email: roh9005@med.cornell.edu.