Salvage Strategy for Failed Spinal Fusion Surgery Using Lumbar Lateral Interbody Fusion technique: A Technical Note

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Abstract:

Introduction: Failed spinal fusion surgery sometimes requires salvage surgery when symptomatic, especially with post-surgical decrease in intervertebral disc height followed by foraminal stenosis. For such cases, an anterior approach to lumbar lateral interbody fusion (LLIF) provides safe, direct access to the pathological disc space and a potential improvement in the fusion rate. One LLIF approach, oblique lateral interbody fusion (OLIF), targets the oblique lateral window of the intervertebral discs to achieve successful lateral interbody fusion. The current technical note describes spinal revision surgery using the OLIF procedure.

Technical Note: The subjects were patients with leg pain and/or lower back pain derived from decreased intervertebral height followed by foraminal stenosis due to failed spinal fusion surgery. These patients underwent additional OLIF surgery and posterior fusion with no additional posterior direct decompression. Their outcomes were evaluated using the Japanese Orthopaedic Association (JOA) scores at baseline and final follow-up. Bony union was also evaluated using computed tomography images at final follow-up.

Six subjects were evaluated, with two representative cases described in detail. Four patients had an adjacent segment disorder, and the other two patients had pseudarthrosis due to postoperative infection. The mean JOA score improved from 5.7 ± 5.4 to 21.2 ± 2.3, with a mean recovery rate of 65.0%. All cases showed intervertebral bony union.

Conclusions: We introduced a salvage strategy for failed posterior spine fusion surgery cases using the OLIF procedure. Patients effectively achieved recovered intervertebral and foraminal height with no additional posterior direct decompression.

Keywords:

Failed spinal fusion surgery, Salvage surgery, Oblique lateral interbody fusion, minimally invasive surgery, cortical bone trajectory

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Introduction

Failed spinal fusion surgery sometimes requires salvage surgery when symptomatic[1)]. However, it is sometimes challenging to salvage these postoperative patients. In particular, salvaging patients who have been treated with posterior interbody fusion surgery via a second posterior approach can be tough and dangerous because of adhesion to neural elements, which can lead to considerable complications[2)]. An anterior approach can overcome this issue[3)] with direct access to the intervertebral disc (IVD) and a potential improvement in fusion rate. In terms of anterior surgery, a minimally invasive anterior lumbar interbody fusion surgery has been attracting attention: lumbar lateral interbody fusion

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(LLIF). LLIF has two major approaches, one of them is psoas-splitting LLIF (extreme lateral interbody fusion: XLIF), and the other is oblique lateral interbody fusion (OLIF), which approaches the oblique lateral window of the IVDs to achieve more rigid interbody fusion with large cages. The procedure has the ability to approach the retroperitoneal space with decreased invasion and fewer complications compared with posterior surgery[4,5], which can be of great use in salvage surgery. The current technical note will discuss the strategy for salvage revision surgery using the LLIF technique for cases with postoperative failures.

Methods

The current study is a retrospective case series with subjects who required salvage surgery after primary posterior/transforaminal interbody fusion (PLIF/TLIF) surgery for the pathology of decreased intervertebral and foraminal height, which were salvaged with anterior LLIF surgery. Outcomes were evaluated using the Japanese Orthopaedic Association (JOA) scores at baseline and final follow-up. In assessing the improved JOA score, recovery rates were also evaluated as follows: (postoperative score-baseline score)/(29×[full score]-baseline score) × 100 (%)[6]. Bony union, which was evaluated by three separate spine surgeons, was diagnosed when bridging bone between the fused level in the LLIF cage was confirmed via computed tomography (CT) scan at final follow-up.

Oblique Lateral Interbody Fusion and Posterior Fusion

In the current article, we mainly applied the OLIF technique for salvage surgery. OLIF surgery was performed based on the standard procedure[7,8]. Briefly, patients were put in the lateral decubitus position on their right side, and the target IVD was identified under fluoroscopic guidance. A 4-cm skin incision was made 6 to 10 cm anterior to the midportion of the disc. The surgeons approached the retroperitoneal space by blunt dissection and mobilizing the peritoneum anteriorly to expose the oblique lateral just in front of the psoas muscle (Fig. 1A), which was followed by discectomy and cage insertion (Clydesdale Spinal System; Medtronic Sofamor Danek, Memphis, TN). After anterior fusion, patients were placed in the prone position to undergo posterior fusion using percutaneous pedicle screws or cortical bone trajectory (CBT)[9] with no additional direct decompression.

Results

Table 1 lists the six subjects evaluated in this study. All patients had undergone posterior fusion surgery for a primary diagnosis of spondylolisthesis. Four of the six patients developed adjacent segment disorder after fusion, and the other 2 patients developed pseudarthrosis due to infection (case 1) or instability (case 5). The mean JOA score improved from 5.7 ± 5.4 to 21.2 ± 2.3, with a mean 65.0% recovery rate. Iliac and/or local bone was used as autograft to fill the intervertebral cage in all cases.

Case Presentations

Below we present two representative cases (Cases 1 and 2)

Case 1

A 58-year-old woman had undergone L4-5 TLIF using two posterior intervertebral cages under diagnosis of L4-5 lumbar spinal stenosis (Fig. 1A-C). Two years after surgery, she complained of robust spontaneous lower back pain followed by fever and was diagnosed as lumbar spinal infection with pseudarthrosis with unstable translation of the L4 vertebrae, endplate destruction, and subsidence of the cages with maintained apophyseal ring (Fig. 1D, E). The extreme L4-5 foraminal stenosis (Fig. 1F) resulted in severe L4 radiculopathy and gait disturbance due to pain as well as quadriceps muscle weakness. The radicular pain and hypesthesia noted for the lateral side of the lower leg also indicated involvement of L5 radiculopathy. Therefore, salvage surgery was performed as follows. After the posterior rod removal and screw replacement, surgeons approached the oblique lateral aspect of the concerned L4-5 IVD via small skin incision on the decubitus position, and then removed the failed posterior cage through the portal on the IVD without psoas splitting, followed by LLIF cage insertion (Fig. 2 A). Intraoperative bleeding was measured at 140 mL in a total of 4 hours and 57 min.

Fig. 2(B-D) shows the radiological studies 18 months after salvage surgery. The fused segment is stabilized with massive bridging and intervertebral bony fusion. Foraminal height had an acceptable recovery, compared with the preoperative evaluation (Fig. 2D vs. Fig. 1F). The patient's chief complaint of robust leg/back pain and muscle weakness fully resolved, allowing her to return to work.

Case 2

A 59-year-old woman who had undergone L3-4 anterior interbody fusion surgery 12 years prior to her consultation (Fig. 3A-D) visited our clinic complaining of robust left leg pain, which was refractory to analgesic agents including opioids. She showed L4 radiculopathy with neurological intermittent claudication at less than 50 meters. Radiologically, adjacent segment disorder at L4-5 with extremely decreased disc height with foraminal stenosis was observed (Fig. 4A-D). Considering the pathology of L4 radiculopathy, recovering L4-5 foraminal height was mandatory for this patient. PLIF/TLIF was considered for salvage surgery but was inappropriate for two reasons. First, one of her major comorbidities was severe renal failure from chronic glomerulonephritis, for which she had been receiving triweekly hemodialysis treatment for 20 years. Her water balance had to be strictly controlled and any intra- or postoperative massive bleeding was allowed. Second, the existing anterior implants (anterior screws and plates) were difficult to remove because of adhe-

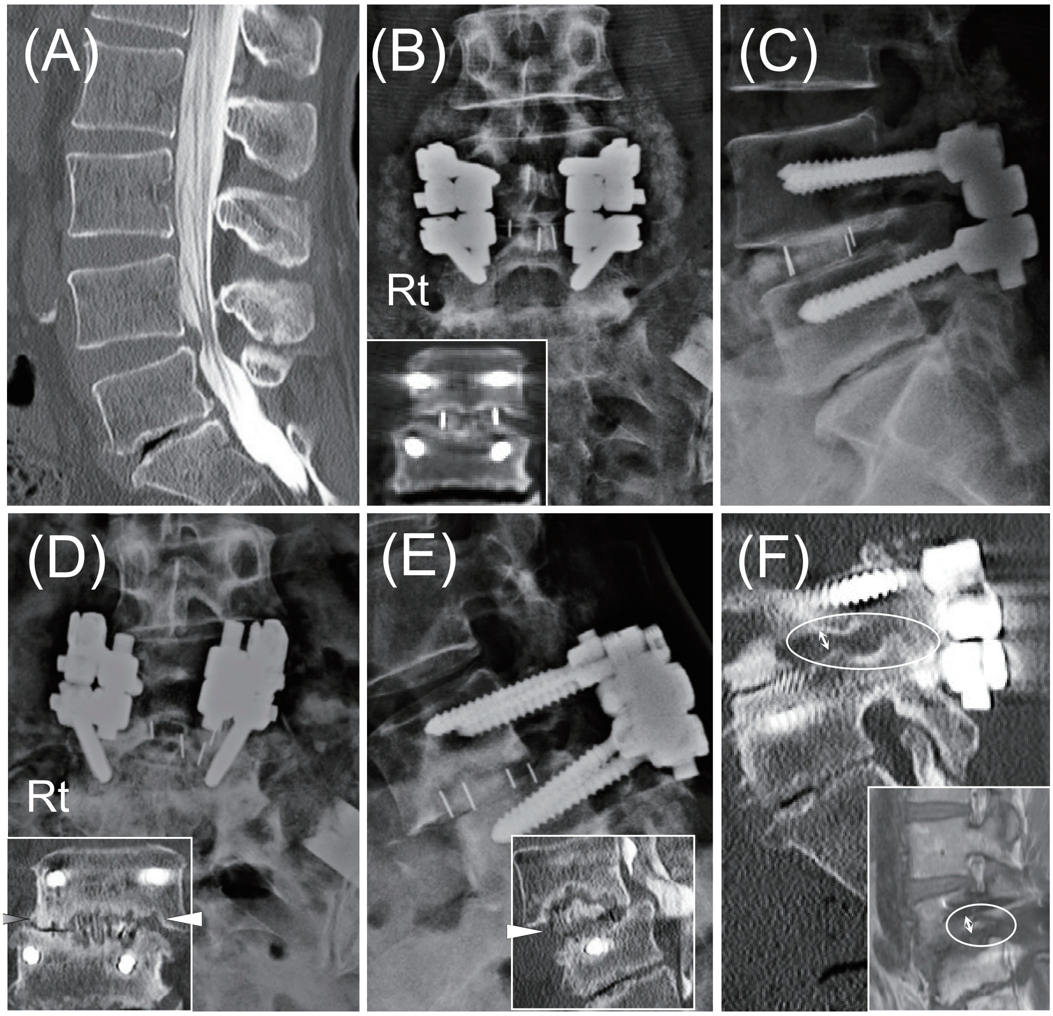

Figure 1. Primary surgery for case 1. A-C, The patient had undergone L4-5 posterior lumbar interbody fusion (PLIF) using two posterior carbon intervertebral cages upon diagnosis of L4-5 lumbar spinal stenosis. D-F, Two years after the primary surgery, the fused segment showed infection followed by pseudarthrosis with unstable translation of L4 vertebrae, endplate destruction, and subsidence of the cages (*arrowhead*), which extremely narrowed the L4-5 foramen (F: *circled*). Severe L4 radiculopathy and gait disturbance resulted.

Table 1. Patients Demographics*.

	age/ sex	Primary Op.	Onset (years)	Failure Pathology	Salvage Operation	JOA score (max: 29)		Bony union
						Baseline	Postoperative (Recovery rate (%)†)	
1	58F	L4-5 TLIF	5.4	L4-5 PA (post-infectious)	L4-5 OLIF+PS	5	22 (70.8)	+
2	59F	L3-4 ALIF	8	L4-5 ASD	L4-5 OLIF+pCBT	2	24 (81.5)	+
3	61F	L4-5 ALIF+PLF	4.8	L5-S1 ASD w/paraplegia	L5-S1OLIF+L2-iliac PLF	-3	18 (65.6)	+
4	63F	L2-iliac PLF	5.5	L1-2 ASD	L1-2OLIF+ Additional T4-L1 PLF	11	19 (44.4)	+
5	72M	L5-S1 TLIF	3.2	L5-S1 PA	L5-S1 tpALIF+PS	9	23 (70.0)	+
6	76F	L4-5 PLF	7.2	L3-4 ASD	L3-4 OLIF+PS	10	21 (57.9)	+

*All patients were primarily diagnosed as spondylolisthesis

†Recovery rate (%): = [Postoperative score - Baseline score]/[29×(full score) - Baseline score]×100 (%)

Abbreviations. JOA score, Japanese Orthopaedic Association Score (higher is better); ALIF, anterior lumbar interbody fusion; PA, pseudoarthrosis; ASD, adjacent segment disorder; OLIF, Oblique lateral interbody fusion; pCBT: percutaneous cortical bone trajectory fixation; TLIF, transforaminal lumbar interbody fusion; PS, pedicle screw fixation; FS, foraminal stenosis; PLF, posterolateral fusion; tpALIF, transperitoneal ALIF.

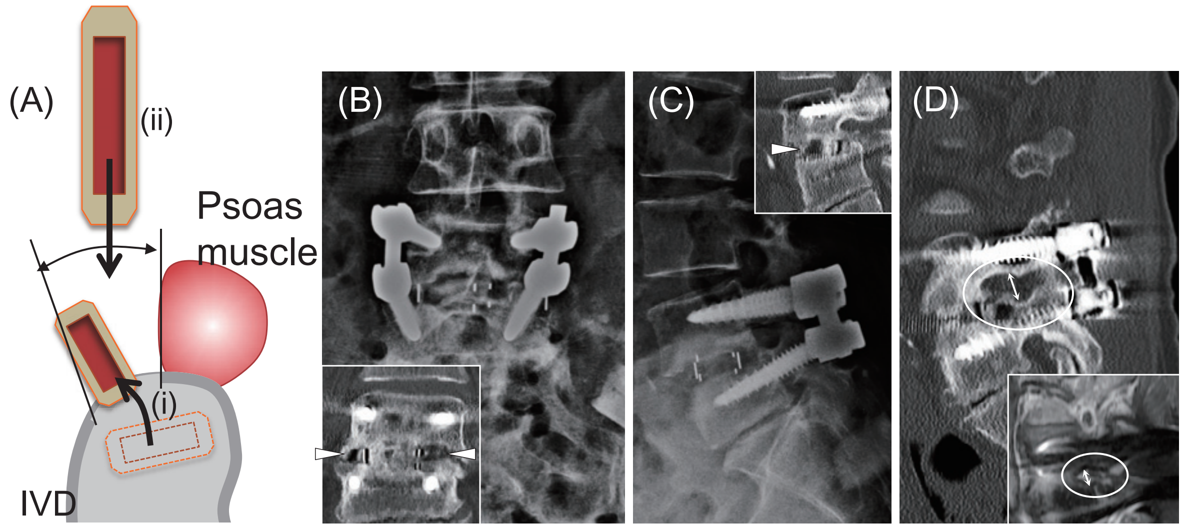

Figure 2. Strategy and radiological evaluation post-salvage surgery. A, Salvage strategy for case 1. Note that the psoas muscle is depicted as retracted posteriorly without any muscle splitting, which is achieved by using a specially prepared OLIF retractor. B-D, Radiological studies 18 months after salvage surgery. B-C, The fused segment is stabilized and massive bridging intervertebral bony fusion is observed (*arrowhead*). Foraminal height is recovered compared with the preoperative images (D, *circled*).

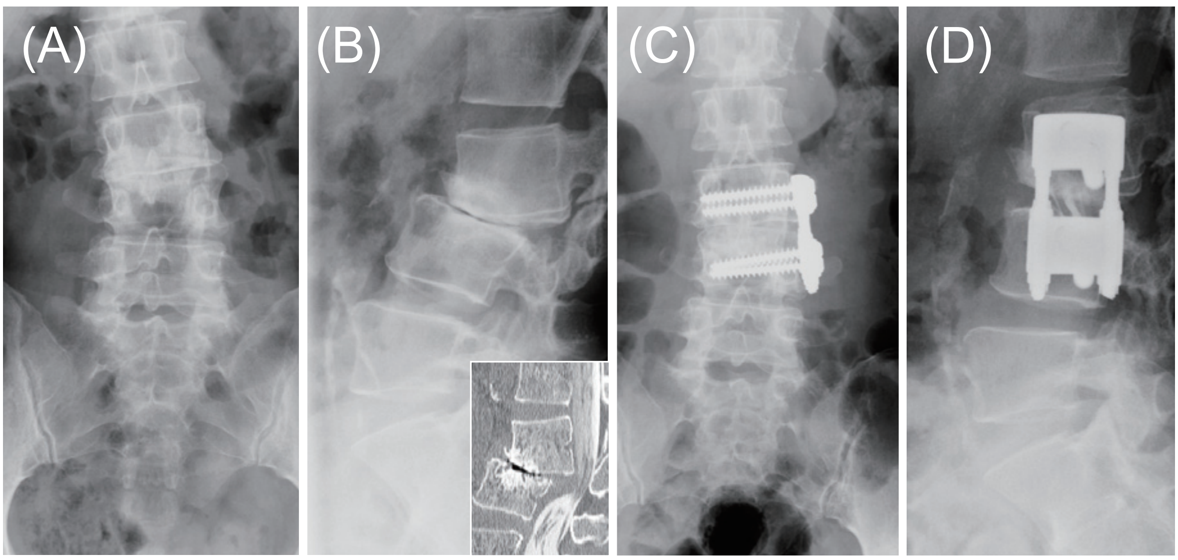

Figure 3. Primary surgery for case 2. A-B, The patient had primarily shown retrograde L3 spondylolisthesis and underwent L3-4 anterior interbody fusion (C-D). Note the intervertebral disc space of L4-5 is high enough to be intact.

sion, and the trajectory of the anterior screws directly interfered with the planned pedicle screw trajectory (Fig. 4D). Considering these limitations requiring less invasiveness, we employed OLIF surgery to achieve minimal invasiveness and effective intervertebral height recovery, which was achievable using an LIF cage installed on the apophyseal ring. Furthermore, previously reported percutaneous CBT screw insertion allowed us to control the direction of the screw under fluorescent guidance[9]. Fig. 4(E-F) shows the plain radiography and CT images 1 year after salvage surgery. Rigid interbody fusion as a bony massive bridge within the intervertebral space and major recovery of L4-5 foraminal height were achieved (Fig. 4G). The sagittal plane of the CT image shows that the direction of the CBT screw did not interfere with the existing screw (Fig. 4H).

Intraoperative bleeding was minimal (<10 mL) with absolute operative time of 2 hours and 33 min. The patient's robust leg pain disappeared, and there was no effect on her hemodialysis regimen.

Discussion

The current study discusses a salvage strategy for failed posterior fusion surgery, in particular, using the LLIF tech-

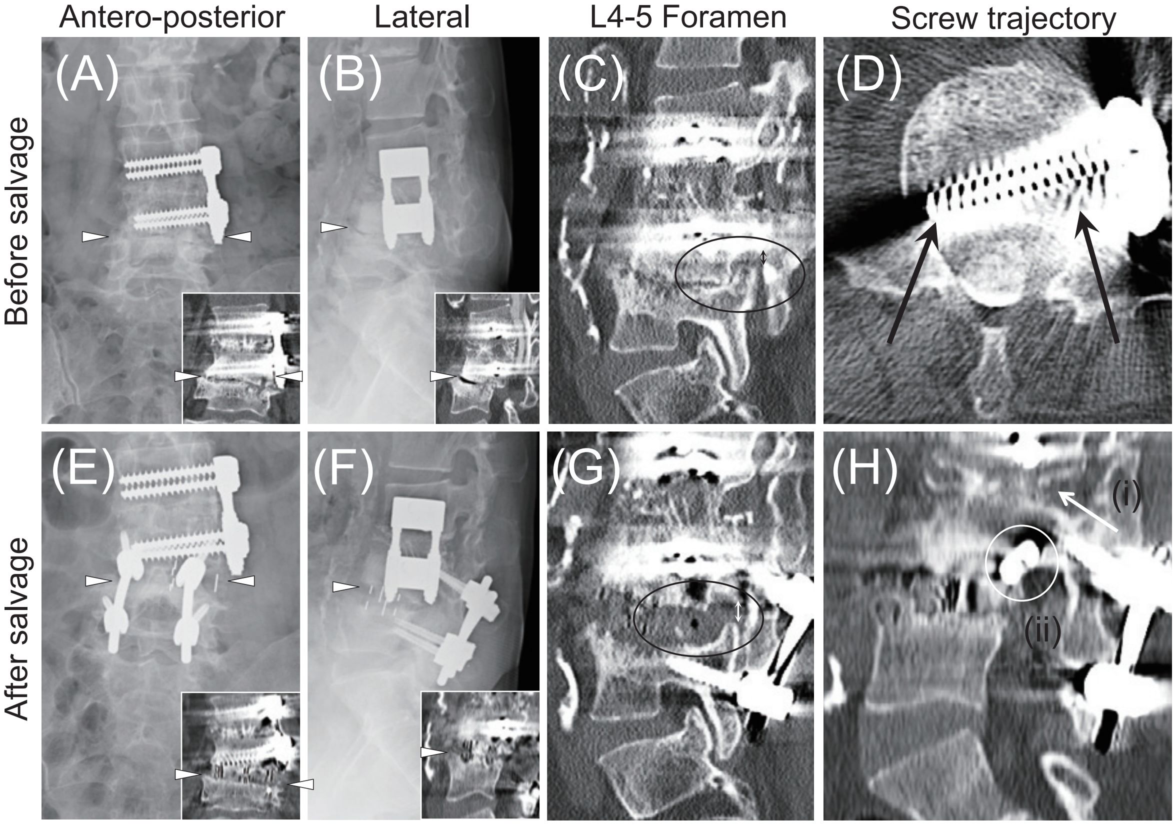

Figure 4. Radiological studies pre- and post-salvage surgery. Ten years after anterior lumbar interbody fusion (ALIF) surgery, the patient complained of robust leg pain in her L4 dermatome area. A-D, Preoperative radiological examination shows caudal adjacent segment disorder with extremely decreased L4-5 intervertebral space (A-B: *arrowhead*) followed by severely decreased L4-5 foraminal height (C: *circled*, *arrow*). D, Axial plane of the ALIF screw trajectory shows direct interference of the ALIF screw for possible pedicle screw (*arrows*). Lower panels (E-H) show the radiological evaluation 1 year after salvage surgery. E-F, Rigid interbody fusion is confirmed as bony massive bridge within the intervertebral space (*arrowhead*) and (G) major recovery of L4-5 foraminal height has been achieved (*circled, arrow*). H (representative image), The sagittal plane of the computed tomographic image shows the direction of the CBT screw (i, *arrow*) does not interfere with the existing ALIF screw (ii, *circle*: describes perpendicular cross-section of the screw).

nique to effectively recover IVD height and efficient bony union for rigid stabilization.

Advantages of the LLIF Procedure in Salvage Surgery for Posterior Surgery

Posterior revision surgery tends to require extensive intracanal manipulation with possible dural tear, nerve injury, and symptomatic neurologic disorders[10]. An anterior approach for salvage surgery is useful in that it does little harm to intracanal neural tissues by achieving indirect decompression followed by spontaneous recovery of intervertebral and foraminal height[7]. LLIF is suitable for this purpose, as it achieves minimally invasive anterior interbody fusion. Anterior salvaging is also reasonable in that it avoids additional muscle damage and neurologic risks inherent to the posterior approach, with much less blood loss achieved by blunt dissection.[11]

The Advantages of LLIF Intervertebral Cages

The most commonly encountered reasons for failed interbody fusion derive from undersized constructs, single midline constructs, lateral cage placement with nerve root irritation, an anteriorly/posteriorly prominent cage, and pseudarthrosis[12]. LLIF overcomes these issues by inserting a much larger cage in the perpendicular direction to the traditional posterior cage, which greatly reduces the possibility of anterior/posterior prominence and irritation of the spinal nerve and results in a low rate of pseudarthrosis with robust circumference fusion, bridging the bilateral edge of the apophyseal ring (Fig. 5). The wide contact area of the cage via a wide portal window is extremely effective in revision fusion surgery[12]. This point is extremely important because posterior removal of failed cages from sometimes results in endplate fracture or irregular endplate surface due to excess debridement. In particular, the salvage surgery for case 1 avoided possible additional pseudarthrosis and achieved a quality-of-life sufficient for the patient to return to work. If the pathology is derived from spinal sagittal alignment with decreased lumbar lordosis, anteriorly installed cages provide lordosis[13].

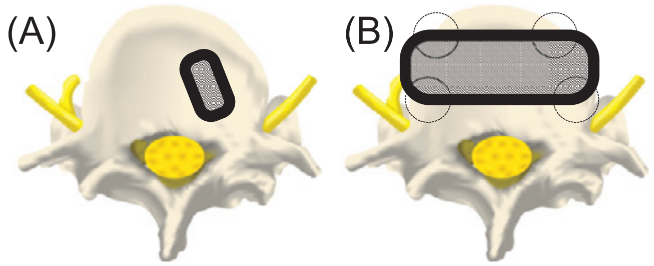

Figure 5. A scheme for approximate size difference between (A) the posterior intervertebral cage and (B) the LIF cage.
The LLIF cage is an effective intervertebral cage in that it has a wide opening (*shaded area*) to contact more endplate area and has at most eight contact points with the conterminous vertebral edges (*dotted circles*) that achieve more stability than posterior cages within the endplate area.

The Indication for Salvage Revision Surgery using the LLIF technique

Adjacent segment stenosis and spondylosis can be treated with various surgical techniques, including posterior, anterior, and direct/anterolateral approaches. Among them, LLIF has been suggested as one of the viable alternatives for these pathologies, providing reduced blood loss and complications, as well as high fusion rates[14,15]. Standard posterior revision surgery would involve a laminectomy with potential concomitant fusion and extension of instrumentation, which can include some major complications, including a higher rate of durotomy followed by cerebrospinal fluid leakage and extensive injury of posterior spinal elements, which may lead to massive bleeding and disruption of the rostral facet joint capsules[15-17]. The LLIF procedure can prevent these complications via an anterior approach by achieving indirect neural decompression through ligamentotaxis. The LLIF approach can be also applied to pyogenic spondylitis patients, although the intervertebral installation of an artificial LLIF cage should be considered. Furthermore, LLIF may not be recommended for the cases with a destroyed/fragile apophyseal ring, which is not rigid enough to support the LLIF cages. If the patient requires direct decompression of the spinal canal, especially the foramen, posterior revision surgery would be better.

In case 1, the possibility of pyogenic spondylitis was ruled out by preoperative radiologic examination, blood test, and physical findings including vital signs. On the other hand, subsidence was seen along with the posterior TLIF cage, which was perpendicular to the LLIF cage trajectory. Considering these preoperative radiological findings, intraoperative findings indicated consolidated rigid endplates. These are the reason why we decided to install the LLIF cage via the OLIF approach. If surgeons cannot dismiss the possibility of pyogenic spondylitis, an iliac autograft can be a viable option for revision surgery.

The current study has some limitations. First, the number of subjects was limited because the need for this type of salvage surgery is rare. Moreover, it is difficult to build a prospective study in this subject area. Second, clinically comparing the outcomes of D/XLIF, despite the fact that OLIF is theoretically a significant procedure, is needed for mini-open adequate surgical site.

In conclusion, we introduced a salvage strategy for failed spinal fusion cases, mainly posterior fusion, using LLIF technique. This procedure has the potential to effectively recover IVD height and induce efficient bony union, allowing pain relief and mitigating paralysis.

Conflicts of Interest: The authors declare no conflicts of interest or sources of funding.

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