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Technical note

Minimal invasive lumbar spine revision surgery at distance from the dura and postsurgical scar tissue: Extraforaminal Lumbar Interbody Fusion (ELIF)

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ABSTRACT

Lumbar spine revision surgery is considered as challenging and related to longer operation time and complications because of the loss of anatomical landmarks and the formation of postoperative epidural fibrosis. Minimal invasive lumbar spinal surgery techniques have been refined over the last 5 years but the reexposure of the dura, the formation of postsurgical scar tissue and related dural tears remain a source of complications.

For lumbar spinal revision surgery we advocate the minimal invasive Extraforaminal Lumbar Interbody Fusion (ELIF) technique. It employs a working corridor of 45° relative to the midline. This angle permits bypassing laterally the dural sac and postoperative epidural fibrosis so that dural tears do not occur.

ELIF is performed without an expandable tubular retractor system, it is atraumatic following the natural intermuscular cleavage plane between the multifidus muscle and the longissimus thoracis muscle pars lumborum. Postoperatively the muscles do not show signs atrophy or fatty degeneration. In case of discectomy alone there is no need for the removal of the facets, if intracanalar lesions are targeted the partial removal of the superior facet is sufficient.

ELIF represents an alternative to posterior lumbar interbody fusion (PLIF), conventional open transforaminal lumbar interbody fusion (TLIF), and minimal invasive (MIS) TLIF for lumbar spinal revision surgery.

1. Introduction

Posterior lumbar interbody fusion (PLIF), popularized by Cloward in the 1950s [2,3], and transforaminal lumbar interbody fusion (TLIF), described by Harms in the late1990s [4], are open interbody fusion techniques that expose widely the dura and the paraspinal muscles resulting in the formation of postoperative epidural fibrosis and iatrogenic soft tissue morbidity [6,7,19–21]. The minimal invasive (MIS) TLIF technique, introduced in 2005 by Schwender et al. [17], still exposes the dura but allows less soft tissue exposure. The extent of the resulting muscle trauma with this approach, however, is still under debate [1,11].

In case of lumbar spinal revision surgery the PLIF, conventional open TLIF and MIS TLIF techniques need to reexpose the dura that is covered with postsurgical scar tissue. Incidental dural tears remain a source of complications and the operation time of the revision surgery is generally prolonged [5,8,18].

For lumbar spinal revision surgery we propose the minimal invasive Extraforaminal Lumbar Interbody Fusion (ELIF) procedure [9,10,13] that bypasses laterally the postero-lateral dura and allows the insertion of two interbody cages.

2. Methods

We describe the ELIF technique with intraoperative photos exemplarily at level L4-L5:

A skin incision of 8 cm of length is placed at 10 cm lateral from the midline along the iliac crest (Fig. 1). It is of paramount importance to maintain a 45° angle relative to the midline throughout the operation (Fig. 2). The subcutaneous tissue and the thoracolumbar fascia (Fig. 3A) are uncovered and incised. The underlying erector spinae aponeurosis (ESA) (Fig. 3B) is then incised at a length of 5 cm (Fig. 3 C) to target the underlying intertransverse L4-L5 space. The natural fatty cleavage plane between the multifidus muscle and the longissimus thoracis muscle (Fig. 3D) is then bluntly dissected to expose the lateral part of the facet joint, the neuroforamen L4-L5 and the transverse processes L4-L5 (Fig. 3E).

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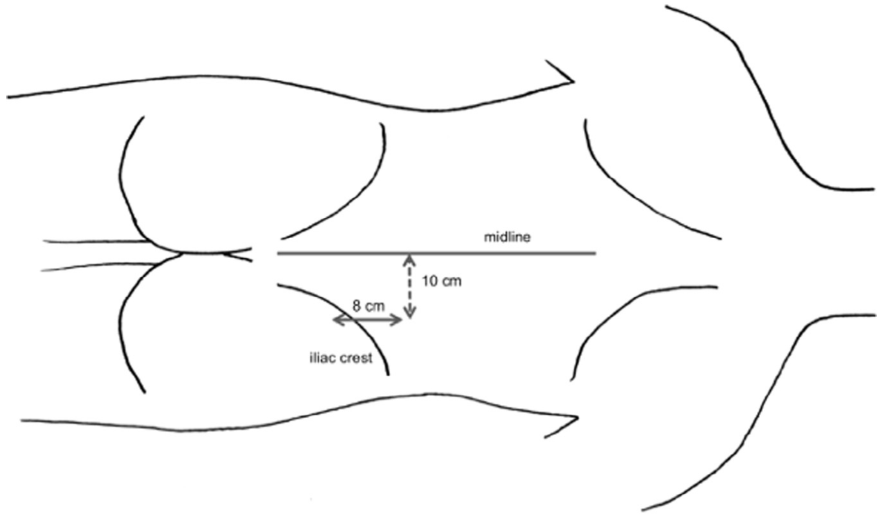

Fig. 1. Illustration showing the patient in prone position. The skin is incised at a length of 8 cm at 10 cm from and parallel to the midline passing over the iliac crest.

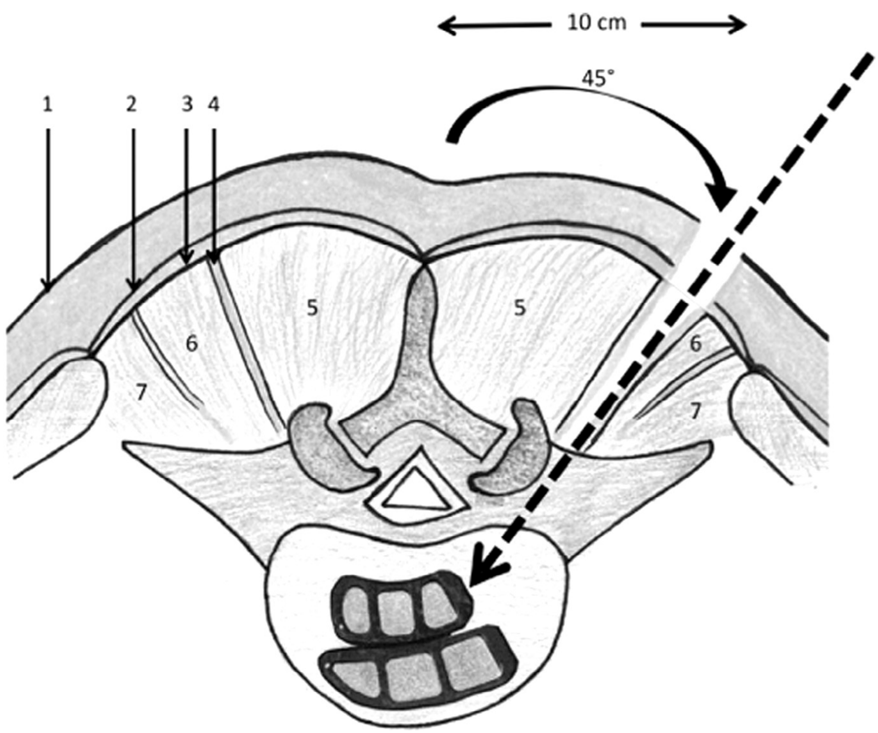

Fig. 2. Illustration depicting the extraforaminal lumbar interbody fusion (ELIF) procedure: The intervertebral disk is targeted laterally from the dural sac with a working channel angled at 45° relative to the midline (*dashed black arrow*) exploiting the cleavage plane (4) between the multifidus (5) and the longissimus thoracis muscle pars lumborum (6). Two C-shaped cages are inserted. 1: skin with subcutaneous tissue, 2: thoracolumbar fascia, 3: erector spinae aponeurosis (ESA), 7: ilicostalis muscle.

Unilateral pedicle screws are placed in the pedicles L4 and L5 guided by fluoroscopy or navigation and then extraforaminal discectomy is performed under distraction. Bone marrow can be harvested from the exposed iliac crest. For fusion we insert two special for this approach designed C-shaped carbon composite cages (Coligne AG, Zurich, Switzerland) filled with the harvested bone marrow (Figs. 2, 3F and G, 4). The first and bigger cage (length: 30 mm, width: 11.3 mm, height: 7, 9, 11 or 13 mm) is inserted close to the anterior longitudinal ligament. This cage is pushed to its definitive position by insertion of a second and smaller cage (length: 23 mm, width: 11.6 mm, height: 7, 9, 11or 13 mm). The pedical screws are connected with a carbon composite plate or titanium rod (Fig. 3H).

The extraforaminal approach makes also foraminal and intracanalar lesions accessible: Their treatment needs partial removal of the superior facet [15]. ·ELIF is also feasible at L5-S1 level [10]. Fig. 5 shows the radiological imaging of a patient operated with the ELIF technique at level L4-L5 as revision surgery.

3. Discussion

We reported the extraforaminal approach to the intervertebral disk in 1985 [15] and its application to lumbar interbody fusion in 2000 [13]. Recently we refined this technique and demonstrated its feasibility at level L5-S1 [10]. This technique meets the criteria

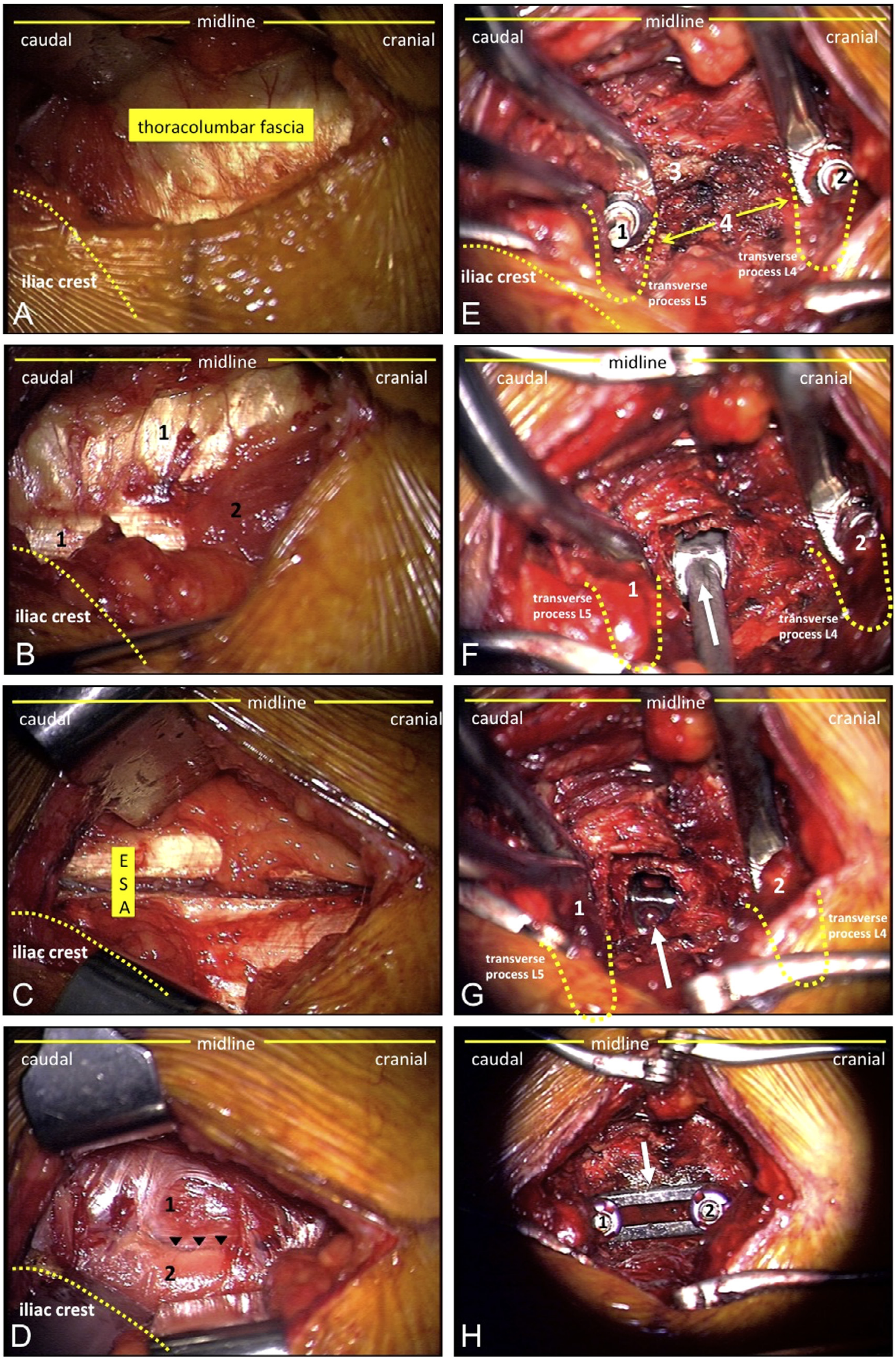

Fig. 3. Intraoperative photos of a right sided extraforaminal lumbar interbody fusion (ELIF) approach at level L4-L5. A: After incision of the skin and the subcutaneous tissue the thoracolumbar fascia is exposed. B: The erector spinae aponeurosis (ESA) is exposed (1). 2: iliocostalis muscle. C: The erector spinae aponeurosis (ESA) is incised at a length of 5 cm in cranio-caudal direction. D: The fatty cleavage plane (*black arrowheads*) between the multifidus (1) and the longissimus thoracis muscle pars lumborum (2) is bluntly dissected. E: Unilateral pedicle screws (1, 2) are inserted in L4 and L5. 3: facet joint, 4: intertransverse space. F: After discectomy L4-L5 insertion of the cage probe (*white arrow*). 1, 2: pedicle screws L4 and L5. G: The first C-shaped cage (*white arrow*) is inserted and will be pushed into its final position by the second one. 1, 2: pedicle screws L4 and L5. H: The L4 and L5 pedicle screws (1, 2) are linked with a carbon composite plate (*white arrow*).

Fig. 4. Lateral-oblique view of the two C-shaped cages illustrating the frame structure, the large surface and space to accommodate autologous bone.

of a minimal invasive procedure: It can be applied as a unilateral or bilateral approach to the levels L1 to S1 [10], it is atraumatic following the natural intermuscular cleavage plane between the multifidus muscle and the longissimus thoracis muscle pars lumborum. The paraspinal muscles show postoperatively no atrophy or signs of fatty degeneration [12]. The ELIF and the Wiltse [22] concept share the same intermuscular cleavage plane but differ fundamentally from the angle at which the intervertebral disk space is approached. While the Wiltse technique [22] exploits a sagittal or slightly angled working channel the ELIF procedure applies a working corridor angled 45° relative to the midline [9,10,13]. The Wiltse concept provides the removal of the facet joints to perform a transforaminal procedure and discectomy. Due to the 45° angle the ELIF technique targets the disk extraforaminally so that there is no need for the removal of the facets joints for discectomy. Foraminal and intracanalar lesions can be treated with ELIF as well what needs only partial resection of the superior facet. The vast lateral exposure of the intervertebral disk space with the ELIF technique allows the insertion of two for this approach designed C-shaped interbody cages [9,10,13]. The size and the frame construction of the cages (Fig. 4) offer a high

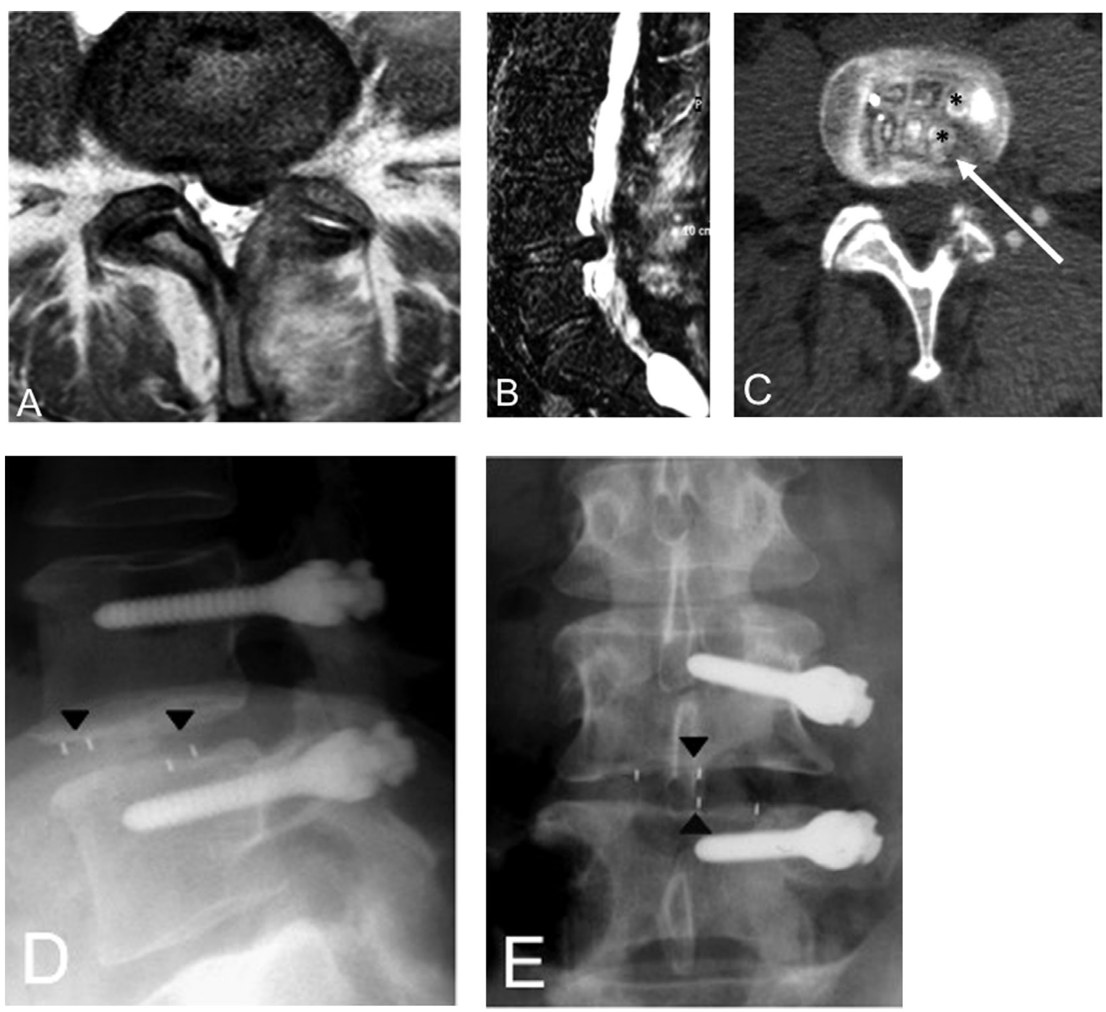

Fig. 5. Radiological imaging of a 44-year-old female patient who developed after an initial surgery with left sided approach a recurrent lumber disk herniation at level L4-L5. The patient had revision discectomy with unilateral left sided Extraforaminal Lumbar Interbody Fusion (ELIF). A and B: T2-weighted axial (A) and sagittal (B) magnetic resonance image performed after the primary surgery showing the recurrent disk herniation L4-L5 in median-paramedian position. C: Computed tomography scan 6 month after revision surgery with unilateral left sided ELIF approached from the left side. It shows the working corridor at 45° from the midline (*white flash*) bypassing the dura and the postsurgical scar tissue of the first surgery. Two C-shaped cages cover a big part of the vertebral endplate (*). D and E: Lateral (D) and anterior-posterior (E) radiographies at 6 months after left sided ELIF surgery showing the two cages and the L4 and L5 pedicle screws linked with a carbon composite plate. The cages and the pedicle screws are radiolucent and have radiopaque metallic markers (*black arrowheads*).

surface of contact to the vertebral endplates and accommodate a high volume of autologous bone to favor fusion.

The ELIF technique is suitable as primary surgery for the treatment of numerous degenerative pathologies like degenerative disk disease, lumbar disk herniation and foraminal stenosis with segmental instability, and isthmic spondylolisthesis according to Meyerding grade I and II [10,16].

As other posterior or postero-lateral approaches to the lumbar spine need to expose the dura and postsurgical epidural fibrosis we apply the ELIF technique also to lumbar revision surgery [10,14]. The advantage of ELIF is that it bypasses the dura and the postoperative epidural fibrosis laterally with no risk of dural tears in surgeries without spinal canal pathology, for example in post-discectomy disk disease. It bears a minimized risk of dural tear of 2% when pathologies within the spinal canal are approached with this surgery, for example recurrent lumbar disk herniation and post-discectomy disk disease with segmental instability [13]. The operation time for revision surgery is nearly equal to an ELIF procedure as a primary surgery (103 versus 106 min) [10,14].

The limits for unilateral ELIF surgery are bilateral pathologies like bilateral foraminal or canalar stenosis; these pathologies need a bilateral ELIF approach.

4. Conclusions

The ELIF concept is a minimal invasive and muscle sparing technique respecting an angle of 45° relative to the midline that is suitable for revision surgery at levels L1 to S1 for patients initially operated with another posterior or postero-lateral technique. Because its working channel is localized lateral to the dural sac it avoids the formation of postoperative epidural fibrosis. Depending on the underlying pathology to be treated this approach has no or a minimized risk of incidental dural tears. Operation time in primary and revision surgery with ELIF is nearly equal. ELIF represents an alternative to PLIF, conventional open TLIF, and MIS TLIF for lumbar spinal revision surgery.

Conflict of interest

None.

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Informed consent

Informed consent was obtained from all individual participants included in the study.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jocn.2017.10.003.

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