Extraforaminal Lumbar Interbody Fusion at the L5–S1 Level: Technical Considerations and Feasibility

Arthur Robert Kurzbuch[1] Denis Kaech[2] Pawel Baranowski[3] Alicja Baranowska[3] Didier Recoules-Arche[1]

[1] Neurochirurgie, Groupe Hospitalier du Havre, Le Havre, France
[2] Department of Neurosurgery, Kantonsspital Graubunden, Chur, GR, Switzerland
[3] Konstancin Mazowieckie Centrum - Rehabilitajci Stocer Sp. Zo.o, Konstancin-Jezornia, Poland

Address for correspondence Arthur Robert Kurzbuch, MD, Groupe Hospitalier du Havre – Neurochirurgie, BP 24, Le Havre 76083, France (e-mail: kurzbuch@web.de).

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Abstract

Background Extraforaminal lumbar interbody fusion (ELIF) surgery is a muscle-sparing approach that allows the treatment of various degenerative spinal diseases. It is technical challenging to perform the ELIF approach at the L5–S1 level because the sacral ala obstructs the view of the intervertebral disk space.

Methods We reported earlier on the ELIF technique in which the intervertebral disk is targeted at an angle of 45 degrees relative to the midline. In this article we describe the technical process we developed to overcome the anatomic relation between the sacral ala and the intervertebral disk space L5–S1 that hinders the ELIF approach at this level. We then report in a retrospective analysis on the short-term clinical and radiologic outcome of 100 consecutive patients with degenerative L5–S1 pathologies who underwent ELIF surgery.

Results The L5–S1 ELIF approach could be realized in all patients. The short-term clinical outcome was evaluated 5 months after surgery: 92% of the patients were satisfied with their postoperative result; 8% had a poor result. Overall, 17% of the patients presented light radicular or low back pain not influencing their daily activity, and 82% of the patients working before surgery returned to work 3 to 7 months after surgery. The radiologic outcome was documented by computed tomography at 5 months after surgery and showed fusion in 99% of the patients. Lumbar magnetic resonance imaging performed in 5 patients at 6 months after surgery revealed the integrity of the paraspinal muscles.

Conclusions ELIF surgery at the L5–S1 level is technically feasible for various degenerative spinal diseases. Analysis of the clinical and radiologic data in a consecutive retrospective cohort of patients who underwent this surgical procedure showed a good short-term clinical outcome and fusion rate.

Keywords
- lumbar interbody fusion
- extraforaminal approach
- ELIF
- L5–S1 level
- paraspinal muscles

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Introduction

Lumbar interbody fusion is a generally recognized treatment concept for a variety of degenerative spinal pathologies. Different surgical techniques have been introduced to access the lumbar spine from the posterior, anterior, and lateral directions. We reported an extraforaminal approach to the lumbar spine in 1985[1] and applied it to lumbar interbody fusion in 2000: extraforaminal lumbar interbody fusion (ELIF).[2] This technique is a posterolateral muscle-sparing approach that targets the intervertebral disk at an angle of 45 degrees relative to the midline.[3] ELIF surgery allows the treatment of various degenerative spinal diseases and lesions situated within the spinal canal: lumbar diskopathy with Modic type 1 alterations, herniated lumbar disks, post-diskectomy disk disease, recurrent lumbar disk herniation with post-diskectomy disk disease, isthmic spondylolisthesis grade 1 and 2 Meyerding, and unilateral foraminal stenosis.[4–6] The unilateral access to the intertransverse space allows extraforaminal diskectomy and the insertion of two C-shaped interbody cages (►**Fig. 1**). Respecting the mandatory angle of 45 degrees at the L5–S1 level is technically challenging because the sacral ala obstructs the view of the intervertebral disk space (►**Fig. 2a**).

We developed a technique that makes ELIF surgery at L5–S1 level feasible. We then evaluated the short-term clinical and radiologic outcome of a consecutive retrospective cohort of 100 patients with various degenerative L5–S1 pathologies who underwent ELIF surgery.

Materials and Methods

Surgical Technique

For unilateral ELIF surgery, a curvilinear skin incision ~ 8 cm in length is made at 10 cm lateral from the midline along the iliac crest to approach the disk level L5–S1. After dissection of the subcutaneous tissue and the thoracolumbar fascia, the erector spinae aponeurosis (ESA) becomes visible. The intertransverse space lies under the ESA and can be exposed at all lumbar levels inclusively at the L5–S1 segment by following the anatomic cleavage plane between the multifidus (MF) muscle and the longissimus thoracis (LT) muscle pars lumborum. The cleavage plane runs at the upper lumbar levels toward the midline and ends caudally on the posterior aspect of the sacrum. The ESA is first cut along the inner edge of the iliac crest and then straight upward ~ 5 cm in length. The MF muscle and the LT muscle are mobilized down to the L5–S1 facet joints. The fibers of the LT muscle are detached from the L5 transverse process, the posterior surface of the sacrum down to the posterior sacroiliac ligaments, and from the L5–S1 facet joints. From L1 to L5 the superior edge of the inferior transverse process runs parallel to the intervertebral space and serves as an anatomic landmark for access to the disk. At the L5–S1 level, however, the anatomic situation is different. The view to the intertransverse space and the intervertebral disk is obstructed medially by the superior articular process of S1 and laterally by the sacral ala and the iliac crest. Furthermore, the L5–S1 intervertebral disk space is directed caudally due to the sacral slope (►**Fig. 2a**).

To create a working corridor leading to the intervertebral disk space L5–S1 at the mandatory 45-degree angle, we remove a 2- to 3-cm portion of the medial part of the sacral ala along a transversal plane down to the posterior sacroiliac ligaments (►**Fig. 2b**). If there are lesions inside the spinal canal to be treated, the partial or complete removal of the tip of the superior articular facet of S1 provides access to the lateral aspect of the spinal canal. Pedicle screws are inserted in L5 and S1, and after distraction diskectomy is performed. Respecting an angle of 45 degrees relative to the midline, there is no risk for the L5 nerve root that transverses the disk space more laterally (►**Fig. 2b**). Two special C-shaped carbon composite cages (Coligne AG, Zurich, Switzerland) filled with bone marrow harvested from the posterior iliac crest (►**Fig. 1** and ►**Fig. 2c, d**) are then inserted: The first is 30 mm long and pushed forward to its final position by the second cage that is 23 mm long. After release of the distraction, the L5 and S1 pedicle screws are linked with a carbon composite plate or titanium rod.

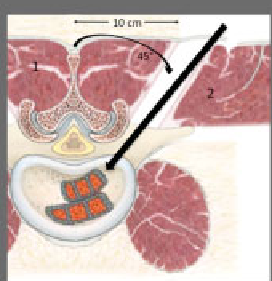

Fig. 1 Extraforaminal lumbar interbody fusion is a posterolateral approach to the intervertebral disk space with an angle of 45 degrees relative to the midline. The unilateral working corridor follows the cleavage plane between the multifidus (MF) muscle and the longissimus thoracis (LT) muscle pars lumborum. Two C-shaped cages filled with bone marrow harvested from the posterior iliac crest are inserted. 1, MF; 2, LT muscle pars lumborum.

Intraoperative Data

The operation time and intraoperative blood loss were recorded.

Postoperative Monitoring

Patients were mobilized 1 day after surgery without a brace. Light physical activity was recommended for 6 weeks. All patients were scheduled for a short-term clinical and radiologic follow-up examination.

Clinical Outcome

All patients had at least one clinical follow-up examination at 5 months after surgery. Back pain and leg pain were investigated with the visual analog scale (VAS). The patients were

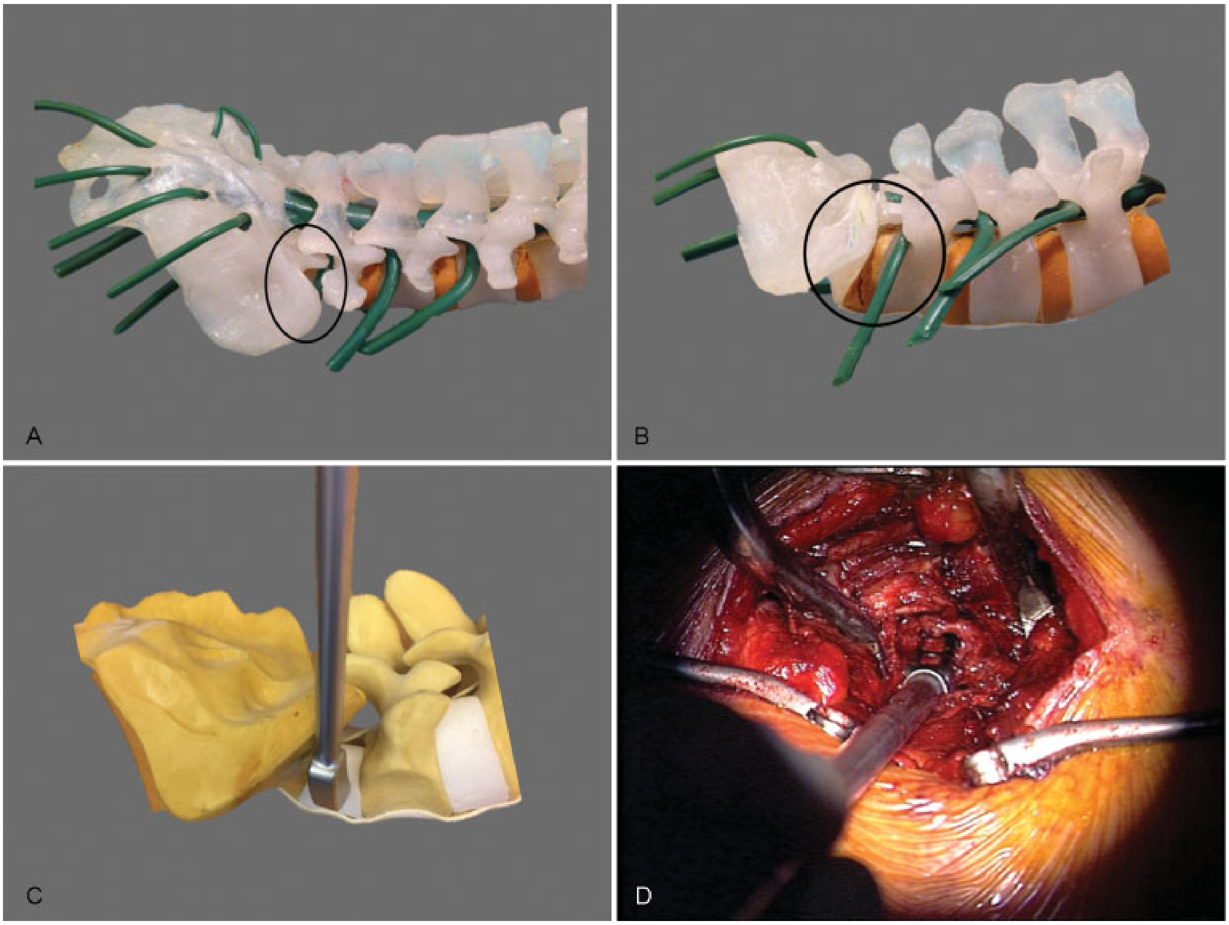

Fig. 2 (**a**) The medial portion of the sacral ala obstructs the access to the intervertebral disk space L5–S1 (solid black circle). (**b**) After partial removal of the medial portion of the sacral ala and the lateral part of the S1 facet, it becomes apparent that the L5 nerve root transverses the disk space laterally (solid black circle). (**c**) The removal of the medial portion of the sacral ala and 2 to 5 mm of the lateral part of the S1 facet uncover the intervertebral disk and also allows the surgeon to access lesions within the canal. The figure exemplifies the insertion of interbody cages at L5–S1. (**d**) Microscopic image of the cage insertion.

asked to describe retrospectively their preoperative pain and the pain at 5 months after surgery. We also asked them whether the pain at 5 months postoperatively influenced their daily activity. We evaluated patients' satisfaction with their postoperative result at the 5-month follow-up asking them whether they would undergo the operation again. All patients were interviewed at the 5-month follow-up and some at the 7-month follow-up regarding their work situation.

Radiologic Outcome

Fusion was assessed with a computed tomography (CT) protocol 5 months after surgery with axial, coronal, and oblique sagittal reconstruction slides at the same angle as the inserted cages. The same radiologist evaluated the CT scans of all patients. Fusion was confirmed when at least one osseous bridge was observed. The integrity of the paraspinal muscles was examined with lumbar magnetic resonance imaging (MRI) with gadolinium in five randomly selected patients at 6 months after surgery.

Results

From April 2010 to October 2013, we operated on 100 consecutive patients with various degenerative spinal diseases at the L5–S1 level with the ELIF technique (►**Table 1**). They were included in a retrospective analysis. The female-to-male ratio was 47:53, and the mean age was 47 years (range: 20–77 years).

Intraoperative Data

The average operation time was 103 ($\pm$18) minutes, the intraoperative blood loss was 110 ($\pm$25) mL.

Clinical Outcome

The average VAS back pain was preoperatively 8 and improved to 3 at 5 months postsurgery. The average VAS leg pain was 7 before the operation and 2 at the 5-month follow-up. A total of 17 patients (17%) had light residual low back pain or radicular pain that did not influence their daily activities.

Table 1 Indication for L5–S1 extraforaminal lumbar interbody fusion surgery

Degenerative spinal disease at the L5–S1 level	No. of patients
Lumbar diskopathy with Modic type 1 alterations	30
Lumbar herniated disks and concomitant segmental instability	14
Post-diskectomy disk disease	6
Recurrent lumbar disk herniation with post-diskectomy disk disease	18
Isthmic spondylolisthesis grade 1 and 2 Meyerding	14
Unilateral foraminal stenosis and concomitant segmental instability	18
Total	100

Overall, 92 patients (92%) were satisfied with their postoperative result and would agree to undergo the operation again.

Sixty-six patients worked before surgery. Fifty-four (82%) of 66 patients returned to work 3 to 7 months after surgery, 4 patients (6%) changed to a lighter activity, and 8 patients (12%) did not return to work.

Radiologic Outcome

Fusion was documented in 99 patients (99%) 5 months after surgery (►**Fig. 3**). In five patients (5%) an intraforaminal hematoma was visualized that was treated conservatively. In five randomly selected patients (5%), a lumbar MRI with gadolinium was performed 6 months after surgery. All of them revealed the integrity of the paraspinal muscles and the absence of atrophy or fatty degeneration (►**Fig. 4**).

Complications

A total of 15 patients (15%) complained of transient L5 radiculopathy that appeared in all cases at the end of the first week after surgery. The radiculopathy was completely regressive after oral treatment with corticosteroids by 1 month in 14 patients (14%). In one case (1%) the radiculopathy persisted $>$ 1 month. In 2 patients (2%) cages were misplaced and required revision. One patient (1%) presented a transient paresis of the L5 nerve root and recovered completely after 2 months.

Discussion

To perform lumbar interbody fusion, several surgical techniques have been developed to access the spine from the posterior, anterior, and lateral directions.[7] The unilateral ELIF and the Wiltse technique are paraspinal approaches to the lumbar spine that share the same intermuscular cleavage plane.[3–5,8] Both techniques differ from the angle at which the intervertebral disk is targeted. The Wiltse approach is directed sagittally or slightly angled to the midline to reach the facet joints that have to be removed to create a transforaminal access.[5] The ELIF approach, however, is angled 45 degrees relative to the midline.[3,4] The disk is accessed laterally from the facet joints that can be entirely spared from removal if no intracanalar lesions must be addressed. The same unilateral approach is also suitable for the treatment of intracanalar pathologies when the facets are partially resected.

At the L5–S1 level, the anatomic situation is different from the L1–L2 to L4–L5 levels. The access to the intertransverse space is obstructed by the lateral part of the superior articular process of S1 and the medial portion of the sacral ala. ELIF was therefore considered not to be suitable at the L5–S1 level.[9,10] We propose a technique that makes ELIF surgery at the L5–S1 level feasible. The removal of a 2- to

Fig. 3 Computed tomography scan 5 months after surgery with (**a**) sagittal and (**b**) coronal reconstruction showing the formation of bony bridges between the inferior end plate of L5 and the superior end plate of S1.

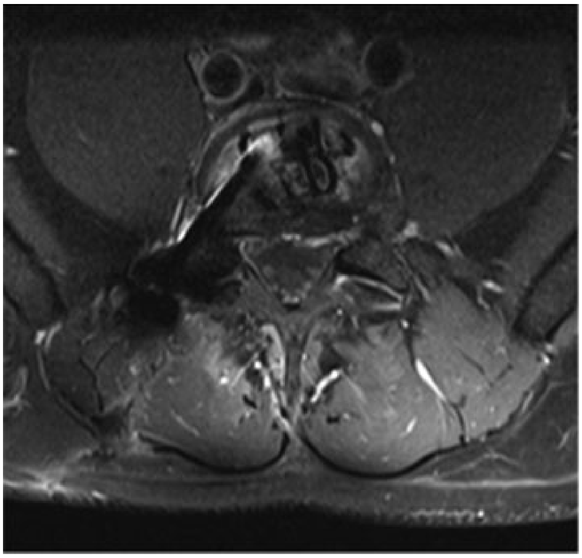

Fig. 4 T1-weighted axial magnetic resonance image with gadolinium performed 6 months after L5–S1 extraforaminal lumbar interbody fusion surgery from the right side. Note the integrity of the paraspinal muscles without signs of muscular atrophy or fatty degeneration and the absence of epidural contrast enhancement.

Fig. 5 Photo of the two inserted cages showing their large supporting surface and their capacity to house a high volume of autologous bone marrow.

3-cm portion of the medial part of the sacral ala opened the working corridor to uncover the intervertebral disk from the lateral aspect of the spinal canal and to insert interbody fusion grafts without creating instability. The partial or complete removal of the tip of the superior articular facet of S1 provided access to the lateral aspect of the spinal canal so lesions within the canal could also be treated.

In all 100 consecutively operated patients, the L5–S1 ELIF approach could be realized. With 92% of patients reporting satisfaction, 17% of residual symptoms not influencing daily activity, and 82% of patients returning to their former work, the clinical short-term outcome of the surgery is favorable. So are the complications with misplaced cages in 2% and transient paresis of L5 nerve root in 1%. The cause of the transient postoperative L5 radiculopathy arising at the end of the first week after surgery and responding to corticosteroids is unclear. An inflammatory genesis or postoperative intraforaminal hematoma may be causative.

The high rate of interbody fusion of 99% at 5 months after surgery could be related to the insertion of two cages covering an extensive part of the surface of the vertebral end plate. The first and bigger cage was 30 mm long and 11.3 mm wide; heights were available at 7, 9, 11, and 13 mm. It can be placed fairly anteriorly due to the 45-degree angle of the ELIF technique. The second and smaller cage was 23 mm long and 11.6 mm wide; its height was available at 7, 9, 11, and 13 mm. ►**Fig. 1** and ►**Fig. 5** illustrate the large supporting surface of both inserted cages that is advantageous in regard to subsidence. Another reason might be the construction of the two inserted cages that accommodates a high amount of autologous bone marrow (►**Fig. 5**). The relatively low mean age of the patients could be an additional factor.

The different techniques providing access to the lumbar spine risk iatrogenic lesions.[7] These depend on the anatomic structures encountered when the intervertebral disk and intracanalar lesions are approached. Classical open and minimal invasive posterior approaches to the spine can damage the paraspinal muscles.[11–13] This trauma generates pain and can cause postoperative muscular atrophy and fatty degeneration and compromise function. The ELIF technique is advantageous in this regard. It is a muscle-sparing approach because its working corridor follows strictly the natural cleavage plane between the MF muscle and the LT muscle pars lumborum without dissecting muscle fibers. The MRI scans we performed in five randomly selected patients 6 months after surgery illustrate the postoperative integrity of the muscles and the absence of atrophy or fatty degeneration (►**Fig. 4**).

Postoperative epidural fibrosis is a known entity after posterior approaches to the lumbar spine that affects the dural sac and the nerve roots. Some clinical studies have confirmed and others denied a positive correlation between excessive fibrosis and the clinical course.[14–18] In case of revision surgery, posterior epidural fibrosis makes the reexposure of the surgical site difficult and is related to a longer operation time and a higher risk for dural tear and nerve damage.[19] ELIF surgery offers another advantage. It avoids the formation of posterior epidural fibrosis because it bypasses the dural sac and the nerve roots due to its extraforaminal working corridor angled 45 degrees relative to the midline. The ELIF technique is also suitable for revision surgery in patients with manifested posterior epidural fibrosis after previous surgery with another approach.

The ELIF technique is subject to limitations in case of bilateral compression; here a bilateral approach is necessary.

Critical points of this retrospective analysis are that the clinical outcome was limited to a short-term assessment at 5 months after surgery, that the preoperative VAS for leg and back pain were evaluated retrospectively, and that there was no comparison group.

Conclusion

The muscle-sparing ELIF technique is also feasible at the L5–S1 level and offers access to the intervertebral disk space and the spinal canal. It allows the treatment of various degenerative pathologies with a favorable short-term clinical and radiologic outcome. Prospective studies with long-term follow-up are necessary to compare the ELIF technique with other interbody fusion techniques.

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