Unilateral Extraforaminal Lumbar Interbody Fusion (ELIF)

Surgical Technique and Clinical Outcome in 107 Patients

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Study Design: Description of the technique and retrospective study of patients treated with unilateral extraforaminal lumbar interbody fusion (ELIF) for degenerative lumbar spinal disorders.

Objective: To investigate clinical and radiologic outcome of patients treated with unilateral ELIF.

Summary of Background Data: Lumbar interbody fusion is the classic treatment for higher grades of degenerative disk disease or lumbar segment instability and is performed by posterior (PLIF), posterolateral, or anterior (ALIF) approaches. Those techniques are well established with known limitations and complications. Today, minimally invasive procedures generate more interest especially in terms of muscle damage to achieve better functional outcome. We introduce a unilateral extraforaminal fusion technique which respects neural as well as muscle structures aiming to preserve function.

Methods: Intraoperative and perioperative data, neurological status, Oswestry Disability Index, the Visual Analogue Scale for leg and back pain, and patient satisfaction were investigated preoperatively and at latest follow-up. Fusion status was controlled by x-ray and CT scans at a 6 months' follow-up investigation.

Results: A total of 107 patients [female/male: 67/40; average age, 52.8 (± 13.8) y] were included at a maximum of 31(± 9.4) months. Complications occurred in 4% of patients. Transient radicular pain was investigated in 16 patients. The Oswestry Disability Index and the Visual Analogue Scale for back and leg pain improved significantly. Patients showed a short hospital stay and high percentage of return to work ratio (70%). Fusion was achieved in 97% of patients.

Conclusions: The unilateral ELIF fusion technique demonstrates encouraging clinical and radiologic midterm outcome that for some indications is comparable with established fusion techniques.

Key Words: lumbar interbody fusion, extraforaminal approach, unilateral approach, muscle preservation

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Lumbar interbody fusion remains a surgical gold standard for the treatment of advanced stages of degenerative spinal pathologies, which include disk degeneration, facet joint arthritis, and segmental instability.[1–3] Although different techniques are clinically established, that is, posterior lumbar interbody fusion (PLIF), transforaminal,[4] or anterior lumbar interbody fusion (ALIF), they do not significantly differ in terms of clinical or radiologic outcome.[5–7]

Specific complications even in the case of minimally invasive surgery (MIS) exist for each of these techniques and they are well described.[4,8] In anterior surgery, predominantly vascular, neurological, and intra-abdominal complications are faced. In the widely used posterior techniques, the approach-related muscle destruction and postsurgical scar tissue formation[9–12] are usually encountered. This results in muscle dysfunction, decreased mobility, and pain that can even be located in nonfused adjacent segments. To avoid these specific complications, minimally invasive procedures have become increasingly the focus of interest.[13–16] However, even with minimally invasive approaches, the grade of surgery-associated muscle destruction is under discussion. Alternatives to fusion were also developed in the hopes to preserve motion and address the complications associated with traditional fusion techniques. Despite the growing alternatives for surgical treatment, the individual degree of stabilization as well as the remaining instability is an unsolved problem as shown in various clinical and biomechanical studies.[17–20]

We describe a unilateral extraforaminal approach that was introduced by our group for clinical application after several years experience.[21,22] The clinical and radiologic outcome results of patients who underwent a unilateral extraforaminal lumbar interbody fusion (ELIF) procedure are presented in this study.

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MATERIALS AND METHODS

Patients

We retrospectively analyzed all patients who underwent ELIF surgery for higher grades of degenerative disk disease, including spondylolisthesis grades Meyerding I and II. In all cases, surgery was recommended after a conservative treatment scheme had been unsuccessful for >6 months and the clinical symptoms of degenerative disease persisted (ie, low lumbar pain, radicular pain including neurological deficits, segmental facet joint pain), in combination with radiologic signs of degeneration that were assessed on lumbar x-rays in upright position, as well as dynamic x-ray investigations and CT/MRI scans. Preoperative surgical treatment and preoperative neurological deficits were documented. Concomitant diseases were recorded.

SURGICAL APPROACH

Unilateral ELIF Without Spinal Canal Pathology

The procedure is performed under general anesthesia in a prone position with hips and knees slightly angled to maintain lumbar lordosis. Initial relaxation is recommended. Skin incision (Fig. 1) was made 8–10 cm lateral (about 4 fingers) to the affected side parallel to the spinous process line. The skin incision is about 6 cm long and equally located for the approach to L4/5 and L5/S1 right cephalad to the posterior iliac crest.

The approach to the intertransverse space is achieved through a cleavage between the medial multifidus muscle and the lateral longissimus (M. longissimus thoracis pars lumborum). From this point, the surgeon should maintain a 45-degree angle to reach the foramen. The plane of preparation is located parasagittaly and spans from the superficial aponeurosis to the intertransverse region (Figs. 1, 2).

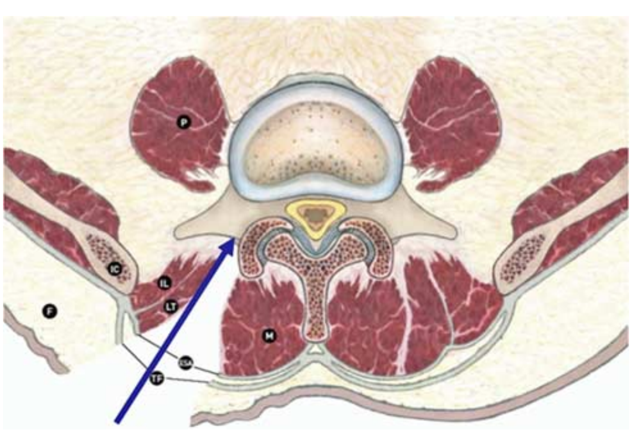

FIGURE 1. Anatomic access to reach the intervertebral disk space by cleavage of the muscle layers. The arrow displays graphically the characteristic 45 degrees approach to the extraforaminal space. ESA indicates erector spinae aponeurosis; F, subcutaneous fat layer; IC, iliac crest; IL, ileocostalis muscle; LT, M. longissimus thoracis pars lumborum; M, multifidus muscle; P, psoas muscle; TF, thoracolumbar fascia.

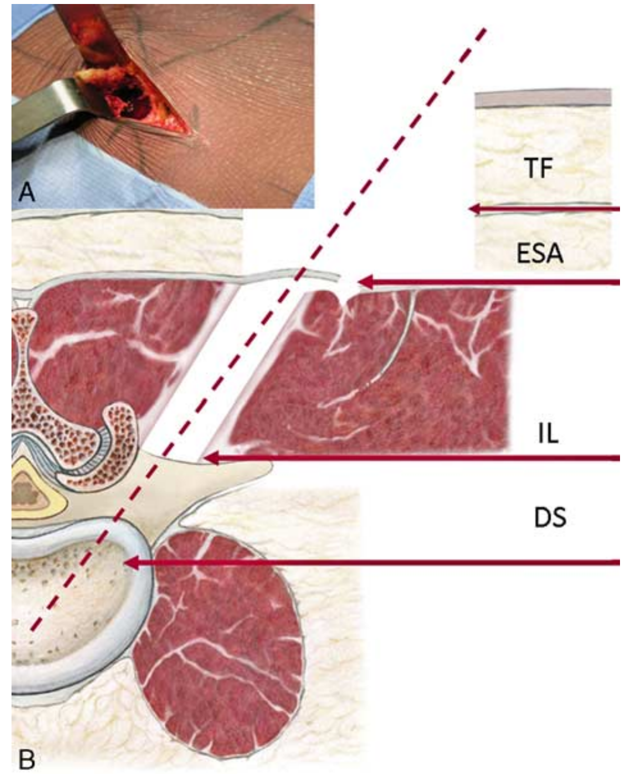

FIGURE 2. A, Intraoperative view of the 45-degrees oblique approach. B, Soft-tissue layers dissected to reach the intervertebral disk using the ELIF approach. The arrows indicate the different anatomical layers reached by the ELIF approach. The dotted line displays graphically the approach to the extraforaminal space. DS indicates disk space; ESA, erector spinae aponeurosis; IL, intertransverse ligament; TF, thoracolumbar fascia.

For orientation, 2 important aponeurosis layers have to be identified under the fatty subcutaneous layer: superficially, the oblique cross-hatched thoracolumbar fascia and below, the erector spinae aponeurosis (ESA).

After the subcutaneous plane has been cut, the superficial thoracolumbar fascia can be exposed. As a benchmark for the identification of the correct layer during preparation, it can easily be recognized by the oblique direction of its fibers. The incision is then extended vertically upward, parallel but 2 cm more medial to the skin incision giving an access to the deeper fascia of the ESA. The ESA is easily detected by its long fibers that run parallel to the midline.

At this point, once the thoracolumbar fascia has been opened and the ESA is exposed, the intermuscular plane has to be identified. First, the internal border of the muscular belly of the iliocostalis pars thoracis must be located. Using this internal border of the muscular belly of the iliocostalis to the posterior iliac crest as orientation, an incision through the ESA is made along this "line." As soon as the incision of the ESA reaches the iliac crest, the surgeon continues this incision following the internal inner border of the iliac wing for 2–3 cm. The intermuscular fatty plane can be bluntly opened with a gauze pad. Following this plane, the edge between the lateral part of the facet joint and the transverse process can be reached (Fig. 2). The entering points of the pedicle screws are prepared between a plane defined by the transverse process and the lateral border of the facet joint for both vertebrae that are instrumented with pedicle fixation. Following the screw canal that was created by a pedicle awl, the screws are placed and controlled under fluoroscopy (Fig. 3).

The intertranverse membrane is opened to allow safe passage of the interbody cages and instruments. The first step is intertranverse membrane mobilization along the superior edge of the inferior transverse process. With a spatula introduced at a 45-degree angle, the underlying disk can be palpated 5–10 mm deeper. In this space, the approach to the intervertebral disk is without risk to the foraminal nerve root that crosses the plane of the disk level more anterior and laterally. As a second step, the membrane is detached from the inferior to the superior transverse process making the preparation of the disk possible. Nevertheless, the area for exposing and preparing the disk is limited.

- Caudally: by the superior edge of the inferior transverse process.
- Medially: by the superior articular facet of the inferior vertebrae.
- Laterally: by the foraminal root.

Following exposure, the discectomy is easily performed. Blunt smooth spreaders of various sizes are used to distract the interbody space. A distractor (Coligne, Zurich, Switzerland) rests on the pedicle screws to maintain the achieved distraction. The preparation of the endplates is equally performed as already described for other intervertebral techniques. For anterior support and restoration of disk space height, 2 carbon composite cages (Coligne AG) are used. Both cages are "C" shaped and are specifically designed to fill the disk space from this approach. Both cages are filled with autologous cancellous bone. Usually, bone harvesting from the posterior iliac crest is possible using the same approach.

The first cage is inserted at an angle of ≥ 45 degrees orientated in the sagittal plane. In this way, the anterior tip of the cage is placed beyond the midline. Then the cage can slightly be moved anteriorly to allow the insertion of the second cage. Following the cage placement, segmental distraction is removed and position can be controlled by fluoroscopy. At this stage of surgery, the corresponding preserved facet joint can be prepared for articular fusion. Unilateral segment stabilization can be achieved using the mentioned titanium pedicle screws combined with a carbon composite plate or rod system (Coligne) (Fig. 3).

Compression can be applied through this construct. Following local lavage and drain insertion, layer by layer wound closure is performed.

Addressing Pathology Within the Spinal Canal

To address spinal canal pathologies, partial or even complete removal of the facet joints can be performed using the above-mentioned intermuscular approach. Removal of the superior part of the facet joint, or the entire facet (with the inferior part of the facet of the upper vertebrae), when necessary, uncovers the entire foramen and allows the access to the lateral part of the spinal canal and the lateral aspect of the intracanalar nerve root (Fig. 3). The removal of both joint parts uncovers the yellow ligament and, if needed, the lateral aspect of the cauda equina. Contralateral spinal canal stenosis or radicular compression cannot be addressed by this unilateral approach.

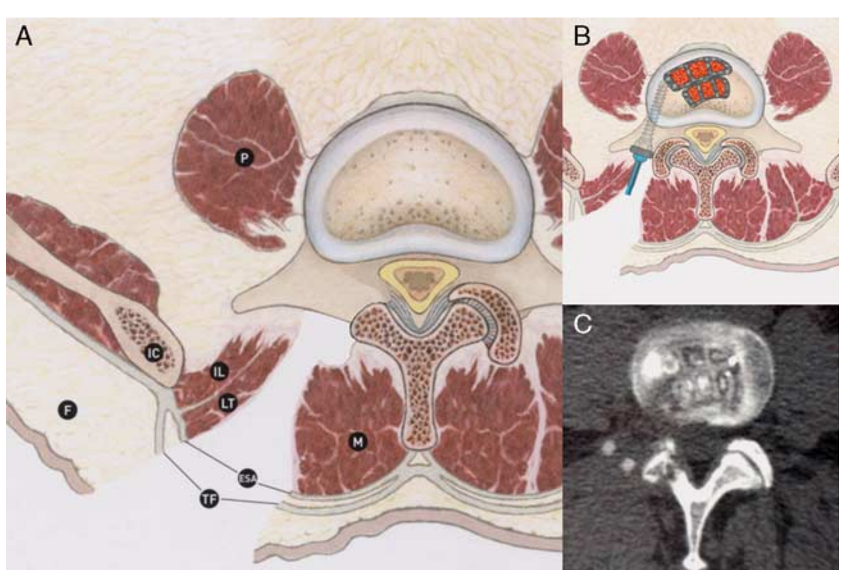

FIGURE 3. A, Intracanalar access by removing the lateral part of the facet joint. B and C, Anterior fusion by 2 carbon composite cages and unilateral pedicle screw plate/rod construct. ESA indicates erector spinae aponeurosis; F, subcutaneous fat layer; IC, iliac crest; IL, ileocostalis muscle; LT, M. longissimus thoracis pars lumborum; M, multifidus muscle; P, psoas muscle; TF, thoracolumbar fascia.

Surgical Parameters

Duration of surgery and intraoperative blood loss were analyzed. Days at hospital as well as perioperative and postoperative complications were documented (severe/moderate). New temporary or persistent postoperative neurological deficits were registered.

Clinical Outcome

Regular control investigations were performed at 3 and 6 months postsurgically and at latest follow-up. Indications and techniques of reoperations within the investigation period were analyzed. The quality of residual pain (regional/radicular) was registered. Changes in pain intensity were recorded using the Visual Analogue Scale (VAS) ranging from 0 to 10 (0:"no pain" and 10:"the most severe pain ever experienced"). Physical spinal function was evaluated using the Oswestry Disability Index (ODI). Patients VAS und ODI were investigated preoperatively, 3 months postoperatively, and at latest follow-up. Furthermore, satisfaction of patients' actual health status on a 10-point VAS[23] (0: "not satisfied" and 10: "completely satisfied") and surgeon's consideration of patient outcome ("poor," "fair," and "good" result) were assessed preoperatively and postoperatively. At latest follow-up, patients were interviewed regarding their work situation.

Radiologic Outcome

Conventional x-ray images were taken at the 3 months' control investigation (Figs. 4, 5). At the second follow-up investigation (6 mo postoperatively), a CT scan (axial, coronal, and oblique sagittal reconstruction in the cage angle) was performed to assess the existence of bone bridges spanning between the adjacent endplates. CT scan analysis was performed by a senior musculoskeletal radiologist and a spine surgeon who were blinded to the patients' outcome. Implant loosening and pseudarthrosis were defined as appearance of radiolucent lines, stress shielding, implant dislocation compared with previous investigations, and implant breakage.

Statistical Analysis

Statistical analysis was performed using the SPSS software package (SPSS Inc., Chicago, IL). The means, SDs, and minimum/maximum were determined. Both the time course of all patients' parameters and differences between the study groups in each follow-up were calculated.

For analysis of differences, the Student *t* test and the Mann-Whitney *U* test were performed. Connections between the parameters were recorded. A significance was specified for a P-value <0.001 for all statistical test methods.

RESULTS

Patients

A total of 107 patients [female/male: 67/40; average age, 52.8 (± 13.8) y] were treated with a unilateral ELIF procedure at the levels L5/S1 (n = 41), L4/L5 (n = 57), L3/L4 (n = 8), and L2/L3 (n = 1). Of them, 17 showed higher segmental instability by demonstrating a spondylolisthesis (≤ Meyerding grade II).

Surgery

Average duration of surgery was 110.2 (± 28) minutes, and the intraoperative blood loss was 150 (± 50) mL. Patients stayed at mean 4.1 (± 1.8) days at the hospital. Regarding intraoperative or perioperative complications, 1 patient developed a hematoma and 2 patients presented with superficial wound disturbances requiring revision surgery with local wound drainage. Sixteen

FIGURE 4. Preoperative AP (A) and lateral view (B) x-rays of a patient with degenerative changes L4/L5 and resulting segmental deformity. Follow-up investigation (C+D).

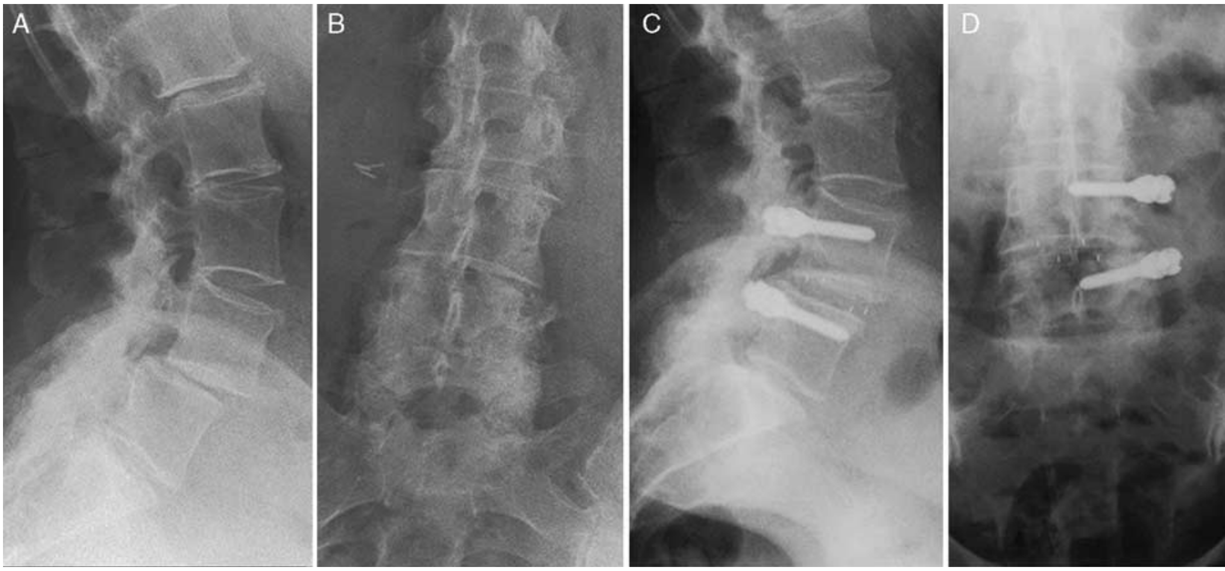

FIGURE 5. Preoperative AP (A) and lateral (B) x-rays of a patient suffering from degenerative spondylolisthesis in L4/5 and following ELIF surgery at a follow-up investigation (C+D).

patients (6.7%) complained of transient nerve root pain on the side of the approach that was treated with low-dose corticoids for 2 weeks and were reversible in all cases. One patient developed a transient radicular motor loss due to implant dislocation. After revision operation with cage removal, symptoms completely regressed. All patients were mobilized on the first day after surgery and underwent a standardized 6 weeks' postoperative rehabilitation program.

Clinical Outcome

At a maximum follow-up of 31 (16–84) months, parameters displaying pain relief (VAS score) for lumbar and radicular pain improved significantly ($P \leq 0.001$). Spinal function displayed by the ODI evenly improved significantly ($P \leq 0.001$) following surgery over the investigation time points (Table 1).

Regarding patient satisfaction, the mean value after operation was 9 (± 2) points revealing a high success rate. Regarding the development of patients' outcome considered by the surgeons' estimation, 83% reached a good, 11% a fair, and 7% a poor result after 6 months (Table 2). Regarding the neurological outcome, 1 patient improved from a sensory deficit after operation and 1 remained unchanged with a sensory deficit postsurgically. All the other patients presented with full function at follow-up.

Of the 55 patients who were employed before surgery, 70% (n = 38) returned to their original place of work. Seven percent (n = 4) were not able to return to regular work activities. Thirteen patients (23%) changed their job for disease-related reasons.

The results were again divided for the indication subgroups with (n = 17) and without a deformity (n = 80). The results for both groups are displayed in Table 3. There were no significant differences for the estimated outcome parameters between both groups.

Radiologic Outcome

According to the above-defined criteria in CT scans, the fusion was achieved in 103 patients (97%) half a year following surgery. Neither in the remaining 4 patients nor in the fused group, any signs of implant breakdown or loosening were noted (Figs. 4, 5).

DISCUSSION

The presented unilateral ELIF technique has been performed by our group for several years. In cases where conservative treatment failed, it can be indicated for different lumbar degenerative pathologies [ie, degenerative disk disease, higher grades of osteochondrosis including spondylolisthesis (Meyerding grades I and II), and facet joint arthrosis]. In comparison with the established intervertebral fusion techniques, it is more adaptable with respect to the surgical goal that shall be pursued. In the absence of an intracanalar lesion, a simple extra-articular approach and stabilization can be achieved. Here the indications are comparable with those for an anterior fusion technique (ALIF) or a transforaminal approach.[4] An intracanalar lesion can be addressed by the same unilateral ELIF technique with the partial or complete removal of the facets that permit the surgeon to treat pathologies that are addressed with decompression and stabilizing techniques (eg, PLIF).

Taking into account a general limitation of the comparability to other publications, at a midterm follow-up ranging from 16 to 84 months, the clinical and radiologic results achieved with the ELIF are still encouraging. We were able to show a significant improvement in the clinical outcome parameters, the patients' satisfaction, and

TABLE 1. Development of Clinical Parameters: VAS and ODI

Parameters	Preoperative	3 mo Postoperative	Follow-up (Mean 31 mo)	Significance
VAS BP (points)	7.7 ± 2.1	2.5 ± 2.0	1.9 ± 2.2	$P \leq 0.001$ vs. preoperative
VAS LP (points)	7.4 ± 2.3	2.0 ± 2.1	1.5 ± 2.3	$P \leq 0.001$ vs. preoperative
ODI (%)	53.6 ± 18.7	23.8 ± 16.4	14.9 ± 16.2	$P \leq 0.001$ vs. preoperative

BP indicates back pain; LP, leg pain; ODI, Oswestry Disability Index; VAS, Visual Analogue Scale.

the surgeons' rating. For patients undergoing low lumbar spinal fusion with different techniques due to chronic low back pain, reduction rates of the ODI of approximately 30%[24] were shown. The ODI results following ALIF (30.5%) and PLIF (31%) surgeries are therefore comparable.[25,26] Hackenberg et al[27] found in their population of single-level fusions with a transforaminal lumbar interbody fusion (TLIF), an ODI 33.3 (24.2) and a VAS of 5.3 (2.5) at a mean follow-up of 46 months. In addition, minimal-invasive TLIF surgery revealed outcome results at the same level as achieved in this study.[15,28,29]

Although the achieved clinical outcome parameters range at an equal level, TLIF procedures seem to have advances as compared with PLIF and ALIF plus pedicle screws with regard to intraoperative risks, complication rates, and cost-effectiveness.[30,31] The risk of an intraoperative or perioperative complication was comparably low during the treatment with a unilateral ELIF. Even if the cost-effectiveness was not analyzed in this study, to our experience, ELIF patients had a shorter time of surgery and hospital stay due to the less blood loss and no need for wound drainage compared with open fusion techniques. In a recent study, Goz et al[32] were able to show an average hospital stay for open PLIF/TLIF procedures in the United States of approximately 4.5 days. In a meta-analysis of international publications about the results of MIS versus open TLIF surgeries, the hospital stay ranged from 3 to 10.6 days and 4.2 to 14.6 days, respectively.[33] Our results suggest a longer hospital stay compared with MIS fusions but shorter than open techniques. The relatively rapid patient recovery is underlined by a high rate of employed patients who were able to return to their original job.

However, even if the ELIF covers most indications, the presented procedure differs markedly from the established options and offers different advantages.

In PLIF and ALIF procedures, either the stabilizing posterior or anterior longitudinal ligament must be cut in order to approach the intervertebral disk. Instability is significantly altered.[34,35] Partial (PLIF) or total[4] resection of the facet joints must be performed in posterior techniques for the approach and as a result must be combined with constructs that provide high primary stability. The ELIF merely cuts the posterolateral aspect of the disk and respects muscles and the articular mass. The partial resection of the lateral mass of a hypertrophic facet is therefore only associated with a minor or no destabilizing effect. Even the removal of the tip of the superior facet will result in a minimal unilateral instability due to the fact that the inferior facet still remains in contact with the inferior part of the superior facet. Biomechanical in vitro investigations showed a less stabilizing effect of an uni-

TABLE 2. Surgeons' Postoperative Evaluation

	Follow-up [n (%)]			
Parameters	1 mo	3 mo	6 mo	Significance
Surgeons' evaluation				
Good	73 (68)	78 (73)	88 (83)	—
Fair	25 (24)	22 (21)	11 (10)	—
Poor	9 (8)	7 (6)	8 (7)	$P \leq 0.001$ vs. good

TABLE 3. Comparison of the Outcome Results for Patients With (Spondylolisthesis) and Without Deformity

			Significance
	Spondylolisthesis	DDD	Mann-Whitney-U-test
Female:male	13:4	55:35	
Follow-up	31 ± 15.2	31 ± 7.9	0.522
Clinical results			
1 mo			
Good	13	59	0.442
Fair	4	21	
Poor		9	
3 mo			
Good	15	63	0.146
Fair	2	20	
Poor		7	
6 mo			
Good	15	73	0.551
Fair	2	9	
Poor		8	
Bony bridge	16	90	
Implant failure	0	0	
Frankel score			
E	17	88	
D		2	
Back pain VAS			
Preoperative	7.5 ± 2.4	7.8 ± 2.1	0.585
Postoperative	1.9 ± 2.4	2 ± 2.2	0.877
Leg pain VAS			
Preoperative	6.5 ± 2.9	7.6 ± 2.2	0.216
Postoperative	1.3 ± 1.9	1.6 ± 2.4	0.878
ODI			
Preoperative	49.7 ± 18.3	54.1 ± 18.7	0.25
Postoperative	15.9 ± 17.3	15 ± 16.2	0.864
Patient satisfaction	8.8 ± 1.8	8.6 ± 2.1	0.525

No significant difference was shown for any of the parameters.

DDD indicates degenerative disk disease; ODI, Oswestry Disability Index; VAS, Visual Analogue Scale.

lateral pedicle screw fixation[36] compared with a bilateral with respect to range of motion reduction. This difference is markedly but relatively small depending on the size of the anterior intervertebral support. The high surface area of the 2 cages that were used in this investigation may explain the nonexistence of an implant breakdown and in turn clinical stability of this unilateral fusion construct in our patients.

Classic posterior approaches lead to a significant degradation of posterior paraspinal muscles and ligaments by direct intraoperative destruction as well as a fibrosis and dysfunction by nerve destruction.[9,10,12,37] In the clinical follow-up, significant postoperative muscle atrophy, loss of function, and increased pain[9,38] have been evidenced. In this respect, the introduced ELIF technique may offer an improvement and is target of further MRI investigational studies.

Various publications described foraminal approaches. The Wiltse approach reaches the lumbar spine through the same cleavage plane between the multifidus and the longissimus muscle as the mentioned in ELIF approach. However, there is an important difference: the working angle to reach the intervertebral disk. The Wiltse technique begins with a skin incision near the midline and the approach is nearly straight sagittal and has a higher risk of muscle destruction. To reach the disk, the Wiltse technique requires a complete removal of the articular mass and results in a higher segmental instability with a need for reconstruction. The ELIF technique, in contrast, is a 45-degree angled approach. Beginning with a more lateral skin incision, it uses intermuscular approach that exposes the lateral part of the disk outside the articular mass at the opening of the foramen. Both intervertebral cages can be inserted without a complete removal of the facet joints. The resection of the facet joint is not required for the approach, but remains a surgical option for treatment.

To achieve anterior fusion, a double carbon-composite cage system was used in all patients characterized by a high-uptake volume for autologous bone. It offers the transplantation of an important amount of biological bony material with an important mechanical support for less subsidence displayed by the achieved radiologic results. The composite material of the cages and the plates/rods (ostaPek) shows the advantage of a low level of artifacts on CT scan or MRI investigations for follow-up purposes (Fig. 5). For fusion protection, a solid unilateral spondylodesis is added by the same approach with no need for further skin incisions. The entry point of the polyaxial screws is located nearby the already prepaired nerval root and transverse processes. For angulation of insertion, the 45-degree axis of the approach matches the axis of the lumbar pedicle.

A PLIF procedure, especially altered in revision surgery, presents with the risks of direct lesions of the dural sac and the cauda equina with hematoma or postoperative fibrosis.[39] The anterior approach presents risks inherent in retroperitoneal surgery, such as digestive and, more importantly, vascular and neurological risks.[40–42] In contrast, by respecting the vascular and nerve structures, the more laterally orientated ELIF technique avoids the risks of severe bleeding and potentially more dangerous dissection of the spinal canal. In this study, 1 patient had a transient L5 root motor loss due to wrong position of a cage that disappeared completely after cage removal. Although only 4% of the patients demonstrated some kind of intraoperative or perioperative complications, approximately 7% presented with postoperative foraminal pain at the side of the approach. Nevertheless, all of the nerval irritations—either simple dysesthesia or true pain—disappeared under low-dose corticoid therapy. Interestingly, nerve root symptoms were never noticed immediately following surgery. The fact that the foraminal pain was always delayed by 3–8 days after surgery and entirely disappeared after 3 or 4 weeks might be explained by the appearance of a periradicular hematoma that is resorbed following the mentioned time period. For TLIF surgeries, overall complication rates between 3% and 8% were described.[30,43,44] A evenly higher rate (up to 27%) of unexpected events was shown for PLIF surgeries.[30]

However, the ELIF technique does have some limitations. Higher grades of spondylolisthesis or segmental deformities are not an adequate indication for ELIF surgery. Even if all lower lumbar levels can be approached by the described technique and 2 levels can be performed by the same skin incision, a bilateral stenosis of the spinal canal can only be addressed by a second approach. For an anatomic variance at the L5–S1 disk that is located very deep between the iliac crest, the ELIF approach cannot be angled to the recommended 45 degrees and the cages cannot be placed beyond the midline. In cases of a very narrow disk, the contralateral part of the disk cannot be adequately distracted.

Retrospective analyses are always limited in different points: this investigation has no control group. Therefore, the results have to be compared with the already published literature. Even with different available comparable pub-

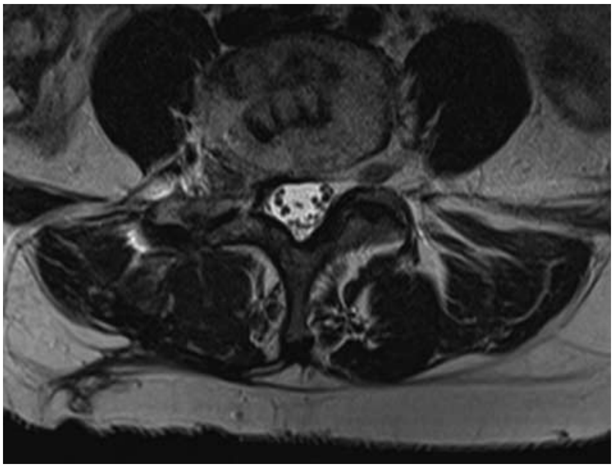

FIGURE 6. Postoperative MRI of an ELIF patient 1 year following surgery revealing a low rate of muscle destruction.

lications, it makes the interpretation of the achieved results difficult. This point is the subject of an already started prospective study. This upcoming study has to further show the effect on muscle preservation, approach-associated morbidities, and scar tissue formation. For the retrospectively analyzed population, only some patients were routinely followed up by an MRI as shown in Figure 6. Only a minority of the treated patients showed a deformity as a sign of high-grade instability. In this term, it could be speculated that the procedure would not be that successful due to technical reasons. However, both investigated groups—with and without a deformity—presented with the same outcome results without any significant difference.

To the best of our knowledge, for the first time this study presents technique and results of a unilateral ELIF. At midterm follow-up, a good clinical and radiologic outcome was shown in 107 patients. Compared with established fusion techniques, comparable clinical and radiologic outcome parameters were demonstrated. It therefore combines the advantages of MIS by muscle preservation, short operation time, and shorter hospital stays.

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