

Experience and Early Results with a Minimally Invasive Technique for Anterior Column Support Through eXtreme Lateral Interbody Fusion (XLIF®)

a report by

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Anterior approaches to the lumbar spine allow for the indirect decompression of the spinal canal and neural foramina by placement of a large interbody graft to reconstruct the anterior column. The risks associated with the traditional anterior approach include injury to the abdominal contents, iliac vasculature, or sympathetic plexus—including the risk of sexual dysfunction.¹ Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) approaches avoid many of the risks associated with the anterior approach, but carry their own sets of concerns—devitalization of the paraspinous musculature, inadvertent duratomy, and traction neuropraxia.²⁻³ Minimally invasive posterior techniques have obviated some of the exposure-related morbidity, but provide a challenging surgical corridor for placement of an adequately sized interbody graft.³

A novel, minimally disruptive spine procedure called the extreme lateral interbody fusion or XLIF® (NuVasive® Inc., San Diego, CA) is a 90° off-midline or direct lateral approach that allows for large graft placement and excellent disc height restoration, and provides indirect decompression of the stenotic motion segment.⁴⁻⁶ This approach can be performed using two 3–4cm skin incisions. Safe passage through the retroperitoneal space is assured by gentle blunt dissection. The psoas muscle is traversed, and the lumbar plexus protected, by the use of automated electrophysiology (NeuroVision® JJB, NuVasive Inc.). Exposure is achieved with an expandable three-bladed retractor (MaXcess®, NuVasive Inc.), which allows for direct illuminated visualization facilitating discectomy and complete anterior column stabilization using a large load-bearing implant. Since the introduction of the XLIF technique to North America in late 2003, a host of advantages for our patients have become apparent:

- less tissue damage leads to quicker recovery and decreased narcotic requirements;
- it is widely applicable to a host of degenerative spinal conditions;
- it is safe and reproducible with few complications due to the use of automated neuromonitoring (NeuroVision®);



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- the large, load-bearing interbody construct provides disc space distraction, indirect decompression, sagittal alignment correction, and stability; and
- improved efficiency resulting in shorter operating room (OR) time and decreased length of stay.

eXtreme Lateral Interbody Fusion Surgical Technique

The surgical technique has been described in detail by Heim et al.⁴ and Ozgur et al.⁵ The safety and reproducibility of the technique have been demonstrated in several retrospective reviews⁷⁻¹⁰ at multiple centers. Experience has taught us that there are five key steps to making XLIF a safe, simple, and efficacious procedure:

- careful patient positioning;
- gentle retroperitoneal dissection;
- meticulous psoas traverse using neurovision;
- complete disc removal and fusion site preparation; and
- proper interbody implant placement.

Careful Patient Positioning

It is imperative that the approach be directly lateral to the operative level. To facilitate the surgery, the intervertebral axis should be orthogonal to the floor of the operating theater and there should be no rotation of the spine relative to the plane of operation. Proper orientation is assured by positioning the patient such that true lateral and anterior–posterior (AP) fluoroscopic images are in use at all times. This is achieved by taking the time to be certain that the pedicles overlay one another in the lateral projection and that the spinous process is centered between the pedicles on the AP image. The table break point should be located between the greater trochanter and the iliac wing. The patient must be securely taped in place prior to flexing the table in order to gain space between the iliac crest and the twelfth rib, as shown in *Figure 1*—this will allow access of levels L4–5 to L1–2.

Gentle Retroperitoneal Dissection

Experience has dictated that safe and reproducible passage through the retroperitoneal space is achieved with two incisions and gentle, blunt finger dissection.^{4,10}

Meticulous Psoas Traverse Using NeuroVision

It is impossible to overemphasize the importance of reliable, timely monitoring of the neural elements as the surgeon traverses the psoas. Visual identification of the lumbar plexus is not possible, but the plexus can be protected by using an automated electrophysiology technology. The NeuroVision system, in detection mode, uses a patented hunting algorithm

that provides five pulses of increasing amplitude current per second until a recording myotome has responded. Once the maximum current level to elicit a response is achieved, the current output will stabilize at this level.

Observations made from direct nerve stimulation during instrumentation procedures have found that clinically normal nerves elicit an electromyogram (EMG) response under an applied stimulus ranging from 1 to 5mA, with an average of about 2mA.^{11,12} Therefore, the closer the proximity of the nerve, the closer the threshold will be to 2mA. Experience with lateral approach procedures has shown that thresholds >10mA provide a distance from nerves that allows adequate exposure to the disc.

The NeuroVision JJB System displays the stimulus responses on a color-coded, numerical graphical user interface (GUI). The responses are also accompanied by an audible tone whereby changes in tone indicate the change in color-coding, allowing the surgeon the freedom to focus on the surgical site instead of the screen. Lateral approaches have been employed in the past and—without the use of realtime, surgeon-driven electrophysiology—have resulted in relatively high complication rates of post-operative thigh paresthesias in approximately six patients, or 30%. The paresthesia resolved within four weeks in four of these six patients.¹³

Complete Disc Removal and Fusion Site Preparation

As previously described in more detail,⁴⁻⁶ exposure is achieved with an expandable three-bladed retractor (MaXcess, NuVasive Inc.), which allows for direct illuminated visualization. The retractor system is attached firmly to the operating table with an articulating arm. An important feature of the retractor is the ability to stabilize the most dorsally oriented blade using an intradiscal shim, thus protecting the lumbar plexus from being compressed against the transverse process. The stabilization of the posterior blade allows the anterior blades to be safely deployed to create sufficient access space for discectomy and implant placement.

Proper Interbody Implant Placement

The XLIF approach allows for complete anterior column stabilization using a large, load-bearing implant. Another important aspect of the surgical technique is the release of the contralateral annulus and the selection of an implant that is large enough to span the ring apophysis, as shown in *Figure 2*.

Early American Experience

Proper training is vital for a technique as novel as XLIF. After the initial descriptions by Pimenta^{4,5} in Brazil, the technology was introduced to surgeons in the US. The early experience with XLIF in the US was reported by Wright.¹⁰ The first 145 patients (166 levels) treated by 20 surgeons presented with multiple indications. The distribution of procedures and levels in this early experience was:

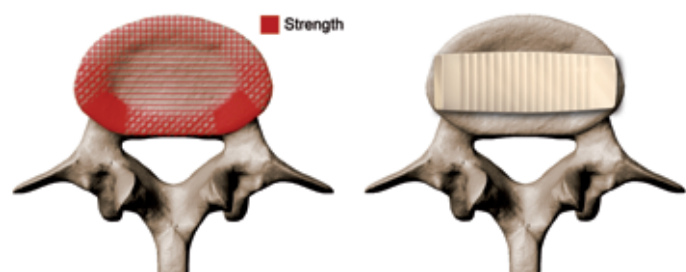
L4–L5	63 (52%)	Single-level	79%
L3–L4	43 (35%)	Two-level	20%
L2–L3	16 (13%)	Three-level	1%

While traversing the psoas with a muscle-splitting approach, NeuroVision identified nearby nerves at risk in 46% of the cases—reinforcing the importance of reliable automated electrophysiology. Wright et al.¹⁰ summarized their findings as follows:

Figure 1: Proper Patient Positioning



Figure 2: Implant Placement



Left: red zone indicates the strongest region of the anterior vertebral column L4. Right: position of the XLIF implant on the strongest bone—the ring apophysis.

- 81% of patients had supplemental fixation;
- the average surgical time was 74 minutes/level;
- the average hospital stay was one day; and
- the average blood loss was <100cc.

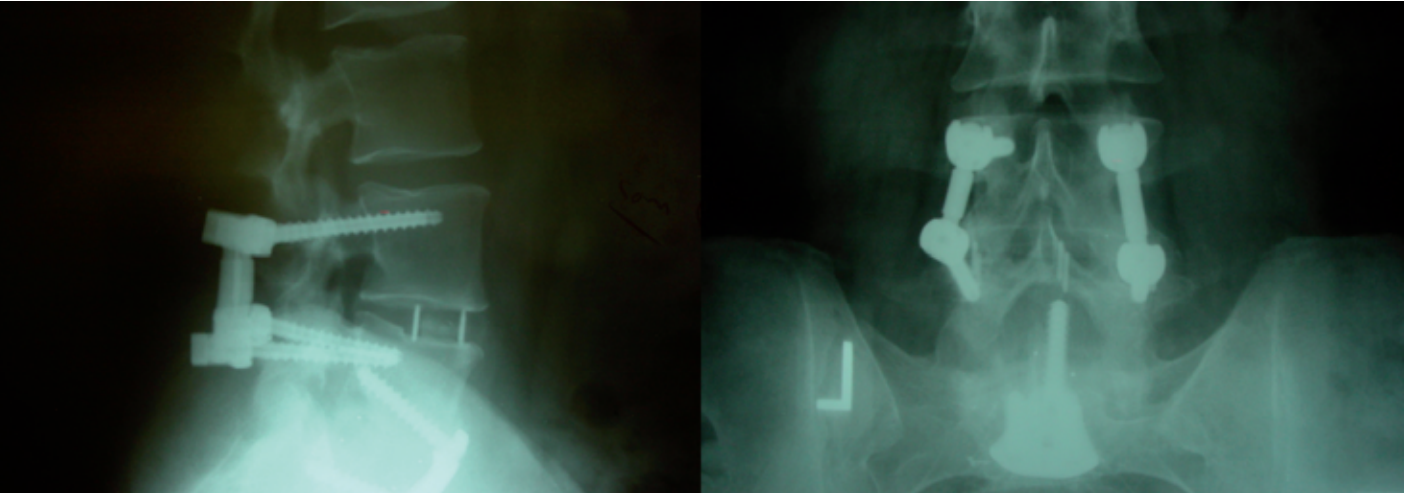
Most importantly, there were no vascular or visceral injuries reported in this large clinical series. There were two cases of transient thigh numbness (ipsilateral to the approach), which resolved within two weeks. Five patients reported transient hip flexor weakness—these symptoms resolved one to eight weeks post-operatively in all five.

Expanded Indications

After the technique was shown to be safe and reproducible, a variety of expanded surgical indications have been described, including degenerative disc disease (DDD) with instability, post-laminectomy instability, junctional disease, or, adjacent to previous fusion, recurrent disc herniation, degenerative spondylolisthesis (grade 2), degenerative scoliosis, pseudarthrosis, discitis, vertebral osteomyelitis (without active infection), and revision of failed total disc replacement (TDR).

The two indications that have been proved most rewarding for patients are adjacent segment degeneration and degenerative scoliosis—which typically affects older patients with significant comorbidities who are unable to tolerate large, disruptive surgeries.

Figure 3: Lateral and Anterior–Posterior Radiographs Three Months After L4–5 eXtreme Lateral Interbody Fusion for Adjacent Segment Degeneration Above an L5–S1 Anterior Lumbar Interbody Fusion



For surgery adjacent to fused levels, the lateral approach allows the surgeon to avoid the previously operated approach pathway—either dorsally or ventrally. Reconstruction of the anterior column is accomplished by the large interbody implant (CoRoent® XL). Supplemental fixation can be applied with percutaneous pedicle screws (SpheRx DBR®) (see *Figure 3*) or, if the surgeon prefers, with a recently designed lateral lumbar plate (XLPTM).¹⁵

Even more exciting is the use of XLIF in elderly patients with significant scoliosis. Phillips and Pimenta⁷ have summarized the results of their prospective study of XLIF treatment of degenerative scoliosis. An example of three-level correction on a 72-year-old patient is shown in *Figure 4*. Of particular note is the correction of the rotational deformity in addition to the coronal deformity, as seen by the alignment of the spinous processes in the post-operative radiograph. In brief, their findings from this two-year follow-up study included a reduction in Oswestry Disability Index (ODI) from a pre-operative value of 49.0 to a two-year average value of 21.4. The Visual Analog Scale (VAS) score for pain reduced from a pre-operative value of 9.1 to a two-year average value of 5.1. The Cobb angle was reduced from an average pre-operative value of 18° to an average post-operative value of 8°. The lordosis increased from a pre-operative average value of 34° to a post-operative average value of 41°.

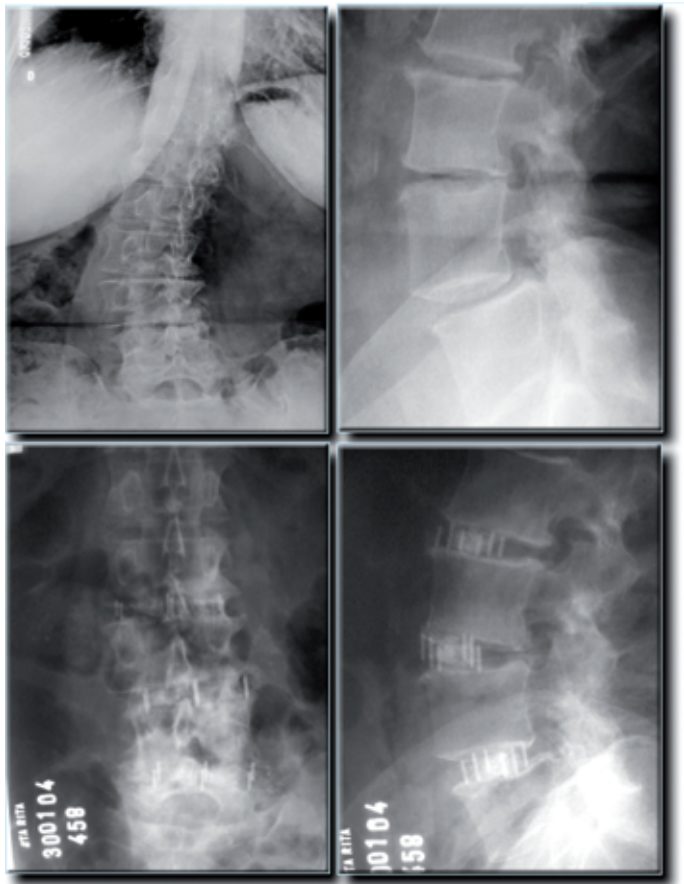
Personal Experience

The prospective series of our first 100 patients treated with XLIF has been most encouraging. One hundred patients (122 levels) were operated on by the senior surgeon. Their primary diagnoses were stenosis (33), spondylolisthesis (23), degenerative disc disease (18), post-laminectomy instability (14), herniated nucleus pulposus (HNP) (7), and scoliosis (5). Eighty patients had concomitant deformity of scoliosis (17) or spondylolisthesis (63).

The distribution of procedures and levels was:

L4–L5	37%	Single-level	72%
L3–L4	33%	Two-level	22%
L2–L3	24%	Three-level	5%
L1–L2	6%	Four-level	1%

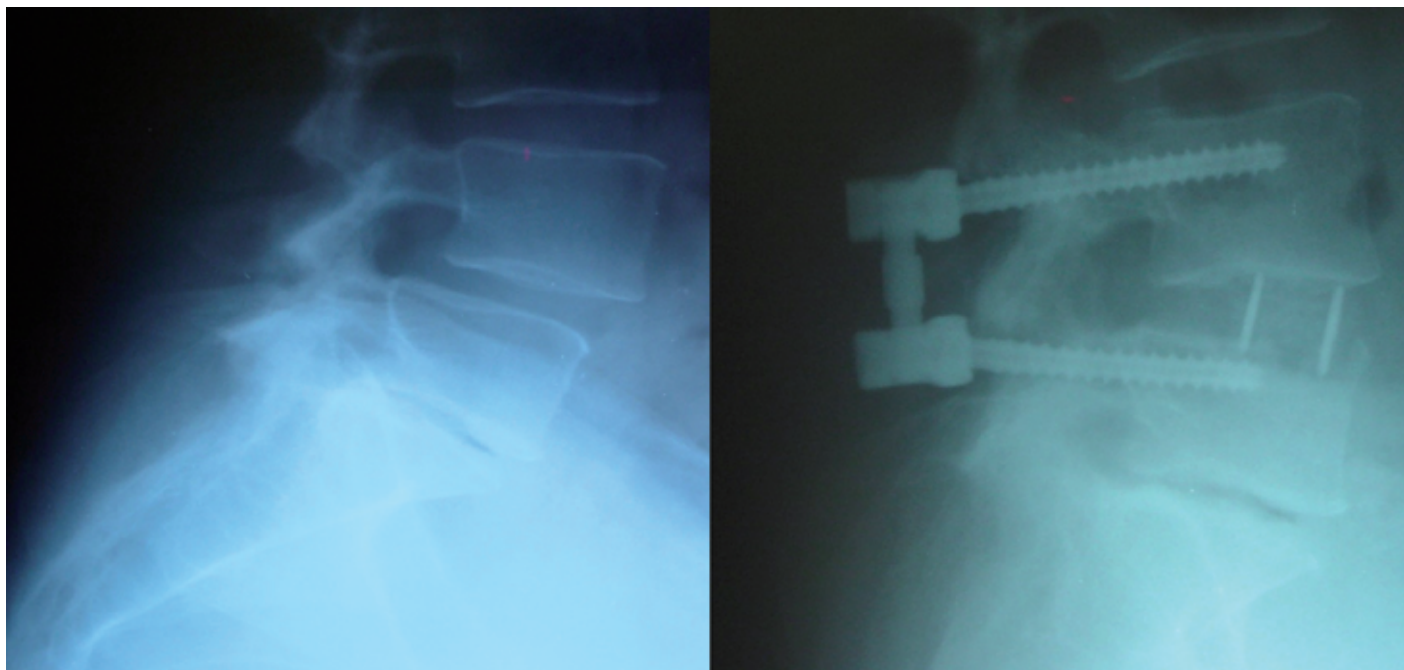
Figure 4: Pre- and Post-operative Anterior–Posterior and Lateral Radiographs of Degenerative Scoliosis



Three levels were staged and treated without posterior instrumentation.⁷

In 99 cases supplemental posterior fixation was used—unilateral pedicle screw-rod constructs (79), bilateral pedicle screw-rod constructs (8), and trans-facet screws (12). It is our impression that facet screws allow more settling of the graft than pedicle screw-rod constructs. Unilateral pedicle screw-rod constructs appear to be as clinically stable as bilateral constructs

Figure 5: Pre- and Post-operative Lateral Radiographs of L4–5 Spondylolisthesis Treated with eXtreme Lateral Interbody Fusion



and biomechanical data suggest that this fixation should be adequate.¹⁵

Results were as follows:

Average length of stay (days): 1.5

Hemoglobin change (pre-op/post-op) (g):	1.71	Range: 0–4.2	
	Pre-op	Post-op	
Disc height (mm):	6	10	

Spondylolisthesis (63 levels) (see Figure 5)

Slip (mm):	4.3	0.5	0.8	1.8
Scoliosis (17 cases) (degrees):	17.9	9.7	13.4	
Lenke score: ¹⁶			2.1	1.6
VAS:	8.3		2.4	2.6

Complications:	Ileus 2
	Transient weakness tibialis anterior 1

Post-operative thigh discomfort was routine, and slight lateral thigh numbness rare. These symptoms resolved completely within four to six weeks in all cases. The patient with transient tibialis anterior weakness had complete recovery by six weeks post-operatively. No significant hip flexor weakness was noted beyond six weeks. There were no wound infections and no patient required blood transfusion.

Conclusion

XLIF technology is revolutionizing the care of patients needing thoracolumbar spinal fusion between T6–7 and L4–5. More rapid recovery is facilitated by decreased tissue trauma.

By adhering to the five key steps, spinal surgeons can employ this technique safely and reproducibly. It is vital that we attend to careful positioning and employ reliable neuromonitoring as we meticulously traverse the psoas in order to offer our patients the results they deserve. ■

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