Extreme Lateral Interbody Fusion (XLIF): a novel surgical technique for anterior lumbar interbody fusion

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Abstract
BACKGROUND: Minimally disruptive approaches to the anterior lumbar spine continue to evolve in a quest to reduce approach-related morbidity. A lateral retroperitoneal, trans-psoas approach to the anterior disc space allows for complete discectomy, distraction, and interbody fusion without the need for an approach surgeon.

PURPOSE: To demonstrate the feasibility of a minimally disruptive lateral retroperitoneal approach and the advantages to patient recovery.

METHODS/RESULTS: The extreme lateral approach (Extreme Lateral Interbody Fusion [XLIF]) is described in a step-wise manner. There have been no complications thus far in the author’s first 13 patients.

CONCLUSIONS: The XLIF approach allows for anterior access to the disc space without an approach surgeon or the complications of an anterior intra-abdominal procedure. Longer-term follow-up and data analysis are under way, but initial findings are encouraging.

Keywords: XLIF; Lateral; Retroperitoneal; Trans-psoas; Minimally Invasive; Split-blade retractor; EMG; Minimally disruptive

Introduction

Since 1991, when Obenchain described the first laparoscopic lumbar discectomy [1], the field of minimally invasive spine surgery has continued to evolve. Surgeon and patient alike have been attracted by the advantages of minimally invasive surgery, including less tissue trauma during the surgical approach, less postoperative pain, shorter hospital stays, and faster return to activities of daily living. These reported advantages led to the laparoscopic anterior lumbar approach and mini-open anterior lumbar interbody fusion (ALIF) becoming commonly performed procedures [2–7].

However, greater acceptance of these minimally invasive procedures has been hampered by known complications and challenges associated with endoscopic spine surgery. Reported problems include anesthetic complications [8], visceral damage [9], large vessel bleeding [10,11], and sexual dysfunction [12,13]. Surgeons attempting to use this surgical technique are challenged by the required technical skills, steep learning curve, and continued requirement for access surgeon. The current report describes a novel, minimally disruptive spine procedure called the Extreme Lateral Interbody Fusion or XLIF (NuVasive, Inc., San Diego, CA). This technique is novel in that it can be used to gain access to the lumbar spine via a lateral approach that passes through the retroperitoneal fat and psoas major muscle. Hence, the potential complications with an anterior transperitoneal approach to the lumbar spine can be avoided, major vessels are not encountered, an anterior access is not required, and the procedure can be done through two, 3–4-cm incisions. Here we report the techniques of this approach to the lower lumbar spine.
Materials and methods

Patient selection and surgical indications

Patients who presented with axial low back pain without severe central canal stenosis were considered candidates for this surgery if they failed at least 6 months of conservative, traditional nonoperative management. Contraindications included significant central canal stenosis, significant rotatory scoliosis, and moderate to severe spondylolisthesis. In some patients, discography was used as a tool to assist in level selection. The group of patients is essentially the same as those with degenerative disc disease and considered candidates for fusion (ALIF) or more potentially lumbar disc arthroplasty. Figure 1 demonstrates images from a representative patient with degenerative disc disease at L2–L3.

Surgical technique

Patient preparation

With general endotracheal anesthesia achieved and intravenous lines started, the patient is placed in a true 90° right lateral decubitus position with the left side elevated and taped in this position. A cross-table anterior-posterior (AP) image helps to confirm the true 90° position. The table and/or patient should be flexed in such a way as to increase the distance between the iliac crest and the rib cage, especially useful at upper lumbar levels and at L4–L5. At times it is helpful to place a bump/roll under the contralateral flank (Fig. 2).

After aseptic treatment of the skin, a k-wire and lateral fluoroscopic image are used to identify the lumbar disc’s mid-position (Fig. 2). A mark is made on the patient’s lateral side, overlying the center of the affected disc space.

Fig. 1. Preoperative images demonstrating degenerative disc disease at L2–L3.
Through this mark, a small incision will be created for insertion of atraumatic tissue dilators and an expandable retractor, which will be the working portal (Fig. 3).

**Retroperitoneal access**

A second mark is made posterior to this first mark at the border between the erector spinae muscles and the abdominal obliques. At this second mark, a longitudinal incision of about 2 cm is made to accommodate the surgeon’s index finger which is inserted anteriorly through the muscle layers (Fig. 4A) to identify the retroperitoneal space. Blunt dissection scissors are used to carefully spread the muscle fibers until the retroperitoneal space is reached. Care should be taken to avoid perforation of the peritoneum. After passing through the fascia and accessing the retroperitoneal space (Fig. 4B), the index finger is used to sweep the peritoneum anteriorly and then to palpate down to the psoas muscle. Once the psoas muscle is identified, the index finger is swept up to the direct lateral target mark. An incision is made at this direct lateral location and an initial dilator (MaXcess System, NuVasive, Inc.) is introduced. The index finger, which is already in the retroperitoneal space, is used to escort the dilator safely from the direct lateral incision to the psoas muscle, protecting the intra-abdominal contents.

Fig. 2. Images demonstrating patient positioning and k-wire planning.
The dilator is then placed over the surface of the psoas muscle, exactly over the disc space to be operated, as confirmed by AP and lateral fluoroscopy.

Trans-psoas access

The fibers of the psoas muscle are then gently separated with the initial dilator using blunt dissection and the Neuro-Vision JJB electromyographic (EMG) monitoring system (NuVasive, Inc.) to assess close proximity of the lumbar nerve roots to the advancing dilator. Care should be taken to minimize trauma to the psoas muscle. The psoas should be parted between the middle and anterior third of the muscle, ensuring that the nerves of the lumbar plexus are located posteriorly and outside the operative corridor. Additionally, direct lateral trajectory through the psoas ensures that the great vessels remain anterior to the operative corridor. The nerves are not visualized, and the size of the psoas muscle does not seem to be a factor in this technique.

The MaXcess dilators are insulated to minimize current shunting while an isolated electrode at the distal tip acts as the stimulation source, connected via a Dynamic Stimulation Clip to the proximal end of the dilator. Experience has suggested that threshold values greater than 10 mA indicate a distance that allows for both continued nerve safety and ample working space.

Disc exposure

The dissection continues, delicately spreading the mid portion of the psoas muscle fibers laterally, while avoiding the genitofemoral nerve, until the surface of the disc is reached (Fig. 4D). Final position should be reconfirmed by fluoroscopy. Subsequent dilators are introduced, gradually spreading the psoas muscle until the MaXcess retractor is inserted over the final dilator (pointing handles of the retractor directly posteriorly) (Fig. 5). Cross-table AP fluoroscopy is used to confirm the position of the retractor blades on the lateral border of the spine. A rigid articulating arm is attached to both the retractor and the surgical table to provide hands-free retraction. The retractor blades are expanded in a cranio-caudal direction to the desired aperture by squeezing the retractor handles. Anterior-posterior exposure is achieved by turning the knobs on the sides of the retractor. Because the articulating arm is attached to the independent posterior blade, expansion by turning the knobs is preferentially anterior so as to minimize blade pressure on the posterior portion of the psoas muscle and the nerves within it. The size of the exposure is customizable as needed and changeable intraoperatively.

A bifurcated light cable is provided with the MaXcess System to provide direct light and visualization into the wound. The single end of the bifurcated cable should be passed off and attached to a xenon arthroscopy light source; the two remaining ends placed down into the retractor blades and bent out of the way of the exposure. The operative corridor is thus established and should be thoroughly explored. Direct visualization and the NeuroVision EMG pedicle probe can be used to affirm a neurologically clear operative corridor. Bipolar electrocautery can be used to prepare disc visualization.

Discectomy and interbody implant placement

Under direct vision (Fig. 6), a thorough discectomy is performed using standard instruments such as an up-biting curette, pituitary rongeur, and various scrapers and broaches (Figs. 7 and 8). The posterior annulus is left intact, with the annulotomy window centered in the anterior half of the disc space and wide enough to accommodate a large implant. Disc removal and release of the contralateral annulus using a Cobb dissector provides the opportunity to place a long implant that will rest on both lateral margins of the epiphyseal ring, maximizing end plate support. Interbody distraction and implant placement in this anterior and bilateral epiphyseal position provides strong support for disc height restoration, and sagittal and coronal plane imbalance correction.

Closure

The exposure is copiously irrigated, and the retractor is removed slowly, so as to observe the psoas muscle...
rebounding and to confirm hemostasis. For both incision sites, the fascial layer is closed with 0 Vicryl and the subcutaneous layer is closed with 2.0 Vicryl sutures (Fig. 9). A 4.0 monocryl is used for subcuticular closure followed by skin glue for the final layer of closure. No drains have thus far been required. The patient is then placed prone for placement of percutaneous pedicle screws or done later at a second stage.

Fig. 4. Extreme Lateral Interbody Fusion procedure demonstrated sequentially. Schematic drawing showing (A) the surgeon’s index finger inserted into the paraspinal incision site, (B) identifying the retroperitoneal space, and (C) guiding the initial dilator into position. Completion of the dilator positioning is achieved when (D) the retractor is inserted into the retroperitoneal space, penetrating the psoas major, and positioned directly on the lateral intervertebral disc space. (Schematics reprinted with permission from NuVasive, Inc., San Diego, CA).
Results

During preoperative consultation, all patients were informed of all surgical options including ALIF, posterior lumbar interbody fusion, transforminal lumbar interbody fusion (TLIF), and XLIF. A complete discussion and description of the XLIF technique was described to all patients interested in the technique. Informed consent was attained for every patient.

Fig. 5. Operative photograph of laterally inserted dilators. With patient in lateral decubitus position, sequentially larger dilators are shown inserted into the patient’s side, penetrating the psoas major, and resting on the desired disc space.

Fig. 6. View of the lateral lumbar spine. The retractor has been inserted through the retroperitoneal space and psoas muscle, exposing the disc space. A bifurcated light cable clearly illuminates the lumbar spine.

Fig. 7. Operative photo of discectomy being conducted under direct vision, facilitated by elongated instruments, a secured retractor, and fiber-optic lighting.

Fig. 8. Operative photo of a distractor inserted into the lumbar disc space, before insertion of a bone graft.
All XLIF procedures were supplemented with percutaneous pedicle screw fixation (either immediate or staged), and all procedures concluded without complication. Figure 10 represents images from a patient having had an L3–L4 XLIF followed by percutaneous pedicle screw instrumentation. Nerve avoidance equipment alerted us to a nearby spinal nerve during the trans-psoas approach in one patient, prompting redirection of the approach more anteriorly, away from the nerve, with no consequence. Thus far, there have been no complications in this institution’s first 13 patients. No postoperative intensive care unit stay or blood transfusions were required. The majority of patients needed only Vicodin and nonsteroidal anti-inflammatory drugs for analgesia and ambulated on postoperative day 1. Visual analog scale and Oswestry disability indexes were collected by our clinic nurse by means of a patient questionnaire that was filled out at every clinic visit. These follow-up results are forthcoming.

Discussion

New techniques and technologies continue to push the limits of minimally invasive spine surgery [19]. Laparoscopic ALIF has been reported to be a safe surgical technique [2] and is commonly performed [2–7]. The primary advantages over the open surgical approach are less tissue trauma, reduced postoperative pain, shorter hospital stays, and earlier return to work. Nonetheless, the advantages of laparoscopy over open techniques have recently been questioned [20].

Laparoscopic techniques are not without their complications. During the initial percutaneous approach, the bowel may be injured [9]. CO2 insufflation may lead to physiological complications [8] such as low cardiac output, elevated mean arterial pressure, and elevated vascular and systemic resistance. Other reported complications have included injury to great vessels [10,11], retrograde ejaculation [12,13], and arterial thromboembolism [21].

Moreover, significant technical challenges limit the value of laparoscopic anterior approaches. Mastering the operative use of laparoscopic instruments is a significant challenge, especially if not routinely employed. Depth perception is compromised with the use of two-dimensional video imaging. Access to the anterior lumbar spine at L4–L5 is particularly challenging with laparoscopy, given that it requires ligation of the iliolumbar vein and mobilization of the great vessels. Lastly, access to the anterior lumbar spine is still dependent on the general surgeon.

Reports have shown that the laparoscopic anterior lumbar approach offers no significant advantage over the mini-open approach [6,22]. Recently, Kaiser et al. reported on 98 patients who underwent ALIF procedures, 47 via laparoscopic approach and 51 via mini-open technique [22]. A significantly longer preparation time was observed when using a laparoscopic approach versus a mini-open approach. The average procedural time for the laparoscopic approach was 185 minutes. Although some of our earlier cases took longer than this time, it is notable that there is a learning curve associated with using a new technique and trusting the nerve monitoring equipment in avoiding nerve injury. Currently we are averaging 45 minutes per XLIF level.

The XLIF technique is a modification of the retroperitoneal approach to the lumbar spine. The technique was first presented in 2001 by Pimenta, who has performed more than 100 lateral trans-psoas surgeries since 1998 [23]. The equipment used in this procedure is uncomplicated, conventional, and does not require additional capital expenditure. An operative microscope may be used, but certainly is not required. In fact, thus far all of our cases have been performed simply using operative loupes. Furthermore, the attachable illumination provided by the MaXcess System enables unparalleled visibility without the discomfort of wearing a headlight.

When compared with anterior laparoscopic approaches to the lumbar spine, the lateral approach has several advantages. First, a general surgeon is not needed for access. A far lateral approach eliminates the need to violate or retract the peritoneum, or to retract the great vessels. Second,
compared with laparoscopic techniques, no steep learning curve exists for this minimally disruptive technique. All tissue dissection occurs under direct vision, without impairment of depth perception. Third, a far lateral approach avoids many of the known complications of laparoscopic anterior approaches, such as damage to the great vessels during mobilization [10,11], and retrograde ejaculation [12,13] most likely from disturbance of the superior hypogastric nerve plexus. Fourth, the most significant advantage we report between the laparoscopic ALIF and our XLI FL is in operative time. When compared with mini-open laparotomy, a laparoscopic ALIF has been noted to have longer operative time [24].

Limitations do exist with this far lateral approach. First, the inferior edge of the 12th rib and the superior edge of the iliac crest limit the potential exposure sites to L1–L2, L2–L3, L3–L4, and L4–L5. Also, dissecting the psoas major, though technically straightforward, must be done carefully so as not to injure the nerves of the lumbar plexus or cause significant trauma to the psoas major. Prior reports of lateral retroperitoneal approaches included mobilization of the psoas muscle from the lumbar spine, but a high incidence of transient numbness along the genitofemoral nerve has been reported after retraction of the psoas muscle [25,26]. Because the XLI FL approach requires neither retraction of the psoas major, nor significant dilation of the dissection site in the psoas major (as the exposure is expanded preferentially anteriorly by locking the posterior retractor blade to the surgical table), transient sensory deficits along the genitofemoral nerve are unlikely. Use of the NeuroVision EMG monitoring system is critical to the safe passage by the nerves within the psoas muscle itself. To date, this initial cohort has not shown any evidence of trauma to the psoas muscle or nerves.

As with most minimally disruptive spinal techniques, intraoperative fluoroscopy use is critical. The actual timing of fluoroscopy use is important; however, it is significantly affected by the experience of the technician as well as the surgeon. We found that our fluoroscopy time was decreased; however, quantitative analysis has not been performed thus far. We hope that we can provide this information in future follow-up studies.

The surgical results of this procedure have shown that it is a safe and reproducible technique. It has demonstrated the benefits of a minimally invasive procedure, with quick recovery and improvements in pain and function scales. It has also demonstrated that the underlying objectives of surgery need not be compromised for the sake of less morbidity. Disc heights were restored and stability maintained by preserving ligamentous structures and inserting a large interbody implant. This can indirectly improve the foraminal volume and result in reduction of radiculopathy. Sagittal balance was maintained or improved by placement of the implant in an anterior position. Coronal imbalances were corrected by ensuring full bilateral end plate coverage by the implant. Although it is still early to fully assess fusion rates, the longer follow-up patients in this study have shown solid fusion progression, apparently uncompromised by the technique.

Conclusion

Given the known complications and challenges of endoscopic spine surgery, the XLI FL may be a valuable alternative to laparoscopic anterior approaches for an interbody spine fusion. Subsequent articles shall report our longer-term follow-up data and efficacy. As comfort with this technique expands, so too do the indications for it. It has more recently also been used to treat low-grade spondylolisthesis and adult degenerative lumbar scoliosis with great success [27]. Longer follow-up is certainly required, but early results are encouraging. Time and increased numbers will also help us in determining fusion rates for future studies. Furthermore, we are in the process of trying to come up
with a control group as well as a more traditional surgical group for comparison.

References

[17] Peloza J. Validation of neurophysiologic monitoring of posterolateral approach to the spine via discogram procedure. Proceedings of the 9th International Meeting on Advanced Spine Techniques (IMAST); May 2002; Montreux, Switzerland.