Clinical Experience, Outcomes, and Learning Curve Following XLIF for Lumbar Degenerative Conditions

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ABSTRACT
BACKGROUND: Many minimally invasive techniques are associated with long surgeon adjustment periods. The XLIF technique has been shown to be minimally invasive with respect to blood loss, hospital stay, and surrounding tissue disruption, but uses familiar instrumentation under direct visualization to minimize the technique learning curve.

MATERIAL AND METHODS: The records and radiographs of 78 consecutive XLIF patients were retrospectively reviewed to assess perioperative and follow-up outcomes measures. A subset of single-level patients was examined for evidence of an early learning curve.

RESULTS: Average patient age was 62.1 years. On average, patients were treated at 1.4 levels and 95% of procedures included posterior fixation. Average blood loss was 109.9 cc, average time was 221.0 minutes. One third of patients experienced transient postoperative thigh discomfort/dysesthesia. There were 8 cases of implant settling/subsidence which were not clinically significant. Evidence of a learning curve was identified with respect to blood loss and procedure time.

CONCLUSION: The reduction in operative time and blood loss over time was suggestive of a slight learning curve; but even the earliest measures were comparable or lower than traditional open procedures. Complications in XLIF are uncommon, and fusion rates are comparable to traditional open procedures.

KEY WORDS: Lateral spine, Learning curve, Lumbar fusion, Transpsoas approach, XLIF

INTRODUCTION
Minimally invasive techniques with tubular and endoscopic technology are often associated with steep learning curves created by a reduction in familiar tactile feedback, high demands for manual dexterity, and the challenging task of interpreting two-dimensional video imaging of three-dimensional anatomy. Minimally invasive techniques for the treatment of the lumbar spine are often celebrated for reducing surgical blood loss, minimizing surrounding soft tissue damage, and shortening hospital stays; however these excellent results are generally documented by surgeons who have overcome the challenges of learning curve and are well versed in the technique.

Variations in technique complexity and surgeon ability complicate definitions of learning curve length and severity, but some studies have reported learning periods as short as 20 cases or as high as 100 cases (4). Procedure times early in a surgeon's experience have been reported to last up to 47% longer than after proficiency is achieved (17).

The lateral retroperitoneal approach to the lumbar spine with the extreme lateral interbody fusion (XLIF) technique has been shown to be minimally invasive with respect to blood loss, hospital stay, and surrounding tissue disruption, but the technique is performed under direct visualization of the surgical site through a small open incision. Direct visualization and an ability to use familiar
instrumentation with the XLIF technique have reduced many of the training hurdles surgeons have faced when learning minimally invasive techniques.

This report summarizes one surgeon’s early experience with the XLIF technique.

MATERIAL AND METHODS

Patient population

The records and radiographs of 78 consecutive XLIF procedures in 76 patients treated between April 2004 and August 2006 were retrospectively reviewed to assess perioperative and follow-up measures including operative time, blood loss, hospital stay, complication rates, and clinical and radiographic outcomes. Prior to surgical intervention, all patients underwent a course of conservative treatment in the form of physical therapy, pain medication, and/or epidural steroid injections. All procedures were performed by a single surgeon (J.H.) at a single center.

Surgical procedure

The XLIF procedure was performed as described by Ozgur (15). The decision of a left-sided vs. right-sided approach was made at the surgeon’s discretion depending on the patient’s anatomy and pathology. Continuous nerve monitoring (NeuroVision®, NuVasive®, Inc., San Diego, CA) was used to safely traverse the psoas muscle during the approach. Once access to the disc space was achieved, a thorough discectomy was performed. The anterior and posterior annulus were left intact and the contralateral annulus was released with a Cobb elevator to allow for symmetrical distraction in the coronal plane. Implants were sized to span the entire endplate and rest laterally on the apophyseal ring. Recombinant bone morphogenic protein (rhBMP-2) was used in the disc space to encourage bone formation for fusion. Most cases were supplemented with either unilateral or bilateral percutaneous posterior pedicle screws to increase segmental stability. Unilateral posterior fixation was performed on the ipsilateral side immediately following the XLIF procedure without repositioning. Patients treated with bilateral fixation were repositioned to prone prior to posterior fixation.

Postoperative care

Within hours of surgery, patients were encouraged to begin ambulation and advised to incrementally increase walking distances as their pain levels permitted throughout their recovery. All patients were prescribed lumbosacral corset for up to six weeks following surgery.

Plain radiographs were collected at patient follow-up visits and computed tomography (CT) scans were obtained between the 6 and 12 month postoperative period to assess fusion. Fusion assessment was based on bridging bone, lack of lucency and lack of significant motion on radiographs when plain films were available.

RESULTS

Demographic data

A total of 78 XLIF procedures were conducted on 76 patients (2 patients returned for treatment at adjacent levels, both were treated with adjacent level XLIF) during the studied time period. Nearly two thirds of the patients were women (57 women and 21 men). The patients ranged from 26 to 85 years of age (mean 62.1 + 14.0 years). Preoperative symptoms included mid-back pain, lower back pain, unilateral or bilateral leg pain, numbness and/or weakness, groin, hip, and/or buttock pain, and trouble walking. Indications for surgery included degenerative disc disease, stenosis, spondylolisthesis, instability, post-laminectomy syndrome, disc herniation, scoliosis, adjacent segment disease, spondylosis, and one case of spina bifida. On average, patients were treated at 1.4 levels. Two thirds of cases were single-level procedures, but as many as four levels were treated during a single XLIF procedure. L4-5 accounted for half (50.9%) of the levels treated. Figure 1 summarizes treatment levels. Most patients (95%) underwent posterior fixation; 60% unilateral and 35% bilateral.

Perioperative Results

Average blood loss for all patients was 109.9 cc (range: 10-650cc). The average blood loss of patients who underwent instrumented XLIF at a single level without repositioning was 63.2 cc (range: 10-250 cc). The average blood loss of patients undergoing XLIF at 1 or 2 levels
plus an additional procedure requiring intraoperative repositioning (e.g., laminectomy, L5-S1 procedure (TLIF or AxiaLIF®, Trans1®, Wilmington, NC), or bilateral posterior fixation) was 107.2 cc (range: 20-650cc). The average operative time for all patients was 221.0 minutes (range 78-489 minutes). The average operative time for a single-level XLIF that did not include patient repositioning for additional procedures was 119 minutes (range: 78-237 minutes), while the more complex surgeries at one or two XLIF levels requiring repositioning and additional procedures averaged 306.9 minutes (range: 135-489 minutes).

No procedures required revision to an alternative approach as a result of technical difficulties. Patients returned to the recovery room in stable neurological condition.

Patients experienced the following immediate postoperative complaints: transient thigh discomfort/dysesthesia (n=26, 33.3%), lower leg pain (n=24, 30.8%), groin/thigh pain (n=5, 6.4%), foot numbness (n=2, 2.6%), back stiffness/discomfort (n=10, 12.8%), wound irritation (n=5, 6.4%) including 2 incidences of dehiscence, and deep vein thrombosis (n=1, 1.3%). There was one reported bowel perforation and a urinary complication; both were approach-related complications related to a non-XLIF approach to L5-S1.

The average length of hospital stay (LOS) was 2.7 days (range 1-7 days); 22% of patients were in the hospital for one day, 35% for two days, 22% for three days, 13% for four days, 8% for more than 4 days (Figure 2).

Patients were prescribed low dose Percocet or equivalent for 2 weeks and gradually weaned to acetaminophen for residual pain. If necessary, depending on symptoms, patients were prescribed physical therapy at 3 months. Therapy was tailored to meet patient needs and typically included back stabilization exercises without stretching. Multi-level fusion patients were typically provided bone growth stimulators to use at home for up to six months.

**Evidence of Learning Curve**

Evidence of a learning curve was examined using the largest subgroup of patients in this cohort: single-level
XLIF patients with or without unilateral pedicle screws who were not repositioned for any additional posterior treatment (n=28). Both blood loss and operative time were reduced over the course of experience, however the relationship between blood loss and patient ID was not significant (p=0.214). Operative time over the course of the experience had a significant correlation to the subject ID (p=0.002). (Figure 3) Additionally, average blood loss and operative time were calculated and compared using independent t-testing for the first and last 10 patients in this subgroup. Average operative time for the first ten patients was 129 minutes; average operative time for the last 10 patients was 112 minutes. Average blood loss for the first ten patients was 80 cc; average blood loss for the last ten patients was 62 cc. No statistical differences between the first ten and last ten patients were identified with respect to blood loss and operative time (blood loss p = 0.554, operative time: p=0.355).

**Long-term Follow-up**

Chart notes for 57 (75.0%) patients were available for review at 6 months, 37 (48.7%) patients at 12 months, and 7 (9.2%) patients at 24 months.

Six-month postoperative or later radiographs were evaluated to assess fusion by the treating physician. Of the 78 cases reviewed in this study, 47 had CT scans and 18 had plain radiographs available. At the time of review 65/65 (100%) of the evaluated cases demonstrated signs of fusion. On average, fusion was observed 8.7 + 4.4 months after surgery. There were 8 cases of implant settling/subsidence (10.3% of surgeries). Seven of these cases fused without clinical consequence and 1 was lost to follow-up; all 8 of these cases included posterior fixation.

In this cohort of patients, pedicle screws were removed if the patient was symptomatic with screw-related bursitis. One patient had screws removed 8 months postoperatively because of a suspected metal allergy. Upon removal of the screw, the patient's symptoms resolved almost immediately.

**DISCUSSION**

With the increasing availability of technically demanding minimally invasive procedures across all surgical fields, patient safety during implementation of technical procedures has become a notable concern (7,12). The XLIF technique uses direct visualization and as a result, does not have the extended learning curve of endoscopic procedures. Jhala et al. reported on their early experience with their first 100 endoscopic lumbar discectomy patients. Though the study had reasonable outcomes, they reported 7 dural punctures and technical difficulties related to guide pin insertion, image orientation, and difficulty targeting the correct operative level (8). The current study demonstrated no evidence of intraoperative technical difficulties related to the learning curve of the procedure.

In 2009, Franke et al examined the learning curve associated with a minimally invasive nucleotomy (MIN) procedure by comparing the results of 27 consecutive cases done by an orthopedic surgeon with limited MIN experience (20 training cases prior to the start of the study) to the results of 25 consecutive cases of an experienced MIN physician (over 150 cases prior to the study) (4). The physician with extensive experience with the procedure had significantly shorter approach and total procedure times, with procedure times 17 minutes shorter on average in the experienced physician's
cohort. Compared to a cohort of patients treated with a traditional microdiscectomy, the surgeon with less minimally invasive experience saw no benefits related to operative time, approach time, or clinical outcomes. More importantly, no evidence of a learning curve was identified in the inexperienced physician’s hands, suggesting that the learning curve had not even begun. The report ultimately concluded that the transferability of shorter operation duration and concomitant clinical advantages of a minimally invasive procedure is not given within 25 minimal invasive procedures.

The reduction in operative time and blood loss over the course of experience in this cohort was suggestive of a slight learning curve, but even the average results for the earliest operative time and blood loss data were comparable or lower than traditional open treatment methods. In the current study, the average operative time for a single-level XLIF without repositioning (with or without unilateral posterior fixation) was 119 minutes. Scheufler et al. reported an average operative time of 104 ± 26 minutes for single-level percutaneous TLIF and 132 ± 18 minutes for single-level mini-open TLIF; 23 and Bergey et al. averaged 149 minutes during single-level endoscopic lateral lumbar surgery (1). Park and Ha averaged 191.7 ± 37.7 minutes for their single-level minimally invasive PLIF cases (16).

The average blood loss of patients undergoing a single-level XLIF without repositioning in this cohort was 63.2 cc. Pimenta et al. reported an average blood loss less than 50 cc in his XLIF series (18). Comparatively, the single-level endoscopic lateral cases reported on by Bergey et al. averaged 150 cc of blood loss1 and the laparoscopic ALIF cases in the Kaiser et al. study averaged 188.2 cc.9 Scheufler et al. reported an average of 55 ± 12 cc for single-level percutaneous TLIF patients and 125 ± 31 cc for the single-level mini-open TLIF cohort (23).

Transient postoperative groin/thigh pain is not uncommon in patients undergoing lateral lumbar surgery. In the current study, about one third of patients experienced this postoperative symptom. Though symptom resolution data in the current study is unclear, Bergey et al. reported that 30% of patients developed transient postoperative groin/thigh pain and all but 2 patients (of 21 total patients) resolved within 4 weeks.1 Similarly, Rodgers et al. report this symptom to be common but reduced within 4-6 weeks in all patients in their first 100 XLIF patients (19). In 1995, Matsui and colleagues found that the length of time in which elevated nerve root pressure was applied increased postoperative neurological compromise and concluded that surgeons should minimizing nerve root retraction as much as possible (11). The XLIF surgery is performed quickly through a small incision with active nerve monitoring to avoid direct or prolonged insult. As a result, nerve retraction is held for limited periods, and the retractors are positioned such that they are expanded anteriorly, avoiding compression of the nerves posteriorly.

Lumbar fusion rates vary widely in the literature as a result of treatment methods, patient populations, and inconsistent fusion assessment methods. In this study, fusion status was assessed by the treating physician from CTs or plain radiographs depending on what imaging was available. Six-month or later postoperative imaging was evaluated to assess fusion. Of the 78 cases reviewed, 65 (80.8%) had at least 6-month imaging available for fusion assessment, and 100% of the evaluated cases demonstrated fusion or evidence of developing fusion. Moreover, there were no revisions in this cohort for segmental non-unions. Recent reports on lumbar fusion have ranged from 91-100% in XLIF 2,14,20,21 90-100% in PLIF/TLIF3,5,6,10, with no apparent difference between minimally invasive and traditional open techniques.

In the current study, there were 8 incidences (10.3%) of subsidence. Seven of the subsided levels fused without clinical consequence and 1 was lost to follow-up. A historical review of BMP in the anterior spine reported subsidence rates as high as 25% in the lumbar spine (13). The authors have since performed these procedure using smaller doses of BMP to avoid early resorption and subsidence.

CONCLUSION

Because of its safety, repeatability, and short learning curve, XLIF stands apart from both traditional open and minimally invasive procedures for the treatment of degenerative conditions of the anterior lumbar spine. Relative to standard procedures, the operative time is shorter, intraoperative complications are uncommon, blood loss is minimal, and fusion rates are comparable.
REFERENCES


