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CLINICAL CASE SERIES

Intraoperative and Early Postoperative Complications in Extreme Lateral Interbody Fusion

An Analysis of 600 Cases

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Study Design. Prospective analysis of 600 extreme lateral interbody fusion (XLIF) approach procedures for intraoperative and perioperative complications.

Objective. To delineate and describe complications in a large, prospective series of minimally invasive lateral lumbar fusion procedures (XLIF).

Summary of Background Data. While some small series of lateral lumbar fusion have discussed complications, no results from large studies have been reported.

Methods. A total of 600 patients were treated with a lateral approach to fusion (XLIF) for degenerative spinal conditions. Data were collected prospectively on all patients and analyzed for demographic, diagnostic, and hospitalization information to identify operative and early postoperative complications. Documented complication types and rates in this large series were compared with smaller prior reports on lateral approach fusions, as well as other minimally invasive (mini-anterior lumbar interbody fusion and minimally invasive surgical [MIS] transforaminal lumbar interbody fusion) and more traditional fusion approaches (posterior intertransverse fusion, anterior lumbar interbody fusion, posterior lumbar interbody fusion, transforaminal lumbar interbody fusion).

Results. Seven hundred forty-one levels were treated, 80.8% single level, 15.0% 2 level, 4.0% 3 level, 0.2% 4 level; 59.3%, including the L4 to L5 levels. A total of 99.2% included supplemental internal fixation; 83.2% included pedicle screw fixation (predominantly unilateral). Hemoglobin change from pre- to postoperation averaged 1.38. Hospital stay averaged 1.21 days. The overall incidence of perioperative complications (intraoperation and out to 6 weeks postoperation) was 6.2%: 9 (1.5%) in-hospital surgery-related events, 17 (2.8%) in-hospital medical events, 6 (1.0%) out-of-hospital surgery-related events, and 5 (0.8%) out-of-hospital medical events. There were no wound infections, no vascular injuries, no intraoperative visceral injuries, and 4 (0.7%) transient postoperative neurologic deficits. Eleven events (1.8%) resulted in additional procedures/reoperation.

Conclusions. Compared with traditional open approaches, the MIS lateral approach to fusion by using the XLIF technique resulted in a lower incidence of infection, visceral and neurologic injury, and transfusion as well as markedly shorter hospitalization. Complications in MIS XLIF compare favorably with those from other MIS fusion procedures; duration of hospitalization is shorter than with any previously reported technique.

Key words: complications, lumbar degenerative disease, minimally invasive surgery, outcomes, XLIF. **Spine 2011;36:26–32**

Instrumented fusion of the spine is a well-established treatment for degenerative conditions. Traditionally, fusion has been accomplished through open surgical approaches,[1] including posterior intertransverse fusion (PLF)[2,3]; posterior lumbar interbody fusion (PLIF),[4] either with[5–8] or without[9] supplemental pedicle screw instrumentation; transforaminal lumbar interbody fusion (TLIF)[10–13]; or anterior lumbar interbody fusion (ALIF).[9,14–17] More recently, minimally invasive surgical (MIS) approaches[18]—endoscopic ALIF,[19] mini-ALIF,[20] or MIS TLIF[10,11,20]—have been described. The extreme lateral interbody fusion (XLIF) represents a 90° off-midline retroperitoneal MIS approach: in effect, a lateral mini-ALIF.[21–23]

Perioperative complications, including infection, visceral injury, instrumentation malposition, and neurologic deficits,[1–20] have been reported with all of the previously delineated surgical approaches. Large series have described the complications of traditional open procedures in detail.[1–3,5–9,11,12,14–17] Smaller series of MIS cases have also reported complications.[10,11,19,20] To our knowledge, only one report[24] has specifically addressed complications in patients treated with MIS lateral fusion, although complications have been mentioned in other reports.[21–23] In that series of 58 patients,[24] the authors combined two different lateral techniques—XLIF and direct lateral interbody fusion (DLIF)—but did not distinguish between the two techniques in regard to complication incidence. They reported adverse events in 22.4% of patients, with major complications in 8.6%, including two cases of persistent motor deficits from

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injury to the L4 nerve root. In four additional cases, the procedure was aborted because of concerns about nerve proximity. While the authors noted a reduction in blood loss when compared to historical reports, they reported little improvement in duration of hospitalization—6 days (XLIF) and 4 days (DLIF)—for the two techniques.

Our own experience using one lateral fusion technique (XLIF) has differed significantly in incidence of both adverse events and neurologic problems (postoperative deficits and intraoperative procedure cancellation) as well as hospitalization. The current study sought to enumerate, elucidate, and evaluate the intraoperative and early postoperative complications in a large prospectively collected series of MIS lateral-approach lumbar fusions.

MATERIALS AND METHODS

A retrospective review of a prospectively compiled database maintained by the senior author (W.B.R.) was completed. Patients were evaluated after surgery by the operative surgeon (senior author). Patient data, including demographic, surgical, radiographic, and clinical outcome details were entered into the database as were all intraoperative and postoperative complications and adverse events. All consecutive patients treated by the two spinal surgeons at our institution with the XLIF procedure since its introduction in 2006 were reviewed. Patients were candidates for surgery if fusion was indicated because of degenerative disease and if a full course of conservative care had been exhausted. For study purposes, we intended to exclude any nonelective or nondegenerative fusion procedure; thus, all neoplastic, traumatic, and infectious cases would have been excluded, but none met this criterion.

Six hundred XLIF approaches formed the study group. All procedures were performed at St. Mary's Health Center. Appropriate Health Insurance Portability and Accountability Act guidelines were followed. The St. Mary's Health Center institutional review board (IRB) gave approval to the study and this report.

A perioperative complication was any unexpected adverse event that occurred during the procedure. An *early postoperative complication* was defined as any unexpected adverse event occurring within the first 6 weeks of the index procedure. Complications were recorded whether or not the event required any additional treatment or intervention. These were divided into categories of surgical or medical complications and occurring in hospital or out of hospital. Complications were further categorized by system as follows: wound, neural, cardiac, renal, gastrointestinal, respiratory, and vertebral body/instrumentation-related complications. Complications that required readmission to the hospital or reoperation were specifically noted. Complications were recorded prospectively by the senior author (W.B.R.), and charts were reviewed by the institutional research coordinator (J.R.P.). Furthermore, the chair of the IRB reviewed the manuscript for validity.

Multivariate logistic regression analysis was performed by using age, sex, obesity (defined by body mass index), diagnosis, comorbidities (including diabetes mellitus, coronary artery disease, chronic obstructive pulmonary disease, chronic steroid use, and smoking), and number of levels treated to test whether each parameter was independently associated with complications. Student t tests and χ^2 tests were used where appropriate to assess differences between those with complications and those without complications. All analyses were performed by using Analyze-It software (Analyze-It Software, Ltd., Leeds, England) with significance level of 0.05.

The XLIF approach has been described previously in detail.[21,22] Six hundred procedures were performed on 370 women and 230 men. Demographics, diagnoses, and comorbidities are shown in Table 1. Age at the time of surgery ranged from 22 to 89 years. Body mass index ranged from 16.5 to 61.8. A total of 76.5% had at least one preexisting comorbidity. Of the 237 (39.5%) patients who had had prior surgery, 148 (62.4%) of those were prior fusion procedures (Figure 1). Four hundred eighty-five procedures were single level, 90 were two levels, and 25 involved three or more levels (average: 1.24 levels). Supplemental posterior instrumentation was used in 511 procedures (these cases having been judged to have clinically significant deformity or instability—scoliosis, unstable listhesis, or extreme patient body habitus), and lateral fixation alone in 84 procedures; 5 (0.8%) cases were performed without additional stabilization.

RESULTS

Surgeries resulted in an average hemoglobin change from pre- to postoperation of 1.38 g. Length of hospitalization averaged 1.21 days. Visual analog scale (VAS) pain scores decreased from

TABLE 1. Group Demographics.

Average age	61.4 yrs
% female	62.0
Average BMI	31.1
Primary diagnosis	
Stenosis	50.8%
Spondylolisthesis	14.5%
DDD	11.8%
HNP	9.7%
Scoliosis	6.8%
Postlaminectomy	6.2%
Osteomyelitis	0.2%
Smoking	34.8%
Diabetes	22.2%
CAD	50.0%
COPD	4.5%
Chronic steroid use	11.3%
Cancer	10.5%
Prior surgery	39.3%

BMI indicates body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DDD, Degenerative Disk Disease; HNP, Herniated Nucleus Pulposus.

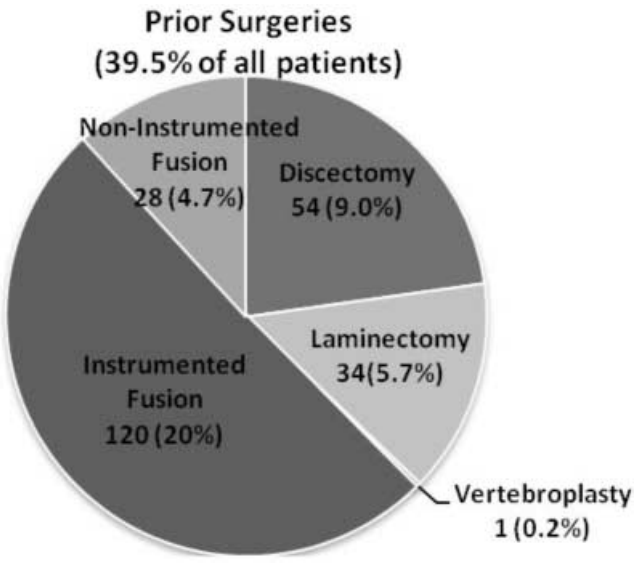

Figure 1. Breakdown of prior surgeries by type (percentage of total number of XLIF patients, 600).

an average 8.82 to 3.12, a 65% immediate improvement. A total of 86.7% patients with minimum 1-year follow-up (n = 308) reported satisfaction with their procedures, 90.4% stating that they would elect to have the surgery again.

There were 37 total complications (Table 2) that were classified into medical (60%) and surgical (40%). The overall incidence of perioperative complications (intraoperation and out to 6 weeks postoperation) was 6.2%: 9 (1.5%) in-hospital surgery-related events, 6 (1.0%) out-of-hospital surgery-related events, 17 (2.8%) in-hospital medical events, and 5 (0.8%) out-of-hospital medical events. Medical complications by organ system (3.7%) included seven gastrointestinal, seven respiratory, six cardiac, and two renal.

There were no wound infections, no vascular injuries, no intraoperative visceral injuries, and four (0.7%) transient postoperative neurologic deficits. Eleven events (1.8%) resulted in additional procedures/reoperation.

While average age initially appeared to be a marginally statistically significant factor (average age was 65.6 yrs in those with complications and 61.1 yrs in those without complications; *t* test $P = 0.0461$), more careful statistical analysis revealed that increasing age was not an overall factor for the occurrence of complications (χ^2 test $P = 0.3632$; Table 3).

Patients with comorbidities were no more likely to have complications than those without comorbidities ($P = 0.6014$). No individual comorbidity (*e.g.*, diabetes mellitus, heart disease, pulmonary disease, renal failure, or steroid use) was found to be predictive of the development of complications ($P \geq 0.05$).

Prior surgery, and particularly prior fusion surgery, was a statistically significant factor ($P = 0.0266$ and $P = 0.0192$, respectively) in the incidence of complications. The total number of levels treated per surgery was not a factor, but the inclusion of the L4–L5 level was ($P = 0.0163$).

TABLE 2. Detailed List of Complications in 600 XLIF Surgeries

Type	n (%)	Description (n)	Consequence
Wound	2 (0.3)	Hernia (1), Subcutaneous hematoma (1)	Required repair,* drainage*
Neural	4 (0.7)	Quadriceps weakness (3), Anterior tibialis weakness (1)	None, all resolved within 3 mo
Vertebral	6 (1.0)	EP fracture (1), VB fracture/subsidence (1), OP fracture (1); adjacent-level compression fracture (2); iatrogenic HNP (1)	5/6 required reoperation (vertebroplasty/2,* decompression/1,* and/or PLF/2*)
Hardware	2 (0.3)†	Implant fracture/subsidence (1), screw break through endplate/subsidence (1)	Required revision (posterior pedicle screw fixation/2*)
GI	7 (1.2)	Ileus (6), gastric volvulus (1)	Repair of gastric volvulus*
Respiratory	7 (1.2)	Pneumonia (5), pulmonary embolus (2)	2 prolonged intubations, antibiotics, anticoagulation
Cardiac	6 (1.0)	Atrial fibrillation (5), MI at 6 wks (1)	None/medical treatment
Renal	2 (0.3)	Urinary retention (1), peritoneal catheter occlusion (1)	Revision of catheter*
Hematologic	1 (0.2)	Postoperative anemia (1)	Transfusion
Total	37 (6.2)		*11 reoperations

**The hernia in the lateral incision was repaired surgically some months after the index procedure; the large subcutaneous hematoma on the lateral incision was operatively drained the first postoperative night.*

†There were an additional two incidences of interbody implant fracture during impaction, but they were inconsequential and replaced during the index procedure and so are not included in the total number of defined complications.

EP indicates end plate; GI, gastrointestinal; MI, myocardial infarction; OP, osteophyte; PLF, posterior intertransverse fusion; VB, vertebral body.

TABLE 3. Breakdown of Complications by Age

Age (yrs)	n	n, Complications Per Age Group	Complications as a % of Age Group	Medical	Surgical
80–89	50	4	8.0	3	1
70–79	137	13	9.5	10	3
60–69	152	9	5.9	4	5
<60	261	11	4.2	5	6
Totals	**600**	**37**	**NA**	**22 (3.7%)**	**15 (2.5%)**
		*$P = 0.3632$			

*Decade of life was not a statistically significant factor in the incidence of complication.

With respect to neural complications, it should be noted that after the fourth postoperative motor deficit (of 314 consecutive cases), the senior author began to administer dexamethasone (10 mg intravenously (IV) before skin incision) prophylactically in all XLIF patients in whom the L4–L5 level was to be approached. In the last 286 patients since the use of dexamethasone, there was not an additional neural deficit. This difference was not statistical ($P = 0.0563$). However, since the time of the original writing of this report, additional 72 patients were treated at L4–L5 level, using dexamethasone and without neural deficit, which had brought the result to a significant level ($P = 0.0245$).

Neither pain score improvement nor patient satisfaction was significantly different between those with and without complications ($P = 0.6960$ and $P = 0.8479$, respectively).

DISCUSSION

No medical or surgical intervention can be completely free of complications and adverse events. MIS procedures have been advocated in the hope that through lessening the collateral damage incumbent in an open approach to the spine, the corollary complications would decrease—as would the duration of hospitalization and out-of-hospital recuperation. To our knowledge, this report represents the first discussion of the complications of one minimally invasive spinal fusion approach option, XLIF, in a large series of cases.

Complications of spinal surgery may be discussed as general complications of surgery (bleeding requiring transfusion, wound infection, *etc.*), approach-related complications (visceral or vascular injury in anterior approaches; dural laceration or epidural hematoma in posterior approaches), spine surgery–specific complications (neural injuries, sensory or motor, at the level of the spinal cord or cauda equina, nerve root, or lumbar plexus), technique-related complications (early reoperation for misplaced instrumentation or inadequate decompression), and medical complications in the acute perioperative period (usually discussed by organ system). Length of hospitalization, while not indicative of complications *per se*, has a direct effect on the cost of medical care and can be used as a shorthand method of describing efficiency.

The literature describing the complications of spinal surgery is usually discussed in an approach-derivative format. However, review of the existing reports can yield some information about the incidence of the general complications of surgery. In regard to transfusion for the anemia incumbent in the blood loss of spinal fusion surgery, the incidence has ranged from 0.0% for MIS TLIF and TLIF[12,13] to 4.7% for anterior-posterior ("360") surgery,[12] 26.5% for instrumented posterolateral fusion,[2] and 63.4% for revision-instrumented posterior fusion.[7] Unfortunately, the largest series of ALIFs to be reported—338,[15] 471,[14], and 1310[16] patients, respectively—fail to mention the incidence of transfusion. The data from the current study presented herein (1/600 transfusions, or 0.2%) compare favorably with all reported techniques. In the one case, a 78-year-old woman with degenerative scoliosis after a prior laminectomy and severe cardiac disease, transfusion was performed for a hemoglobin of 8.4 g after a three-level instrumented MIS fusion (XLIF L3–L5, AxiaLIF L5–S1, posterior pedicle screw instrumentation L3–S1, TranS1, Wilmington, NC; before surgery, the patient's hemoglobin had measured 11.9 g.

In like manner, the incidence of infection varies widely by technique, ranging from 0.0%[12] to 3.6%[13] for TLIF and 2.7%[12] to 3.1%[11] for MIS TLIF. Posterolateral fusion fares somewhat similarly with infection occurring in 0.4% 6 to upward of 11% of patients for instrumented PLF or PLIF.[1–3,7,11,25–30] The large ALIF series do not report infection rates,[14–16] while a small series of endoscopic ALIF reported 3.2%[19]; it should be noted that this study has been erroneously cited as describing the XLIF technique.[18] While TLIF does show excellence in this regard, it should be remembered that the reported series included only 51 patients. MIS decompression alone has been reported to have an incidence of infection of 2.3%,[31] but neither Knight's report of 58 patients[24] nor the current report of 600 patients has shown an infection with a lateral MIS fusion technique.

XLIF, as mentioned previously, may be considered a lateral MIS ALIF. The most devastating complications of open ALIFs have been visceral and vascular injuries. In intermediate-sized series, visceral injuries have ranged from 0.0%[9] to 3.3%.[17] Larger series have discussed vascular injuries, with rates from 1.9% to 3.0%.[14–16] Once again, neither Knight's small series[24] nor our large one reported a vascular complication, neither did Bergey's series of 21 endoscopic ALIFs[19]; however, two

small series comparing laparoscopic and mini-open ALIFs have reported cases of ureteral and vascular injuries in 2% to 4% of cases.[32,33] Retroperitoneal hematomas requiring hospitalization—either from surgical bleeding or small vascular injury—have also been reported in endoscopic and mini-open ALIF procedures.[32,33] ALIF studies have also reported an incidence of retrograde ejaculation in men of 0.6% to 45%[12,17,32]; this complication has not been reported with the lateral MIS approach, since L5 to S1 levels are approached very infrequently, if at all, laterally. Above L5 to S1, the lateral MIS approach appears to obviate many of the concerns about visceral and vascular injury through an orthogonal approach to the spine through the retroperitoneal space.

Our series of 600 cases included 511 cases with supplemental posterior instrumentation. In no case was a dural injury noted—unlike reports of posterior lumbar fusion approaches with reports as high as 93.5% (report of Scaduto *et al*[9] of threaded-cage PLIF without supplemental posterior instrumentation). More commonly, dural injuries occur from 0.0% to 20% in posterior fusions[2,6,10–12,28,29] and have been reported in ALIFs as well (0.2%). Fourteen TLIF, designed to minimize dural exposure, has nonetheless reported an incidence from 0.0% to 19.6%.[11,12] A series of 220 MIS posterior decompressions without fusion reported an incidence of 7.7%.[31] Epidural hematoma, while rare, has been reported in some series (2.1%–9.7%).[9,26]

Reoperation rate can also be used as a marker of complications. Early reoperation is, generally, reflective of technique difficulties—misplaced implants and/or instrumentation, dural tears resulting in chronic cerebrospinal fluid (CSF) leakage, or infection. While the rates of early reoperation vary widely, this has been reported in up to 25% of instrumented posterolateral fusions3 and 12.5% of MIS TLIF cases.[11] Implant/instrumentation problems requiring revision are particularly noted in MIS TLIF studies—9.5%[10] and 12.3%[12] in two studies. Knight mentions these problems in 1.7% of that lateral MIS series.[24] While not specifically addressing early reoperations, two studies of ALIF[17] and mini-ALIF[20] have noted incisional hernias in 3.3% and 2.2%, respectively. We have seen two cases of cage fracture on insertion (revised during the index procedure) as well as one case of vertebral body fracture with implant subsidence, one case of postoperative implant fracture and subsequent subsidence, and another where the laterally placed screws broke through the end plate, all three events requiring early revision. No other early implant/instrumentation failures were noted but, it must be mentioned that of the 600 patients treated in this series,[10] 1.7% have required subsequent formal posterior decompression within 6 months. Two other patients required early foraminotomy—one for a disc herniation contralateral to the side of the operative approach presumably caused by inadequate disc removal during the XLIF procedure and another for foraminal stenosis that developed 4 days after XLIF when a corner of the superior vertebral body fractured off and into the foramen. One patient developed a subcutaneous hematoma, drained the night after surgery, and another developed an incisional hernia, repaired at 3 months.

Motor deficits are, perhaps, the area of greatest concern to spinal surgeons and have been discussed frequently in relation to the lateral approach to the spine. Study by Knight reported two cases of permanent motor deficits thought to be due to injury to the L4 root.[24] While certainly concerning considering the proximity of the lumbar plexus to the approach zone in lateral surgery, it must be remembered that permanent motor deficits have been reported in 0.8% to 3.6% of instrumented PLFs,[1–3,26] 1.0% 6.1% of PLIFs,[5,6,25,30] 4.1% of MIS TLIFs,[12] 6.5% of endoscopic ALIFs,[19] 1.5% of open ALIFs,[14] and 0.5% of MIS decompressions.[31] We have found that motor deficits do occur during XLIF procedures despite the use of neurologic monitoring in all cases but that the incidence is lower than with other fusion techniques (4 deficits/600 cases, 0.6%). In our series, we noted several key findings. The deficits always occurred in patients treated at L4 to L5, usually (three of four cases) involved quadriceps weakness,\ and resolved nearly completely in all cases within 3 months. Premedication of the patients undergoing surgery at L4 to L5 levels with dexamethasone 10 mg IV before surgery has significantly reduced the incidence of these transient motor deficits and is now statistically significant.

Another area of concern in lateral-access spinal surgery is postoperative thigh pain. Patients were evaluated by a mid-level provider at each visit and were queried about pain and weakness. In our experience, thigh pain and hip flexor weakness are nearly universal—due, perhaps, to direct trauma to the psoas muscle, as opposed to the neural deficits discussed previously. This is always transient. Some symptoms experienced by patients in the early course of healing (*e.g.*, pain and/or weakness in an operatively traumatized muscle) are quite likely a normal part of recovery, at least within the first 6 weeks of a procedure. Of the 600 patients in this report, 308 have returned for 1-year follow-up. In these surveys, 86.7% of respondents rated themselves as "Satisfied" or "Very Satisfied" with the procedure, and 90.4% responded that they would elect to either "Definitely" or "Likely" have the procedure again.

Medical complications also deserve some mention. These have been reported in all series and are thought to be more common in the elderly.[2] Indeed, in that series of 98 patients older than 65 years treated with instrumented PLF, more than one-third developed urinary tract infections, one-fifth had gastrointestinal complications, and more than 10% developed respiratory and cardiac problems. In this series of 600 patients, 50 were aged 80 years or older, with an additional 137 aged 70 to 79 years. The total incidence of medical complications for the series was 3.7%, with no difference in incidence of complications among the later decades of life ($P = 0.3532$). We have reported elsewhere our detailed experience with medical complications in the elderly[34] in XLIF surgery, as well as in the obese—another group often considered at higher risk of complication.[23]

Finally, length of hospitalization is often an indicator of the severity of the stress of a given procedure on the patient. This can vary widely from country to country, but, in series from the American literature, ALIFs show a length of hospitalization of around 4 days,[9,14,17] while PLIFs and instrumented PLFs trend from 4 to 10 days[1,2,7,9] and TLIFs 3 to 6 days.[10,12,13]

In our series of XLIFs, the average hospitalization was 1.2 days, nearly exactly the same as the literature reports for MIS decompression alone.[31]

It is in this area among several others where our experience with lateral-access spinal surgery differs significantly from that reported earlier by Knight *et al*.[24] That article reported 58 cases by using both XLIF and DLIF without delineating the number of each type of procedure or distinguishing the complications by procedure. Two permanent motor deficits were noted and, in addition to the 58 procedures performed, another four cases (all at L4–L5) were aborted because of concern about neural proximity. Since the recommended technique was somewhat different in the two procedures and the duration of hospitalization in that series was so prolonged (XLIF, 6 days; DLIF, 4 days), one might argue that that study was a learning-curve comparison and should not be cited as definitive. Clearly, our results are somewhat at odds with that study, as is our motor complication rate and length of stay. To date, we have not had to abort an XLIF procedure because of neural proximity or other anatomic issues.

However, a methodologic flaw must be noted with our study in this regard. Complications were recorded by the treating physician and reviewed by the senior author (W.B.R.). The totality of the patient group was reviewed by the research coordinator (J.R.P.) and assessed by the chair of the IRB for validity. We believe that these two additional checks—research coordinator review and IRB chair assessment—somewhat obviate legitimate concerns about underreporting of those complications presented to us (*i.e.*, all complications in the medical records were assuredly included in this analysis). We concede, however, that the actual rate of patient complaints might have been higher if a more formal process for seeking patient reporting of complications had been undertaken, rather than the observational design of this study.

Spinal surgery in general, and fusion surgery in particular, has been much in the news of late. Even though surgery for spondylolisthesis has been shown to be more effective than nonoperative care, recent interpretations of the Spine Patient Outcomes Research Trial have questioned the cost-effectiveness of fusion surgery compared to decompression alone for degenerative stenosis with spondylolisthesis.[35] This study noted a quality-adjusted life year (QALY) gain of 0.23 in the fusion cohort but this came at a cost of $115,600 per QALY gained. No breakdown of the 344 fusion surgeries (269 with instrumentation) by type of procedure was provided, but on the basis of the timeframe of the study, it may be inferred that the vast majority of those fusions were performed by using traditional open techniques. As we have shown in this and other reports,[23,34,36] the complications associated with MIS XLIF fusion are less than the complications reported with traditional open approaches, and the length of hospitalization is markedly shorter. It stands to reason that modern surgical fusion options—like XLIF—would be expected to yield a markedly decreased dollar cost per QALY gained, because these MIS techniques require shorter hospital stays and result in fewer expensive complications.

In summary, this report represents the first large series of XLIF procedures prospectively monitored for early complications. In comparison to traditional open posterior or anterior techniques, XLIF demonstrated fewer total, and fewer serious, complications. In like fashion, XLIF proved equal or superior to literature-reported rates of complications for MIS fusion alternatives—TLIF, mini-ALIF, endoscopic ALIF, *etc*. In cohorts of the ill, obese, and elderly, the complication profile was lower than the one that has been reported for other techniques. MIS procedures, such as XLIF, offer great hope of reducing the morbidity, cost, and recovery time for patients who need spinal fusion surgery.

➢ Key Points

- ❑ The extreme lateral lumbar fusion approach can be performed safely.
- ❑ Complication rates for minimally invasive surgery are lower than those for traditional open procedures as reported in the literature.
- ❑ Complications are statistically more common if the L4 to L5 level is an operatively treated level.
- ❑ Postoperative neural deficits were extremely rare (<0.7%), transient, and might be prevented by the preoperative administration of dexamethasone (10 mg IV) before skin incision.

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