Original Study

Analysis of single-position for revision surgery using lateral interbody fusion and pedicle screw fixation: feasibility and perioperative results

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Background: To analyze perioperative and radiographic outcomes following revision surgery using lateral lumbar interbody fusion (LLIF) performed entirely in the lateral position. Traditionally, patients undergoing interbody fusion in the lateral decubitus position are placed prone for pedicle screw fixation. However prone positioning carries known risks and may increase surgical time due to the need to re-drape and reposition. Little is published regarding revision surgery in a single position.

Methods: Sixteen patients over the age of 18 with degenerative lumbar pathology who underwent a revision of previous lumbar fusion using interbody fusion via lateral access and revision of posterior instrumentation from a single surgeon met inclusion criteria. Patients who underwent combined procedures requiring repositioning or had inadequate preoperative imaging were excluded. Patients remained in the lateral decubitus position for the entirety of the procedure including interbody placement, revision of prior instrumentation, and pedicle screw fixation. Demographics, surgical details, and perioperative outcomes were reported.

Results: The mean operative time was 211 minutes for all cases, 161 minutes for single-level procedures and 296 minutes for two-level procedures. Mean estimated blood loss was 206 cc. The mean patient age was 66, 70% of which were male. The mean body mass index (BMI) was 27.4 and Charleson Comorbidity Index (CCI) was 3. All cases were performed on the lumbar spine (T12/L1–L4/L5), with the majority of procedures performed at the L2/3 level (44%). The mean pelvic incidence (PI) was 60 degrees (range, 41–71 degrees) with mean preoperative PI/lumbar lordosis (LL) mismatch of 23.9 degrees. Mean postoperative PI/LL mismatch was 12 degrees.

Conclusions: Revision surgery in the lateral position is feasible with complication rates comparable to published literature. The need to reposition is eliminated and single position surgery reduces operative time.

Keywords: Lateral interbody fusion; pedicle screw fixation; lateral access surgery; lateral decubitus position; revision surgery

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Introduction

Lateral access surgery or lateral lumbar interbody fusion (LLIF) for treatment of degenerative lumbar conditions has seen an increase in popularity among spine surgeons since its initial introduction (1-4). More recently, the feasibility of single position lateral surgery has been explored (5). Revision lumbar spine surgery carries a significant complication profile (6-9). Little has been published

regarding the utility of performing single position lumbar revision surgery.

The lateral position tends to be better tolerated by the patient compared to prone surgery and avoids many of the major concerns that exist with prone positioning including but not limited to: postoperative vision loss, cardiovascular complications, hypovolemia, reduced pulmonary compliance, and cardiac arrest (10-12).

The purpose of this study was to present perioperative complications and short-term outcomes from a series of patients who underwent LLIF for revision of prior instrumented lumbar fusions with revision of the posterior instrumentation and bilateral percutaneous pedicle screw placement while maintaining the patients continuously in the lateral decubitus position.

Methods

This retrospective chart review was approved by the Stanford University Institutional Review Board (#7935). All revision LLIFs performed via lateral access from a single surgeon (I Cheng) from November 2014 to June 2018 were eligible for study inclusion.

Patient population and data collection

Inclusion criteria were patients over the age of 18 undergoing revision LLIF for any degenerative lumbar pathology who also had previous instrumented lumbar fusions. Exclusion criteria included patients with a history of retroperitoneal surgery, those with inadequate preoperative imaging available for review, and patients undergoing combined procedures including direct posterior decompression, trans-foraminal lumbar interbody fusion, posterior lumbar interbody fusion, or anterior lumbar interbody fusion (ALIF).

The final cohort consisted of sixteen patients. Patient demographics [age, sex, and body mass index (BMI)] and surgical details (previous lumbar spine surgeries, indications for surgery, and number of operative spinal levels) were recorded. Imaging consisted of preoperative and postoperative anteroposterior (AP) and lateral lumbar films with measurement of overall and segmental lordosis. Two senior orthopaedic residents that remained independent of the surgeries measured the radiographs. Surgical characteristics investigated included estimated blood loss, operating room time, pre- to post-operative change in overall lordosis, length of stay, comorbidities and reoperation rates (within 30 days).

Postoperative protocol for the primary surgeon includes formal standing films for all postoperative fusion patients prior to discharge and then again at first follow up at 6 weeks post op. Computed tomography is not routinely obtained. Pedicle screw breach, if relevant, is monitored clinically and with radiographs.

Surgical technique

Patients were all placed in the lateral decubitus position for the lateral approach, discectomy, interbody sizing, and placement. Electromyography and fluoroscopy were used during the entirety of the procedure. Patients remained in the lateral decubitus position for revision of the posterior instrumentation and percutaneous pedicle screw fixation. Revisions of the posterior instrumentation included removal of implants and/or adding onto the prior instrumentation.

Tip and tricks

For those unfamiliar with single-position lateral decubitus surgery for interbody placement, fixation, and revisions, the authors have learned some tips and tricks which may be helpful. First, proper patient positioning is crucial. To access the dorsal aspects of the patient adequately, the patient should be placed with their back closer to the edge of the operating table than may be usual. Second, draping must be carefully performed to provide access to the downside of the patient. Stapling the drapes may be helpful in maintaining sterility of the field. Third, sufficient space should be provided for the C-arm fluoroscopy to image each operative level both in the AP and lateral views. This may require positioning the patient's arms with the elbows bent at 90-degree and placement of any retractor arm attachments on the dorsal aspect of the patient. Fourth, practicing lateral position screw placement in a laboratory setting can be a boon. The authors have found that the visual-spatial orientation of placing pedicle screws at a 90-degree angle to typical screw placement can be daunting. It may be beneficial to use navigation in the early stages of screw placement. Finally, the authors have found that paraspinal Wiltse-type incisions provide easier access to previously placed instrumentation than a midline approach. Fluoroscopic identification of the location of prior implants prior to incision can aid in precise dissection.

Results

Sixteen patients met inclusion criteria and were included

Table 1 Patient demographics

Variable	Number
Number of patients	16
Age (y), mean	66
Male %	70
Female %	30
Charleson Comorbidity Index, mean (range)	3 (0–6)
BMI mean (range)	27.4 (19.9–42.5)

Table 2 Surgical characteristics

Variable	PJK	Pseudarthrosis	DDD
Number of patients	6	5	5
Anterior release	4	1	1
Posterior instrumentation replaced	4	2	3

PJK, proximal junctional kyphosis; DDD, degenerative disk disease.

Table 3 Radiographic parameters

Parameter	Number
Pre-op lumbar lordosis, mean	35.7
Post-op lumbar lordosis, mean	45.1
Pelvic incidence, mean [range]	59 [41–71]
Pre-op PI-LL mismatch, mean	23.9
Post-op PI-LL mismatch, mean	12

PI, pelvic incidence; LL, lumbar lordosis.

Table 4 Complications

Surgery	Complication
LLIF L1–L3	Hip flexion weakness, resolved by 6 weeks postop
LLIF L3–L4	Urinary retention required discharge with Foley
LLIF L2–L4	Hip flexion weakness, resolved by 6 weeks postop
LLIF T12–L2	Hip flexion weakness, resolved by 6 weeks postop
LLIF L3–L4	Hip flexion weakness, improving

LLIF, lateral lumbar interbody fusion.

in the analysis. The majority of cases were undergoing revision for a diagnosis of adjacent segment disease (ASD) (85% of cases) followed by pseudarthrosis in 23%. All pseudarthrosis diagnoses were confirmed upon exploration of the fusion. Fifty-four percent of cases were a single-level, 46% were two-level. All cases were performed by a single surgeon at a single institution. The mean patient age was 66 years (range, 19–88 years), 70% of which were male. The mean BMI was 27.4 (range, 19.9–42.5) and 38% had diabetes. The mean Charleson Comorbidity Index (CCI) was 3 (range, 0–6) (see *Table 1* for patient demographics; see *Table 2* for surgical characteristics).

All patients successfully underwent revision in the lateral position for both LLIF and bilateral pedicle screw and rod fixation. The extent of revision varied by indication. In 46% of cases an anterior longitudinal ligament (ALL) release was performed in addition to the placement of the anterior interbody device. In the majority of cases the previous posterior instrumentation was removed prior to new posterior instrumentation (69%), and in 38% rod connectors were utilized (see *Table 2* for operative characteristics) The mean operative time was 211 minutes for all cases, 161 minutes for single-level procedures and 296 minutes for two-level procedures. Mean estimated blood loss was 206 cc. The mean patient age was 66, 70% of which were male. Mean hospital stay was 3 days. The mean BMI was 27.4 and CCI was 3. All cases were performed on the lumbar spine T12/L1–L4/L5), except for a single T10–11 pseudarthrosis (with the majority of procedures performed at the L2/3 level (52%). The mean pelvic incidence (PI) was 60 degrees (range, 41–71 degrees) with mean preoperative PI/lumbar lordosis (LL) mismatch of 23.9 degrees. Mean postoperative PI/LL mismatch was 12 degrees.

There were no reoperations within 30 days (*Tables 3,4*; *Figures 1,2*).

Discussion

Revision spine surgery after lumbar fusion is a challenging proposition. Even with clear indications for reoperation, clinical outcomes measured by Oswestry Disability Index (ODI) and patient reported surveys after revision may not capture statistically significant improvement (8,13,14). This is complicated by the fact that revision surgery is associated with a high complication rate, in addition to the considerable cost associated with revision surgery (6,7). This makes careful review of high risks versus the benefits by the surgeon and patient extremely important prior to proceeding with revision lumbar fusion. With safety as the primary concern, once the decision has been

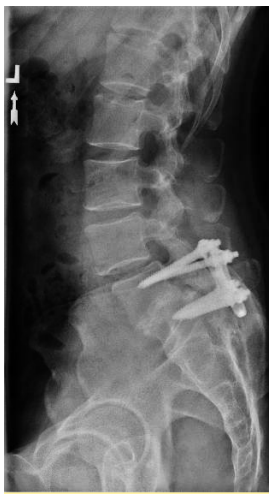

Figure 1 Preoperative lateral lumbar radiograph in a 50-year-old patient presenting with severe low back and left leg pain. Imaging notable for solid 5-1 fusion performed 16 years prior to presentation. Note proximal listhesis of 4 on 5 of 6 mm.

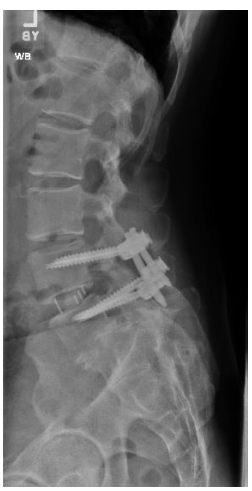

Figure 2 Postoperative imaging status post LLIF with removal of prior instrumentation and extension of fusion to L4. LLIF, lateral lumbar interbody fusion.

made to proceed with revision surgery, it is important to consider modifiable variables that may alter the risk profile of the surgery. One of those important considerations is the position in which the procedure is performed. Most commonly, these procedures are performed in the prone position, or a combination of supine and prone positioning, due to the convenience of prone positioning in terms of ease of access as well as surgeon familiarity. The prone position, however, carries with it significant and well-documented risks that can result in permanent disability, including but not limited to: postoperative vision loss, cardiovascular complications, hypovolemia, reduced pulmonary compliance, and cardiac arrest (10-12). The lateral position, on the other hand, tends to be better tolerated by the patient compared to prone surgery and avoids many of the major concerns that exist with prone positioning (10-12).

As healthcare systems move towards value-based care, considerations of alternative forms of surgical techniques that decrease cost without compromising patient safety and surgical outcomes deserve investigation (15,16). Lateral access surgery is one of these techniques that can enable decrease cost through shorter operative time and lowered risk (5). The feasibility of lateral access surgery has been well documented, and its increasing popularity dovetails with this trend of value-based care (1-5). Our study builds on the previous work of Blizzard and Thomas, which was a case series on single-position for primary surgeries (5). Our feasibility study of 16 patients investigated surgical characteristics including operative time, blood loss, length of stay, and degree of lordosis correction obtained in patients undergoing revision lateral lumbar surgery all in the single lateral position.

Indications for revision spine surgery in our series are similar to those that have been previously published, with the majority of surgeries being performed for pseudarthrosis and junctional disease, including both degenerative changes alone and proximal failure with kyphosis. Previous reports have shown that revision surgery for these indications can improve patient reported outcomes (PRO). Dede *et al.* retrospectively reviewed 64 patients with either a primary diagnosis of degenerative disk disease or spondylolisthesis that underwent revision surgery for pseudarthrosis by means of anterior, posterior, or combined approaches with or without interbody (8). The investigators found that 50% of patients noticed improvement on PRO after their revision surgery when their primary diagnosis was degenerative disc disease, and 64% noticed improvement when their primary diagnosis was spondylolisthesis (8). These findings are consistent with other studies investigating revision outcomes and help to characterize the improved outcomes attainable with revision surgery (9).

ASD was also a common indication for revision surgery. Du *et al.* reported a pilot study of 20 patients who underwent unilateral pedicle screw fixation after LLIF for treatment of lumbar ASD (4). Mean operative time was 214 minutes, mean blood loss was 187 cc, and mean hospital

stay was 4.4 days. These patients all had unilateral pedicle screw placed in the newly fused, adjacent level. This study demonstrated the utility of LLIF for treatment of adjacent disease with improvement in postoperative visual analog scale (VAS) pain scores. Preoperative to postoperative comparisons of functional outcomes scores including ODI and SF12-PC did not show a significant difference. Our study had comparable means in terms of blood loss and operative time with bilateral pedicle screw placement, further demonstrating the feasibility of using a single position technique for the treatment of ASD.

Owens *et al.* further showed that the specific approach during revision surgery can affect the outcomes of the revision surgery. In their series they reviewed the impact of surgical approach when addressing pseudarthrosis. Approaches investigated included ALIF, posterolateral fusion (PSF), transforaminal interbody fusion (TLIF), and combined anterior and posterior fusions (AP). They identified significant differences in EBL (mean range, 272–770 mL), OR time (mean range, 178–327 min), and length of stay (mean range, 4–6 days) (17). In the study by Du *et al.*, they also reported perioperative outcomes in their series of patients undergoing single level revision surgery for ASD utilizing a two-position approach with LLIF combined with unilateral posterior fusion. They reported a mean operative time of 214 min, mean EBL of 187 mL, and mean LOS of 4.4 days (4). Our surgical characteristics for revision surgery performed entirely in the lateral position included a mean operative time of 161 minutes for single level fusions, mean EBL of 206 cc, and mean length of stay of 3.2 days. These values are similar to published rates for single level revision lumbar spine surgery using two position LLIF as reported in Du's study (4). When compared to the study by Owens *et al.* the reported values for all four approaches are higher compared to those reported in our study (17). Thus, we present an additional approach spine surgeons may utilize when addressing the complex issue of lumbar pseudarthrosis.

In addition to the potential decreased risk associated with single position lateral surgery, there is also potential for decreased cost as well. In the cost effectiveness analysis by Adogwa *et al.*, revision decompression and extension of fusion was associated with a mean 2-year cost of $80,594 per quality-adjusted life-year (QALY) gained (6). This cost per QALY is well below the accepted cost-ineffectiveness thresholds and further studies have corroborated these findings (7). Furthermore, single position surgery eliminates the need to reposition the patient as well as the need for a second set of surgical drapes or prep. Considering that, there is potential for further cost saving based on equipment and more importantly, OR time, which can contribute considerable cost to a surgery (16). In combination with the already acceptable cost-effectiveness of revision spine surgery, single position lateral access surgery represents an additional cost savings that has not yet been explored.

It is well accepted that restoring lordosis is key to successful lumbar fusion surgery. Therefore, when discussing options for lumbar fusion, it is also important to consider their effects on sagittal alignment. There have been many studies showing that prone positioning with hip extension significantly increases postural lordosis when compared to supine positioning (18,19). Furthermore, this increase in lordosis is subsequently maintained postoperatively after instrumented fusion (20). There is theoretical concern that single position all lateral surgery, as in this series, would not permit sufficient sagittal correction. Interestingly, this is not what we found in our series as we have shown significant increase in LL with correction of mismatch. The majority of the previous studies showing an increase in lordosis in the prone position are in patients without any anterior surgery or intervertebral implant. More recent studies have actually shown that significant sagittal and coronal correction is obtained through lateral position surgeries with the interbody cage alone, as well as with compression of the posterior instrumentation construct, and that in fact the posterior positioning itself actually contributed no significant increase in lordosis (21).

This study has several limitations. Given the pilot nature of the study the cohort of patients is relatively small and there is no control group. However it is critical to report early outcomes in order to refine technique. Long-term fusion results are also not reported but further studies demonstrating fusion rates and need for revision surgeries are underway.

Conclusions

Revision lumbar surgery in the lateral position is feasible with surgical characteristics including blood loss, operative time, and hospital stay comparable to published literature. The need to reposition is eliminated and single position surgery theoretically reduces operative time and represents a potential cost savings. Single position lateral surgery is an additional approach that can be considered for revision lumbar surgery.

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None.

Footnote

Conflicts of Interest: I Cheng—Nuvasive, Royalties, consulting; Globus Medical, Royalties; Stryker Spine, Consulting; Spine Wave, Royalties; SpineCraft, Consulting; Cytonics, Stock; Spine Innovations, Stock; SpinalCyte, Stock. The other authors have no conflicts of interest to declare.

Ethical Statement: This retrospective chart review was approved by the Stanford University Institutional Review Board (#7935).

References

1. Ozgur BM, Aryan HE, Pimenta L, et al. Extreme Lateral Interbody Fusion (XLIF): a novel surgical technique for anterior lumbar interbody fusion. Spine J 2006;6:435-43.
2. Berjano P, Balsano M, Buric J, et al. Direct lateral access lumbar and thoracolumbar fusion: preliminary results. Eur Spine J 2012;21 Suppl 1:S37-42.
3. Formica M, Berjano P, Cavagnaro L, et al. Extreme lateral approach to the spine in degenerative and post traumatic lumbar diseases: selection process, results and complications. Eur Spine J 2014;23 Suppl 6:684-92.
4. Du JY, Kiely PD, Al Maaieh M, et al. Lateral lumbar interbody fusion with unilateral pedicle screw fixation for the treatment of adjacent segment disease: a preliminary report. J Spine Surg 2017;3:330-7.
5. Blizzard DJ, Thomas JA. MIS Single-position Lateral and Oblique Lateral Lumbar Interbody Fusion and Bilateral Pedicle Screw Fixation: Feasibility and Perioperative Results. Spine (Phila Pa 1976) 2018;43:440-6.
6. Adogwa O, Owens R, Karikari I, et al. Revision lumbar surgery in elderly patients with symptomatic pseudarthrosis, adjacent-segment disease, or same-level recurrent stenosis. Part 2. A cost-effectiveness analysis: clinical article. J Neurosurg Spine 2013;18, 147-53.
7. Adogwa O, Parker SL, Shau DN, et al. Cost per quality-adjusted life year gained of laminectomy and extension of instrumented fusion for adjacent-segment disease: defining the value of surgical intervention. J Neurosurg Spine 2012;16:141-6.
8. Dede O, Thuillier D, Pekmezci M, et al. Revision surgery for lumbar pseudarthrosis. Spine J 2015;15:977-82.
9. Adogwa O, Parker SL, Shau D, et al. Long-term outcomes of revision fusion for lumbar pseudarthrosis: clinical article. J Neurosurg Spine 2011;15:393-8.
10. Kwee MM, Ho YH, Rozen WM. The prone position during surgery and its complications: a systematic review and evidence-based guidelines. Int Surg 2015;100:292-303.
11. Anastasian ZH, Gaudet JG, Levitt LC, et al. Factors that correlate with the decision to delay extubation after multilevel prone spine surgery. J Neurosurg Anesthesiol 2014;26:167-71.
12. DePasse JM, Palumbo MA, Haque M, et al. Complications associated with prone positioning in elective spinal surgery. World J Orthop 2015;6:351-9.
13. Lauerman WC, Bradford DS, Ogilvie JW, et al. Results of lumbar pseudarthrosis repair. J Spinal Disord 1992;5:149-57.
14. Waddell G, Kummel EG, Lotto WN, et al. Failed lumbar disc surgery and repeat surgery following industrial injuries. J Bone Joint Surg Am 1979;61:201-7.
15. Macario A. What does one minute of operating room time cost? J Clin Anesth 2010;22:233-6.
16. Tan JM, Macario A. How to evaluate whether a new technology in the operating room is cost-effective from society's viewpoint. Anesthesiol Clin 2008;26:745-64, viii.
17. Owens RK, Djurasovic M, Crawford CH, et al. Impact of Surgical Approach on Clinical Outcomes in the Treatment of Lumbar Pseudarthrosis. Global Spine J 2016;6:786-91.
18. Tan SB, Kozak JA, Dickson JH, et al. Effect of operative position on sagittal alignment of the lumbar spine. Spine 1994;19:314-8.
19. Stephens GC, Yoo JU, Wilbur G. Comparison of lumbar segmental alignment produced by different operative positions. Spine 1996;21:1802-6.
20. Harimaya K, Lenke LG, Mishiro T, et al. Increasing lumbar lordosis of adult spinal deformity patients via intraoperative prone positioning. Spine (Phila Pa 1976) 2009;34:2406-12.
21. Yson SC, Sembrano JN, Santos ER, et al. Does prone repositioning before posterior fixation produce greater lordosis in lateral lumbar interbody fusion (LLIF)? J Spinal Disord Tech 2014;27:364-9.

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