Transforaminal Versus Lateral Interbody Fusions for Treatment of Adjacent Segment Disease in the Lumbar Spine

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Study Design: Retrospective comparative study.

Objective: This study compared outcomes for patients managed with a lateral approach to interbody fusion [lateral (LLIF) or oblique (OLIF)] versus a posterior (PLIF) or transforaminal interbody fusion (TLIF) for treatment of adjacent segment disease (ASD) above or below a prior lumbar fusion construct.

Summary of Background Data: No study has compared outcomes of lateral approaches to more traditional posterior approaches for the treatment of ASD.

Methods: Retrospective review was performed of patients who underwent single-level lateral or posterior approaches for lumbar interbody fusion for symptomatic ASD between January 2010 and December 2021. Exclusion criteria included skeletal immaturity (age below 18 y old) and surgery indication for malignancy or infection. Patient demographics, medical comorbidities, operative details, postoperative complications, and revision surgery profiles were collected for all patients. Standard descriptive statistics were used to summarize data. Comparative statistical analyses were performed using Statistical Package for the Social Sciences (Version 28.0.1.0; Chicago, IL).

Results: A total of 152 patients (65 ± 10 y) were included in the study with a mean duration of follow-up of 1.6 ± 1.4 years. The cohort included 123 PLIF/TLIF (81%), 18 LLIF (12%), 11 OLIF (7%). TLIF/PLIF experienced greater mean operative time (210 ± 62 min vs. 184 ± 80 OLIF/105 ± 64 LLIF, $P < 0.001$) and estimated blood loss (414 ± 254 mL vs. 49 ± 29 OLIF/36 ± 33 LLIF, $P < 0.001$). No significant difference in rate of postoperative complications. Postoperative radicular pain was significantly greater in OLIF (7, 64%) and LLIF (7, 39%) compared with PLIF/TLIF (16, 13%), $P < 0.001$. No statistically significant difference in health care utilization was noted between the groups.

Conclusion: Lateral fusions to treat ASD demonstrated no significantly different risk of complication compared with posterior approaches. Our study demonstrated significantly increased operative time and estimated blood loss for the posterior approach and an increased risk of radicular pain from manipulation/retraction of psoas following lateral approaches.

Level of Evidence: Level III.

Key Words: PLIF, TLIF, LLIF, OLIF, ASD, spine outcomes

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Lumbar fusion is a common surgical procedure indicated for treatment of lumbar degenerative disease, trauma, infection, and neoplasia.[1,2] The procedure entails the placement of an implant within the intervertebral space to restore stability and decompress the neural elements with the goal of promoting fusion and relieving symptoms such as radiculopathy.[1–4] As the overall number of lumbar fusions performed in the United States continues to increase as well as the options available to surgeons in addressing spine pathologies, it is important to understand the differences in outcomes between approaches.[1,5] This rise in incidence coincides with a rise in cost. From 2004 to 2015, the total cost of elective lumbar fusion increased by 177.2% and the mean adjusted cost per case increased 69.4%.[5]

Lumbar fusion promotes a series of biomechanical changes to adjacent intervertebral disks and spinal segments that increase the stress, shear force, and mobility both above and below the construct.[1,6] One adverse sequela of lumbar fusion and frequent indication for reoperation is the development of adjacent segment disease (ASD). Symptomatic ASD is present in anywhere from

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5% to 16% of patients at 5 years and 10% to 36% of patients at 10 years postoperatively.[3,4,7,8] The typical presentation of symptomatic ASD may include severe back pain, radiculopathy, and/or neurogenic claudication that correlate with radiographic changes in the levels adjacent to the spinal fusion.[3]

Oftentimes the symptoms associated with ASD are initially managed conservatively, but after the exhaustion of nonoperative management, patients may elect to undergo revision surgery to access the instrumentation, decompress the same and/or adjacent level(s), and extend the construct to additional levels for the restoration of stability. In the treatment of adjacent segment disease, both posterior and lateral approaches are commonly used.[2] These approaches include posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), lateral lumbar interbody fusion (LLIF), and oblique lumbar interbody fusion (OLIF). Currently, there is a paucity of literature that directly compares revision lumbar ASD outcomes based on surgical approach, which is a notable limitation as this information may help prognosticate fusion longevity and complications.[9] As a result, the decision with regards to approach to the lumbar spine for a revision ASD surgery is at the discretion of the operating surgeon. Therefore, this study aimed to compare the outcomes between posterior and lateral approaches for treatment of ASD with consideration of the perioperative and postoperative outcomes.

MATERIALS AND METHODS

Study Population

We conducted a retrospective review of consecutive patients who underwent a single-level PLIF/TLIF, LLIF, or OLIF revision for symptomatic adjacent segment disease at a single tertiary care academic medical center between January 2010 and December 2021. All surgeries were performed by fellowship-trained orthopedic spine and neurosurgeons. Patients were identified by using Common Procedure Terminology (CPT) codes. Patients were excluded if they were skeletally immature (below 18 y old), had pre-existing long-segment fusions that extended across the thoracolumbar junction into the thoracic spine, or were operated on for malignancy or infection. Formal institutional review board was attained to carry out this study with a waiver of informed consent as a minimal risk study. We allowed for an all-comer follow-up population to account for variable follow-ups experienced by a treating surgeon.

Surgical Technique

In the lateral approach cohort, OLIF and LLIF were performed by fellowship-trained orthopedic spine surgeons or neurosurgeons. The patients were placed in the lateral decubitus position. A retroperitoneal approach was utilized to gain access to the psoas muscle. In OLIF, the intervertebral disc space was accessed anterior to the psoas muscle belly; in LLIF, the psoas muscle belly was dissected with the aid of real-time dynamic EMG monitoring. In all but 2 of the cases, stand-alone interbody cages were utilized with integrated holes for vertebral body screw fixation. In the other 2 (1 LLIF and 1 OLIF), additional posterior screw augmentation was utilized. The choice of augmented bone grafting of the disc space was decided on a case-by-case basis.

The open posterior decompression and TLIF/PLIF procedures were also performed by fellowship-trained orthopedic spine surgeons or neurosurgeons. The incision from the index procedure was opened and the prior instrumentation/fusion bed was exposed along with the adjacent lamina, carefully developing a plane between the prior scar and the lamina. The prior hardware was removed as required with the decision on removal and reinstrumentation left to the surgeon's discretion. A laminectomy was performed in the adjacent segment in standard manner, with careful development of a plane between dura and scar, undercutting of the medial facet joints for lateral recess and foraminal decompression. Pedicle screws were placed at the adjacent segment. For PLIF, the midline thecal sac and traversing root were carefully retracted at the level of the joint to gain access to the posterior annulus. For TLIF placement, a partial or complete facetectomy was performed on one side per surgeon discretion to gain access to the foramen. With protection of traversing and exiting nerve roots, the posterior annulus and disc space was identified and an annulotomy performed. The disc space was then prepped with a combination of curettes, rongeurs, and subsequent trials. An appropriately sized interbody was then placed along with corticocancellous graft (autograft or allograft). Pedicle screw instrumentation was connected to the prior construct with appropriately sized rods per surgeon discretion. Corticocancellous graft was placed in posterolateral gutters (if able) to achieve fusion.

Patients were admitted to the hospital for pain control, physical therapy, and medical management. Once appropriately mobilizing with therapy, patients were discharged with scheduled follow-up.

Data Collection

A retrospective review of the electronic medical record was performed to collect demographic information on age, race, ethnicity, sex, body mass index (BMI), and comorbidities (diabetes, hypertension, cardiac history, tobacco use, chronic obstructive pulmonary disease). Race was reported by the patients and recorded as African American/Black, White, Asian, or unknown. Intraoperative variables were procedure type (LLIF, OLIF, or PLIF/TLIF), bone graft type (allograft, autograft, bone morphogenetic protein-2), indication for surgery (lumbar stenosis, foraminal stenosis/radiculopathy, spondylolisthesis, degenerative disc disease) level of fusion, laterality, ASD location (superior, inferior), estimated blood loss, operative time, and intraoperative complications (durotomy, vasculature injury, cutaneous nerve injury, neurological injury, retroperitoneal visceral injury, abort procedure).

Postoperative variables were length of stay, postoperative complications up to 90 days (CSF leak, surgical

TABLE 1. Demographics and Medical History

Demographic	PLIF/TLIF (n = 123), n (%)	OLIF (n = 11), n (%)	LLIF (n = 18), n (%)	*P*
Age (mean ± SD)	63 ± 10	67 ± 10	70 ± 9.9	0.027*
BMI (mean ± SD)	31.4 ± 6.4	28.6 ± 4.9	31.6 ± 5.3	0.339
Sex - Female	63 (51)	4 (36)	12 (67)	0.265
Current smoker	6 (5)	0	2 (11)	0.341
Diabetes	25 (20)	4 (36)	10 (56)	0.004*
Hypertension	75 (61)	7 (64)	17 (94)	0.021*
Cardiac history	28 (23)	4 (36)	6 (33)	0.416
COPD	4 (3)	0	3 (17)	0.038*

*Denotes *P*-value < 0.05.

site infection, wound dehiscence, superficial wound infection, deep wound infection, transitory neurological defect, deep vein thrombosis, pulmonary embolus, anemia, radicular pain, hematoma, ileus, hip flexor pain), instrumentation complications (prominent/painful instrumentation, instrumentation failure, pseudoarthrosis, flat-back deformity, endplate fracture, sacral lamina fracture), lateral approach related complication [urological injury, abdominal incisional pain, abdominal wound dehiscence, vascular injury, revision of abdominal scar, abdominal wound infection, retrograde ejaculation, transient thigh or groin/numbness/pain, transient hip flexor weakness, permanent motor neurological deficit (weakness), sympathetic plexus injury, pseudohernia] 30-day and 90-day return to the OR, 30-day readmission, number of emergency department visits and readmissions within 90 days of revision surgery, and reoperation within 13 months after revision surgery. To differentiate postoperative symptoms within the clinical record, we defined hip flexor pain specifically as pain with active hip flexor (eg, iliopsoas) firing, radicular pain as a neuropathic pain radiating down the lower extremity, and a transient neurological deficit as a postoperative neuromotor deficit. Any neuromotor deficit that persisted throughout the postoperative follow-up period was indicated as a "permanent motor neurological deficit" complication.

Statistical Analysis

Patient demographics, medical comorbidities, operative details, postoperative complications, and revision surgery profiles were collected for all patients. Standard descriptive statistics (eg, frequency, percentage rates for categorical variables; mean, SD for continuous variables) were used to summarize data. Between PLIF/TLIF, LLIF, and OLIF procedural cohorts, categorical variables were compared with a χ^2 test whereas continuous variables were compared with a Kruskal-Wallis one-way ANOVA test. Significance was defined as $P < 0.05$. All statistical analyses were performed using Statistical Package for the Social Sciences (Version 28.0.1.0; SPSS Inc., Chicago, IL).

RESULTS

Demographics

After exclusion, 152 consecutive patients were included in the analysis. The mean age was 65 ± 10 years. Mean follow-up for our patient cohort was 1.6 ± 1.4 years (range 5 d–6.2 y). Only 3 follow-ups of the full sample (all 3 TLIFs) had follow-up times < 40 days: 5 days, 14 days, 39 days. Seventy-nine (52%) of patients were female, 136 (89%) of patients identified as white. Total of 123 (81%) patients underwent a PLIF/TLIF, eighteen (12%) underwent a LLIF, and 11 (7%) underwent an OLIF. Demographic and patient-specific variables between procedural cohorts were homogenous except for age ($P = 0.027$) and incidence of diabetes ($P = 0.004$), hypertension ($P = 0.021$), and COPD ($P = 0.038$) (Table 1). Of the 78 TLIF/PLIF patients for whom postoperative fusion status was available, 74 (94.8%) achieved radiographic fusion on follow-up after 3 months. Two of the 4 (50%) nonunions had subsequent reoperations for revision fusions due to symptomaticity. Of the lateral groups, 1 OLIF (9%) and 1 LLIF (5.6%) exhibited nonunions, with the OLIF nonunion undergoing subsequent reoperation for revision fusion.

Intraoperative Variables and Complications

The PLIF/TLIF cohort experienced a significantly greater mean operative time and blood loss (210 ± 62 min; 414 ± 254 mL) as compared with OLIF (184 ± 80 min; 49 ± 29 mL) and LLIF (105 ± 64 min; 36 ± 33 mL) ($P < 0.001$, < 0.001). There was no difference in rate of intraoperative complications between procedural cohorts (Table 2). There was only 1 case of permanent neuromotor deficit in the whole study in an OLIF patient with persistent lower extremity weakness on follow-up.

TABLE 2. Intraoperative Variables and Complications

Demographic	PLIF/TLIF (n = 123), n (%)	OLIF (n = 11), n (%)	LLIF (n = 18), n (%)	*P*
Operative time (min, mean ± SD)	210 ± 62	184 ± 80	105 ± 64	< 0.001*
Estimated blood loss (min, mean ± SD)	414 ± 254	49 ± 29	36 ± 33	< 0.001*
Durotomy	6 (4.8)	0	0	0.479
Vascular injury	0	0	0	—
Cutaneous nerve injury	0	0	0	—
Cord injury	0*	0	0	—
Retroperitoneal viscera injury	0	0	0	—
Abort procedure	0	0	0	—

*Denotes *P*-value < 0.05.

TABLE 3. Postoperative Symptoms and Complications

Demographic	PLIF/TLIF (n = 123), n (%)	OLIF (n = 11), n (%)	LLIF (n = 18), n (%)	*P*
Transient neurological deficit	11 (9)	2 (18)	2 (11)	0.605
Radicular pain	16 (13)	7 (64)	7 (39)	< 0.001*
Hip flexor pain	5 (4)	1 (9)	2 (11)	0.384
Any medical complication (< 90 d)	5 (4)	1 (9)	0	0.470
DVT/PE	3 (2)	1 (9)	0	0.32
Anemia*	2 (2)	0	0	0.787
Ileus	0	0	0	—
Wound complications	5 (4)	0	0	0.544
Superficial infection	1 (0.8)	0	0	0.888
Deep infection	1 (0.8)	0	0	0.888
Hematoma	1 (0.8)	0	0	0.888
CSF leak	4 (3)	0	0	0.616

*Denotes *P*-value < 0.05.

Postoperative Symptoms

The most common symptoms postoperatively were radicular pain (n = 30, 20%) and hip flexor pain (n = 8, 5%). There was a significantly greater incidence of radicular pain for the OLIF cohort (n = 7, 64%) as compared with LLIF (n = 7, 39%) and PLIF/TLIF (n = 16, 13%) ($P < 0.001$). Medical complications following surgery were infrequent and comparable between procedural cohorts (Table 3).

Health Care Utilization

There was a nonsignificant increased length of stay for the PLIF/TLIF cohort (3.7 d) as compared with OLIF (2.6 d) and LLIF (2.4 d) cohorts ($P = 0.08$). There was a nonsignificant increased rate of 90-day readmission for PLIF/TLIF (n = 15, 13%) as compared with OLIF (n = 0, 0%) and LLIF (n = 0, 0%) cohorts ($P = 0.14$). Overall, there was no difference in rate of 30-day readmission ($P = 0.25$), 30-day ($P = 0.62$), or 90-day ($P = 0.745$) return to OR, 90-day emergency department utilization ($P = 0.964$), nor reoperation within 13 months ($P = 0.873$) between procedural cohorts (Table 4).

DISCUSSION

This study aimed to compare posterior versus lateral approaches for treatment of ASD by comparing the perioperative and postoperative outcomes in patients who received a posterior (PLIF/TLIF), lateral (LLIF), and oblique (OLIF) interbody revision. Both posterior and lateral approaches to the lumbar spine demonstrated similar risk profiles with regards to intraoperative complications, postoperative health care utilization, and postoperative complications.

In accordance with the literature, posterior approaches demonstrated greater mean operative time and blood loss.[9–11] Compared with a lateral operation, the posterior approach for repeat surgery is complicated by increased scar tissue and dural fibrosis as well as the need to address the instrumentation from the prior surgery.[12] The increased blood loss associated with the posterior approach may also necessitate a blood transfusion, which has offers an additional risk profile.[13,14] Previous studies have found advanced age, higher body mass index, greater surgical complexity, and longer multilevel fusion constructs to be associated with higher blood loss.[13,15] The concern for increased blood loss is often compounded by hidden blood loss through routes such as extravasation into the tissues, residual blood in dead space, and hemolytic loss.[14] In addition to the increased blood loss noted by surgeons during posterior spinal fusion, there is an additional association between posterior fusions and increased hidden blood loss.[14] Within posterior approaches, Lei et al[15] found PLIF procedures had higher hidden blood loss than TLIF and hypothesized this was due to the dissection and epidural retraction. It should be noted that within the lateral groups, OLIF (184 min) tended to have a longer operative time than LLIF (105 min) in our cohorts. Although the exact circumstance behind this trend needs further inquiry and are limited by the small sample sizes, possible reasons include unique approach considerations for an oblique exposure, such as blood vessel maneuvering/mobilization, variable use of intraoperative navigation, and more direct influence of body habitus on operative duration versus a direct lateral approach.

TABLE 4. Health Care Utilization

Demographic	PLIF/TLIF (n = 123), n (%)	OLIF (n = 11), n (%)	LLIF (n = 18), n (%)	*P*
Length of stay, days (mean ± SD)	3.7 ± 2.8	2.6 ± 0.81	2.4 ± 1.7	0.080
30-day readmission	11 (9)	0	0	0.251
30-day return to the OR	5 (4)	0	1 (6)	0.752
90-day emergency department utilization	13 (11)	1 (9)	1 (6)	0.801
90-day readmission	16 (13)	0	0	0.123
90-day return to OR	6 (5)	0	1 (6)	0.749
Reoperation within 13 mo	16 (13)	1 (9)	2 (11)	0.917

Further study is most certainly warranted to further elucidate these trends.

In addition to increased blood loss and operative time, it should be noted that revision posterior approaches risk epidural fibrosis and almost double the rates of incidental dural tears.[16] Notably, our study found no dural tears in the lateral approach cohort compared with 6 in the posterior group. Though this finding failed to meet statistical significance given the small sample sizes, this is one of the main advantages of approaching the adjacent segment with a lateral (and especially stand-alone) indirect approach and warrants further characterization.

With regards to health care utilization, overall, there was no significant difference in length of stay, rates of 30-day and 90-day readmission, 30-day or 90-day return to OR, 90-day emergency department utilization, or reoperation within 13 months. There was a nonsignificant difference in length of stay between the PLIF/TLIF (3.7 d), OLIF (2.6 d), and LLIF (2.4 d) cohorts. Similarly, we hypothesize this trend is related to the increased blood loss and operative time necessary for a revision approach through a posterior approach.

Lateral approaches, particularly OLIF, demonstrated greater rate of postoperative radicular pain in our study. This finding is supported by previous studies that have demonstrated that retraction or disruption of the psoas muscle may result in increased rates of lumbar plexus or femoral nerve irritation, resulting in radiculopathy and weakness.[17] Apart from radicular pain, the rates of hip flexor pain and transient neuromotor deficits were interestingly not different among our cohorts. Although the resolution on these different symptoms may be poor in our study secondary to small sample sizes and limited clinical record documentation, disruption of the psoas muscle belly itself can risk weakness of hip flexion. These symptoms are often transient, but the duration of these symptoms are often dependent on the level of irritation or injury.

This study can be interpreted in the context of the following limitations. First, this is a retrospective study and is subject to the usual reporting and selection bias associated with studies reliant on the medical record. In addition, this was a single institution study, so there is a risk of selection bias and external generalizability may be limited. Most importantly, there were also relatively smaller numbers of patients undergoing lateral approaches (OLIF and LLIF) included in this study relative to TLIF/PLIF. Undoubtedly, this is the major limitation of this study that prevents strong statistical and clinical correlations in many variables of study and of interest (eg, dural tears). Part of this volume discrepancy is the gradual adoption of these techniques by the institution and surgeon familiarity/comfort. The limitations in the clinical documentation prevent nuanced understanding of why posterior versus lateral approaches were specifically chosen by the index surgeon in this cohort. As the frequency of lateral interbody fusions and their subsequent long-term follow-up increase, we hope this study provides initial insights and promising trends upon which future studies can expand both by our institution and others.

CONCLUSION

Overall, both posterior (TLIF/PLIF) and lateral (OLIF/LLIF) approaches to the lumbar spine demonstrated similar risk profiles with regards to intraoperative complications, postoperative health care utilization, postoperative complications, and postoperative complaints. Future study is required to further compare posterior and lateral-based approaches to adjacent segment disease in the lumbar spine. Future studies should consider the level and length of fusion, incorporate radiographic data and patient reported outcomes, or consider differences in direct health care costs between approaches.

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