Outcomes of Two Different Techniques Using the Lateral Approach for Lumbar Interbody Arthrodesis

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Abstract

Study Design Retrospective cohort study.

Objective To determine the short-term outcomes of two different lateral approaches to the lumbar spine.

Methods This was a retrospective review performed with four fellowship-trained spine surgeons from a single institution. Two different approach techniques were identified. (1) Traditional transpsoas (TP) approach: dissection was performed through the psoas performed using neuromonitored sequential dilation. (2) Direct visualization (DV) approach: retractors are placed superficial to the psoas followed by directly visualized dissection through psoas. Outcome measures included radiographic fusion and adverse event (AE) rate.

Results In all, 120 patients were identified, 79 women and 41 men. Average age was 64.2 years (22 to 86). When looking at all medical and surgical AEs, 31 patients (25.8%) had one or more AEs; 22 patients (18.3%) had a total of 24 neurologically related AEs; 15 patients (12.5%) had anterior/lateral thigh dysesthesias; 6 patients (5.0%) had radiculopathic pain; and 3 patients (2.5%) had postoperative weakness. Specifically, for neurologic AEs, the DV group had a rate of 28.0% and the TP group had a rate of 14.2% ($p < 0.18$). When looking at the rate of neurologic AEs in patients undergoing single-level fusions only, the DV group rate was 28.6% versus 10.2% for the TP group ($p < 0.03$).

Conclusion Overall, 18.3% of patients sustained a postoperative neurologic AE following lateral interbody fusions. The TP approach had a statistically lower rate of neurologic-specific AE for single-level fusions.

Keywords
- lateral interbody
- transpsoas approach
- adverse events
- XLIF
- DLIF

Introduction

Historically, interbody arthrodesis for the lumbar spine has been achieved through open surgical approaches including anterior lumbar interbody fusion, posterior lumbar interbody fusion, and transforaminal lumbar interbody fusion. There have been numerous studies elucidating the complication profiles for each of these surgical techniques. The potential complications involving anterior approaches for anterior lumbar interbody fusion include injury to abdominal viscera, vascular injury, disruption of the sympathetic trunk and/or superior hypogastric plexus and ileus.[1–9] The documented complications for the posterior approaches include soft tissue devitalization, nerve root injuries, postoperative radiculitis, and incidental durotomies.[10–16]

The traditional approaches to the anterior lumbar spine include the transperitoneal and retroperitoneal approach.[17] Recently, newer surgical techniques have been developed in

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hopes of minimizing the aforementioned surgical risks of the traditional anterior approaches.[18–21] One of the more popular of these techniques is the lateral approach to the lumbar spine. There has been substantial growth in the utilization of this new approach. The literature, however, remains sparse with regards to surgical outcomes.

Therefore, this approach can lead to adverse events (AEs) related to lumbar plexopathy including pain, neuropraxia, and weakness.[18,21,22] Recent studies identify a wide range of complication rates from 6.2 to 52%.[16,18,20–30] The disparity between reported complication rates is likely secondary to inconsistent definitions of AEs from publication to publication. Sofianos et al recently performed a multicenter and multisurgeon case series review of 45 patients who underwent a lateral transpsoas approach and found an overall complication rate of 40%, with a 31% rate of postoperative weakness and a 17.8% rate of anterior thigh hypoesthesia.[31] To our knowledge, their study is the largest series to date of lateral approach cases in a multisurgeon study design.

Given a paucity of literature with inconsistent definitions of AEs and broad range of purported AEs, we performed a comprehensive retrospective review of patients undergoing a lateral approach to the lumbar spine at our institution. This review included patients operated on by multiple surgeons with different variations in technique on approaching the lateral lumbar spine. The purpose of the study was to determine if there was a difference in AEs and, in particular, a difference in immediate neurologic effects between lateral approaches to the lumbar spine in the immediate perioperative period.

Materials and Methods

After obtaining approval for the human protocol for our institutional review board, we utilized the Stanford Translational Research Integrated Database Environment (STRIDE) developed at Stanford University by the Stanford Center for Clinical Informatics. STRIDE is a clinical data warehouse containing records on more than 1.4 million patient encounters at Stanford Hospital from 1995 onward. The STRIDE database contains de-identified patient data, including clinical documents such as intraoperative surgical reports, clinic notes, and International Classification of Diseases, ninth revision (ICD-9), Clinical Modification diagnosis and Current Procedural Terminology (CPT) codes. To identify lateral interbody fusion patients, we searched with text phrases instead of ICD-9 or CPT codes as no codes exist that definitively identify lateral interbody fusion. Our search query included surgery performed on or after July 1, 2008, and a clinical document containing the phrase "xlif," "dlif" or "lateral interbody fusion." We chose a broad search so as not to miss any cases; the resultant data was then reviewed manually and many false-positives (e.g., lateral interbody fusion was suggested in a clinic note but the surgery was not yet performed, etc.). In total, 120 cases were included in the study. Inclusion criteria included age greater than or equal to18, lateral approach to the anterior lumbar spine, and minimum 30-day follow-up with postoperative radiographs. Exclusion criteria included situations in which the described operative approach was not a true lateral lumbar spine approach (e.g., no lateral annular incision, the anterior longitudinal ligament had been disrupted, great vessels mobilized from the anterior spine, etc.).

Study data was then collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools hosted by Stanford Center for Clinical Informatics.[32] REDCap is a secure, Health Insurance Portability and Accountability Act (HIPAA)-compliant Web-based application designed to support data capture for clinical research studies, providing: (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources.

All data was collected and analyzed by individuals independent of the actual operations and treatment of included patients. From the medical records, we extracted demographic data including patient age, sex, diagnosis, previous surgery, level of surgery, body mass index (BMI), smoking status, medical comorbidities (Charlson comorbidity index). Perioperative data was recorded including type of supplemental fixation, intraoperative complications, postoperative AEs, implant-related complications, and reoperation rates. A postoperative AE was considered to have occurred if a patient had any new complaint and/or exam finding such as thigh numbness, pain, or weakness that was found that was not present preoperatively. All preoperative and postoperative notes were reviewed, including inpatient documentation.

There were four spine fellowship-trained surgeons in both neurosurgery and orthopedic surgery whose patients were included in the study and who utilized two different variations of the lateral lumbar spine approach: the traditional transpsoas (TP) approach and the direct visualization (DV) approach. Both approaches were performed without the involvement of an access surgeon and both were direct lateral approaches to the lumbar spine splitting the psoas muscle. The approach for each patient was based on surgeon preference. The definitions of the two types of approaches were as follows.

Traditional Approach

The lateral decubitus position is utilized with the table flexed. A posterolateral incision is made at the lateral edge of the paraspinal musculature. The retroperitoneum is then entered sharply. Manual palpation is used to identify the psoas muscle belly and to sweep peritoneal contents ventrally. A direct lateral incision is made, and the dissection is carried down to the deep fascia. The fascia is incised, and using a finger in the posterolateral incision for guidance, the starting probe is placed via the direct lateral incision at the lateral aspect of the psoas muscle. Neuromonitoring is used to pass the neurostimulating probe down to the lateral aspect of the targeted disk space. Sequential dilation is performed using neuromonitoring without direct visualization of the psoas muscle. The final retractor is deployed with neuromonitoring and stabilized to the table. A standard diskectomy and implant placement are then performed.

Direct Visualization Approach

This approach is similar to the TP approach with the difference being that the retractors are placed superficial to the psoas initially and the psoas dissection is performed via direct visualization with care taken to identify the traversing lumbar plexus. The technique has been described by Knight et al[20] and Acosta et al,[33] who advocate not relying exclusively on neuromonitoring to navigate the lumbar plexus to reach the disk space. The surgical field is further explored using a neurostimulating probe to confirm the location of the neural elements. The retractors are then replaced deep within the psoas on the lateral border of the vertebral body, and the standard diskectomy and implant placement are performed (►**Fig. 1**).

Statistical Analysis

Univariate analyses, including unpaired *t* test or paired *t* test for continuous data, and chi-square test or Fisher exact test for categorical data (as appropriate) were performed to test for statistically significant differences in outcomes between groups (overall AE rate by approach and number of levels fused; neurologic AE rate by approach, overall and for single-level fusion only). All statistical tests are two-sided; $p \leq 0.05$ was considered significant. Calculations were performed using SAS software (version 9.3; SAS Institute, Inc., Cary, North Carolina, United States) running on Windows 7 Professional (Microsoft Corp., Redmond, Washington, United States).

Results

A total of 491 patients were identified via the STRIDE query. Of these, 120 patients met our inclusion criteria. There were 79 women and 41 men. Their average age was 64.2 years (range 22 to 86). The average BMI was 27.9 (range 23.8 to 56.3), and there was no significant difference in BMI between approaches (TP = 28.0, DV = 27.8, $p = 0.46$). The average follow-up was 10.0 months (range 2.6 to 27.5). The most common preoperative diagnosis was spondylolisthesis (46.2%), followed by degenerative disk disease (25.2%) and deformity (22.7%; ►**Table 1**). Thirty-two (26.9%) of the patients were smokers, and there was no significant difference in AE between smokers and nonsmokers. Sixty-three (52.5%) of the patients underwent a left-sided approach. Eighty-four (70.0%) had a single-level fusion, 27 (22.5%) had a two-level fusion, 7 (5.8%) had a three-level fusion, and 1 (0.8%) had a four-level fusion. The more common approach was the TP at 58.3% (70 patients). All patients received posterior pedicle screw instrumentation and posterior fusion during the same anesthesia as the lateral procedures.

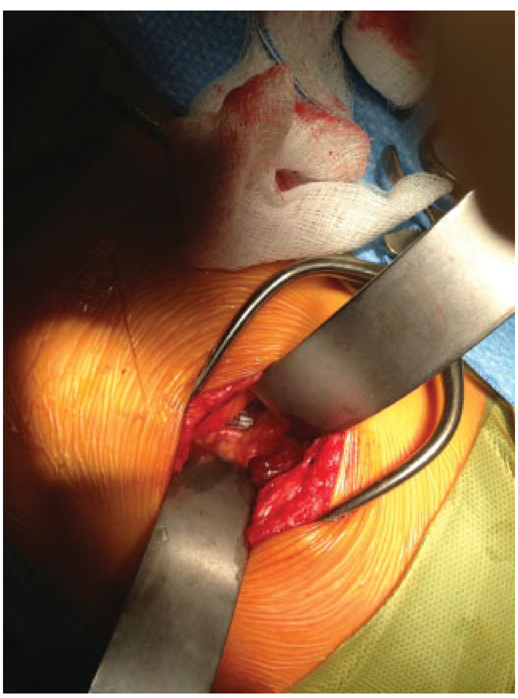

Fig. 1 Intraoperative photo demonstrating the direct visualization technique. The lateral aspect of the psoas muscle is directly visualized prior to dissection down to the spine.

There were a total of 31 patients (25.8%) with AEs. Five of these patients had 2 AEs for a total of 36 postoperative AEs. Two patients had unplanned returns to the OR within 30 days—1 for wound infection and 1 for implant subsidence. There were no deaths. One hundred twelve patients (98.2%) demonstrated independent ambulation at the first postoperative visit. From a surgical perspective, the most common AE was lower extremity paresthesia (15 patients). This was followed by lower extremity intractable pain/ radiculitis (6 patients) and weakness (3 patients). From a medical perspective, 3 patients sustained a perioperative stroke, 2 patients had new-onset atrial fibrillation, 2 patients had a postoperative ileus, 1 patient had a myocardial infarction, and another had a pulmonary embolus (►**Table 2**). A trend was found toward a higher rate of AE in smokers ($p = 0.053$), but there was no statistically significant increase in the rate of overall AE associated with multilevel versus single-level fusions ($p = 0.32$) nor with side of approach ($p = 0.22$).

When looking at the AE rate in relation to specific approaches, the DV group had an overall rate of 28.0% and the TP group had an overall rate of 24.3%, ($p < 0.68$; ►**Table 3**). However, when looking solely at neurologic-related AEs and excluding medical AEs, the DV rate of AEs was 24.0% and the TP rate was 14.2% ($p < 0.18$; ►**Table 4**). Furthermore, the neurologic AE rate, when looking only at single-level fusions, demonstrated an overall rate of 28.6% for the DV group and 10.2% for the TP group ($p < 0.03$). Specifically looking at the L4–L5 level, the direct comparison yielded a 23.1% and 12.5% ($p < 0.29$) rate for the DV and TP groups, respectively (►**Table 5**, ►**Fig. 2**).

Discussion

The lateral approach to the lumbar spine is becoming an increasingly popular approach for interbody lumbar fusions. These lateral transpsoas approaches are quite different from the traditional open anterior retroperitoneal approaches where dissection and manipulation of the great vessels and psoas muscle as a whole are often required. Instead, the lateral approaches traverse the psoas muscle and avoid the iliac vessels.

Table 1 Patient demographics

Variable	Total patients (%)	Traditional (%)	Direct visualization (%)	p Value
Total	120	70 (58.3)	50 (41.7)	
Sex				0.39
Female	80 (74.2)	45 (64.3)	34 (68.0)	
Male	40 (25.8)	25 (35.7)	16 (32.0)	
Indication				0.49
Spondylolisthesis	55 (46.2)	37 (53.9)	18 (36.0)	
Degenerative disk disease	30 (25.2)	13 (18.6)	17 (34.0)	
Deformity	26 (21.7)	13 (18.6)	13 (26.0)	
Adjacent segment disease	6 (5.0)	4 (5.7)	2 (4.0)	
Fracture	1 (0.83)	1 (1.4)	0 (0.0)	
Fixed sagittal imbalance	1 (0.83)	1 (1.4)	1 (1.4)	
Infection	1 (0.83)	1 (1.4)	0 (0.0)	
Prior surgery at operative level	28 (23.3)	20 (28.6)	11 (22.0)	0.18
Comorbidities				0.37
None	67 (55.8)	40 (57.1)	27 (54.0)	
One or more	53 (44.2)	30 (42.9)	23 (46.0)	
Smoker	32 (26.9)	17 (24.2)	15 (30.0)	0.26
Side of approach				0.23
Right	57 (47.5)	31 (44.3)	26 (52.0)	
Left	63 (52.5)	39 (55.7)	24 (48.0)	

Ozgur et al performed some of the initial investigations of the lateral retroperitoneal lumbar interbody arthrodesis in 2001.[21] His retroperitoneal endoscopic approach led to the eventual development of the contemporary lateral transpsoas approaches. This approach eliminates the need for an approach surgeon and retraction of the great vessels.[21] It has the potential for shorter operative times compared with traditional anterior approaches. Also, the lateral annular incision not only maintains the integrity of the anterior longitudinal ligament and anterior annulus but also places the interbody device along the apophyseal ring, theoretically lowering the rate of anterior graft dislodgement and subsidence. The approach does, however, involve traversing the psoas muscle and potentially endangering the lumbar plexus. Davis et al performed a cadaveric study investigating the lumbar plexus anatomy within the psoas muscle and found that in 13 of 18 specimens the femoral nerve was already formed at the L4–L5 disk space and this was the level with the largest diameter of the nerve.[34] Regev et al investigated 100 lumbar magnetic resonance images to identify the "safe corridor" for the lateral approach.[35] They found that the degree of overlap between the retroperitoneal vasculature and the vertebrae increases progressively from L1 to S1 as the vessels move posteriorly and laterally relative to the vertebral bodies. The exiting nerves also move slightly anteriorly relative to the vertebral bodies in the caudal direction, making the safe corridor considerably narrower at the lower lumbar levels.

The previous literature regarding the complication profile for lateral approaches has been inconsistent and had a broad range of AE rates and definitions. This study was an attempt to better delineate the AE profile for lateral access surgery across two differing technique using multiple surgeons. Through this approach, we were better able to refine our understanding of the risks associated with the transpsoas approach for lumbar interbody arthrodesis.

This study identified an overall AE rate of 25.8% for the lateral approach. This is comparable to reported rates of complications with an overall rate of complications of 28% with anterior lumbar interbody fusions[36] and 36% with transforaminal interbody fusions.[37] More specifically, we found a neurologic AE rate of 18.3% when looking at all levels including multilevel fusions. This included all subjective and objective outcome data. The most significant complaint postoperatively was leg paresthesias/dysesthesias. This is a common experience for patients postoperatively and was seen in both approach subgroups. Our data contrast with some more recent literature regarding the lateral approach. In patients undergoing a lateral lumbar interbody fusion with allograft/autograft, Lykissas et al demonstrated a sensory deficit in 48.6% and motor deficit of 38.9% of their patients.[38] Cummock et al also described an incidence of 62.7% of their patients having thigh symptoms postoperatively from a transpsoas interbody fusion.[39] It is unclear why these reported rates are higher than those in our study, but we suspect that as we gain more experience with these techniques and minimize the retractor time with the lateral procedure, we may be able to minimize these effects.

Table 2 Outcomes

	n	%
Adverse events		
None	89	74.1
One or more	31	25.8
Total adverse events		
Zero	89	74.1
One	26	26.1
Two	5	4.2
Return to OR	2	1.7
Died within 30 d	0	0
Good independent ambulation at first postoperative visit	112	98.2
Adverse events		
Lower extremity paresthesia	15	12.5
Lower extremity intractable pain	6	5.0
Lower extremity weakness	3	2.5
Wound infection	2	1.7
Wound dehiscence	1	0.8
Stroke	3	2.5
Atrial fibrillation	2	1.7
Ileus	2	1.7
DVT/PE	1	0.8
MI	1	0.8

Abbreviations: DVT, deep vein thrombosis; MI, myocardial infarction; OR, operating room; PE, pulmonary embolism.

Interestingly, when the AEs are separated from the neurologic events felt to be related to lumbar plexus stretch versus medically related AEs, we were able to identify statistically significant differences in AE outcomes between the two groups in single-level fusion analysis (►**Table 5**, ►**Fig. 1**): 28.6% for the DV group versus 10.2% for the TP group. This suggests that the use of neuromonitoring during transpsoas dissection may be beneficial to minimize postoperative lower extremity issues and that direct visualization of the lumbar plexus does not necessarily protect from neurologic difficulties postoperatively. There may be a few reasons for this difference. First, the neuromonitoring may be more sensitive than direct visualization at identifying neural structures while allowing less dissection of the psoas muscle. Second, directly visualizing the nerves may provide a false sense of security to excessively retract the nerves after final retractor placement.

No statistically significant difference was found at the individual levels when looked at independently, although the study may lack sufficient power to demonstrate a difference for specific levels. We feel that the single-level fusion analysis best minimizes confounding variables when comparing the two approaches directly. Patients with multiple-level fusions introduce multiple factors including timing of problems intraoperatively, certain levels that may have been more challenging than others, and overall extent of dissection through the psoas muscle and lumbar plexus.

There were a few weaknesses of the current study to consider. First was the retrospective nature of the study. There was no uniform protocol postoperatively for rehabilitation, follow-up radiographs, and specific symptom-related questioning in the clinic to try to identify all possible AEs. However, given that the only complaints that we identified were those that were either unsolicited from the patient or were picked up objectively on physical exam, we can state that our study certainly did not overestimate the number of AEs these patients may experience postoperatively. Second, the study was likely underpowered to demonstrate a significant difference between specific lumbar levels treated. Previous studies have demonstrated a higher likelihood of neurologic problems at L4–L5,[28] but we did not find this in our study. We continue to enroll more patients in the current cohorts to further analyze the difference between levels as well as potential differences in multilevel constructs.

We have found in our practice that the incidence and clinical impact of postoperative weakness, dysesthesia, and radicular pain is not trivial for patients undergoing a lateral interbody fusion. The AEs of these approaches demonstrate the need for a thorough understanding of the AE profiles of

Table 3 Adverse events (surgical and medical)

Variable	Any adverse event			*p* Value
	Yes	Total	%	
Overall	31	120	25.8	–
Type of approach				0.6766
Direct visualization	14	50	28.0	
Traditional	17	70	24.3	
Side of approach				0.3011
Right	12	54	22.2	
Left	19	61	31.2	

Table 4 Neurologic adverse events

Variable	Neurologic adverse events			*p* Value
	Yes	Total	%	
Overall	22	120	22.4	–
Type of approach				0.1751
Direct visualization	12	50	24.0	
Traditional	10	70	14.2	

Table 5 Neurologic AEs for single-level fusions

Level	Shallow docking, no. of AEs/total (%)	Traditional, no. of AEs/total (%)	Total	*p* Value
L1–L2	0/2 (0)	0/3 (0)	0/5 (0)	1.00
L2–L3	2/3 (66.7)	1/8 (12.5)	3/11 (27.3)	0.24
L3–L4	2/7 (28.6)	1/14 (6.7)	3/21 (14.3)	0.56
L4–L5	6/23 (23.1)	3/24 (12.5)	9/47 (19.1)	0.16
Total	10/35 (28.6)	5/49 (10.2)	15/84 (17.9)	0.0302[a]

Abbreviation: AE, adverse event.
[a]Statistically significant.

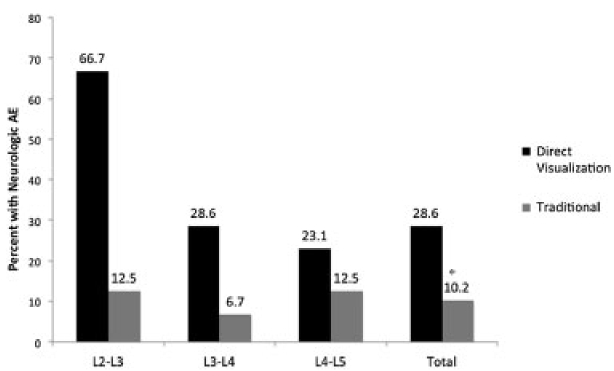

Fig. 2 Neurologic adverse events (AE) for single-level fusions. *Statistically significant.

relatively new techniques. A thorough understanding of the lateral approach and its risks and benefits is essential not only for the surgeon but also for patients as they contemplate the informed consent process preoperatively to maintain adequate expectations. Although we do not advocate one technique over the other, our hope is that this study will serve to better inform our patients and manage their expectations of the potential side effects of each approach to the lumbar spine. Ideally, this will lead to a more realistic and thorough discussion of the risks, benefits, and alternatives of this approach between surgeons and patients in efforts to develop an optimal plan of care.

Disclosures

Ivan Cheng, Consultant: Nuvasive, Stryker Spine, Bioventus; Royalties: Nuvasive; Stock/stock options: Cytonics, Spine Innovations
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Robert T. Arrigo, none
Navpreet Bains, none
Shashank Ravi, none
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