Original Study

Decreased estimated blood loss in lateral trans-psoas versus anterior approach to lumbar interbody fusion for degenerative spondylolisthesis

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Background: The goal of the current study was to compare the perioperative and post-operative outcomes of eXtreme lateral trans-psoas approach (XLIF) versus anterior lumbar interbody fusion (ALIF) for single level degenerative spondylolisthesis. The ideal approach for degenerative spondylolisthesis remains controversial.

Methods: Consecutive patients undergoing single level XLIF (n=21) or ALIF (n=54) for L4–5 degenerative spondylolisthesis between 2008–2012 from a single academic center were retrospectively reviewed. Groups were compared for peri-operative data (estimated blood loss, operative time, adjunct procedures or additional implants), radiographic measurements (L1–S1 cobb angle, disc height, fusion grade, subsidence), 30-day complications (infection, DVT/PE, weakness/paresthesia, etc.), and patient reported outcomes (leg and back Numerical Rating Scale, and Oswestry Disability Index).

Results: Estimated blood loss was significantly lower for XLIF [median 100; interquartile range (IQR), 50–100 mL] than for ALIF (median 250; IQR, 150–400 mL; P<0.001), including after adjusting for significantly higher rates of posterior decompression in the ALIF group. There were no significant differences in rates of complications within 30 days, radiographic outcomes, or in re-operation rates. Both groups experienced significant pain relief post-operatively.

Conclusions: The lateral trans-psoas approach is associated with diminished blood loss compared to the anterior approach in the treatment of degenerative spondylolisthesis. We were unable to detect differences in radiographic outcomes, complication rates, or patient reported outcomes. Continued efforts to directly compare approaches for specific indications will minimize complications and improve outcomes. Further studies will continue to define indications for lateral versus anterior approach to lumbar spine for degenerative spondylolisthesis.

Keywords: Lumbar; degenerative spondylolisthesis; lumbar approaches

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Introduction

Degenerative lumbar spondylosthesis is characterized by progressive instability of the lumbar spine and most commonly occurs at the L4–5 segment (1). Surgical decompression and fusion with or without instrumentation is an effective treatment for persistent symptoms refractory to conservative management (2-5). Whether decompression alone or decompression with fusion is superior remains controversial (6-11). Several approaches for degenerative spondylolisthesis have been described (3,12,13); however,

the best approach remains debatable (14).

The eXtreme lateral trans-psoas approach (XLIF) provides an alternative method for accessing the anterior lumbar spine, with the goal of maximizing graft surface area while minimizing exposure-related complications that can occur with a direct anterior approach (15). Lumbar fusion through the XLIF approach is associated with low estimated blood loss, improvement in post-operative patient reported outcomes, and low complication rates, but is also associated with exposure-related sensory and motor changes in the ipsilateral lower extremity, particularly at L4–5 where the lumbar plexus may be more anterior and the iliac crest may limit direct lateral access (16,17). Anterior and XLIF trans-psoas approaches for single level fusions at any lumbar segment yield similar complication rates, radiographic and early clinical outcomes (18-20). There is, however, a paucity of literature directly comparing anterior lumbar interbody fusion (ALIF) with XLIF for degenerative spondylolisthesis. To better inform the choice of surgical approach for treatment of degenerative spondylolisthesis, the specific complications and outcomes associated with these approaches need to be delineated (21).

Therefore, the purpose of this study was to compare the peri-operative outcomes, complications, and patient-reported outcomes of patients with degenerative spondylolisthesis treated at a single level with XLIF versus ALIF.

Methods

This retrospective, single-institution study was approved by the Institutional Review Board at our academic institution (IRB # 7935), and consent was waived by the IRB for the retrospective chart review. All anterior and anterolateral fusion cases from 4 fellowship-trained orthopaedic and neurosurgeons were identified using CPT code 22558 over the period from 2008–2012. Overall, 1,065 instances of the particular CPT code occurred. To create as homogeneous of a cohort as possible, we included only patients undergoing lumbar interbody fusion via an ALIF or XLIF approach at the single L4–5 level for a diagnosis of degenerative spondylolisthesis. Patients were required to have at least 30 days of follow up for complications. ALIF or XLIF was performed at discretion of operating surgeon. A vascular access surgeon was used for anterior approaches. For XLIF, neuromonitoring was used during cage insertion. Screws were placed percutaneously and utilized neuromonitoring. Patient demographics were recorded from the electronic medical record (EMR). Differences in peri-operative data (estimated blood loss, operative time, and adjunct procedures or additional implants), 30-day complications (infection, DVT/PE, stroke, weakness/paresthesias, leg pain, and ileus), and overall re-operation rates at L4–5 level were also identified via the EMR. Fusion was assessed on lateral lumbar films (22) (grade I, fused with remodeling and trabeculae; grade II, graft intact, not fully remodeled and incorporated though but with no lucencies above or below; grade III, graft intact but a definite lucency at the top or bottom of the graft; grade IV, definitely not fused with resorption of bone graft and with collapse). Subsidence >2 mm was documented as previously described (23). Disc height was calculated on lateral radiographs as the average of the anterior and posterior disc height normalized against the mid-sagittal diameter of the L4 vertebral body as previously described (24). Pre- and post-operative L1–S1 Cobb angle and disc height were calculated from radiographs. Spondylolisthesis was characterized by Meyerding grade (25). Lumbar stenosis was characterized on pre-operative MRI. At pre- and post-operative clinic visits, patients were asked to complete the following outcomes tools: Numerical Rating Scales (NRS) for back and leg pain and the Oswestry Disability Index (ODI).

Descriptive statistics are presented as frequencies and percentages for categorical variables. For continuous variables, means and 95% confidence intervals (CI) are presented unless non-normally distributed, in which case medians and inter-quartile ranges (IQR) are presented (e.g., EBL). Data distributions were examined visually through histograms and quantile-quantile plots. Differences between XLIF and ALIF were assessed with chi-squared and Fisher's exact tests for categorical variables, independent samples *t*-tests for normally distributed continuous variables, and Mann Whitney U tests for non-normally distributed continuous variables. Pre- to postoperative differences in radiographic parameters were assessed with paired *t*-tests. Multivariable generalized estimating equations (GEEs) were used to assess differences in OR time and EBL after adjusting for differences in relevant surgical details that differed between groups in univariate analyses. All analyses were performed with SAS version 9.4 (Cary, NC, USA) with a two-sided level of significance of α=0.05.

Results

Baseline factors

A total of 76 patients meeting the inclusion and exclusion

Table 1 Cohort demographics

Dependent variable	ALIF	XLIF	P value
Age (years)	65.1 (62.0–68.2)	65.7 (61.2–70.1)	0.844
BMI	27.7 (26.3–29.1)	28.6 (25.8–31.5)	0.509
Male sex	28 (50.9)	7 (33.3)	0.171
Charlson Comorbidity Present	24 (43.6)	11 (52.4)	0.581
Smoker	26 (47.3)	8 (38.1)	0.394
Osteoporosis	4 (7.3)	1 (4.8)	>0.999
Previous surgery	8 (17.8)	6 (28.6)	0.346
Meyerding grade			0.023
1	14 (37.8)	14 (73.7)	
2	23 (62.2)	5 (26.3)	
Stenosis			
Foraminal	25 (62.5)	8 (38.1)	0.105
Central	18 (60.0)	18 (85.7)	0.064
Subarticular	8 (20.0)	8 (38.1)	0.141

Descriptive statistics are presented as frequencies (percentages) for categorical variables and means (95% confidence intervals) for continuous variables. Note, radiographic measures were made in the subset of patients with complete imaging available. ALIF, anterior lumbar interbody fusion; XLIF, eXtreme lateral trans-psoas approach.

Table 2 Operative details

Dependent variable	ALIF	XLIF	P value
Pedicle screws	55 (100.0)	20 (95.2)	0.284
Standalone	0 (0)	0 (0)	>0.999
Posterior decompression	43 (78.2)	11 (52.4)	0.034*
BMP use	40 (72.7)	16 (76.2)	>0.999
Structural allograft	42 (77.8)	0 (0)	<0.001*
PEEK	12 (21.8)	22 (100.0)	<0.001*

Descriptive statistics are presented as frequencies and percentages. *, P<0.05. ALIF, anterior lumbar interbody fusion; XLIF, eXtreme lateral trans-psoas approach; BMP, bone morphogenetic protein.

criteria were identified: 55 patients undergoing ALIF and 21 patients undergoing XLIF at the single L4–5 level. There were no significant differences in patient age, sex, body mass index, presence of Charlson co-morbidities, presence of osteoporosis, or smoking status (*Table 1*). All patients had either grade 1 or 2 spondylolisthesis, although ALIF patients were more likely to have a grade 2 spondylolisthesis than XLIF patients (62.2% *vs.* 26.3%, P=0.023). There were no significant difference in the proportion of patients with stenosis or previous spine surgery between groups (*Table 1*).

Surgical details

There were no standalone cases in either group, and no significant difference in rate of use of pedicle screws or BMP use (*Table 2*). One XLIF case underwent interspinous fixation instead of pedicle screws. The implant material differed between groups (P<0.001), with structural femoral ring allograft used in 77.8%, and PEEK interbody graft used in 21.8% of ALIF patients, whereas PEEK interbody graft was used in all XLIF patients. Of note, there was a higher rate of posterior decompression during ALIFs than XLIFs (78.2% *vs.* 52.4%, P=0.034).

Perioperative outcomes

The median length of stay was 4 days for both groups (*Figure 1*). However, OR time was on average 40 min shorter for XLIF than for ALIF (P=0.026, *Table 2*, *Figure 1*). Interbody fusion time was available for a subset of patients (ALIF: n=51, XLIF: n=15), but did not differ between groups [ALIF 107 (IQR, 95–121) min, XLIF 91 (IQR, 72–108) min, P=0.174; *Figure S1*). In addition, the median estimated blood loss was 100 (IQR, 50–100) mL for XLIF, which was lower than that for ALIF (median 250; IQR, 150–400 mL; P<0.001, *Figure 1*). The OR time and EBL results were unchanged when the single case of interspinous suture fixation during an XLIF was excluded.

Multivariable analyses were undertaken to determine whether the differences in OR time and EBL persisted after accounting for the difference in posterior decompressions between groups. Posterior decompression was associated with an increase of 41.9 (95% CI: 8.4–75.3) min in OR time (P=0.015). After adjustment for this, the reduction in OR time with XLIF *vs.* ALIF was no longer significant but still trended towards being lower [difference: 31 (95% CI: −65.7 to 2.04) min, P=0.065]. Posterior decompression was not associated with EBL (P=0.842), and XLIF was still associated with lower EBL than ALIF after posterior decompression was included in the multivariable model

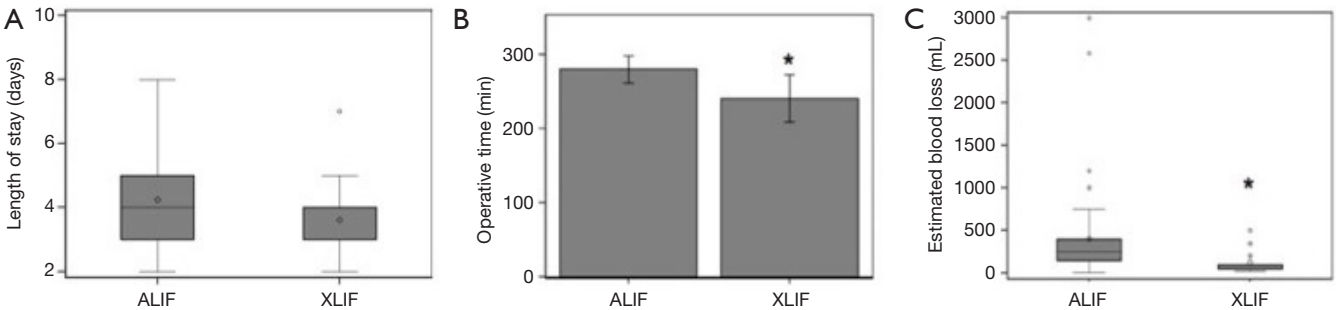

Figure 1 Length of stay (A), operative time (B) and EBL (C) in XLIF and ALIF groups. *, P<0.05. Box plots are displayed for outcomes that were non-normally distributed, whereas bar graphs indicating the mean and 95% confidence intervals are displayed for normally distributed outcomes.

Table 3 Postoperative complications and reoperations at the same level within 30 days

30-day outcomes	ALIF	XLIF	P value
Any complication	12 (21.8)	8 (38.1)	0.150
Ileus	3 (5.5)	0 (0)	0.553
DVT/PE	0 (0)	1 (4.8)	0.284
Stroke	0 (0)	0 (0)	
Wound dehiscence	0 (0)	0 (0)	
Wound infection	0 (0)	2 (9.5)	0.078
Paresthesias	3 (5.5)	3 (14.3)	0.343
Leg pain	7 (12.7)	0 (0)	0.124
Other	2 (3.6)	4 (19.0)	0.051
Reoperation L4–5 level (any time)	5 (9.3)	0 (0)	0.3461

Descriptive statistics are presented as frequencies and percentages. *, P<0.05. ALIF, anterior lumbar interbody fusion; XLIF, eXtreme lateral trans-psoas approach; DVT/PE, deep vein thrombosis/pulmonary embolism.

[difference: 275 (95% CI: −520 to 30), P=0.028].

Postoperative complications

When looking at postoperative complications, 21.8% of ALIF patients and 38.1% of XLIF patients had a complication within 30 days (P=0.150, *Table 3*). With the available sample size, there were no statistically significant differences in complication rates, both when considered either together or individually. Beyond 1 month, 5 patients undergoing ALIF (9.3%) underwent re-operation at the L4–5 level, compared to none in the XLIF group, though this result was also not statistically significant. Re-operations in the ALIF group were revision decompressions at the same level. Post-operative leg pain was higher in the ALIF group than the XLIF group, but this was not significant. There was no difference in rates of transient paresthesias between groups. Other complications reported were urinary catheter reinsertions for retention, urinary tract infections, and post-operative atrial fibrillation, for which there were no significant differences between groups. There were no re-operations for failed fusions.

Table 4 Postoperative radiographic results and follow up duration in the patients with postoperative radiographs available

Radiographic follow-up	ALIF (n=45)	XLIF (n=19)	P value
Follow up (months)	13.27 (3.23–105.00)	20.7 (6.17–100.00)	0.250
Fusion grade			0.023*
1	14 (37.8)	14 (73.7)	
2	23 (62.2)	5 (26.3)	
Subsidence >2 mm	1 (2.9)	2 (9.5)	0.551

Descriptive statistics are presented as frequencies and percentages for categorical variables, and median and range for continuous variables. *, P<0.05. ALIF, anterior lumbar interbody fusion; XLIF, eXtreme lateral trans-psoas approach.

Radiographic parameters

Radiographs were available for a subset of patients (n=45 ALIF, n=19 XLIF). Median radiographic follow-up was comparable in the ALIF group (median 13.27 months, minimum 3.23 months, maximum 105.00 months) and

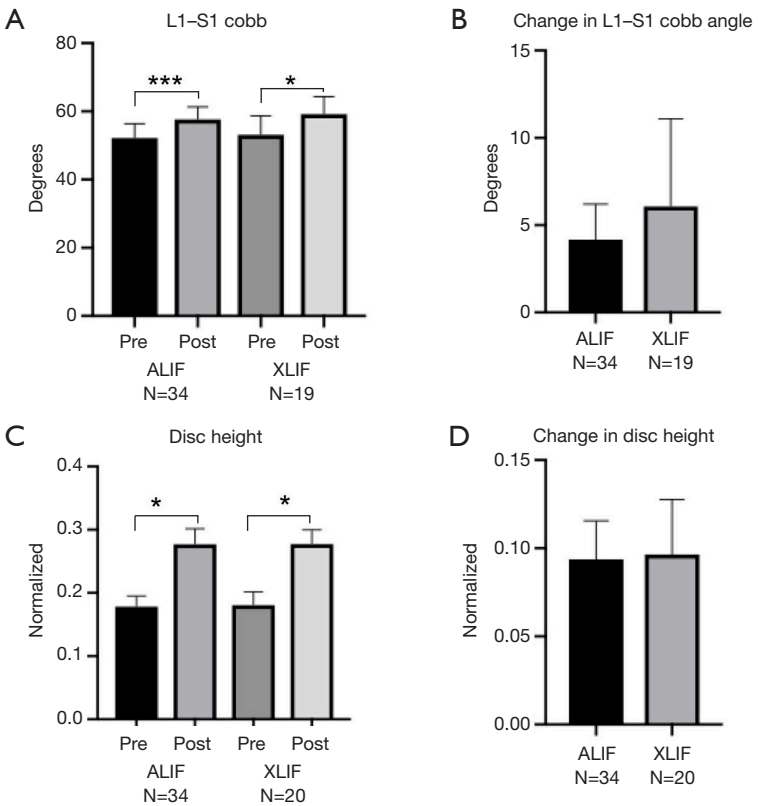

Figure 2 Radiographic results. Pre- and postoperative L1–S1 Cobb angles (A) the change in L1–S1 Cobb angle (B), pre- and postoperative disc height (C), and the change in disc height (D) for anterior lumbar interbody fusion (ALIF) and eXtreme lateral trans-psoas approach (XLIF). Error bars denote 95% confidence intervals. *, P<0.05; ***, P<0.001.

XLIF group (median 20.7 months, minimum 6.17 months, maximum 100.00 months; *Table 4*). Both ALIF and XLIF resulted in increased L1–S1 Cobb angles increases post-operatively compared to pre-operatively (P<0.001 for ALIF, P=0.021 for XLIF, *Figure 2*). However, the magnitude of the increase did not differ between groups (P=0.396). Both ALIF and XLIF increased L4–5 disc height (ALIF P<0.001, XLIF P<0.001), with the increase again not differing between groups (P=0.879). All cases demonstrated solid bony fusion, although XLIF group had a higher rate of Grade 1 fusions than ALIF (73.7% *vs.* 37.8%; P=0.023; *Table 4*). There was no difference in rate of subsidence between groups and no revisions for pseudo-arthrosis.

Patient reported outcomes

Patient reported outcomes were available for only a small subset of patients (ALIF n=13; XLIF n=9). The average follow-up time for these assessments was roughly 4.5 (95% CI: 4.0–4.9) years for the NRS and 4.4 (95% CI: 3.9–4.9) years for the ODI. NRS (ALIF n=13 back, n=12 leg; XLIF n=5 back, n=7 back) and ODI (ALIF n=12, XLIF n=9) measures were available for a limited subset of patients from the ALIF and XLIF groups (*Figure 3*). In this subset of patients, both ALIF and XLIF groups demonstrated pre- to postoperative improvement in NRS leg and back pain scores and ODI scores (P<0.001 for each, *Figure 3*). Median improvement in NRS leg pain was 4.2 (95% CI: 1.5–6.8) in ALIF and 6.0 (95% CI: 0.0–8.0) in XLIF. Median improvement in NRS back pain was 2.3 (95% CI: 0.0–6.3) in ALIF and 6.0 (95% CI: 3.0–7.0) in XLIF. There were no significant differences in the pre- to post-operative changes in NRS leg (P=0.610) or back (P=0.553) pain or the ODI (P=0.915) between the ALIF and XLIF groups for those patients who completed both pre- and post-operative patient reported outcomes (*Figure 3*).

Discussion

Our results demonstrate that the XLIF approach for L4–5

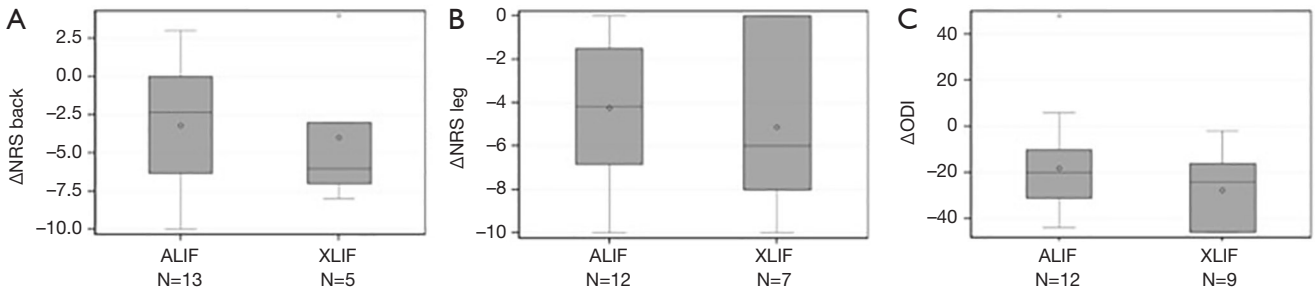

Figure 3 Boxplots showing the pre- to post-operative change in back (A) and leg (B) Numerical Rating Scales (NRS) scores, and Oswestry Disability Index (ODI) (C).

degenerative spondylolisthesis was associated with decreased blood loss compared to the ALIF approach. Several studies have looked at complications or outcomes following lumbar interbody fusion from the two approaches, and others have compared interbody fusions at different levels, (e.g., ALIF L5–S1 *vs.* XLIF L4–5) (18,21,26-28). In this retrospective review we report our experience with XLIF *vs.* ALIF at L4–5 for degenerative spondylolisthesis.

One goal of the limited soft tissue dissection in XLIF approach is earlier patient mobilization. The lateral approach is characterized by a smaller incision, indirect decompression of neural elements, and unlike the anterior approach, does not require mobilization of vascular structures with ligation or sacrifice of the middle sacral or iliolumbar veins. Our results show significantly less blood loss from the lateral approach, even after adjusting for posterior decompression, which was performed more frequently in the ALIF group. Other studies have demonstrated less EBL in XLIF compared to posterior approaches at L4–5 for degenerative spondylolisthesis (29). A recent retrospective comparison of XLIF at L4–5 to ALIF at L5–S1 demonstrated less EBL (61 mL) with XLIF compared to ALIF (100 mL), although the difference was not significant (27). Another previous retrospective study demonstrated greater EBL with two level fusions compared to single level fusions (30). The same study demonstrated longer operative time in two-level fusions compared to single level fusions for XLIF. In the present study, the mean surgical time of 241 min in the XLIF group was greater than previous reports of 73–199 min (27,31-33), although removing the posterior decompression and percutaneous screw fixation resulted in a more comparable interbody fusion time 90.1 min (95% CI: 71.7–101.4). Furthermore, our median LOS of four days for the XLIF group was higher than the mean of 1.2–2.2 days previously described (27,31,34). Compared to previous studies, we note that our patients had significant comorbidities typical of an academic tertiary referral center.

Previous studies have demonstrated that for low grade spondylolisthesis, XLIF indirectly decompresses neural elements, and can mitigate the need for posterior decompression (20,34). In this study a lower rate of posterior decompressions occurred in the XLIF group. While the need for a posterior decompression presents one relative indication for a transforaminal approach, transforaminal approaches can also be limited by inadequate decompression of the contralateral nerve root and incomplete disc removal (35-37). For low grade spondylolisthesis, one can reliably perform indirect decompressions with the XLIF approach given the surface area and apophyseal ring contact for disc height restoration. While the ALIF approach provides indirect foraminal decompression as well (38), there may be need for further decompression. The presence of a posterior decompression can account at least in part for the increased operative time associated with ALIF in this study, although the increase in EBL in ALIF was independent of the additional posterior decompression,

Consistent with previous findings, there was no difference in rate of complications within thirty days between ALIF and XLIF, although our sample size limits this analysis (21,26). We observed a rate of 14% approach-related lower extremity paresthesias or pain after XLIF, in line with previous studies of 10–31% (26,28,29,32,34,39). Paresthesias or radicular symptoms have been previously reported in the ALIF population as well, at low rates (18). Previous studies have demonstrated low re-operation rates in XLIF (28,31,32,34), which we demonstrate is durable over longer mean follow-up.

Durable relief of leg and back symptoms was evident

in the small subset of our patients with patient reported outcomes available. In this small subset, both XLIF and ALIF patients had improvements in both back and leg scores and the ODI, though these improvements did not differ between groups. Previous studies have estimated the minimum clinically important difference (MCID) in lumbar surgery as approximately 1.2 points on the scale for back, 1.6 points for leg, and approximately 13 points for the ODI (40). Improvements in both posterior and XLIF patient reported outcomes (29) as well as after ALIF (41) met these MCID.

Our study did have limitations. There were relatively few numbers of patients in each group which led to a lack of power to demonstrate significant differences between the approaches, particularly in detecting differences in complications and reoperation rates. While there were more posterior decompressions in the ALIF group, ALIF was still independently associated with increased EBL and a trend towards increased OR time. Small sample size limited power to detect significant differences in multivariate analysis as well as in interbody fusion time. The XLIF group also represented an early series for the surgeons performing the procedure and may have been influenced by a learning curve. A follow up study could compare complication rates with a more recent series. Our focus on a specific indication at a single level in order to more accurately compare the approaches resulted in a smaller sample size and a slightly narrower clinical application. Future studies will address larger patient populations.

Lumbar interbody fusion with decompression is an effective treatment for persistently symptomatic degenerative spondylolisthesis at L4–5. The XLIF approach is associated with diminished blood loss, without a noticeable increase in complications or compromise in patient outcomes.

Acknowledgments

None.

Footnote

Conflicts of Interest: I Cheng disclose the following conflicts of interest: AAOS: Board or committee member; Cervical Spine Research Society: Board or committee member; Empirical Spine: Research support; Globus Medical: IP royalties; Paid consultant; Nuvasive: IP royalties; Stock or stock Options; Scoliosis Research Society: Board or committee member; Spinal Cyte: Stock or stock Options; Spine Innovations: Stock or stock Options; Spine Wave: IP royalties; Stock or stock Options; SpineCraft: Paid consultant; Stryker: Paid consultant. The other authors have no conflicts of interest to declare.

Ethical Statement: This retrospective, single-institution study was approved by the Institutional Review Board at our academic institution (IRB #7935), and consent was waived by the IRB for the retrospective chart review.

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Supplementary

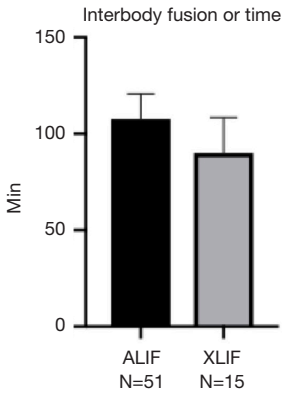

Figure S1 Comparison of Interbody Fusion operating room time between anterior lumbar interbody fusion (ALIF) and eXtreme lateral trans-psoas approach (XLIF). ALIF *vs.* XLIF interbody fusion time. P=0.17.