Perioperative Outcomes and Segmental Angle Changes following Primary L5/S1 Fusion: A Retrospective Comparison of ALIF vs TLIF vs PLIF vs PLF Techniques

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Abstract

Background: Lumbosacral fusion is a common spinal procedure performed to address refractory lower back pain and improve the functional outcomes for the patient. The aim of this study is to explore differences in perioperative outcomes, revision surgery rates, Lumbar Lordosis (LL) and L4-S1 Segmental Lordosis (SL) following lumbosacral fusion between ALIF vs TLIF vs PLIF vs PLF

Methods: Electronic patient records, surgical and radiological databases were accessed. Retrospective analysis was performed on the four primary L5-S1 fusion techniques over a nine-year period. Patients having undergone multi-segment fusion and revision L5-S1 fusion procedures were excluded from our patient population

Results: 115 patients were included in our study. There were no significant differences in perioperative outcomes, revision surgery rates and LL angle change pre- vs post-operatively between ALIF vs TLIF vs PLIF vs PLF ($p>0.05$ for all). However, significant differences were noted in pre- and post-operative changes in SL with the greatest increase in SL observed in ALIF and greatest decrease in SL observed in TLIF ($p<0.05$).

Conclusion: Spinal fusion is a complex surgery that necessitates a collaborative effort between the surgeon and the patient. It is important to inform the patient regarding benefits and risks of specific spinal fusion techniques as well as consider alignment changes post-fusion, especially with the aim of restoring adequate lumbar lordosis.

Introduction

Spinal fusion has evolved into one of the most commonly performed orthopaedic procedures worldwide, owing to its numerous indications in the management of diverse spinal pathologies [(1)]. One can only expect this upward trajectory to continue due to an increasingly ageing population and the advancements in spinal fusion procedures. The Lumbo-sacral (L5-S1) junction between the mobile lumbar spine and the fixed sacrum is a common site for spinal pathologies. Fusion is performed at this junction in patients with refractory low back pain with the objective of creating spinal stability by immobilisation of this spinal segment and addressing the underlying pathology [(2)].

The lordotic lumbar curvature of the human spine is an essential physiological characteristic which facilitates mechanical advantage for strength and postural stability. The lumbo-sacral junction has particular importance within the lumbar segment due to its greatest overall contribution to lumbar lordosis and the highest incidence of degenerative pathology [(3, 4)]. Inadequate restoration of lumbar lordosis following complete ankylosis of the lumbo-sacral junction can result in patients experiencing chronic low back pain, positive sagittal balance and adjacent segment disease [(5)].

Interbody fusion is a commonly utilised surgical technique in lumbo-sacral fusion with the anterior, posterior and trans-foraminal approaches having their unique indications, complications as well as peri-operative and long term-outcomes [(2, 6)]. Furthermore, studies have also demonstrated significant changes in global lumbar lordosis and segmental lordosis following L5-S1 fusion depending on the type of surgical approach [(7)].

The aim of this retrospective study is to evaluate peri-operative outcomes as well as pre- and post-operative lumbar lordosis (LL) and L4-S1 segmental lordosis (SL) changes in patients

undergoing Posterior Lumbar Interbody Fusion (PLIF), Transforaminal Lumbar Interbody Fusion (TLIF), Anterior Lumbar Interbody Fusion (ALIF) and Posterolateral Fusion (PLF) at a tertiary care centre.

Methods

This retrospective study was carried out at a tertiary care hospital in the United Kingdom with a dedicated specialised spinal orthopaedics surgery department.

Spinal surgical databases were accessed to identify all patients undergoing primary L5-S1 fusion between January 2013 and December 2022. Electronic patient records were reviewed using Bluespier® and Welsh Clinical Portal® (WCP) for retrieving patient demographics, classifying primary L5-S1 fusions into specific surgical techniques (ALIF/TLIF/PLIF/PLF) and to ascertain perioperative complications.

Lateral lumbar flexion-extension (FE), neutral weight bearing and neutral non-weight bearing radiographs were reviewed on Synapse® radiology portal. Immediate pre-operative and post-operative X-rays were used for the measurement of Lumbar Lordosis (LL) and L4-S1 Segmental Lordosis (SL). To ensure consistency in angle measurements, wherever possible, the same imaging modality was used for both pre-operative and the most recent post-operative lumbar radiographs. LL was calculated from the superior endplate of L1 to the superior endplate of S1 while L4-S1 SL was calculated from the superior endplate of L4 to the superior endplate of S1.

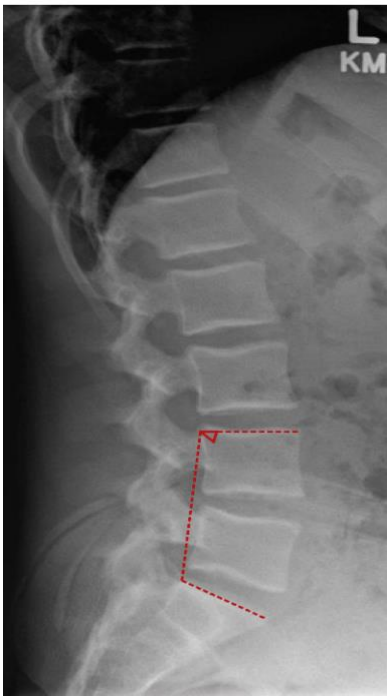


Image 1 - L4-S1 Segmental Lordosis [8]

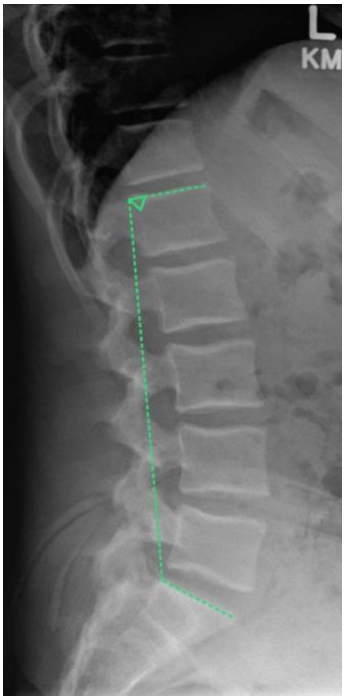


Image 2 - Lumbar Lordosis [8]

Our primary inclusion criteria involved selecting patients undergoing primary L5-S1 ALIF/TLIF/PLIF/PLF ± decompression/discectomy. Patients requiring revision surgery or those with multi-segment fusion were excluded from the study cohort. Refer to *Figure 1* for a detailed breakdown of the inclusion criteria –

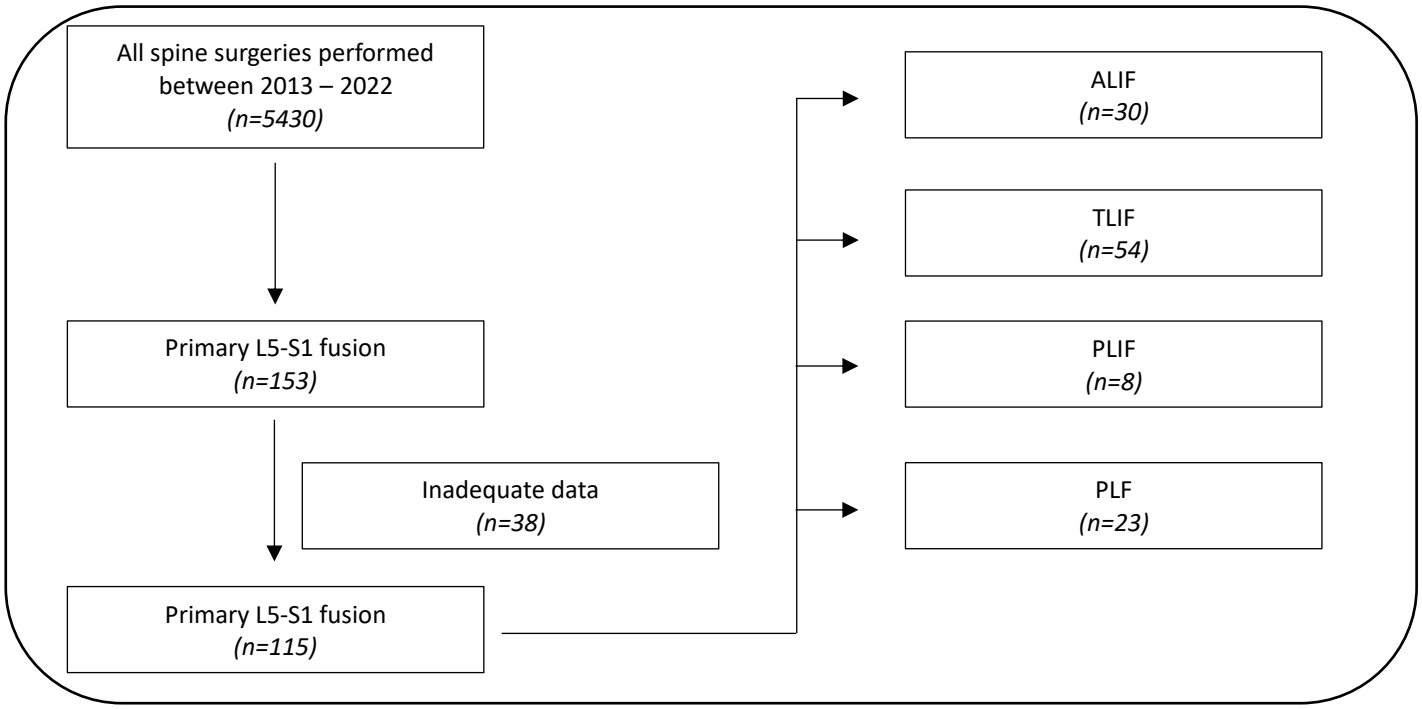


Figure 1- Study Inclusion Criteria

Results

Overview of the Data

Over the nine-year period, a total of 153 patients on the spinal database underwent primary L5-S1 fusion. 38 patients within this group were excluded due to inadequate X-ray and/or surgical data for analysis. Therefore, in our final cohort of 115 patients, 53% (n=61) were female and 47% (n=54) were male.

The retention rate was determined by identifying patients seen in the Welsh National Health Services within the last 12 months. During our follow-up period, the patient retention rate was 83% (n=96). Furthermore, only one patient mortality was documented on WCP. Patient ages at the time of the surgery ranged from 14 to 81 years with a mean average of 48 years old (SD=13). Average intra-operative blood loss across all surgical techniques was 337.93 mL. Of the available data, the most common primary indication for surgery across all four surgical techniques included spondylolisthesis (n=43) followed by radiculopathy (n=34), disc disease (n=29), degenerative spinal disease (n=5) and lumbar spinal stenosis (n=4).

Peri-operative Complications and Re-operation Rates

We analysed intra-operative and post-operative complications, as well as return to theatre (RTT) rates in patients receiving either ALIF vs TLIF vs PLIF vs PLF intervention. Some common intra- and post-operative complications include dural leak, venous bleed and wound breakdown. The most common reason for RTT was screw malplacement in our patient cohort. Overall, rates of an eventful spinal fusion were 17% for ALIF (n=5), 17% for PLF (n=4), 0% for PLIF (n=0) and 15% for TLIF (n=8).

We performed a Chi-Square Test to establish if the type of spinal surgery procedure is associated with an increase or decrease in peri-operative complications. From our analysis, we discovered that there is no statistically significant difference between the type of spinal surgery procedure and the rate of perioperative complication ($p>0.05$).

Furthermore, we also investigated re-operation rates in patients following a primary L5-S1 fusion. The most common indication for subsequent lumbar surgery in our patient group was revision and removal of metalwork (n=11). Rates of secondary lumbar surgery were 17% for ALIF (n=5), for 4% PLF (n=1), 0% for PLIF (n=0) and for 15% TLIF (n=8). Following a Chi-Square Test, we ascerained that the type of spinal procedure does not influence the secondary lumbar surgery following a primary L5-S1 fusion ($p>0.05$).

Segmental Angle Changes

Our study also analysed changes in LL and L4-S1 SL following L5/S1 fusion. The primary aim of this analysis was to establish if a specific spinal fusion technique leads to a superior restoration of adequate lordosis in a fixed lumbo-sacral junction following fusion. A full breakdown of the data collected is outlined in Table 2 below -

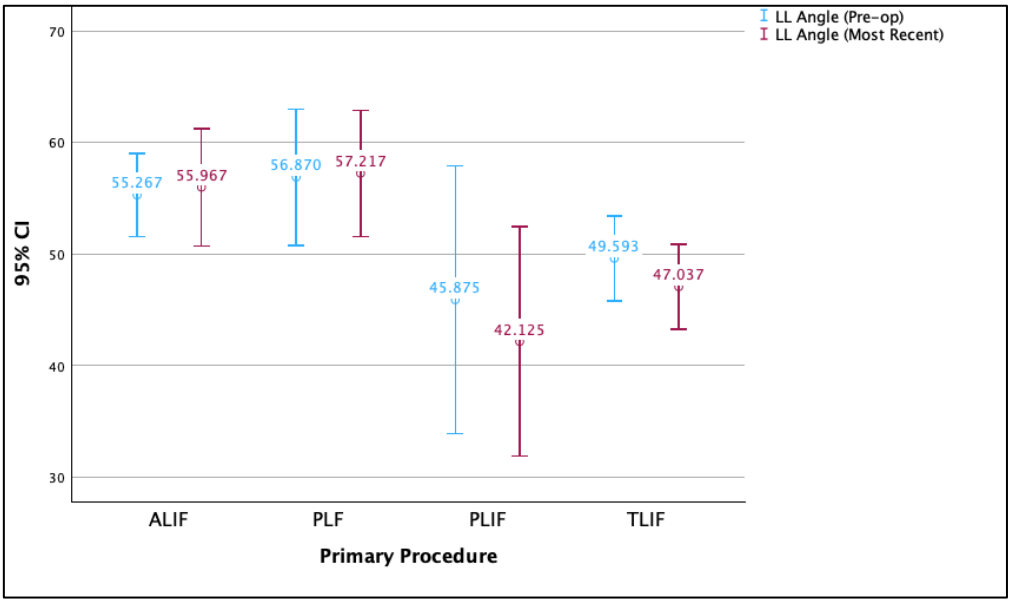
Segmental Angle Changes - ALIF vs PLF vs PLIF vs TLIF

Primary Procedure		LL Angle Change	L4/S1 Angle Change
ALIF	Mean	0.70	3.23
	N	30	30
	Std. Deviation	10.151	6.976
	Sum	21	97
PLF	Mean	0.35	0.17
	N	23	23
	Std. Deviation	7.202	6.638
	Sum	8	4
PLIF	Mean	-3.75	-2.00
	N	8	8
	Std. Deviation	6.628	5.043
	Sum	-30	-16
TLIF	Mean	-2.56	-3.02
	N	54	54
	Std. Deviation	10.666	7.352
	Sum	-138	-163
Total	Mean	-1.21	-0.68
	N	115	115
	Std. Deviation	9.725	7.380
	Sum	-139	-78

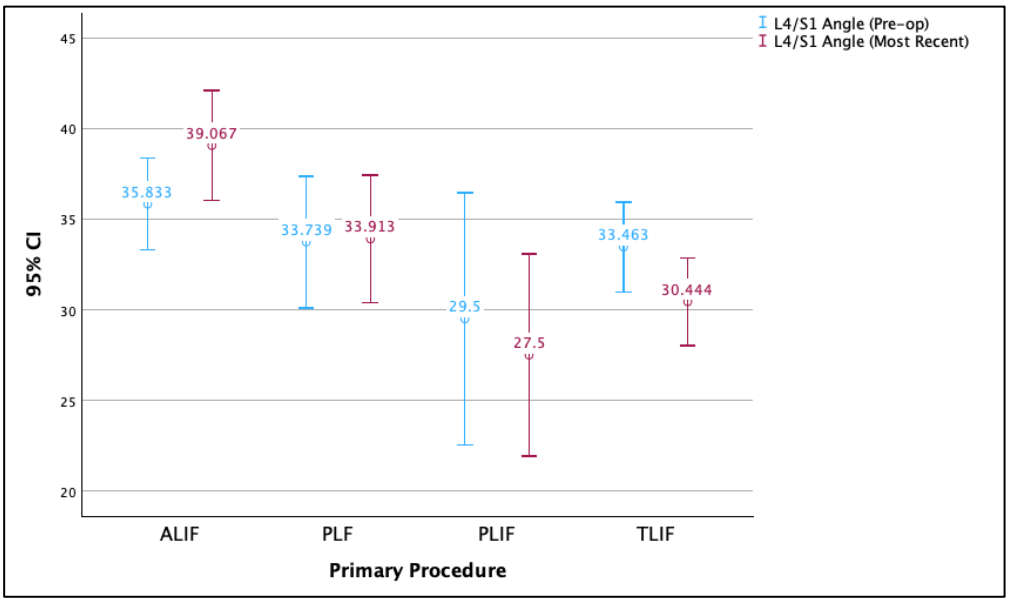
Table 1 – Data relating to pre- and post-operative LL and L4-S1 SL in patients undergoing spinal fusion

From our results, we observed that the mean LL and L4-S1 SL angle change pre- to post-operatively was greatest following ALIF at 0.70° (SD=10.151) and 3.23° (SD=6.976) respectively. Consequently, the greatest decrease in mean LL was observed in patients following a PLIF at -3.75° (SD=6.628) and the greatest decrease in L4-S1 SL angle change pre- to post-operatively was observed following a TLIF at -3.02° (SD=7.352).

Following an ANOVA analysis of segmental angle changes among the four surgical techniques, there were no statistically significant difference in lumbar lordosis between ALIF vs PLF vs PLIF vs TLIF (p>0.05). However, a statistically significant difference in pre- to post-operative L4-S1 SL was revealed in our analysis (P<0.05).)



Graph 1- Mean Change in LL for ALIF vs PLF vs PLIF vs TLIF



Graph 2 - Mean Change in L4-S1 Segmental Lordosis for ALIF vs PLF vs PLIF vs TLIF

Discussion

Several observations emerged from our study focusing on perioperative complications, re-operation rates and segmental angle changes following a primary L5-S1 fusion. Firstly, it should be emphasised that our study highlights that the type of fusion technique does not influence patient outcomes and revision rates.

A meta-analysis performed in 2022 comparing complications following ALIF/TLIF/PLIF in patients undergoing lumbosacral fusion reported higher complications and perioperative mortality with ALIF, whilst lower rates were recorded with TLIF [(9)]. This is attributed to the favourable access to posterior structures in TLIF in comparison with ALIF which has a greater proximity and exposure to vascular structures [(6)]. In our patient cohort, there was no significant difference in perioperative complications between ALIF and TLIF group.

Our results also show that the type of spinal fusion technique does not determine if patients proceed to have subsequent lumbar surgery in the form of revision or extension of metal work to address symptomatic adjacent segment disease. Studies demonstrate that long term follow up of patients treated with ALIF vs TLIF show no significant differences in treatment outcomes [(10)], with conflicting conclusions regarding incidence of adjacent segment disease following lumbar fusion reported in several other studies [(11-13)].

Although there is limited literature evidence regarding re-operation rates following lumbosacral fusion using different surgical techniques, a recent study comparing re-operation rates for symptomatic ASD among ALIF vs PLIF vs TLIF patients undergoing lumbar fusion reported no differences in re-operation rates for patients with symptomatic ASD [(14)].

Additionally, our findings indicate statistically significant differences in L4-S1 SL in patients following different spinal fusion techniques. The greatest increase in SL is evident in ALIF at 3.23°, followed by PLF at 0.17°, PLIF at -2.00° and TLIF at -3.02°. When comparing patients in the ALIF vs TLIF subset, the pre-operative L4-S1 SL is similar between the groups, however, post-operative SL increases following fusion in the ALIF group and decreases in the TLIF group. The literature data aligns with our results with one study reporting greater L4-5 and L5-S1 segmental lordosis in ALIF compared to TLIF/PLIF [(7)].

With the rising incidence of lumbosacral fusion, further research into complications, symptomatic adjacent segment disease and alignment changes using different surgical techniques is necessary over a longer period of time and a larger patient sample size.

Limitations

During LL and SL data collection, we encountered some challenges due to different pre- and post-operative lateral lumbar X-ray modalities. Although where possible, consistent pre- and post-operative X-ray modalities have been utilised, there is a potential for variable angle readings for some patients. To minimise this error, we repeated our analysis with a subset of patients having had pre- and post-op Neutral-Weight Bearing X-rays. Subsequent to our analysis, we observed similar trends in this specific subset of individuals when compared to the results from our overall patient population.

Conclusion

All in all, given the surge in spinal fusion procedures worldwide, it is essential that patients and surgeons are aware of the risks associated with specific spinal techniques. This will enable patients and the clinical team to make holistic and patient-centric decisions. Our study clearly outlines that there are no statistically significant differences between peri-operative complications, re-operation rates and lumbar lordosis between ALIF vs TLIF vs PLIF vs PLF. However, ALIF causes a statistically significant increase segmental lordosis, which is an important factor to consider as it may influence long-term patient outcomes. Nevertheless, further research and robust analysis is necessary to improve the quality of evidence.

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