

Comparative Analysis of Transforaminal Interbody Fusion and Posterior Lumbar Interbody Fusion in Degenerative Spinal Disease

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Abstract: Lumbar degenerative spinal diseases are a leading source of disability in all parts of the world and often necessitate surgical stabilization in cases where efforts to manage the same have failed. The most common ones include transforaminal lumbar interbody fusion (TLIF) and posterior lumbar interbody fusion (PLIF), but comparative evidence in low- and middle-income countries is limited. **Objective:** To identify the comparable perioperative outcomes, functional recovery, radiographic fusion, and complication rates between TLIF and PLIF in patients undergoing surgery for degenerative lumbar spine disease. **Methods:** It is a comparative observational study conducted at the Rawalpindi Teaching Hospital in Pakistan from 8 May 2024 to 8 April 2025. Sixty adult degenerative lumbar pathology patients who had to undergo a single- or two-level interbody fusion were selected and randomly assigned to TLIF (n = 30), or PLIF (n=30), either according to surgeon choice or shared decision. Demographics, comorbidities, operative variables and patient-reported outcomes, such as the Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) for back and leg pain, were recorded. The patients were followed up for 12 months. The outcomes included the duration of surgery, blood loss, hospital stay, fusion rates, complications, and functional recovery. The comparative and multivariate analyses were performed at the $p = 0.05$ level. **Results:** There were no significant differences in baseline demographic and clinical characteristics. TLIF was linked to much less intraoperative blood loss (median 300 mL vs. 420 mL, $p < 0.001$) and reduced hospital stay (median 3 vs. 4 days, $p = 0.015$). The 12-month radiographic fusion rate was even (93.3% TLIF vs. 90.0% PLIF; $p = 0.64$). The two groups showed similar, significant results in ODI and VAS scores at 12 months ($p > 0.05$). There were no significant differences in early and late complication rates. TLIF patients were able to walk independently earlier and go back to work sooner than PLIF patients. PLIF on adjusted analysis was not associated with functional or radiographic outcomes, but was nonetheless independently associated with greater blood loss and a longer hospital stay. **Conclusion:** TLIF and PLIF are both reasonable surgical procedures for degenerative lumbar spinal disease, and they give similar fusion rates, pain relief, and functional outcomes. TLIF is associated with benefits, including reduced blood loss, a short hospital stay and a quick postoperative recovery. These results endorse TLIF as a patient-focused and cost-effective tool, especially in healthcare settings with limited resources.

Keywords: Degenerative lumbar disease, TLIF, PLIF, lumbar fusion, functional outcome

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Introduction

The degenerative spinal diseases are conditions of weakening the intervertebral discs and following alterations in the structure of the spine, which have been increasing in prevalence and necessitating effective surgical procedures. Transforaminal Lumbar Interbody Fusion (TLIF) and Posterior Lumbar Interbody Fusion (PLIF) are the two most common surgical methods for treating such conditions. They both aim to achieve spinal stabilization and pain relief through fusion of the affected vertebrae; however, they employ distinct methodologies and anatomies that could contribute to substantial postoperative outcomes. TLIF was originally mentioned by Harms and Rolinger in 1982 and to some extent, it applies a strategy of minimizing the disturbance of paraspinal muscles and soft tissues, which ultimately could reduce the pain of postoperative patients and enable shorter recovery periods. This less-invasive aspect is a significant innovation in lumbar fusion procedures, enabling reduced blood loss and hospitalization compared to conventional open surgeries (1-3). On the other hand, with PLIF, the back muscles and ligaments are more frequently dissected out, and recovery time may be prolonged and complications, including adjacent segment degeneration and infection, are more likely (4, 5). According to recent comparative effectiveness studies, both methods have advantages, but TLIF can be better in terms of clinical results in a particular setting, in terms of functional recovery and patient satisfaction. Research has shown that TLIF has lower postoperative and intraoperative complications, including lower rates of

nerve root injury and infection (6, 7). The systematic reviews and meta-analyses have implied that TLIF can be especially beneficial in geriatric populations or patients with comorbidities (8, 9). The healthcare trends and socioeconomic factors also affect surgical decision-making, particularly in areas such as Pakistan, where degenerative diseases are increasing with changes in lifestyles (10). The study that specifically focuses on Turkish populations is badly needed because special socio-cultural and health-specific aspects may impact the incidence of these diseases and the efficiency of surgical procedures. The economic limitations and the difference in availability of healthcare also dictate a unique method of surgical setup that should allow local data to guide the best practice in managing degenerative disease of the spine in an effective and sustainable manner (11). On the whole, a comparative analysis of TLIF and PLIF highlights the necessity of tailoring treatment plans to the patient's profile and the dynamism of the local healthcare environment, which preconditions the development of more nuanced health policies and surgical guidelines in the Pakistani context.

Methodology

We conducted a comparative observational study at the Rawalpindi Teaching Hospital in Pakistan from 8 May 2024 to 8 April 2025. Consecutive adult patients (≥ 18 years) undergoing instrumented single- or two-level lumbar interbody fusion for degenerative pathology (lumbar



canal stenosis with instability, degenerative spondylolisthesis grade I–II, or recurrent disc herniation with instability) were eligible. Exclusion criteria were deformity requiring three or more levels, active infection, tumor, traumatic fracture, previous instrumented fusion at the index level, severe osteoporosis (T-score ≤ -2.5 with fragility fracture), and incomplete 12-month follow-up. The surgical approach (transforaminal [TLIF] or posterior lumbar interbody fusion [PLIF]) was chosen by the attending spine surgeon based on pathology, anatomy, and shared decision-making. Perioperative care followed institutional enhanced-recovery pathways, including standardized multimodal analgesia, early mobilization, and DVT prophylaxis per local protocols.

Demographic data (age, sex), comorbidities (diabetes, hypertension, smoking), anthropometrics (BMI), ASA class, imaging (index levels, spondylolisthesis grade), and baseline patient-reported outcomes (Oswestry Disability Index [ODI] version 2.1a; Visual Analog Scale [VAS] for back and leg pain, 0–10) were recorded preoperatively using standardized forms. Operative variables included surgical level(s), operative time (skin-to-skin), estimated blood loss (anesthesia record), transfusion, incidental durotomy, and intraoperative neuromonitoring alerts. Postoperative variables included length of stay, 30-day complications (Clavien–Dindo adapted for spine), discharge disposition, urinary retention >48 h, and readmissions. Radiographic fusion was assessed at 12 months using dynamic radiographs and CT when clinically indicated; fusion was defined a priori as $<3^\circ$ angular motion with continuous trabecular bridging or presence of continuous posterolateral mass, adjudicated by two blinded musculoskeletal radiologists with adjudication by a third in case of disagreement. Cage subsidence was defined as ≥ 2 mm endplate violation on follow-up imaging.

All patients were scheduled for follow-ups at 6 weeks, 3 months, 6 months, and 12 months, at which ODI and VAS were collected by trained staff not involved in surgery. Return-to-work and time to independent ambulation were assessed via clinic interview using predefined anchors. Data were double-entered and cross-checked against source documents. Sample size was fixed at 60 (30 per group) for this single-center series to provide $\geq 80\%$ power to detect a between-group mean difference of 120 mL in blood loss (assumed SD 160 mL) at $\alpha=0.05$, while describing patient-reported outcomes with adequate precision for confidence interval estimation.

Statistical analyses were performed using two-sided tests with $\alpha=0.05$. Continuous data were summarized as mean (SD) or median (IQR) based on distribution (Shapiro–Wilk) and compared using Student’s t-test or Mann–Whitney U test. Categorical variables were compared using χ^2 or Fisher’s exact test. Effect sizes were expressed as mean differences (MD) or risk differences (RD) with 95% confidence intervals (CIs). For adjusted estimates, multivariable linear or logistic regression included covariates selected a priori (age, sex, BMI, diabetes, levels fused, baseline ODI or VAS). Model assumptions (linearity, homoscedasticity, multicollinearity) were checked, and robust standard errors were used when appropriate. Prespecified subgroup analyses evaluated interaction by diabetes status, age ≥ 55 years, and current smoking using ANCOVA with baseline adjustment and multiplicative interaction terms. Missing data were minimal ($<5\%$ per variable) and handled with complete-case analysis. Radiographic endpoints were assessed by readers blinded to surgical approach; patient-reported outcomes were collected by personnel independent of the operating team. The study adhered to the Declaration of Helsinki; institutional ethics approval was obtained, and all participants provided written informed consent.

Results

Table 1: Baseline demographic and clinical characteristics of the cohort (n = 60)

Variable	Overall (n=60)	TLIF (n=30)	PLIF (n=30)	p-value
Age, years, mean (SD)	52.1 (10.8)	51.7 (11.2)	52.5 (10.6)	0.80
Male sex, n (%)	36 (60.0)	18 (60.0)	18 (60.0)	1.00

The mean age of the overall cohort was 52.1 ± 10.8 years, with no significant difference between groups (TLIF: 51.7 ± 11.2 ; PLIF: 52.5 ± 10.6 ; $p = 0.80$). Males constituted 60% of the total population, evenly distributed between both groups ($p = 1.00$). The mean BMI was similar in both cohorts (TLIF: 27.0 ± 3.6 vs. PLIF: 27.4 ± 3.9 ; $p = 0.68$). Among comorbidities, diabetes mellitus was present in 36.7% and hypertension in 45% of participants, with no significant between-group differences ($p = 0.59$ and $p = 0.42$, respectively). Approximately 21.7% were current smokers, and 28.3% were classified as ASA class III—both parameters evenly distributed across the groups. The majority had single-level fusion (70%), most commonly at L4–L5 (51.7%), and low-grade spondylolisthesis (43.3%) was the prevalent diagnosis. Baseline disability and pain scores were comparable: median ODI 56 (IQR 48–64), mean VAS-Back 7.6 ± 1.2 , and VAS-Leg 7.4 ± 1.3 . (Table 1).

As shown in Table 2, the mean operative time was similar between TLIF (173 \pm 32 min) and PLIF (180 \pm 35 min) ($p = 0.41$). However, estimated blood loss was significantly lower in TLIF (median 300 mL [250–400]) than in PLIF (420 mL [350–550]; $p < 0.001$). Transfusion requirements and length of hospital stay differed modestly, with TLIF showing shorter median stay (3 vs. 4 days; $p = 0.015$).

Radiographic fusion rates at 12 months were 93.3% (TLIF) vs. 90% (PLIF) ($p = 0.64$), indicating equivalent fusion success. Functional recovery also showed no statistically significant difference in 12-month outcomes for ODI (mean 18.9 vs. 19.5; $p = 0.83$) or pain reduction (VAS-Back: 2.1 vs. 2.3; $p = 0.54$; VAS-Leg: 1.9 vs. 2.0; $p = 0.74$).

Within 30 days, complication rates were low and comparable (13.3% TLIF vs. 20.0% PLIF; $p = 0.49$). The most frequent early complication was incidental durotomy (3.3% vs. 10.0%), while superficial/deep surgical site infections occurred in 3.3% and 6.7% respectively. Neurologic deficits and urinary retention were rare and similar in both groups. No deep vein thrombosis or pulmonary embolism was recorded. At 12 months, reoperation rates were identical (6.7%), and radiographic complications such as cage subsidence or adjacent segment disease were infrequent and statistically nonsignificant. (Table 3).

Table 4 shows stratified analyses. Neither diabetes, age group, nor smoking status significantly modified the effect of surgical technique on functional outcomes. For diabetic patients, mean Δ ODI improvement was -32.4% in TLIF vs. -31.0% in PLIF ($p = 0.67$), and for non-diabetics, -38.1% vs. -37.2% ($p = 0.77$). There was no evidence of interaction across strata (p -interaction values 0.28–0.66), indicating consistent efficacy of both fusion methods irrespective of patient comorbidities or habits.

TLIF demonstrated superior recovery parameters. Patients ambulated independently sooner (median 2 vs. 3 days; $p = 0.021$) and returned to work earlier (median 9.0 vs. 10.5 weeks; $p = 0.047$). Although a higher proportion of TLIF patients were discharged directly home (83.3% vs. 70.0%), the difference did not reach statistical significance ($p = 0.22$). (Table 5)

After adjusting for potential confounders (age, sex, BMI, diabetes, ASA class, fused levels, and baseline ODI/VAS), PLIF was associated with significantly greater blood loss (+112 mL; 95% CI 59–165; $p < 0.001$) and a longer hospital stay (+0.9 days; 95% CI 0.1–1.7; $p = 0.029$). Other outcomes, including operative time, radiographic fusion, disability improvement, pain reduction, complications, and reoperation rates, showed no significant differences between techniques. Functionally, PLIF patients required approximately one extra day for independent ambulation ($p = 0.021$) and 1.5 additional weeks for return-to-work ($p = 0.047$). (Table 6).

BMI, kg/m ² , mean (SD)	27.2 (3.8)	27.0 (3.6)	27.4 (3.9)	0.68
Diabetes mellitus, n (%)	22 (36.7)	10 (33.3)	12 (40.0)	0.59
Hypertension, n (%)	27 (45.0)	12 (40.0)	15 (50.0)	0.42
Current smoker, n (%)	13 (21.7)	6 (20.0)	7 (23.3)	0.76
ASA class III, n (%)	17 (28.3)	8 (26.7)	9 (30.0)	0.78
Levels fused, 1/≥2, n	42/18	22/8	20/10	0.57
Primary level L4–L5, n (%)	31 (51.7)	16 (53.3)	15 (50.0)	0.80
Spondylolisthesis grade I–II, n (%)	26 (43.3)	12 (40.0)	14 (46.7)	0.60
ODI %, median (IQR)	56 (48–64)	55 (47–64)	57 (49–65)	0.53
VAS-Back, mean (SD)	7.6 (1.2)	7.5 (1.2)	7.6 (1.2)	0.69
VAS-Leg, mean (SD)	7.4 (1.3)	7.3 (1.3)	7.5 (1.2)	0.51

Table 2: Perioperative metrics and primary outcomes

Outcome	TLIF (n=30)	PLIF (n=30)	Effect (95% CI)	p-value
Operative time, min, mean (SD)	173 (32)	180 (35)	MD -7 (-24, 10)	0.41
Blood loss, mL, median (IQR)	300 (250–400)	420 (350–550)	MD -110 (-170, -60)	<0.001
Intraop transfusion, n (%)	3 (10.0)	5 (16.7)	RD -6.7% (-26.4, 12.9)	0.49
Length of stay, days, median (IQR)	3 (2–4)	4 (3–5)	MD -1.0 (-1.8, -0.2)	0.015
Radiographic fusion at 12 mo, n (%)	28 (93.3)	27 (90.0)	RD +3.3% (-12.1, 18.7)	0.64
ODI at 12 mo, %, mean (SD)	18.9 (9.6)	19.5 (10.1)	MD -0.6 (-6.2, 5.0)	0.83
ΔODI (baseline→12 mo), mean (SD)	-36.1 (11.4)	-35.0 (12.1)	MD -1.1 (-7.3, 5.1)	0.72
VAS-Back at 12 mo, mean (SD)	2.1 (1.3)	2.3 (1.4)	MD -0.2 (-0.9, 0.5)	0.54
VAS-Leg at 12 mo, mean (SD)	1.9 (1.2)	2.0 (1.3)	MD -0.1 (-0.8, 0.6)	0.74

Table 3: Early (30-day) and late (12-month) complications

Complication	TLIF (n=30)	PLIF (n=30)	p-value
Any 30-day complication	4 (13.3)	6 (20.0)	0.49
Incidental durotomy	1 (3.3)	3 (10.0)	0.30
Surgical-site infection (superficial/deep)	1 (3.3)	2 (6.7)	0.55
New neurologic deficit	1 (3.3)	1 (3.3)	1.00
DVT/PE	0 (0)	0 (0)	—
Urinary retention requiring catheter >48 h	1 (3.3)	2 (6.7)	0.55
12-mo reoperation (any cause)	2 (6.7)	2 (6.7)	1.00
Cage subsidence (>2 mm) at 12 mo	3 (10.0)	2 (6.7)	0.64
Adjacent segment disease at 12 mo	1 (3.3)	1 (3.3)	1.00

Table 4: Subgroup outcomes at 12 months

Stratum	Outcome	TLIF	PLIF	p (within stratum)	p-interaction
Diabetes (Yes)	ΔODI, %	-32.4 (10.8)	-31.0 (11.5)	0.67	0.28
	VAS-Back, 12 mo	2.3 (1.4)	2.5 (1.5)	0.58	
Diabetes (No)	ΔODI, %	-38.1 (11.2)	-37.2 (11.7)	0.77	0.41
	VAS-Back, 12 mo	2.0 (1.3)	2.1 (1.2)	0.73	
Age ≥55 y	ΔODI, %	-35.7 (11.9)	-34.6 (12.4)	0.75	0.66
Age <55 y	ΔODI, %	-36.4 (11.1)	-35.3 (11.9)	0.73	
Current smoker	ΔODI, %	-34.2 (10.7)	-33.5 (11.3)	0.86	0.51
Non-smoker	ΔODI, %	-36.9 (11.6)	-35.8 (12.1)	0.72	

Table 5: Resource utilization and functional recovery

Metric	TLIF (n=30)	PLIF (n=30)	Effect	p-value
Time to independent ambulation, days, median (IQR)	2 (2–3)	3 (2–4)	MD -1.0 (-1.8, -0.2)	0.021
Return-to-work (if employed), weeks, median (IQR)	9.0 (8–11)	10.5 (9–12)	MD -1.5 (-2.9, -0.0)	0.047
Discharge home (no rehab), n (%)	25 (83.3)	21 (70.0)	RD +13.3% (-7.9, 34.5)	0.22

Table 6: Adjusted Multivariable Analysis of Key Outcomes Between TLIF and PLIF

Outcome Variable	Adjusted Effect (PLIF vs TLIF)	95% CI	p-value
Estimated blood loss (mL)	+112 mL	59 – 165	<0.001
Operative time (min)	+7 min	-10 – 24	0.41
Length of hospital stay (days)	+0.9 days	0.1 – 1.7	0.029
Radiographic fusion at 12 months (OR)	0.72	0.14 – 3.72	0.69
ODI at 12 months (%)	+0.4 %	-3.7 – 4.5	0.84
VAS-Back at 12 months	+0.1	-0.5 – 0.6	0.75
VAS-Leg at 12 months	+0.1	-0.6 – 0.8	0.74

Any 30-day complication (OR)	1.53	0.38 – 6.15	0.55
Reoperation within 12 months (OR)	1.00	0.14 – 7.25	1.00
Time to independent ambulation (days)	+1.0 day	0.2 – 1.8	0.021
Return-to-work (weeks)	+1.5 weeks	0.0 – 2.9	0.047

Discussion

The comparative assessment of Transforaminal Lumbar Interbody Fusion (TLIF) and Posterior Lumbar Interbody Fusion (PLIF) has gained momentum in recent years due to the rising prevalence of degenerative spinal diseases, which affect a substantial portion of the population. Given the increasing demand for effective surgical solutions, recent literature emphasizes variations in operative outcomes between TLIF and PLIF, particularly regarding intraoperative parameters, complication rates, functional recovery, and overall effectiveness in managing conditions such as spondylolisthesis and disc degeneration.

In the present study, the mean age of the cohort was 52.1 years, aligning with findings from Khattak et al. (2023), who reported similar demographics and effective treatment outcomes for both TLIF and PLIF in populations with similar profiles (12). The distribution of males and females was consistent across both groups, a finding corroborated by, who noted that gender distribution does not significantly impact surgical outcomes (13). The comorbidities prevalent in the current study, specifically diabetes and hypertension, also parallel findings from El-Ghandour et al. (2021), further emphasizing the importance of recognizing these auxiliary health factors in the spondylolisthesis population (14).

The findings regarding operative time and blood loss demonstrate critical differences between TLIF and PLIF. The TLIF group exhibited significantly lower estimated blood loss (median 300 mL) compared to PLIF (420 mL), substantiating the conclusions of that highlight the minimally invasive advantages of TLIF to mitigate intraoperative morbidity (15). Moreover, the shorter hospital stay recorded in TLIF patients (3 days) aligns with the findings of (16). Who reported similar benefits associated with minimally invasive techniques (16).

The complication rates observed (13.3% for TLIF vs. 20.0% for PLIF) are consistent with previous literature, where lower complication rates in TLIF procedures have been noted, particularly concerning instances of incidental durotomy and wound infections (17). However, both surgical techniques exhibited manageable complication and reoperation rates, underscoring the reliability of these procedures in a clinical context (12). Functional outcomes at 12 months showed comparable improvements across both cohorts, with no statistically significant differences in Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) scores. This observation is harmonized with findings reported by (18). Emphasizing the equivalence of functional recovery between these surgical approaches when performed on a similar demographic (18). Notably, patients undergoing TLIF achieved independent ambulation sooner and returned to work earlier than those in the PLIF group, aligning with the meta-analysis by Ohrt-Nissen et al. (2021) that advocated for TLIF's enhanced recovery parameters over PLIF (19).

Our analysis indicated that PLIF was associated with greater blood loss and a longer hospital stay post-adjustment for multiple confounding factors. This observation is corroborated by the extensive findings of Ohrt-Nissen et al. (2021), who emphasized that the surgical approach significantly affects complications and recovery metrics (19). Furthermore, the comparison to similar studies indicates that the minor differences in functional improvement should encourage sustained focus on the tailored application of minimally invasive techniques like TLIF (14, 20).

This comparative analysis highlights the nuances in surgical outcomes between TLIF and PLIF for treating degenerative spinal disease within the context of a Pakistani population. Considering the rising incidence of degenerative spinal conditions correlated with lifestyle factors in Pakistan, there is a pressing need for treatments that minimize recovery time and complications. The reduced blood loss and shorter hospital stays

associated with TLIF could result in significant healthcare savings and improved patient outcomes in this demographic. As spine surgery continues to evolve, localized data will prove crucial in informing evidence-based practice and optimizing patient management strategies in Pakistan.

Conclusion

Transforaminal and posterior lumbar interbody fusion in patients with degenerative lumbar spinal disease gives similar long-term functional and radiographic results. Nonetheless, TLIF has been shown to offer distinct perioperative and postoperative benefits, such as reduced blood loss, a shorter hospital stay and an earlier return to mobility and employment. The benefits can translate into improved patient output and reduced economic burden in resource-limited healthcare systems. The choice of surgical techniques must therefore be based not only on radiographic and functional outcomes, but also on perioperative efficiency and the profile of patient recovery.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-RPADKBB-203-24)

Consent for publication

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

FA (Resident Neurosurgeon)

Manuscript drafting, Study Design,

SA (Associate Professor & HOD)

Review of Literature, Data entry, Data analysis, and drafting article.

BAK (Resident Neurosurgeon)

Conception of Study, Development of Research Methodology Design, Study Design, manuscript review, critical input.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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