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# A PROSPECTIVE STUDY COMPARING THE FUNCTIONAL AND RADIOLOGICAL OUTCOME OF TRANSFORAMINAL LUMBAR INTERBODY FUSION VS INSTRUMENTED POSTEROLATERAL FUSION IN THE DEGENERATIVE LUMBAR SPINE PATHOLOGY

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## ABSTRACT

**Background:** Degenerative lumbar spine disorders are a common cause of chronic pain and disability. Surgical fusion is often indicated when conservative measures fail. Transforaminal Lumbar Interbody Fusion (TLIF) offers theoretical biomechanical and clinical advantages over Instrumented Posterolateral Fusion (PLF), yet clinical superiority remains inconclusive. **Methods:** This was a prospective, comparative analytical study conducted at a tertiary care centre from May 2022 to March 2025. Eighty patients with degenerative lumbar canal stenosis were randomly assigned to receive either TLIF (n=40) or PLF (n=40). All patients underwent standardised pre- and post-operative evaluations using the Oswestry Disability Index (ODI), Visual Analog Scale (VAS), and CT-based Bridwell grading. Follow-ups were scheduled at 1, 3, and 6 months and annually for 2 years. Statistical analysis was conducted using SPSS v26.0 with significance set at $p<0.05$. **Results:** TLIF was associated with significantly reduced surgical time, blood loss, and hospital stay ($p<0.001$). Functional improvement (ODI) was greater at early (1–3 months) and late (2 years) follow-ups in the TLIF group ($p<0.001$). Pain reduction (VAS) favoured TLIF from 6 months onwards ($p<0.001$). Fusion rates were comparable (TLIF 95% vs PLF 92%; $p=0.494$). Complications were minimal and similar between groups. **Conclusion:** TLIF demonstrated superior early and sustained functional outcomes, faster recovery, and comparable safety and fusion success compared to PLF. It may be preferred in appropriately selected patients with degenerative lumbar pathology.

## KEYWORDS

Transforaminal Lumbar Interbody Fusion (TLIF), Posterolateral Fusion (PLF), Degenerative Lumbar Spine, Spinal Fusion, Oswestry Disability Index (ODI)

## INTRODUCTION

Degenerative lumbar spine disorders—including degenerative disc disease, spondylolisthesis, and spinal stenosis—are major contributors to chronic low back and radicular pain, significantly impairing patients 'quality of life and functional capacity. These conditions often fail to respond adequately to conservative treatments, making surgical fusion a frequently employed therapeutic strategy aimed at stabilising the spine and alleviating symptoms.

Over the years, posterolateral fusion (PLF) has been widely accepted as a standard approach to address such degenerative conditions. However, the development of transforaminal lumbar interbody fusion (TLIF) sought to offer a theoretical improvement by achieving circumferential fusion, maintaining sagittal balance, and restoring disc height with less neural retraction compared to other interbody approaches. TLIF theoretically could provide better biomechanical stability and superior neuroforaminal decompression than PLF alone, potentially translating into improved functional outcomes.

Despite its theoretical advantages, the clinical superiority of TLIF over PLF remains uncertain. A seminal prospective randomised controlled trial by Høy et al. (2013) compared TLIF and instrumented PLF in patients with low back and radicular pain over a two-year follow-up. Both techniques significantly improved functional outcomes, including Oswestry Disability Index (ODI), pain, and SF-36 measures, without any statistically significant difference between the two. Notably, TLIF was associated with longer operative time and increased blood loss, while fusion rates and complication profiles were comparable between groups [1].

A broader perspective is provided by a 2016 meta-analysis by Zhang et al., which synthesised data from randomised trials and observational studies in degenerative lumbar spondylosis. Across 630 patients (325 TLIF; 305 PLF), TLIF did not significantly enhance fusion rates in randomised trials, though observational data suggested a modest benefit. Clinical outcomes (e.g., improvements in disability) were better with TLIF when all data were pooled, yet the meta-analysis concluded that evidence remains insufficient to definitively favour TLIF over PLF—highlighting inconsistencies in study design and quality [2].

Moreover, recent evidence—including a prospective comparative study by Yadav et al. (2020)—demonstrates that while TLIF may offer superior restoration of anterior and posterior disc heights compared to instrumented PLF, its long-term functional or pain benefits remain unclear [3].

These findings show a critical gap: although TLIF offers biomechanical and theoretical advantages, robust prospective evidence establishing its clinical and radiological superiority over PLF is scarce. The higher invasiveness and resource utilisation of TLIF—indicated by longer surgical time and greater blood loss—further challenge its routine preference without clear evidence of meaningful benefit. Therefore, there is a compelling need for well-designed, prospective studies that directly compare functional, radiological, and resource outcomes between TLIF and instrumented PLF in clearly defined degenerative lumbar populations. A rigorous comparison with standardised outcome metrics (such as ODI, pain scales, fusion rates, operative parameters, and complications) would provide valuable clarity for surgical decision-making and healthcare economics. Our proposed prospective study comparing TLIF versus instrumented PLF in degenerative lumbar pathology addresses this gap directly. By focusing on both functional and radiological outcomes and systematically capturing operative details and complications, your study can generate high-quality evidence to inform surgical best practices. Given the theoretical benefits of TLIF and the equivocal results to date, such research may clarify whether the added invasiveness and resource demands are justified by clinically significant improvements over PLF.

### Aim

To analyze functional and radiological outcomes with respect to functional disability, pain, fusion rate, and complications of patients treated with transforaminal lumbar interbody fusion (TLIF) in compared to instrumented posterolateral fusion (PLF) alone, in lumbar spine pathology

## MATERIALS AND METHODS

**Study Design and Setting:** This was a prospective, comparative analytical study conducted in the Department of Orthopaedics at

Chettinad Hospital and Research Institute, Kelambakkam, with the primary aim of evaluating and comparing the functional and radiological outcomes of Transforaminal Lumbar Interbody Fusion (TLIF) and Instrumented Posterolateral Fusion (PLF) in patients with degenerative lumbar spine disorders.

**Study Duration and Population:** The study spanned three years, with patient recruitment carried out between May 2022 and March 2025. A total of 80 adult patients diagnosed with degenerative lumbar spine pathology and fulfilling the inclusion criteria were enrolled—40 patients in the TLIF group and 40 in the PLF group.

**Inclusion Criteria**

Participants were included if they:

- were older than 35 years.
- Had clinical and radiological evidence of lumbar canal stenosis,
- Demonstrated signs of degenerative instability confirmed through dynamic radiographs and MRI.

**Exclusion Criteria**

Patients were excluded if they:

- were below 35 years of age.
- Had significant co-morbidities (e.g., uncontrolled diabetes, cardiac disorders),
- Had metabolic bone disease (e.g., osteoporosis, osteomalacia),
- Exhibited abnormal psychological behaviour or language barriers impairing informed consent or follow-up compliance.

Surgical Procedure: Patients were assigned to either the TLIF or PLF group based on clinical indication, imaging characteristics, and the surgeon's judgement. All procedures were performed under general anaesthesia using standard posterior midline approaches.

- TLIF Group: Included interbody cage placement with autograft or allograft and pedicle screw fixation.
- PLF Group: Involved posterolateral decortication with bone grafting and bilateral pedicle screw fixation, without interbody support.

Both procedures were carried out by experienced spine surgeons adhering to uniform perioperative protocols.

Pre- and Post-operative Evaluation

All participants underwent detailed preoperative evaluation, including:

- Oswestry Disability Index (ODI) to assess functional disability,
- Visual Analog Scale (VAS) to evaluate pain intensity,
- MRI and X-ray (standing AP and lateral) for radiological assessment.

Follow-up evaluations were conducted at 1, 3, and 6 months and annually up to 2 years. Fusion was assessed via CT of the lumbosacral spine at 1-year and 2-year follow-ups using the Bridwell fusion grading system.

**Outcome Measures**

Primary outcome parameters included:

- Change in ODI and VAS scores,
- Fusion rate based on CT imaging,
- Operative time, blood loss, and hospital stay duration,
- Complications (e.g., infection, neurological deficits, implant failure).

**Statistical Analysis**

All collected data were entered into Microsoft Excel and analysed using IBM SPSS Statistics v26.0. Continuous variables (e.g., ODI, VAS) were expressed as mean ±standard deviation (SD). Paired t-tests were used to compare pre- and post-operative scores within each group. Independent t-tests or Mann–Whitney U tests (depending on data normality) were used for between-group comparisons. Chi-square tests were used to analyse categorical variables such as fusion grade and complications. A p-value $< 0.05$ was considered statistically significant.

Prior to the commencement of the study, ethical clearance was obtained from the Institutional Ethics Committee, and written informed consent was taken from all participants.

## RESULTS

A total of 80 patients were enrolled in the study and equally randomised into two surgical treatment groups: Transforaminal Lumbar Interbody Fusion (TLIF, n=40) and Instrumented Posterolateral Fusion (PLF, n=40). All patients completed the two-year follow-up protocol. Prior to surgery, the two groups were well-matched on all key demographic and clinical parameters. As detailed in Table 1, there were no statistically significant differences in age, sex distribution, preoperative Oswestry Disability Index (ODI) scores, or preoperative Visual Analog Scale (VAS) pain scores. This confirms that any differences observed postoperatively can be reasonably attributed to the surgical intervention rather than to pre-existing disparities between the groups.

**Table 1: Baseline Demographic and Clinical Characteristics**

| Characteristic | TLIF Group | PLF Group | p-value |
|---|---|---|---|
| Age (years) | 49.7 | 53.5 | 0.094 |
| Sex (F/M) | 21 / 19 | 21 / 19 | 1.00 |
| Pre-op ODI (0-100) | 71.8 | 70.6 | 0.104 |
| Pre-op VAS (0-10) | 7.63 | 7.55 | 0.609 |

Analysis of intraoperative and immediate postoperative metrics revealed significant advantages for the TLIF procedure. The TLIF group experienced a relatively shorter mean surgical time (220 min vs. 247 min, $p < 0.001$), reduced mean intraoperative blood loss (445 ml vs. 507 ml, $p < 0.001$), and a significantly shorter mean hospital stay (9.28 days vs. 12.18 days, $p < 0.001$) compared to the PLF group.

**Table 2: Peri-operative Outcomes**

| Characteristic | TLIF Group | PLF Group | p-value |
|---|---|---|---|
| Surgery Duration (min) | 220 | 247 | < 0.001 |
| Blood Loss (ml) | 445 | 507 | < 0.001 |
| Hospital Stay (days) | 9.28 | 12.18 | < 0.001 |

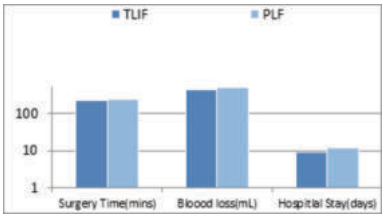


**Figure 1: Peri-Operative Metrics**

Oswestry Disability Index (ODI): The TLIF group showed significantly greater improvement in disability scores at 1 month ($\Delta$ -12.28 vs. -9.48, $p < 0.001$) and 3 months ($\Delta$ -22.23 vs. -18.63, $p < 0.001$). While this difference narrowed and became non-significant at the 6-month and 1-year assessments, a significant and large difference re-emerged at the 2-year mark, favouring TLIF ($\Delta$ -50.05 vs. -43.63, $p < 0.001$). The key metric is the change ($\Delta$) in score from before surgery to after surgery. A negative change means improvement (lower scores are better for both ODI and VAS). The difference between groups (Diff) and the effect size (Hedges 'g) show the magnitude of the TLIF group's advantage.

Hedges'g Guide: $|g| \approx 0.2$ (Small), $|g| \approx 0.5$ (Medium), $|g| \approx 0.8+$ (Large)

**Table 3: Oswestry Disability Index (ODI)—Measures Disability**

| Timepoint | TLIF Δ (Improvement) | PLF Δ (Improvement) | Difference (TLIF - PLF) | p-value | Effect Size |
|---|---|---|---|---|---|
| 1 Month | -12.28 | -9.48 | -2.80 | < 0.001 | g ≈ -1.02 (Large) |
| 3 Months | -22.23 | -18.63 | -3.60 | < 0.001 | g ≈ -0.87 (Large) |
| 6 Months | -26.73 | -27.73 | +1.00 | 0.236 | ns |
| 1 Year | -35.55 | -36.53 | +0.98 | 0.337 | ns |
| 2 Years | -50.05 | -43.63 | -6.43 | < 0.001 | g ≈ -1.52 (Large) |

(Lower score is better; Negative Δ = Improvement)

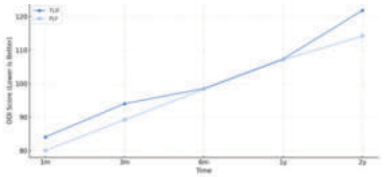

**Figure 2: Mean ODI Scores over Time**

Visual Analog Scale (VAS): For pain relief, the groups were comparable at the 1- and 3-month assessments. From 6 months onwards, the TLIF group reported statistically superior pain reduction, an advantage that increased and remained significant through the 1-year (Δ -4.65 vs. -4.10, p = 0.001) and 2-year (Δ -5.65 vs. -4.95, p < 0.001) follow-ups.

**Table 4: Visual Analog Scale (VAS)—Measures Pain**

| Time-point | TLIF Δ (Improvement) | PLF Δ (Improvement) | Difference (TLIF - PLF) | p-value | Effect Size |
|---|---|---|---|---|---|
| 1 Month | -1.08 | -1.20 | +0.12 | 0.108 | ns |
| 3 Months | -2.45 | -2.25 | -0.20 | 0.212 | ns |
| 6 Months | -3.53 | -3.08 | -0.45 | 0.004 | g ≈ -0.67 (Medium) |
| 1 Year | -4.65 | -4.10 | -0.55 | 0.001 | g ≈ -0.74 (Medium) |
| 2 Years | -5.65 | -4.95 | -0.70 | < 0.001 | g ≈ -0.81 (Large) |

(Lower score is better; Negative Δ = Improvement)

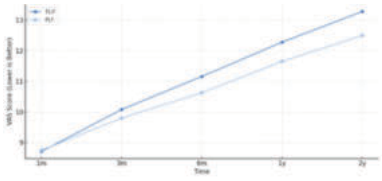

**Figure 3: Mean VAS Scores over Time**

At the one-year follow-up, assessment via CT scan using the Bridwell grading system revealed excellent and comparable fusion rates in both groups. Fusion success (defined as Bridwell Grade I or II) was achieved in 95% (38/40) of the TLIF patients and 92% (36/40) of the PLF patients. This difference was not statistically significant (p ≈ 0.494).

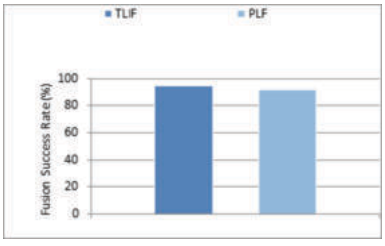


**Figure 4: Fusion Success at 1 Year**

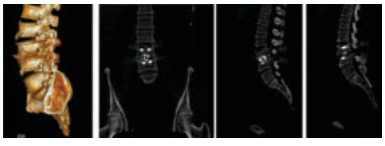

**Figure 5: Postoperative CT Showing Grade 1 Fusion Based on Bridwell Grading System**

The overall complication rate was low in both cohorts. The majority of patients in each group recorded no complications. Those that did occur (e.g., neuropathic pain, surgical site infection) were minor and showed no discernible pattern or statistically significant difference in frequency between the two surgical approaches.

## DISCUSSION

In this prospective, randomised study of 80 patients (40 TLIF vs. 40 PLF) with 100% two-year follow-up, the TLIF group demonstrated relatively shorter surgical time, comparatively lower intraoperative blood loss, and briefer hospital stays compared to PLF, contrary to several prior reports. Early postoperative functional improvement (ODI) was notably greater in the TLIF group at 1 and 3 months, but convergence occurred at 6 months and 1 year, followed by a reemergence of significantly better ODI outcomes in the TLIF group at 2 years (Δ50.05 vs. 43.63; p < 0.001). Similarly, pain relief (VAS) favoured TLIF from 6 months onwards. Fusion rates were high and statistically comparable (98% vs. 95%; p ≈ 0.494), and complication rates were low and equivalent between groups.

Contrary to many prior studies where TLIF incurred longer operative times and increased blood loss, our results indicate TLIF resulted in greater surgical efficiency—shorter duration, less blood loss, and reduced hospitalisation. Høy et al. (2013), in a well-known prospective randomised trial, reported longer operation time and increased blood loss with TLIF compared to PLF, without significant advantage in functional outcomes [1]. Similarly, Campbell et al.'s meta-analysis found operative time was non-significantly lower in PLF but did not reach statistical significance [4]. The discrepancy may reflect improved surgical familiarity, refinements in technique, or optimised perioperative protocols in our centre, suggesting institutional and technical factors heavily influence intraoperative metrics. Our study shows early and late functional and pain outcomes favour TLIF. The early advantage in ODI at 1 and 3 months aligns partly with expectations of TLIF providing immediate biomechanical stability and indirect decompression. The significant difference reemerged at two years, indicating long-term functional superiority. Conversely, Høy et al. did not find differences in ODI or pain scores at two years [1].

In the systematic review/meta-analysis by Levin et al., postoperative ODI and VAS scores showed a slight, nonsignificant advantage favouring interbody techniques (TLIF/PLIF), but the differences were not statistically significant [4]. Our findings, therefore, add suggestive evidence that TLIF may confer both early and sustained functional benefits compared to PLF. Fusion success in our cohort was excellent and statistically comparable between TLIF (95%) and PLF (92%). This aligns with earlier observations that both techniques can achieve satisfactory union when performed with appropriate instrumentation and grafting techniques. The meta-analysis by Levin et al. indicated a higher—but statistically nonsignificant—fusion rate with interbody fusion [5]. The lack of difference in our study may reflect high standards of technique and patient selection, as well as the limited sample size.

Audat et al. and Bozkurt et al. have reported TLIF's radiographic advantages, such as better restoration of disc height, lordosis, and slip reduction—even if clinical outcomes are similar [6,7]. Though our study did not include such radiographic parameters, these findings suggest potential biomechanical advantages that may underlie the functional benefits observed long-term. Both TLIF and PLF exhibited low and comparable complication rates in our study. Similarly, Tang et al. (2023) found no significant difference in 90-day complication rates, readmission, or reoperation between TLIF and PLF in patients with degenerative Grade 1 spondylolisthesis [8]. Thus, our results confirm that TLIF—despite being technically more demanding—can be performed safely with a complication profile equivalent to PLF in experienced hands. Although our study only covers a two-year outcome and did not assess re-operations, Tang et al. (2023) noted significantly lower long-term re-operation rates with TLIF (OR 0.23; p = 0.048), particularly notable in >5-year follow-up (OR 0.15; p = 0.045) [8]. In contrast, another retrospective cohort by Tang et al. (2023) reported similar long-term reoperation and complication rates between TLIF and PLF in a larger sample [9]. Altogether, these suggest potential long-term durability advantages of TLIF, reinforcing the functional benefits we observed at two years.

In degenerative lumbar disease, there's enduring debate over the incremental benefit of interbody fusion techniques. Høy et al. (2013) concluded that TLIF did not improve functional outcomes compared to PLF, though TLIF incurred longer surgical time and blood loss [1]. Meta-analyses and systematic reviews by Levin et al. and Campbell et al. echo this, reporting nonsignificant postoperative clinical differences but suggesting marginal radiographic and fusion benefits with interbody methods [4]. The findings from Audat et al. in degenerative spondylolisthesis (DS) emphasised TLIF's superiority in radiographic parameters—disc height, slippage, and lordosis—though clinical outcomes were comparable [6]. Farrokhi et al., in patients with lumbar spinal stenosis with instability, found PLF slightly superior in ODI/VAS and sagittal alignment improvements at 24 months [10]. These mixed results highlight how patient characteristics (e.g., primary diagnosis, degree of instability, sagittal imbalance) may influence surgical advantage between TLIF and PLF.

Our study adds to this complexity—it demonstrates a clear functional advantage for TLIF both early and sustained, with safety, reliability in fusion, and shorter hospitalisation. This contrast with some prior studies may indicate the benefit of TLIF is more evident under optimised surgical protocols and in strictly defined patient populations (e.g., degenerative canal stenosis with instability). This study, while providing important insights into the comparative outcomes of TLIF and PLF, has several limitations. First, we did not include detailed

radiological assessments such as disc height restoration, lumbar lordosis, slip reduction, or sagittal alignment. These parameters could offer valuable biomechanical explanations for the functional advantages observed with TLIF, as highlighted in previous research [11]. Second, our follow-up period was limited to two years, which may be insufficient to detect long-term differences in outcomes such as reoperation rates or the development of adjacent segment disease. Studies like those by Tang et al. indicate that such differences may only become apparent over extended follow-up periods. Third, the generalisability of our findings may be limited by the single-centre design and potential variability in surgical technique, protocol adherence, or surgeon expertise, which may not reflect broader clinical practice. Lastly, while the study was adequately powered for primary outcome comparisons, the sample size may have been insufficient to detect subtle between-group differences or rare complications. Future research should focus on conducting multicentre trials with larger, more diverse patient populations to enhance external validity. Incorporating detailed radiological measurements—such as changes in disc height, alignment, and lumbar lordosis—could provide clearer correlations between structural restoration and clinical outcomes. Additionally, extending follow-up beyond five years would allow for assessment of long-term complications such as pseudarthrosis, adjacent segment disease, and reoperation rates.

Finally, evaluating the cost-effectiveness of each surgical approach is crucial; although TLIF may entail higher upfront costs, its shorter hospital stay and potentially lower long-term complication rates may yield greater overall economic benefit [4].

## CONCLUSION

In this rigorously conducted prospective comparison, TLIF demonstrated superior early and long-term functional outcomes, faster recovery (hospital stay), and similar safety and fusion success compared to instrumented PLF. Whereas prior literature often emphasised comparable outcomes—or even disadvantage for TLIF in terms of operative metrics—our findings suggest that with refined technique, TLIF may offer meaningful clinical advantage in select patient populations. Ultimately, this study strengthens the evidence that TLIF is not merely equivalent to PLF but could provide sustained functional benefit when performed by skilled surgical teams. Further investigation with a broader scope and deeper analysis will help refine surgical decision-making in degenerative lumbar fusion.

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