Original Article

Comparative study of clinical outcomes between posterior lumbar interbody fusion (PLIF) and transformal lumbar interbody fusion (TLIF) in patients with spondylisthesis using experimental design

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Abstract

Background: Spondylolisthesis is a spinal disorder characterized by the displacement of one vertebra relative to the adjacent vertebra, which may cause lower back pain, radiculopathy, and functional impairment. Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) are commonly performed surgical procedures for treating symptomatic spondylolisthesis. However, differences in their clinical outcomes, complication profiles, and postoperative recovery remain important considerations. Objective: To compare the clinical outcomes of PLIF and TLIF in patients with spondylolisthesis, focusing on pain reduction, functional improvement, surgical duration, intraoperative blood loss, and postoperative complications. Methods: This experimental comparative study was designed to include patients diagnosed with symptomatic spondylolisthesis requiring surgical intervention. Participants would be allocated into two groups: Group A undergoing PLIF and Group B undergoing TLIF. Clinical outcomes would be assessed using the Visual Analog Scale (VAS) for pain and the Oswestry Disability Index (ODI) for functional disability before surgery and at scheduled postoperative follow-ups. Operative duration, estimated blood loss, hospital stay, fusion status, and postoperative complications would also be recorded. Appropriate statistical tests would be used to compare outcomes between the two groups, with statistical significance defined as p less than 0.05. Results: The study is intended to evaluate differences in pain relief, functional recovery, operative characteristics, and complication rates between PLIF and TLIF. Actual results, including numerical comparisons and statistical significance, must be reported after patient recruitment, data collection, and statistical analysis are completed. Conclusion: Both PLIF and TLIF are established surgical approaches for managing selected patients with symptomatic spondylolisthesis. A comparative evaluation may help identify differences in clinical effectiveness, surgical morbidity, and postoperative recovery, supporting individualized surgical decision-making.

Keywords: Spondylolisthesis, posterior lumbar interbody fusion, transforaminal lumbar interbody fusion, spinal fusion, postoperative pain, functional outcomes, Oswestry Disability Index, surgical complications.

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Introduction

Spondylolisthesis is a spinal condition characterized by the displacement of one verte vertebra relative to the adjacent vertebra, which may result in mechanical lower back pain, nerve root compression, radiculopathy, and functional disability. It commonly affects the lumbar spine and may develop due to degenerative changes, congenital abnormalities, trauma, or defects in the pars interarticularis. The severity of symptoms varies according to the degree of vertebral displacement, spinal instability, and neural compression. Although conservative management, including physiotherapy, analgesic medications, and activity modification, may provide relief in selected patients, surgical intervention is often considered when symptoms persist despite appropriate treatment or when neurological deficits and significant instability are present [1, 2].

Lumbar spinal fusion is an established surgical option for patients with symptomatic spondylolisthesis who require stabilization of the affected spinal segment. The primary objectives of surgery are to reduce pain, decompress neural structures, restore spinal alignment, achieve solid interbody fusion, and improve patients' functional capacity. Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) are two commonly used techniques that facilitate interbody fusion through a posterior surgical approach. Both procedures involve the placement of an interbody cage and bone graft material to promote fusion between adjacent vertebral bodies, usually alongside pedicle screw instrumentation to provide stability during the healing process [3, 4].

PLIF involves bilateral access to the intervertebral disc space through the posterior aspect of the spinal canal. This approach allows disc removal and interbody cage placement from both sides, providing broad access to the disc space. However, adequate exposure may require greater manipulation of the dura mater and nerve roots, potentially increasing the risk of neural injury, dural tears, and postoperative complications. These considerations are particularly important in patients with pre-existing neural compression, anatomical variations, or complex degenerative changes [4, 5].

In contrast, TLIF uses a more lateralized transforaminal corridor to access the intervertebral disc space, generally requiring less bilateral retraction of the neural structures. This technique may reduce neural manipulation while facilitating discectomy, cage insertion, and segmental stabilization. TLIF has therefore gained considerable attention as an alternative to PLIF, particularly in patients with degenerative lumbar disorders. Nevertheless, its clinical advantages may depend on patient selection, surgical expertise, the severity of spondylolisthesis, and the presence of associated spinal stenosis or instability [5, 6].

Clinical evaluation of these procedures requires consideration of both patient-reported outcomes and objective surgical parameters. The Visual Analog Scale (VAS) is commonly used to quantify back and leg pain, while the Oswestry Disability Index (ODI) assesses limitations in daily activities resulting from spinal disorders. Additional measures, including operative duration, intraoperative blood loss, length of hospital stay, radiological fusion, neurological complications, and reoperation rates, provide a broader assessment of treatment effectiveness and safety. A systematic review and meta-analysis comparing PLIF and TLIF in lumbar spondylolisthesis reported broadly similar pain outcomes, alongside lower pooled complication

rates and shorter operative duration for TLIF, although differences between individual studies and patient populations must be considered [7, 8].

Despite the established use of both surgical techniques, further comparative evaluation is valuable to determine their relative effectiveness in specific clinical settings. Therefore, the present experimental comparative study aims to evaluate clinical outcomes among patients with spondylolisthesis undergoing PLIF or TLIF. By comparing pain reduction, functional improvement, operative characteristics, postoperative complications, and fusion outcomes, this study seeks to provide evidence that may assist surgeons in selecting an appropriate surgical approach for individual patients.

Methodology

Study Design

This experimental comparative study was designed to evaluate and compare the clinical outcomes of posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) in patients diagnosed with spondylolisthesis. The study focused on postoperative pain relief, functional improvement, surgical characteristics, and complications associated with both surgical techniques.

Study Setting and Duration

The study was planned at a tertiary care hospital with a specialized orthopedic or neurosurgical spine unit. The study duration would be determined according to the approved research protocol, patient recruitment requirements, and follow-up schedule.

Sample Size and Sampling Technique

The sample size would be calculated using an appropriate statistical method based on the expected difference in postoperative clinical outcomes between the two groups, the desired statistical power, and the significance level. Eligible patients would be recruited using consecutive sampling or another approved sampling technique. The final sample size and recruitment period should be specified according to the actual study protocol.

Study Population

Patients diagnosed with symptomatic lumbar spondylolisthesis who required surgical treatment after inadequate improvement with conservative management would be considered for inclusion.

Inclusion criteria:

- Adult patients aged 18 years or older.
- Radiologically confirmed lumbar spondylolisthesis.
- Persistent lower back pain, radiculopathy, or functional disability despite appropriate conservative treatment.
- Clinical indication for lumbar interbody fusion.
- Willingness to participate and provide informed consent.

Exclusion criteria:

- Previous lumbar fusion surgery at the affected level.
- Spinal infection or primary or metastatic spinal tumors.
- Acute traumatic spinal injuries requiring a different surgical approach.
- Severe medical comorbidities contraindicating surgery.
- Incomplete baseline clinical assessment or inability to complete the planned follow-up.

Group Allocation

Eligible patients would be divided into two groups according to the approved allocation protocol:

- Group A: Patients undergoing posterior lumbar interbody fusion (PLIF).
- Group B: Patients undergoing transforaminal lumbar interbody fusion (TLIF).

If the study is intended to be a randomized experimental trial, participants should be allocated using a predefined randomization method, such as computer-generated random sequences. If treatment is selected by the surgeon according to clinical indications, the study should instead be described as a prospective comparative cohort study.

Surgical Procedures

All procedures would be performed by qualified spine surgeons using standardized surgical protocols and appropriate perioperative care.

In the PLIF group, posterior access to the affected lumbar segment would be established. Decompression and discectomy would be performed as indicated, followed by preparation of the intervertebral space, placement of an interbody cage with suitable bone graft material, and pedicle screw fixation where indicated.

In the TLIF group, the intervertebral disc would be accessed through a unilateral transforaminal corridor. Neural decompression and discectomy would be performed as required, followed by endplate preparation, cage insertion with bone graft material, and instrumented stabilization according to the surgical plan.

The operative level, number of fused segments, use of decompression, cage characteristics, and any additional procedures would be documented for both groups.

Data Collection

Baseline demographic and clinical information would be recorded, including age, sex, body mass index, comorbidities, symptom duration, type and grade of spondylolisthesis, affected spinal level, and preoperative neurological status.

Intraoperative variables would include operative duration, estimated blood loss, intraoperative complications, and need for blood transfusion. Postoperative data would include length of hospital stay, surgical-site infection, dural tear, neurological deterioration, implant-related complications, readmission, and reoperation.

Outcome Measures

The primary outcomes would be changes in pain intensity and functional disability following surgery.

1. Visual Analog Scale (VAS): Back and leg pain would be assessed using the VAS before surgery and at scheduled postoperative assessments.
2. Oswestry Disability Index (ODI): Functional disability would be measured before surgery and during follow-up.
3. Operative duration: Recorded in minutes from the beginning to the completion of the surgical procedure, according to the predefined protocol.
4. Estimated blood loss: Recorded in milliliters using the institution's standard measurement method.
5. Radiological fusion: Evaluated using predefined imaging criteria at the designated follow-up interval.
6. Postoperative complications: Documented throughout hospitalization and subsequent follow-up.

Clinical assessments would be performed preoperatively and at predefined postoperative intervals, such as 6 weeks, 3 months, 6 months, and 12 months, depending on the approved protocol.

Statistical Analysis

Data would be analyzed using appropriate statistical software, such as SPSS. Continuous variables would be presented as mean and standard deviation or median and interquartile range, depending on their distribution. Categorical variables would be expressed as frequencies and percentages.

Independent-samples t-tests or Mann–Whitney U tests would be used to compare continuous outcomes between the PLIF and TLIF groups, as appropriate. Chi-square or Fisher's exact tests would be used for categorical variables. Changes in VAS and ODI scores over time would be evaluated using suitable repeated-measures or mixed-effects analyses. Where appropriate, multivariable analysis would be used to account for relevant baseline differences and potential confounders.

A two-sided p-value of less than 0.05 would be considered statistically significant. Effect sizes and 95% confidence intervals would be reported where appropriate.

Ethical Considerations

The study would require approval from the relevant institutional research ethics committee before recruitment begins. Written informed consent would be obtained from all participants. Patient confidentiality would be maintained, and data would be stored securely. For a randomized trial, the randomization procedure and trial registration would be completed according to applicable ethical and regulatory requirements.

Important: Before using this methodology in a manuscript, specify the actual study setting, recruitment dates, sample size, allocation method, and follow-up period. These details must reflect the study that was genuinely conducted or formally planned; they should not be invented for publication.

Results

The results section compares the clinical outcomes of posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) in patients with lumbar spondylolisthesis. The main variables include demographic characteristics, pain reduction, functional improvement, operative parameters, and postoperative complications.

The comparative study evaluated clinical outcomes among patients with lumbar spondylolisthesis undergoing posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF). In the illustrative dataset of 100 patients, 50 patients were assigned to each group. The mean age was 54.6 ± 9.2 years in the PLIF group and 53.8 ± 8.7 years in the TLIF group. Both groups demonstrated comparable baseline characteristics, including body mass index, symptom duration, sex distribution, and severity of spondylolisthesis. Grade I spondylolisthesis was observed in 68% of the PLIF group and 72% of the TLIF group, while Grade II disease was present in 32% and 28%, respectively. These findings suggest that the groups were broadly comparable before surgery in this hypothetical example.

Regarding pain relief and functional improvement, both surgical approaches demonstrated reductions in postoperative pain and disability. The mean Visual Analog Scale

(VAS) score decreased from 7.6 ± 1.1 before surgery to 2.4 ± 0.9 at 12 months in the PLIF group, compared with a reduction from 7.5 ± 1.0 to 2.0 ± 0.8 in the TLIF group. Similarly, the mean Oswestry Disability Index (ODI) score improved from 58.2 ± 8.4% to 25.6 ± 6.8% in the PLIF group and from 57.6 ± 8.1% to 22.1 ± 6.2% in the TLIF group. In this illustrative dataset, postoperative VAS and ODI scores were lower in the TLIF group, with between-group p-values of 0.021 and 0.008, respectively.

The assessment of operative and postoperative parameters indicated that the TLIF group had a shorter mean operative duration than the PLIF group (142.7 ± 24.3 versus 168.4 ± 28.6 minutes, $p < 0.001$). Estimated blood loss was also lower in the TLIF group (310 ± 95 versus 420 ± 110 mL, $p < 0.001$), while mean hospital stay was 4.3 ± 1.2 days compared with 5.2 ± 1.4 days in the PLIF group ($p = 0.001$). Radiological fusion rates at 12 months were similar, at 92% for TLIF and 90% for PLIF, without a statistically significant difference ($p = 0.723$). These illustrative findings suggest comparable fusion outcomes despite differences in operative parameters.

Postoperative complications were numerically less frequent in the TLIF group than in the PLIF group. At least one complication was recorded in 14% of TLIF patients compared with 24% of PLIF patients, although this difference was not statistically significant ($p = 0.202$). Dural tears occurred in 4% and 10% of patients, respectively, while surgical-site infections were reported in 4% of the TLIF group and 6% of the PLIF group. Reoperation within 12 months was required in 4% of TLIF patients and 6% of PLIF patients. Overall, the illustrative findings indicate improvement following both surgical procedures, with potentially favorable perioperative outcomes for TLIF.

Note: The following tables are illustrative templates using hypothetical data to demonstrate how the results could be presented. They are not actual patient findings and must be replaced with verified study data before submission or publication.

Table 1. Demographic and Baseline Clinical Characteristics

Variables	PLIF Group (n=50)	TLIF Group (n=50)	p-value
Age (years), mean ± SD	54.6 ± 9.2	53.8 ± 8.7	0.654
Male, n (%)	28 (56.0%)	26 (52.0%)	0.689
Female, n (%)	22 (44.0%)	24 (48.0%)	0.689
BMI (kg/m²), mean ± SD	27.4 ± 3.6	27.1 ± 3.4	0.671
Grade I spondylolisthesis, n (%)	34 (68.0%)	36 (72.0%)	0.660
Grade II spondylolisthesis, n (%)	16 (32.0%)	14 (28.0%)	0.660
Symptom duration (months), mean ± SD	14.2 ± 5.8	13.7 ± 5.4	0.656

Interpretation: In this hypothetical example, the two groups demonstrate comparable baseline demographic and clinical characteristics. Mean age, BMI, and symptom duration are similar, while the distribution of sex and spondylolisthesis grades shows no statistically significant differences. Such baseline comparability would support a more meaningful assessment of differences in postoperative outcomes. However, additional baseline variables, including neurological status, affected spinal level, comorbidities, and preoperative pain severity, should also be considered.

Table 2. Comparison of Pain and Functional Outcomes

Outcome measure	PLIF Group (n=50)	TLIF Group (n=50)	p-value
Preoperative VAS score	7.6 ± 1.1	7.5 ± 1.0	0.637
Postoperative VAS score at 12 months	2.4 ± 0.9	2.0 ± 0.8	0.021
Preoperative ODI score (%)	58.2 ± 8.4	57.6 ± 8.1	0.716
Postoperative ODI score at 12 months (%)	25.6 ± 6.8	22.1 ± 6.2	0.008
Improvement in VAS score	5.2	5.5	—
Improvement in ODI score (percentage points)	32.6	35.5	—

Values are illustrative means ± SD. Lower VAS and ODI scores indicate less pain and disability.

Interpretation: In the hypothetical results, both surgical techniques are associated with improvements in pain and functional disability at 12 months. The TLIF group has lower postoperative mean VAS and ODI scores than the PLIF group. The between-group differences are statistically significant in this example. Nevertheless, these findings would require confirmation through actual patient data and appropriate analyses that account for baseline measurements and other potential confounding factors.

Discussion

Spondylolisthesis is an important cause of chronic lower back pain, radiculopathy, and functional disability, particularly in patients with degenerative lumbar changes. Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) are established surgical techniques used to achieve spinal stabilization, neural decompression, and interbody fusion in appropriately selected patients. The present comparative study focuses on differences in pain relief, functional recovery, operative characteristics, radiological fusion, and postoperative complications. The discussion below is structured around the illustrative results presented previously; those numerical findings must be replaced or verified against actual patient data before publication.

In the illustrative dataset, both groups demonstrated substantial improvements in pain and functional disability after surgery. The TLIF group had a lower mean postoperative Visual Analog Scale (VAS) score than the PLIF group at 12 months. This finding is consistent with the clinical rationale for TLIF, which provides access to the intervertebral disc through a unilateral transforaminal corridor and may reduce manipulation of the dural sac and nerve roots. Nevertheless, differences in pain outcomes can also be influenced by baseline disease severity, surgical technique, decompression adequacy, rehabilitation, and patient characteristics. Consequently, a lower postoperative pain score alone does not establish the overall superiority of one technique over the other [1, 2].

Functional recovery is another important indicator of successful lumbar fusion. The Oswestry Disability Index (ODI) measures limitations in everyday activities, including walking, lifting, sitting, and personal care. In the hypothetical results, ODI scores improved in both groups, with greater improvement in the TLIF group. These changes would suggest better functional recovery if confirmed by actual observations and appropriate statistical analysis. However, the clinical importance of the difference should also be assessed, because statistical significance does not necessarily indicate a meaningful improvement in patients' daily lives. Standardized follow-up and

consistent rehabilitation protocols are essential for making valid comparisons between surgical approaches [2, 3].

Operative characteristics are particularly relevant when selecting an appropriate surgical technique. The illustrative results show shorter operative duration and lower estimated blood loss in the TLIF group. One potential explanation is that TLIF permits disc-space access through a unilateral corridor, potentially reducing bilateral neural retraction and extensive posterior exposure. PLIF, by comparison, typically requires access to the disc space from both sides of the spinal canal, which may involve greater manipulation of neural structures. Nevertheless, the differences in operative duration and blood loss depend on surgeon experience, the number of fused levels, the extent of decompression, anatomical complexity, and the severity of spondylolisthesis. Comparative evidence has also identified differences in perioperative outcomes between the two techniques, although findings vary across studies and clinical settings [4, 5].

Radiological fusion is a further consideration when evaluating the long-term effectiveness of lumbar interbody fusion. In the illustrative results, fusion was achieved in 90% of patients in the PLIF group and 92% in the TLIF group. These findings suggest similar fusion outcomes, but the small numerical difference should not be interpreted as evidence of superiority. Zhang et al. reported no statistically significant difference in radiographic fusion between PLIF and TLIF in their meta-analysis, supporting the view that both approaches can provide satisfactory fusion in appropriately selected patients [6]. A later systematic review by de Kunder et al. similarly found that the principal differences between the procedures were related more to perioperative outcomes than to pain relief [7].

Postoperative complications are important because they can delay recovery, increase healthcare costs, and adversely affect patient satisfaction. In the hypothetical dataset, the overall complication rate was 24% following PLIF and 14% following TLIF, although the difference was not statistically significant. Potential explanations for fewer complications with TLIF include reduced bilateral neural retraction and more limited exposure of the posterior spinal canal. Lan et al. reported that both approaches achieved similar fusion rates and clinical satisfaction, while TLIF was associated with lower rates of certain neural complications and more favorable operative parameters [8]. However, complication rates may vary according to patient selection, surgeon experience, instrumentation, and the criteria used to define adverse events.

Limitations

Several limitations should be considered when interpreting this comparative study. First, the illustrative numerical results presented in the tables cannot establish clinical effectiveness until they are replaced with actual patient data. Second, differences in baseline disease severity, surgical levels, comorbidities, and rehabilitation may influence postoperative outcomes. Third, a 12-month follow-up may be insufficient to evaluate long-term fusion durability, adjacent-segment disease, and late reoperation. Future studies with adequate sample sizes, standardized outcome assessments, clearly defined allocation procedures, and longer follow-up would strengthen the evidence comparing PLIF and TLIF.

Conclusion

Both posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) are effective surgical approaches for managing appropriately selected patients with symptomatic lumbar spondylolisthesis. Both procedures may improve postoperative pain and functional disability and achieve satisfactory

radiological fusion. TLIF may offer advantages in operative duration, intraoperative blood loss, hospital stay, and reduced neural manipulation, while clinical outcomes and fusion rates may be comparable between the two techniques. The selection of an appropriate surgical approach should be individualized according to patient characteristics, spinal pathology, and surgeon expertise. Further prospective comparative studies with adequate sample sizes and long-term follow-up are needed to establish the relative benefits and safety of these procedures.

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