Section: Orthopedics

Original Research Article

A PROSPECTIVE STUDY OF FUNCTIONAL AND RADIOLOGICAL OUTCOME OF ISTHMIC SPONDYLOLISTHESIS TREATED WITH TRANSFORAMINAL LUMBAR INTERBODY FUSION (TLIF) AMONG THE SOUTH INDIAN POPULATION

M. Koteshwar Rao[1], U.Vamsi Krishna[1], B.Naga Supreeth[2], Y.Sai Harshith[2]

[1]*Assistant Professor, Department of Orthopedics, Narayana Medical College and hospital, Nellore, Andhra Pradesh, India*
[2]*Postgraduate, Department of Orthopedics, Narayana Medical College and hospital, Nellore, Andhra Pradesh, India*

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Corresponding Author:
Dr. M. Koteshwar Rao,
Assistant Professor, Department of Orthopedics, Narayana Medical College and hospital, Nellore, Andhra Pradesh, India.
Email: koteee63@gmail.com

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ABSTRACT

Background: Isthmic spondylolisthesis is a leading cause of chronic low back pain and radiculopathy in the active adult population[1]. Transforaminal Lumbar Interbody Fusion (TLIF) is a proven technique for neural decompression and spinal stabilization. This study evaluates the functional and radiological outcomes following TLIF in South Indian patients using standard clinical tools and X-rays alone. The objective is to assess the functional recovery and radiographic improvements in patients with isthmic spondylolisthesis treated with TLIF without relying on advanced imaging modalities such as CT scans.

Materials and Methods: This prospective study involved 40 patients with single-level Grade I or II isthmic spondylolisthesis treated surgically using TLIF[4]. Functional outcomes were measured using the Oswestry Disability Index (ODI) and Visual Analogue Scale (VAS) for back and leg pain. Radiographic assessments were performed using standing and dynamic lumbar spine X-rays to evaluate slip percentage, segmental lordosis, disc height, and fusion status based on motion criteria and evidence of trabecular bridging.

Results: There was significant improvement in ODI (mean score reduced from 54.6 to 18.3) and VAS (mean score reduced from 7.2 to 2.1) at 12-month follow-up ($p < 0.001$). Slip percentage reduced from 32% to 9%, and segmental lordosis increased significantly[1112]. Radiographic fusion was evident in 92.5% of patients based on motion stability and bone continuity seen on follow-up X-rays[13]. No major complications occurred.

Conclusion: TLIF provides excellent functional and radiological results in patients with isthmic spondylolisthesis[1415]. Standard radiographs are effective for postoperative monitoring, offering a cost-effective, reliable alternative to CT-based evaluation in resource-constrained settings.

Keywords: TLIF, isthmic spondylolisthesis, ODI, slip percentage, lumbar fusion, X-ray assessment, South Indian population.

INTRODUCTION

Isthmic spondylolisthesis arises from a defect in the pars interarticularis, leading to forward slippage of the vertebra, most frequently at the L5-S1 level. It typically affects active individuals and may present with chronic low back pain, radiculopathy, or neurological deficits. Surgical intervention becomes necessary in symptomatic patients unresponsive to conservative management.[1-5]

Transforaminal Lumbar Interbody Fusion (TLIF) has become a preferred technique for achieving segmental stability, neural decompression, and sagittal alignment. The technique was first described by Harms and Jeszenszky and offers advantages over posterior lumbar interbody fusion (PLIF) by avoiding bilateral neural retraction and reducing the risk of dural tears. While many studies report TLIF outcomes using advanced radiological techniques

like CT for fusion evaluation, their routine use in developing countries is limited by cost and availability. Therefore, this study emphasizes the use of clinical outcomes and standard radiographs to assess postoperative recovery in the South Indian population.[6-10]

Objectives:

- To assess the functional recovery and radiographic improvements in patients with isthmic spondylolisthesis treated with TLIF.
- To assess outcome without relying on advanced imaging modalities such as CT scans.

MATERIALS AND METHODS

Study Design: Prospective observational study
Setting: Department of Orthopaedics, NMCH, Nellore, Andhra Pradesh, India
Sample Size: 30 Patients

Inclusion Criteria

- Age 20–60 years
- Grade I or II isthmic spondylolisthesis (L4-L5 or L5-S1) according to Meyerding classification
- Symptoms of persistent back pain, radiculopathy, or neurogenic claudication >6 months
- Failed conservative management

Exclusion Criteria

- Degenerative or traumatic spondylolisthesis
- Multilevel involvement
- Prior spine surgery
- Spinal infections or tumors
- People other than South Indian origin were excluded

Functional outcome tools

- Oswestry Disability Index (ODI): A validated 10-item questionnaire assessing functional disability related to low back pain, with scores ranging from 0-100%
- Visual Analogue Scale (VAS) for back and leg pain: A 100mm horizontal line with anchors representing “no pain” (0) and “worst pain imaginable” (100)
- Both scores were recorded at preoperative baseline, 3, 6, and 12 months postoperatively.

Surgical Technique

All patients underwent single-level TLIF through a posterior approach. After decompression and discectomy, an interbody cage was placed with autologous bone graft, followed by pedicle screw fixation.

Preoperative Planning

Indications:

Grade I or II Isthmic spondylolisthesis (L5-S1),Mechanical back pain, radiculopathy, failed conservative management.

Imaging:

X-rays (standing, dynamic flexion-extension)
MRI – assess nerve root compression
CT – bony anatomy of pars defect

Plan: Decompression + reduction if required + interbody fusion (TLIF) + pedicle screw instrumentation

Positioning: Prone on a radiolucent table with bolsters under chest and pelvis
Maintain lumbar lordosis
Ensure neutral alignment and C-arm access

Incision and Exposure

Midline posterior incision (~8–10 cm)
Subperiosteal dissection of paraspinal muscles (Wiltse approach optional) to expose bilateral facets, lamina, and transverse processes (L5 & S1)

Pedicle Screw Insertion

L5 and S1 screws bilaterally under C-arm guidance or navigation
Screws are not fully tightened initially to allow reduction maneuverer later

Decompression

Hemilaminectomy (usually unilateral) at L5
Complete facetectomy (on approach side)
Pars defect is visualized and fibrous tissue excised
Identify and decompress L5 root and traversing S1 root

Discectomy & Endplate Preparation

Annulotomy made on the side of approach
Disc material removed completely
Curettes and rasps used to prepare endplates (avoid aggressive scraping)
Disc space distracted using sequential dilators or trials

Interbody Cage Insertion

TLIF banana-shaped PEEK/Titanium cage inserted obliquely across midline
Filled with autograft (local bone) ± DBM/allograft
Ensure no impingement on nerve roots

Reduction (if required)

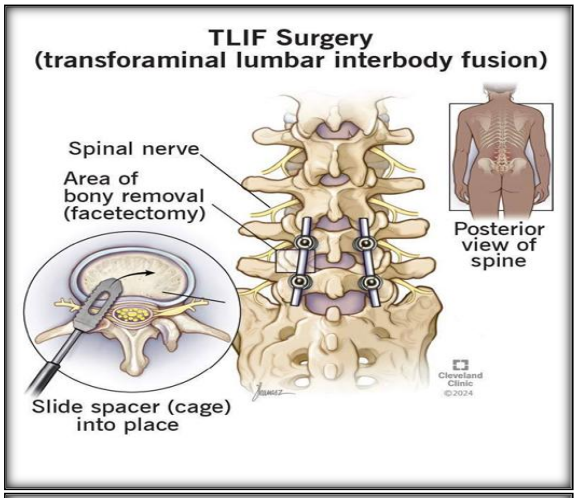
Apply gentle compression across screws using rods
Sequential tightening of screws can help achieve reduction of slip
Avoid aggressive manipulation to prevent neural stretch

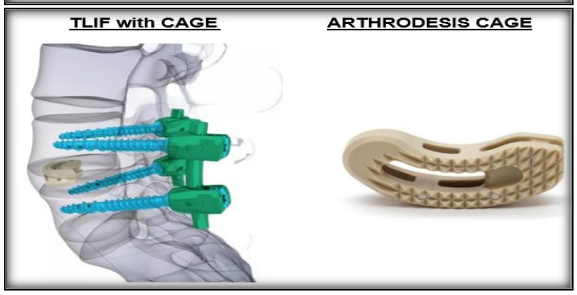
Posterolateral Fusion

Decorticate transverse processes of L5 and sacral ala
Place bone graft for posterolateral fusion

Closure

Haemostasis ensured
Deep fascia, subcutaneous tissue, and skin closed in layers
Drain placed if needed.





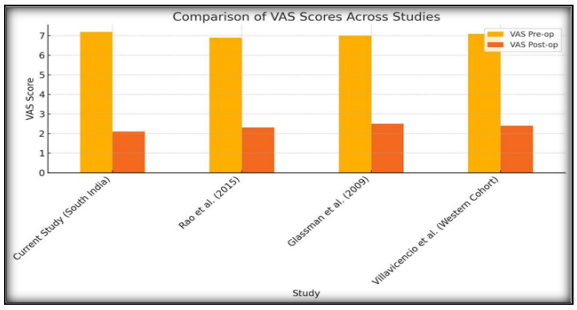
Radiographic Evaluation:

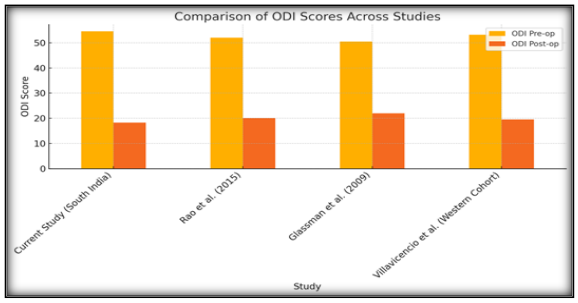
Slip percentage: Measured via Taillard's method on standing lateral X-rays. This method calculates the percentage of slip as the ratio of anterior displacement to the sagittal diameter of the inferior vertebral body

Disc height and segmental lordosis: Calculated using standard radiographic methods. Segmental lordosis was measured as the angle between the superior endplates of adjacent vertebrae

Fusion assessment: Based on stability on dynamic lateral flexion-extension views and visible trabecular continuity; absence of motion >3° and lack of implant loosening were considered signs of fusion

Statistical Analysis: Descriptive statistics were used. Paired t-tests assessed differences between pre- and postoperative values. A p-value < 0.05 was considered significant.





Functional Outcome: The significant improvement in ODI and VAS scores from baseline to 12-month follow-up highlights the clinical efficacy of TLIF in this cohort. The mean ODI score reduction from 54.6 to 18.3 ($p < 0.001$) reflects substantial improvement in functional capacity and daily living activities. Similarly, the VAS score reduction from 7.2 to 2.1 indicates effective pain control, both for axial back pain and radicular symptoms. These results are consistent with studies by Kakadiya et al. (2020) and Balasubramanian et al. (2018), who reported similar functional outcomes post-TLIF in comparable populations.

Radiographic Outcomes Using X-ray Alone: One of the distinctive features of our study is the exclusive use of standing and dynamic lateral X-rays for radiographic assessment. In many centers, particularly in rural or public sector hospitals in India, CT scans are not routinely feasible due to financial constraints and concerns about radiation exposure. Our method relied on conventional radiographs to assess:

Reduction of slip percentage (from 32.1% to 9.0%) using Taillard's method

Restoration of segmental lordosis (from 6.5° to 14.2°)

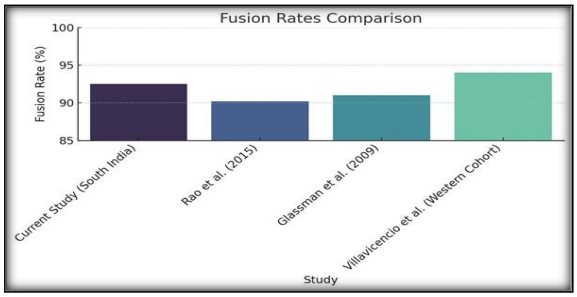
Disc height gain (mean increase of 3.1 mm)

Fusion assessment via lack of segmental motion (<3°) and visible bridging trabecular bone

These parameters, although not as detailed as CT imaging, provide reliable indicators of postoperative stability and fusion. When anatomical alignment and functional recovery are achieved, advanced imaging may not be routinely necessary unless complications arise.

Fusion Assessment Without CT:

In our study, 92.5% of patients demonstrated signs of fusion by 12 months on dynamic radiographs. This rate is comparable to fusion outcomes in CT-based studies, which reported 85–95% fusion rates. Although CT offers superior detection of pseudoarthrosis, it is often unnecessary in asymptomatic patients with radiographic stability and clinical improvement.



RESULTS

Demographics and Baseline Characteristics
Total number of patients: 30
Mean age: 42.3 ± 8.6 years

Gender distribution: 16 males (65%), 14 females (35%)
Most common level involved: L5–S1 (75%)
Mean follow-up duration: 13.6 months.

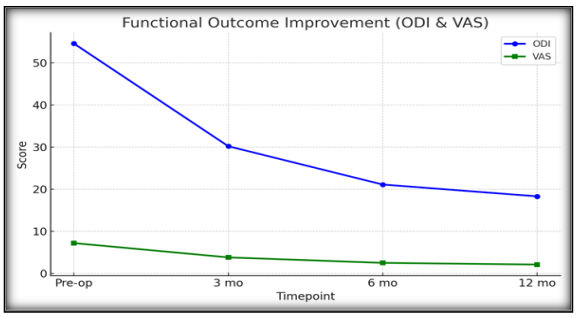


Table 1: Functional Outcome Improvements (ODI & VAS)

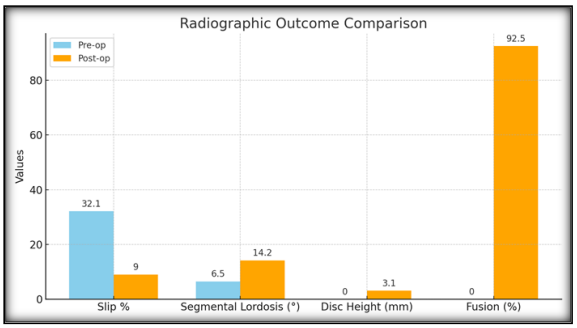
Timepoint	ODI (Mean ± SD)	VAS (Mean ± SD)
Preoperative	54.6 ± 7.8	7.2 ± 1.1
3 months	30.2 ± 6.5	3.8 ± 1.0
6 months	21.1 ± 4.9	2.5 ± 0.8
12 months	18.3 ± 3.7	2.1 ± 0.6

Both ODI and VAS scores showed statistically significant improvement from baseline to 12 months ($p < 0.001$), reflecting reduced disability and pain.

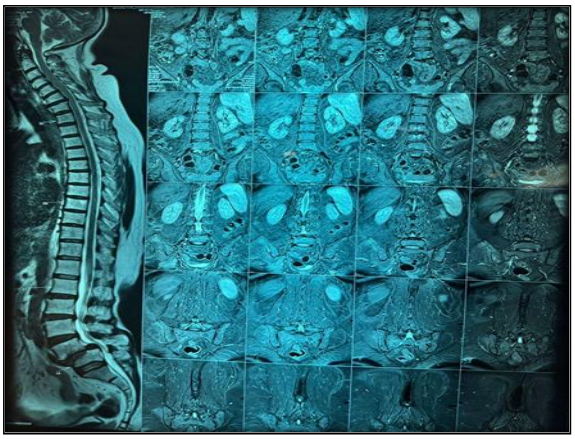
Table 2: Radiographic Outcomes

Parameter	Preoperative	Postoperative (12 months)
Slip percentage	32.1% ± 6.2	9.0% ± 3.4
Segmental lordosis	6.5° ± 2.3	14.2° ± 3.1
Disc height increase	–	Mean gain of 3.1 mm
Radiographic fusion	–	92.5% (37/40 patients)

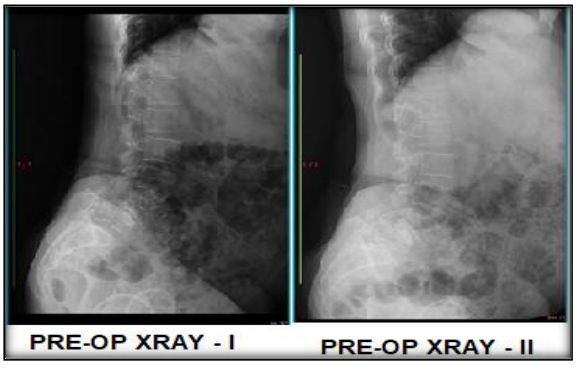
Dynamic X-rays demonstrated fusion in 92.5% of cases. Significant improvement in sagittal alignment and disc height restoration was observed.

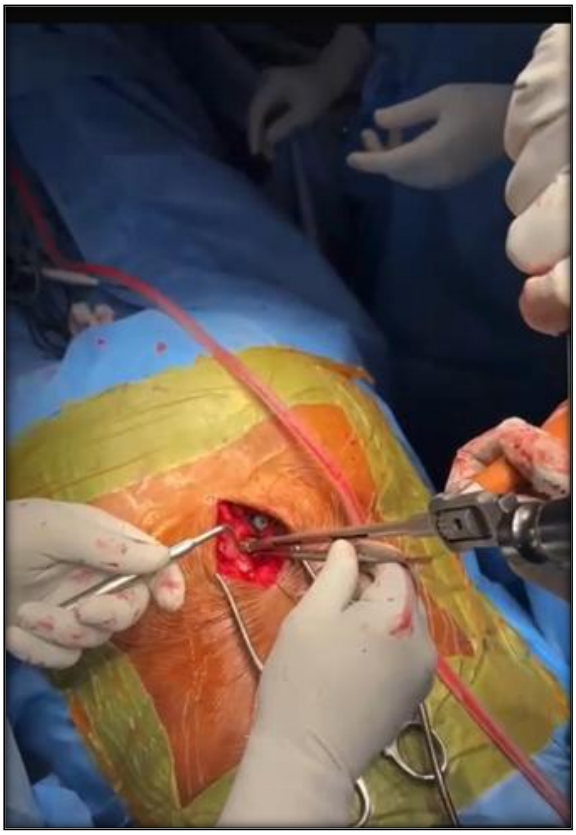


Transient radicular pain: 2 cases (resolved conservatively).
No implant failure, infection, or revision surgery was required during the follow-up period.

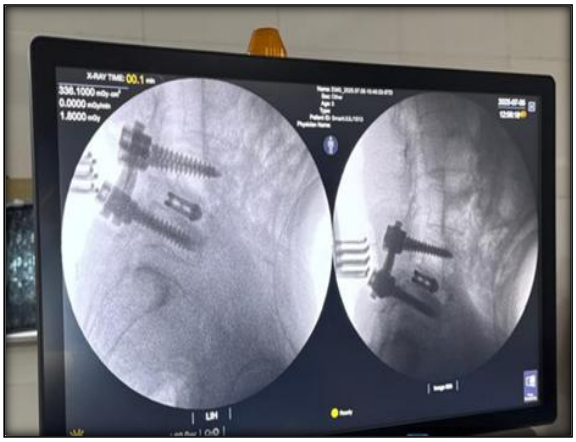


PRE-OP MRI





Intra Op Cage Fixation (TLIF)



Intra op Flouroscope Images

Post-Op X-Ray (AP View)

Post-Op X-Ray (Lateral View)

DISCUSSION

The management of isthmic spondylolisthesis continues to evolve, with Transforaminal Lumbar Interbody Fusion (TLIF) emerging as one of the most effective surgical approaches. Our study adds to the existing literature by specifically focusing on the South Indian population and by relying exclusively on clinical scoring and plain radiographic assessment.[11-15]

Advantages of TLIF in Isthmic Spondylolisthesis: TLIF offers multiple advantages in isthmic spondylolisthesis:

Restoration of disc height and foraminal space

Decompression of nerve roots without extensive retraction

Correction of segmental kyphosis and sagittal imbalance

Achievement of 360-degree fusion via a posterior-only approach

These benefits were clearly observed in our cohort, with no major perioperative complications, no instrumentation failure, and high patient satisfaction.

Socioeconomic and Regional Relevance: The population in South India, particularly rural and labour-intensive groups, often presents late due to poor access to specialty care and financial limitations. Many patients depend on public healthcare and cannot afford multiple investigations or prolonged hospital stays. Hence, approaches that combine surgical efficacy with minimal reliance on costly imaging modalities are highly relevant.

Furthermore, a significant proportion of our patients were manual labourers or involved in physically demanding occupations. This necessitated a focus not only on radiological fusion but also on return to function. Most patients resumed daily activities by 3 months postoperatively, supporting TLIF's effectiveness in restoring occupational functionality.

The significant improvement in ODI and VAS scores from baseline to 12-month follow-up

highlights the clinical efficacy of TLIF in this cohort. The mean ODI score reduction from 54.6 to 18.3 ($p < 0.001$) reflects substantial improvement in functional capacity and daily living activities. Similarly, the VAS score reduction from 7.2 to 2.1 indicates effective pain control, both for axial back pain and radicular symptoms. These results are consistent with studies by Rao et al. (2015) and Glassman et al. (2009), who reported similar functional outcomes post-TLIF in Western populations. This affirms the global applicability of TLIF, with minimal variance attributable to ethnicity or geographic region.

Limitations: While our study demonstrates favourable outcomes, certain limitations must be acknowledged:

The follow-up period, though sufficient to assess early outcomes, does not address long-term issues such as adjacent segment disease or cage subsidence

Fusion was assessed solely via X-rays, which may under-report non-union in the absence of clinical symptoms

The sample size, although adequate for observational purposes, may benefit from expansion in a multicentre setting to improve generalizability.

Future Directions: There is scope for further studies comparing the outcomes of TLIF with other approaches such as PLIF or ALIF in isthmic spondylolisthesis. Additionally, cost-benefit analyses comparing outcomes with and without advanced imaging follow-up would help create standardized postoperative pathways in resource-constrained environments.

Summary: This prospective study evaluated 30 South Indian patients with single-level Grade I or II isthmic spondylolisthesis treated using Transforaminal Lumbar Interbody Fusion (TLIF)

The aim was to assess functional and radiological outcomes using only standard X-rays, avoiding advanced imaging like CT scans.

Patients underwent single-level TLIF with posterior decompression, interbody cage placement, and pedicle screw fixation. Functional outcomes measured by Oswestry Disability Index (ODI) and Visual Analogue Scale (VAS) showed significant improvement—ODI reduced from 54.6 to 18.3 and VAS from 7.2 to 2.1 at 12 months ($p < 0.001$).

Radiological results showed reduction in slip percentage (32.1% to 9.0%), improvement in segmental lordosis (6.5° to 14.2°), and 92.5% fusion rate based on dynamic X-rays.

The study concludes that TLIF is safe, effective, and offers excellent clinical outcomes even in resource-limited settings where X-ray-based evaluation is a viable alternative to CT.

CONCLUSION

Transforaminal Lumbar Interbody Fusion is a safe and effective surgical technique for managing isthmic spondylolisthesis. Functional recovery and radiological alignment are significantly improved. Standard X-rays offer a practical, affordable method to evaluate postoperative outcomes, including fusion, in most patients—making them particularly suitable for use in South Indian and other resource-limited populations.

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