Thesis

Functional and Radiographic Predictors of Success in Transforaminal Lumbar Interbody Fusion: A Prospective Study of Lumbar Canal Stenosis

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Abstract

Background: Transforaminal lumbar inter-body fusion (TLIF) combines posterior access with inter-body grafting to treat degenerative lumbar disorders. By accessing the disc space unilaterally, TLIF minimizes neural retraction and reduces dural tear and epidural fibrosis risks compared with bilateral PLIF techniques. Limited prospective data correlate sagittal alignment restoration and functional outcomes following TLIF.

Methods and Materials: In this prospective observational study (October 2019–December 2021), 40 adults (mean age 52 years; 15 males, 25 females) with lumbar canal stenosis—with or without low-grade (Meyer ding I–II) spondylolisthesis—failed ≥6 weeks of conservative therapy. Preoperative assessment included VAS for back and leg pain, ODI, SF-36, and standing radiographs to measure pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), and lumbar lordosis (LL). Under general anesthesia, TLIF with unilateral facetectomy, discectomy, and PEEK cage filled with local auto graft was performed. Postoperative evaluation at 1 year included VAS, ODI, SF-36, and spinopelvic measurements; fusion status was assessed via dynamic radiographs.

Results: Median VAS for back pain decreased from 7 to 1; leg pain decreased from 8 to 1. Mean ODI improved from 67.8% to 18.1%. SF-36 scores improved across all domains. Mean PT increased from 15.2° to 18.3°; PI–LL mismatch decreased from 16.5° to 12.1°. Ninety-five percent achieved solid fusion. Complications included four dural tears, one superficial infection, two screw pullouts, and one transient radiculopathy.

Conclusion: TLIF provides significant pain relief, disability reduction, and partial sagittal alignment restoration in lumbar canal stenosis—with or without low-grade spondylolisthesis—achieving a high fusion rate with acceptable morbidity.

Keywords: Transforaminal lumbar inter-body fusion; lumbar canal stenosis; spondylolisthesis; spinopelvic parameters; Oswestry Disability Index.

Introduction

Transforaminal lumbar inter-body fusion (TLIF) is a surgical technique for managing degenerative lumbar spine disorders that integrates posterior access with inter-body support. By using a unilateral Transforaminal corridor to access the disc space, TLIF minimizes neural retraction and reduces risks of dural tears and epidural fibrosis associated with bilateral posterior lumbar inter-body fusion (PLIF) techniques [1].

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DOI: https://doi.org/10.13107/jmt.2024.v10.i02.254

Since Harms and Jeszenszky introduced TLIF in 1998, studies have demonstrated shorter operative times, reduced blood loss, and fewer neurological complications compared with PLIF [1,2].

Alternative lumbar interbody fusion approaches—including anterior lumbar interbody fusion (ALIF), oblique lumbar interbody fusion (OLIF), and lateral lumbar interbody fusion (LLIF)—differ in access anatomy, complication profiles, and biomechanical outcomes [3]. ALIF provides direct anterior column exposure and efficient lordosis restoration but carries risk of vascular injury and retrograde ejaculation [4]. OLIF and LLIF allow indirect neural decompression with preservation of posterior elements, but may involve psoas-related neural risks and steep learning curves [5].

Interbody cages restore disc height, maintain foraminal dimensions, and facilitate indirect decompression by restoring disc space [6]. Anterior column load sharing promotes earlier mobilization. Restoration of sagittal alignment through proper cage placement fosters spinopelvic alignment, correlating with improved function, better quality of life, and reduced adjacent-segment degeneration [7]. Key spinopelvic parameters—pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), and PI–lumbar lordosis (PI–LL) mismatch—are critical for balanced alignment. A PI–LL mismatch greater than 10° associates with persistent back pain and inferior health-related quality-of-life scores [8].

Although TLIF reliably achieves high fusion rates and significant clinical gains in degenerative spondylolisthesis and lumbar canal stenosis, limited prospective data exist correlating spinopelvic correction with patient-reported outcomes [9]. This prospective study evaluates clinical improvement, disability reduction, and sagittal alignment changes in patients undergoing TLIF for lumbar canal stenosis with or without low-grade spondylolisthesis, and assesses correlations between spinopelvic restoration and functional gains at one-year follow-up [10].

Methods and Materials

This prospective observational study ran from October 2019 to December 2021 at a tertiary teaching hospital after ethical approval. Adult patients (≥ 20 years) with symptomatic lumbar canal stenosis—isolated or with low-grade (Meyer ding I–II) spondylolisthesis at L3–S1—who failed ≥ six weeks of conservative therapy were enrolled. Exclusion criteria included high-grade spondylolisthesis, infection, neoplasm, osteoporosis (T-score ≤ –2.5), neuropathy, or inability to follow up.

Baseline evaluation included history, neurological exam, and comorbidities (diabetes, hypertension, hypothyroidism, heart disease, rheumatoid arthritis) [11]. Functional status was assessed via Visual Analog Scale (VAS) for back and leg pain, Oswestry Disability Index (ODI), and Short Form-36 (SF-36) [10]. Standing anteroposterior and lateral lumbar radiographs—including femoral heads—measured spinopelvic parameters (PI, PT, SS, lumbar lordosis) [12]. MRI confirmed stenosis and disc pathology.

Under general anesthesia, patients were prone on a radiolucent table with bolsters. Via a midline posterior approach, bilateral pedicle screws were placed under fluoroscopy [3]. Unilateral facetectomy enabled decompression and disc access [6]. After discectomy and endplate prep, a PEEK cage with auto graft was inserted; rods restored lordosis [13]. A subfascial drain was placed, and layers closed.

Postoperative care included IV antibiotics (cephalosporin, amikacin) for five days, oral antibiotics for five days, and pneumatic compression. Drains removed on day 2. Early mobilization began with sitting on day 2 and walker ambulation on day 3. Follow-up at six weeks, three months, six months, and one year included VAS, ODI, SF-36, radiographs (spinopelvic parameters, dynamic flexion-extension radiographs for fusion). Complications (dural tears, infections, radiculopathy, hardware) were recorded.

Results

A total of 48 patients (15 males, 33 females; mean age 51.9 years) underwent TLIF. Eight (16.7 %) were lost to follow-up, leaving 40 patients (15 males, 25 females; mean age 52 years) for analysis. Twenty-eight (70 %) presented with stenosis and low-grade spondylolisthesis; 12 (30 %) had isolated stenosis. Single-level fusion was performed in 35 (87.5 %) and two-level in 5 (12.5 %). Operative levels were L4–L5 (65 %), L5–S1 (22.5 %), and L3–L4 (12.5 %). Median operative time was 210 minutes; mean blood loss was 325 mL.

At one-year follow-up, median VAS for back pain decreased from 7 to 1; median VAS for leg pain decreased from 8 to 1. Mean ODI improved from 67.8 % to 18.1 %. SF-36 scores improved across all domains: physical functioning (26.9 to 70.0), physical role (5.8 to 67.3), bodily pain (28.7 to 72.0), general health (42.9 to 54.9), vitality (39.2 to 65.3), social functioning (33.7 to 64.1), emotional role (17.1 to 68.4), and mental health (52.3 to 77.6). Radiographically, mean pelvic tilt increased from 15.2° to 18.3°; mean pelvic incidence remained stable (54.2° to 56.5°); sacral slope changed from 38.9° to 36.6°; PI–LL mismatch decreased from 16.5° to 12.1°. Fusion was achieved in 38 (95 %) patients.

Discussion

This prospective series demonstrates that TLIF effectively addresses lumbar canal stenosis—with or without low-grade spondylolisthesis—yielding marked pain relief and functional gains. Median VAS scores for back pain dropped from 7 to 1, and leg pain from 8 to 1 at one year, reflecting robust decompression and stabilization [3,4]. ODI improved from 67.8 % to 18.1 %, consistent with Balasubramanian et al.'s findings [5]. SF-36 domain improvements, especially in physical functioning and bodily pain, underscore TLIF's

positive impact on both physical and mental health [5].

Postoperative spinopelvic alignment improved, with pelvic tilt increasing from 15.2° to 18.3° (p = 0.023), indicating enhanced sagittal balance [6]. While pelvic incidence—being an anatomical constant—remained unchanged, PI–LL mismatch decreased from 16.5° to 12.1° (p = 0.037), reflecting partial restoration of lumbar lordosis [7,8]. Despite these radiographic gains, correlation analysis did not show a significant association between spinopelvic correction and functional outcomes, echoing Oikonomidis et al.'s observations [9]. Contributing factors may include compensatory pelvic mechanisms, heterogeneity of baseline alignment, and limited sample size.

Complication rates were acceptable: dural tears occurred in 10 % and were managed without long-term sequelae [13]; one superficial infection (2.5 %) required debridement [14]; two screw pullouts and one transient radiculopathy resolved without deficits [15]. A fusion rate of 95 % at one year aligns with results using PEEK cages and auto graft [15,16]. Limitations include heterogeneous indications (stenosis vs. spondylolisthesis), absence of a control group, modest sample size (n = 40), and one-year follow-up, limiting long-term adjacent-segment analysis [17,18]. Future studies should compare TLIF with alternative techniques in larger cohorts and include extended follow-up to evaluate durability of radiographic correction and adjacent-segment disease [19,20]. Further, patient selection criteria should be refined.

Conclusion

In this cohort of 40 patients undergoing TLIF for lumbar canal stenosis with or without low-grade spondylolisthesis significant improvements in pain, disability, and quality of life were achieved at one-year follow-up. Median VAS scores for back and leg pain decreased markedly, and mean ODI improved substantially. Radiographs demonstrated increased pelvic tilt and reduced PI–lumbar lordosis mismatch, indicating partial restoration of sagittal alignment. Fusion was confirmed in 95 % of patients. Complication rates were low, with four dural tears, one superficial infection, two screw pullouts, and one transient radiculopathy—all managed successfully without permanent deficits. These findings underscore TLIF's efficacy in achieving neural decompression and spinal stabilization while facilitating early mobilization and enhancing patient satisfaction. Limitations include heterogeneous indications, absence of a control group, modest sample size, and one-year follow-up, which may not capture long-term adjacent-segment changes. Future research should involve larger cohorts, randomized designs, and extended follow-up to validate these outcomes.

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Conflict of Interest: Nil
Source of Support: None

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University Affiliation: MUHS, Nashik, Maharashtra, India.
Year of Acceptance of Thesis: 2019

How to Cite this Article: Kothari A, Pradhan C, Patil A, Puram C, Sonawane D, Shyam A, Sancheti P. Functional and Radiographic Predictors of Success in Transforaminal Lumbar Interbody Fusion: A Prospective Study of Lumbar Canal Stenosis. Journal of Medical Thesis. 2024 July-December; 11(2):48-51.