

Impact of Single-Level Transforaminal Lumbar Interbody Fusion on Spinopelvic Parameters and Functional Status in Lumbar Degenerative Disease

Lomber Dejeneratif Hastalıkta Tek Seviyeli Transforaminal Lomber İnterbody Füzyonun Spinopelvik Parametreler ve Fonksiyonel Durum Üzerindeki Etkisi

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ABSTRACT

Background: The present retrospective cohort study aimed to evaluate the functional and radiological outcomes of single-level transforaminal lumbar interbody fusion (TLIF) in patients suffering from degenerative lumbar spine conditions.

Materials and Methods: The present study comprised 48 patients (29 women and 19 men, with a mean age of 54.9±14.2 years) who underwent single-level TLIF between January 2017 and January 2022. Spinopelvic parameters, encompassing pelvic incidence, pelvic tilt, sacral slope, and lumbar lordosis (LL), were meticulously measured preoperatively and postoperatively. The assessment of pain and disability was conducted using the visual analog scale (VAS) and the Oswestry disability index (ODI).

Results: The mean follow-up duration was 5.6±1.4 years. Despite the lack of statistical significance in the observed changes to spinopelvic parameters, a subtle tendency towards enhanced LL and improved pelvic alignment was identified post-operatively. The mean preoperative VAS score demonstrated a statistically significant decrease from 8.7±2.1 to 2.0±2.6 postoperatively (p<0.001), and the ODI score exhibited an improvement from 40.6±9.8 to 7.1±10.8 (p<0.001).

Conclusion: The findings of this study indicate that single-level TLIF can yield clinically significant benefits in terms of pain relief and functional capacity, even in the absence of substantial radiological correction. Further research with larger patient populations is necessary to comprehensively elucidate the relationship between sagittal realignment and long-term clinical outcomes.

Keywords: Transforaminal lumbar interbody fusion, degenerative lumbar spine, spinopelvic parameters, lumbar lordosis

ÖZ

Amaç: Mevcut retrospektif kohort çalışmasının amacı, dejeneratif lomber omurga rahatsızlıkları olan hastalarda tek seviyeli transforaminal lomber interbody füzyonun (TLIF) fonksiyonel ve radyolojik sonuçlarını değerlendirmektir.

Gereç ve Yöntemler: Bu çalışma, Ocak 2017 ile Ocak 2022 arasında tek seviyeli TLIF uygulanan 48 hastayı (29 kadın ve 19 erkek, ortalama yaşları 54,9±14,2 yıl) içermektedir. Pelvik insidans, pelvik eğim, sakral eğim ve lomber lordozu (LL) kapsayan spinopelvik parametreler, ameliyat öncesi ve sonrası ölçüldü. Ağrı ve hastalık seviyesi değerlendirmesi görsel analog skala (VAS) ve Oswestry sakatlık indeksi (ODI) kullanılarak yapıldı.

Bulgular: Ortalama takip süresi 5,6±1,4 yıl idi. Spinopelvik parametrelerde gözlenen değişikliklerde istatistiksel olarak anlamlı bir fark olmamasına rağmen, ameliyat sonrası LL'de artış ve pelvik hizalanmada iyileşme yönünde hafif bir eğilim tespit edildi. Ameliyat öncesi ortalama VAS skoru, ameliyat sonrası 8,7±2,1'den 2,0±2,6'ya istatistiksel olarak anlamlı bir düşüş gösterdi (p<0,001) ve ODI skoru 40,6±9,8'den 7,1±10,8'e gelişme gösterdi (p<0,001).

Sonuç: Bu çalışmanın bulguları, tek seviyeli TLIF'nin, önemli bir radyolojik düzeltme olmasa bile, ağrı kesici ve fonksiyonel kapasite açısından klinik olarak anlamlı faydalar sağlayabileceğini göstermektedir. Sagittal yeniden hizalama ile uzun vadeli klinik sonuçlar arasındaki ilişkiyi kapsamlı bir şekilde açıklamak için daha geniş hasta popülasyonlarıyla daha fazla araştırmaya ihtiyaç vardır.

Anahtar Kelimeler: Transforaminal lomber interbody füzyon, dejeneratif lomber omurga, spinopelvik parametreler, lomber lordoz



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Received: 27.08.2025 **Accepted:** 29.09.2025 **Publication Date:** 30.09.2025

Cite this article as: Sivacioğlu S. Impact of single-level transforaminal lumbar interbody fusion impact on spinopelvic parameters and functional status in lumbar degenerative disease. Hamidiye Med J. 2025;6(3):183-187



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Introduction

Chronic lumbar pain is a prevalent condition in clinical practice and is acknowledged as a significant contributor to global functional impairment. It can arise from various etiologies, including disc herniation, scoliosis, facet joint arthrosis and, most commonly, disc degeneration (1,2). These conditions are collectively categorized as degenerative spinal diseases, with treatment modalities ranging from conservative management to surgical intervention (3). Surgical approaches for disc degeneration typically involve excision of the pathological disc and application of an interbody cage to facilitate osteosynthesis between adjacent vertebral bodies (4). One such surgical technique is transforaminal lumbar interbody fusion (TLIF), which is extensively performed to restore spinal stability in patients with single-level degenerative disc disease, spondylolisthesis, or spinal stenosis (5). TLIF offers several advantages, including a unilateral surgical approach, preservation of posterior elements, and restoration of disc height and sagittal alignment (6). Given that sagittal imbalance can negatively impact surgical outcomes, the restoration or maintenance of spinopelvic alignment, including parameters such as pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), and lumbar lordosis (LL), is essential for preventing adjacent segment pathology and ensuring favorable clinical results (7). Analyzing the changes in these parameters before and after TLIF provides valuable insights into the procedure's biomechanical efficacy and its influence on global spinal alignment. Despite extensive research on the radiological outcomes of TLIF, few studies have assessed the relationship between spinopelvic alignment and clinical improvement, particularly in patients undergoing single-level TLIF. This study aimed to examine the functional and radiological outcomes of patients who underwent single-level TLIF.

Materials and Methods

This retrospective cohort study was conducted at a single center, focusing on patients who underwent single-level TLIF surgery between January 2017 and January 2022. Approval from the International Review Board was obtained from the İstanbul Medipol University Non-Interventional Clinical Research Ethics Committee (approval number: 10840098-202.3.02, dated: 30.08.2025). Informed consent was obtained from all participants, and the study was conducted in accordance with the Declaration of Helsinki. Of the 59 patients initially reviewed, 11 were excluded because of incomplete preoperative records, resulting in a final cohort of 48 patients. Complete radiographic datasets

were available for both preoperative and postoperative assessments for all included patients. The inclusion criteria were as follows: age ≥ 18 years, diagnosis of degenerative lumbar disc disease or low-grade spondylolisthesis, single-level TLIF surgery, and availability of complete preoperative and postoperative radiological and clinical data. The exclusion criteria included multilevel fusion, revision surgery, history of spinal trauma, tumors or infection, and insufficient clinical or radiological documentation (Table 1).

All surgical interventions were performed by a single spine surgeon at the same academic institution, utilizing a conventional posterior approach with patients positioned prone under general anesthesia. At the specified spinal level, an interbody cage filled with either an autologous bone graft or a suitable bone substitute was inserted. Posterior stabilization was achieved by applying pedicle screw instrumentation. Radiographic evaluation entailed the analysis of key spinopelvic alignment parameters, including PI, PT, SS, and LL, which were measured by a senior orthopedic specialist blinded to patient outcomes. All angles were measured in degrees, according to the Cobb technique. Pain and disability were assessed using validated outcome measures, specifically the visual analog scale (VAS) and Oswestry disability index (ODI). These assessments were conducted either in person or via telephone interviews, with a mean follow-up duration of 5.6 ± 1.4 years post-surgery.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics (version 22.0; IBM Corp., Armonk NY, USA). The distribution characteristics of the variables were evaluated using the Shapiro-Wilk test to assess normality. Depending on whether the variables met the assumptions of normality, either the Paired samples t-test or Wilcoxon signed-rank test was employed for pre- and postoperative comparisons. A $p < 0.05$ was considered statistically significant. Table 2 provides an overview of the demographic and surgical distributions of the patient cohort.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Age ≥ 18 years	Multilevel fusion surgery
Diagnosis of degenerative lumbar disc disease or low-grade spondylolisthesis	History of revision surgery
Underwent single-level transforaminal lumbar interbody fusion	History of spinal trauma, tumor, or infection
Availability of complete preoperative and postoperative radiographic data	Incomplete clinical or radiological data
Availability of clinical follow-up data	—

Most procedures were performed at the L4-5 segment (n=26), with fewer cases involving the L5-S1 (n=13), L3-4 (n=8), and L2-3 (n=1) levels. Throughout the perioperative period, encompassing both the intraoperative and early postoperative phases, no complications were observed in the patients included in this study.

Results

The mean age was 54.9 ± 14.2 years, and the cohort comprised 29 women (60%) and 19 men (40%). This retrospective cohort study aimed to evaluate the functional and radiological outcomes of single-level TLIF in patients with degenerative lumbar spine conditions. The study included 48 patients (29 women, 19 men; mean age 54.9 ± 14.2 years) who underwent single-level TLIF between January 2017 and January 2022. Spinopelvic parameters, including PI, PT, SS, and LL, were measured preoperatively and postoperatively. Pain and disability were assessed using the VAS and ODI. The mean follow-up duration was 5.6 ± 1.4 years. Although changes in spinopelvic parameters did not reach statistical significance, a subtle tendency toward improved LL and pelvic alignment was observed postoperatively. The mean preoperative VAS score significantly decreased from 8.7 ± 2.1 to 2.0 ± 2.6 postoperatively ($p < 0.001$), and the ODI score improved from 40.6 ± 9.8 to 7.1 ± 10.8 ($p < 0.001$). These findings suggest that single-level TLIF can provide clinically relevant benefits in pain relief and functional capacity, even in the absence of significant radiological correction. Further research with larger patient populations is necessary to comprehensively elucidate the relationship between sagittal realignment and long-term clinical outcomes. The mean preoperative PI was $47.0 \pm 8.5^\circ$, whereas the postoperative PI was $46.8 \pm 11.3^\circ$, indicating a minimal change in this parameter ($p = 0.786$).

Similarly, PT increased slightly from $18.3^\circ \pm 8.0^\circ$ preoperatively to $19.6^\circ \pm 6.0^\circ$ postoperatively ($p = 0.106$). The SS was recorded as $28.5 \pm 8.9^\circ$ before surgery and $27.2 \pm 6.7^\circ$ after surgery ($p = 0.112$). LL showed a negligible change from $45.2^\circ \pm 13.5^\circ$ preoperatively to $45.9^\circ \pm 8.6^\circ$ postoperatively ($p = 0.551$) (Table 3).

Minor variations were detected across all measured spinopelvic parameters; however, these changes were not statistically significant. Nonetheless, imaging findings revealed a subtle inclination toward postoperative

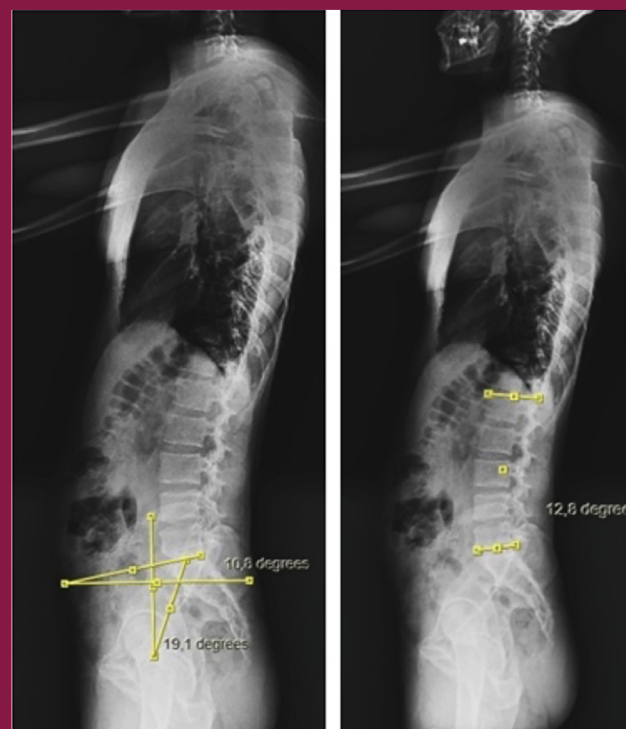


Figure 1. Measurement of preoperative sagittal parameters

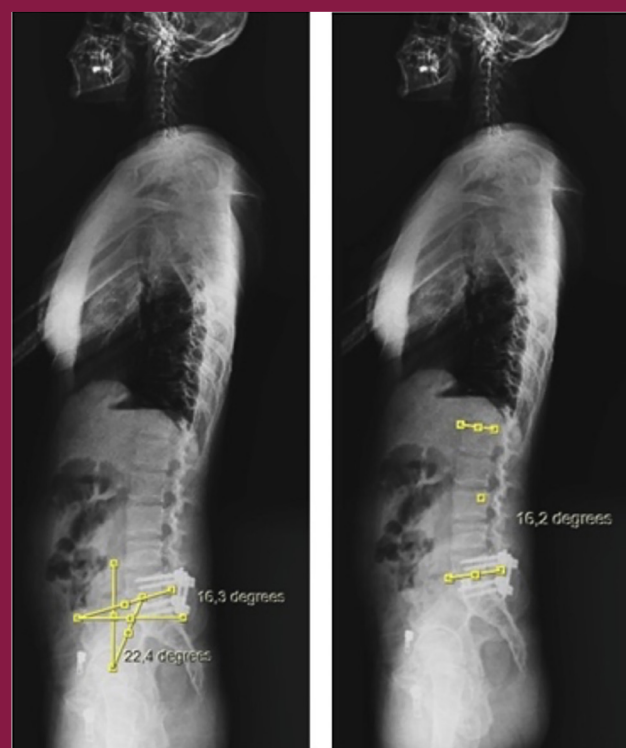


Figure 2. Measurement of postoperative sagittal parameters

Table 2. Demographic characteristics of the study group

Surgical level	Number of patients (n=48)
L4-5	26
L5-S1	13
L3-4	8
L2-3	1

improvement in the LL and pelvic alignment. Regarding functional outcomes, the mean preoperative VAS score was 8.7 ± 2.1 , which significantly decreased to 2.0 ± 2.6 postoperatively ($p < 0.001$). Similarly, the ODI, which assesses the degree of functional limitation, improved markedly from 40.6 ± 9.8 preoperatively to 7.1 ± 10.8 postoperatively ($p < 0.001$) (Table 4).

Discussion

TLIF is widely adopted in the surgical management of degenerative lumbar spine conditions, largely because of its ability to achieve three-column stabilization, restore intervertebral disc height, and improve sagittal alignment (4,5).

This study examined the influence of single-level TLIF on sagittal spinal alignment. Although alterations in spinopelvic orientation metrics, specifically PI, PT, SS, and LL, did not reach statistical significance, radiographic data suggested a postoperative tendency toward improved alignment, particularly in lumbar curvature.

Sagittal alignment, particularly the restoration of LL, plays a crucial role in achieving favorable clinical outcomes following lumbar fusion surgery and in reducing the risk of adjacent segment disease (7,8). In our study group, the mean LL increased from 45.2° to 46.5° , which is consistent with previous studies reporting modest but clinically relevant improvements in lordotic angles after TLIF (9). The relatively small change in lordosis may be attributed to the use of standard cages, lack of aggressive corrective maneuvers, and inclusion of only single-level fusions.

Previous studies have suggested that TLIF may help preserve or slightly improve spinopelvic alignment in

appropriately selected patients. For instance, single-level TLIF resulted in significant improvement in LL in patients with low preoperative lordosis. However, some studies have emphasized that single-level procedures may be insufficient to achieve adequate correction in cases with more pronounced sagittal imbalance (10).

In our study, the pelvic parameters, such as PI, PT, and SS, remained relatively stable. This finding is consistent with the notion that PI is a fixed morphological parameter, whereas PT and SS generally show compensatory changes only in more severe cases of imbalance (11). The slight increase in postoperative PT may reflect a subtle compensatory mechanism aimed at maintaining sagittal balance.

Although the radiological improvements observed in this study did not reach statistical significance, their clinical relevance cannot be overlooked. Even minor improvements in sagittal alignment have been shown to contribute to pain control, enhance the quality of life, and reduce mechanical stress on adjacent segments (12,13).

Similarly, a study conducted by Ünsal et al. (14) reported that radiographic changes in spinopelvic parameters after single-level TLIF were not statistically significant. However, despite these limited angular corrections, significant improvements were observed in clinical parameters, such as pain and function. This supports the idea that TLIF may provide meaningful clinical benefits, even in the absence of marked radiographic changes, when applied to appropriately selected patients.

In our cohort, the mean preoperative VAS score significantly decreased from 8.7 ± 2.1 to 2.0 ± 2.6 postoperatively ($p < 0.001$). Similarly, the ODI score improved from 40.6 ± 9.8 to 7.1 ± 10.8 ($p < 0.001$). The results presented in this study are in agreement with those reported in previous studies. Notably, Foley et al. (15) reported that the ODI decreased from approximately 37.5 ± 15.5 preoperatively to 13.5 ± 12.5 postoperatively, and the VAS score for low back pain improved from 43.5 ± 30.4 to 17.9 ± 22.6 ($p < 0.001$).

In our study, even more pronounced improvements in pain and disability were observed. The preoperative VAS score, categorized as “very severe,” improved to the “mild” level postoperatively. Likewise, the ODI score, initially indicating “severe disability,” improved to the level of “minimal disability.”

The limited number of cases may have compromised the statistical strength of the study, thereby reducing the likelihood of identifying subtle, but clinically meaningful, differences. To better understand the association between radiological changes and clinical outcomes after single-level TLIF, future research should focus on larger cohorts with extended follow-up durations.

Table 3. Comparison of preoperative and postoperative spinopelvic parameters

Parameter	Preoperative (°)	Postoperative (°)	p-value (<0.05)
Pelvic incidence	47.0 ± 8.5	46.8 ± 11.3	0.786
Pelvic tilt	18.3 ± 8.0	19.7 ± 6.0	0.106
Sacral slope	28.5 ± 8.9	27.2 ± 6.7	0.112
Lumbar lordosis	45.2 ± 13.5	45.9 ± 8.6	0.551

Values expressed as mean \pm standard deviation

Table 4. Comparison of preoperative and postoperative functional parameters

Parameter	Preoperative	Postoperative	p-value (<0.05)
VAS	8.7 ± 2.1	2.0 ± 2.6	$< 0.01 \times 10^{-11}$
ODI	40.6 ± 9.8	7.1 ± 10.8	$< 0.008 \times 10^{-13}$

Values expressed as mean \pm standard deviation. VAS: Visual analog scale, ODI: Oswestry disability index

Conclusion

Based on the findings of this study, single-level TLIF may be a valuable surgical intervention for enhancing clinical outcomes in patients with degenerative lumbar spinal conditions. Although the observed changes in spinopelvic parameters, including PI, PT, SS, and LL, did not reach statistical significance, subtle improvements were radiographically evident, particularly in LL and pelvic alignment.

Notably, patients exhibited meaningful postoperative gains in pain relief and functional capacity, as reflected by substantial reductions in the VAS and ODI scores. These results indicate that even in the absence of major radiological correction, TLIF can yield clinically relevant benefits when applied to appropriately selected patients. Further longitudinal research involving larger patient populations is necessary to comprehensively elucidate the connection between sagittal realignment and long-term clinical outcomes.

Ethics

Ethics Committee Approval: Approval from the International Review Board was obtained from the İstanbul Medipol University Non-Interventional Clinical Research Ethics Committee (approval number: 10840098-202.3.02, dated: 30.08.2025).

Informed Consent: Informed consent was obtained from all participants, and the study was conducted in accordance with the Declaration of Helsinki.

Footnotes

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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