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THE EFFECT OF LONG- AND SHORT-LEVEL FUSIONS ON SAGITTAL BALANCE PARAMETERS OF PATIENTS TREATED WITH TRANSFORAMINAL LUMBAR INTERBODY FUSION FOR DEGENERATIVE SPINE OVER OLDER THAN 65 YEARS

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ABSTRACT

Objective: This study assessed the outcomes of transforaminal lumbar interbody fusion (TLIF) in patients with degenerative spine conditions above the age of 65 years and investigate the effects of fusion levels on the sagittal balance parameters.

Materials and Methods: This retrospective study reviewed patients with degenerative spine diseases who underwent lumbar fusion with the TLIF procedure older than 65 years. Patients with three or less segments involved in the fusion were assigned to the short-level fusion group, and the patients with more than three segments involved in the fusion were assigned to the long-level fusion group. The anteroposterior and lateral spine radiographs of the patients were used to measure pelvic incidence (PI), pelvic tilt (PT), sacral slop (SS), lumbar lordosis (LL), distal lumbar lordosis, thoracolumbar kyphosis, thoracic kyphosis (TK), T1 spinopelvic inclination (T1SPI), T9 spinopelvic inclination (T9SPI) and T1 pelvic angle (TPA).

Results: The study included 45 patients, 28 females and 17 males, who met the inclusion criteria. The long- and short-level fusion groups comprised 25 and 20 patients, with the mean ages of 68.87 and 67.72 years and mean follow-up periods of 26.96±15.53 and 27.61±11.83 months, respectively. TK and T9SPI values showed no difference between the groups before and after surgery, but a statistically significant increase in the values was observed postoperatively in the patients who underwent long-level fusion. The preoperative SVA values were significantly higher in the long-level fusion group than in the short-level fusion group. No difference in the postoperative SVA values was found between the groups. The PT, PI, SS, TPA, T1SPI was not statistically differ between the groups before and after surgery.

Conclusion: TLIF contributes to the improvement of the sagittal balance parameters in both short- and long-level fusions in patients above the age of 65 years with degenerative spine conditions.

Keywords: Long level fusion, sagittal parameters, TLIF, degenerative spine

INTRODUCTION

Degenerative spine conditions are characterized by the progressive degeneration of bony structures and intervertebral discs, with overloading being a key pathogenic factor[1]. The age-related pathological changes in the spine may occur due to different factors; commonly including trauma, metabolic conditions, exposure to toxic substances, genetic factors, and vascular disorders[2,3]. Chronic trauma is considered the leading cause, as it has been established that degenerative spine diseases are primarily caused by chronic overload[1].

Although lumbar interbody fusion was introduced approximately 70 years ago, longer life expectancy, novel implant designs, and the desire for a better quality of life have led to an increased frequency of fusion surgeries even today[4]. Transforaminal lumbar interbody fusion (TLIF) has been considered as the gold standard among the techniques applied to the interbody space because of its minimal association with the neurovascular structures and ease of application to the target segments[5].

The maintenance and restoration of the sagittal balance (SB) has become a topic of great interest in lumbar surgery as it directly affects the surgical outcomes and quality of life. Physiological lumbar lordosis (LL) is important in maintaining

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SB, whose impairment is closely associated with chronic lower back pain and disability[6].

Previous studies have reported an increased morbidity and mortality in spinal surgeries with increasing age, as the complication rates rise and the optimal surgical outcomes are compromised[7,8]. Several studies have investigated the efficacy and safety of TLIF therapy in the younger population; however, their impact in elderly patients remains unclear[5].

The objective of surgical treatments in patients with degenerative spine conditions is to obtain a stable spine with decompressed neural elements and coronal and sagittal alignment[9]. The procedure for the restoration of spine alignment may require a surgical approach that combines fusion, decompression, and osteotomy[10]. However, specific information on the number of fusion levels is not available[10].

This study aimed to assess the outcomes of TLIF in patients with degenerative spine conditions above the age of 65 years and investigate the effects of fusion levels on the SB parameters.

MATERIALS AND METHODS

This retrospective study reviewed 135 patients with degenerative spine diseases who underwent lumbar fusion with the TLIF procedure in our Orthopedics and Traumatology Department of between 2016 and 2021. The records of the patients were obtained from the archive system of the clinic. Written informed consent was obtained from all patients before the study. This study was performed after obtaining the institutional review board approval (2022/02) from İstanbul University, İstanbul Faculty of Medicine, Department of Orthopedics and Traumatology committee. Of the 135 patients, 63 were above the age of 65 years. The study included 45 of the 63 patients who had regular outpatient follow-ups for at least 12 months and whose radiological data were accessible. The age, gender, surgical procedure, and postoperative follow-up period of these patients were collected from their medical records. The SB parameters were measured and recorded preoperatively and at the final follow-up visit. The patients with neuromuscular and inflammatory comorbidities, incomplete follow-ups, and no spinal radiography were excluded from the study.

As per the literature, patients with three or less segments involved in the fusion were assigned to the short-level fusion group, and the patients with more than three segments involved in the fusion were assigned to the long-level fusion group[10,11]. Short-level fusion was only conducted on the patients with nerve compression and degeneration in the upper and lower segments, whereas long-level fusion was conducted on the patients with multisegmental nerve compressions, degeneration, and instability[11] (Figure 1-4).

Surgical Procedure and Follow-up

A senior surgeon and his team performed posterior fixation with multiaxial pedicle screws using an interbody cage and allograft on all the patients. Using the standard TLIF method, the cage was inserted in the correct position through unilateral facetectomy and partial laminectomy. Postoperative corsets were not used on the patients and early mobilization was conducted. The patients were evaluated in the outpatient clinic at 1, 6, and 12 weeks. Patients without postoperative complications were called for the control visits at intervals of 6 months.

Radiological evaluation

The radiographs of the patients were used to measure pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), LL, distal LL (DLL), thoracolumbar kyphosis (TLK), thoracic kyphosis (TK), T1 spinopelvic inclination (T1SPI), T9 spinopelvic inclination (T9SPI), T1 pelvic angle (TPA).

PI is the angle between the perpendicular line drawn at the sacral-end upper-plate midpoint and the line connecting the axis of the femoral head to this midpoint. PT is the line connecting the vertical line drawn from the femoral head axis and the sacral-end upper-plate midpoint from the femoral head axis. SS is the angle between the line drawn from the last upper sacral plate and the horizontal line drawn from the last upper sacral plate midpoint. LL is the Cobb angle between L1 vertebra upper endplate and S1 vertebra upper endplate. DLL

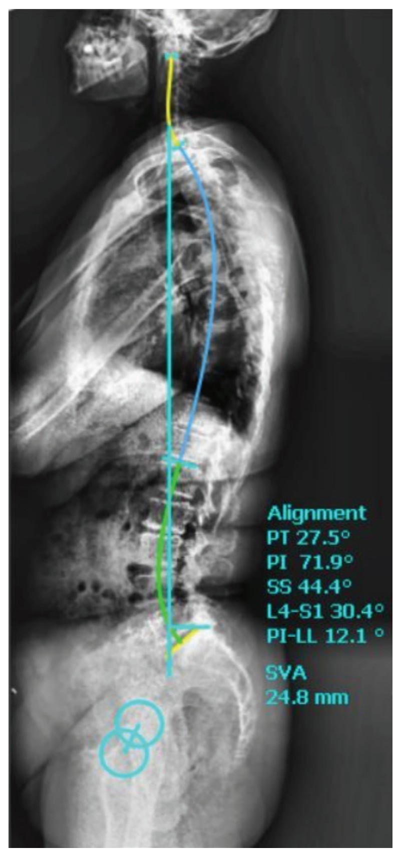

Figure 1. Preoperative lateral spine radiograph of patients treated with short level fusion surgery

PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, SVA: Sagittal vertical axis is the Cobb angle between L4 vertebra upper endplate and S1 vertebra upper endplate TLK is the Cobb angle between T10 vertebra upper endplate and L2 vertebra lower endplate. TK is the Cobb angle between T4 vertebra upper endplate and T12 vertebra lower endplate. T1SPI is the angle between the line drawn from the center of T1 vertebra to the femoral head axis and the vertical plumb line. T9SPI is the angle between the line drawn from the center of the T9 vertebra to the femoral head axis and the vertical plumb line. TPA is the angle between the line drawn from the femoral head axis to the center of T1 vertebra and the line drawn from the femoral head axis to the sacral-end upper plate. SB is the distance from the vertical descending line at the center of C7 vertebra to the posterior upper-plate posterosuperior corner of the S1 vertebral body. The distance of this line from the S1 vertebral body to the final upper-plate posterosuperior corner, 2.5 cm anteriorly and posteriorly, is considered a neutral SB. Distance of >2.5 cm anteriorly was considered positive SB and that posteriorly was considered negative SB.

Statistical Analysis

The statistical data of the study was analyzed using the SPSS (Statistical Package for Social Sciences) for Windows 25.0. Descriptive statistics, including minimum, maximum, and median values, were used in the analysis of the data. Since the sample sizes of the study groups were smaller than 30, non-parametric tests were used for statistical analysis. Wilcoxon test was used to determine whether the two dependent variables differed, and Mann-Whitney U test was used to test whether the two independent groups differed with regard to a quantitative variable. This study considered $p<0.05$ as statistically significant.

RESULTS

The study included 45 patients, 28 female and 17 male, who met the inclusion criteria. The long- and short-level fusion groups comprised 25 and 20 patients, with the mean ages of 68.87±4.94 and 67.72±6.61 years and mean follow-up periods of 26.96±15.53 and 27.61±11.83 months, respectively (Table 1). Both preoperative and postoperative LL values were significantly higher in the short-level fusion group than in the long-level fusion group. Postoperative LL values showed significant increase in both the groups compared with the preoperative LL values.

The TK and T9 spino-pelvic inclination (T9SPI) values showed no difference between the groups before and after surgery, but a statistically significant increase in the values was observed

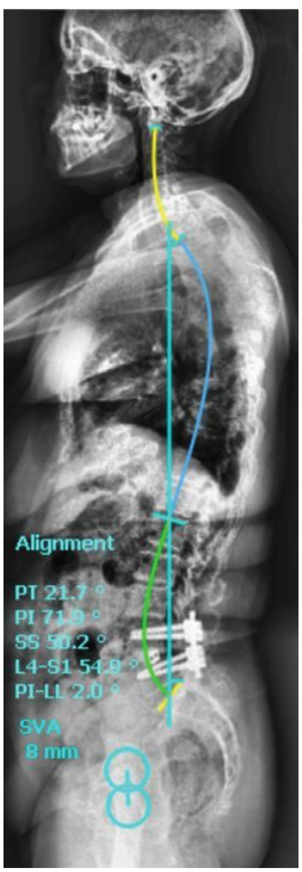

Figure 2. Postoperative lateral spine radiograph of patients treated with short level fusion surgery

PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, SVA: Sagittal vertical axis

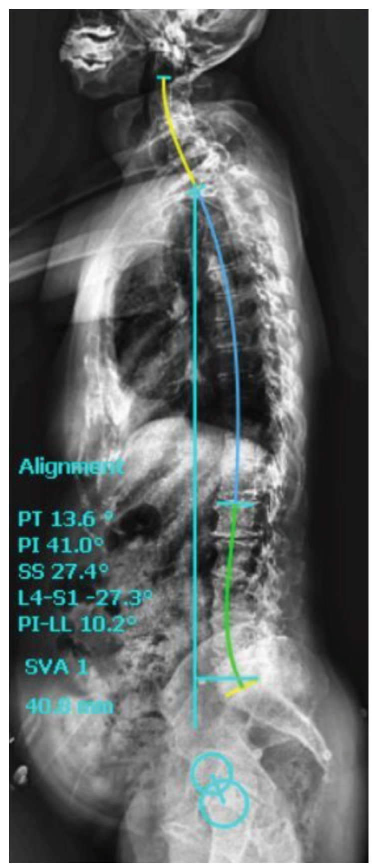

Figure 3. Preoperative lateral spine radiograph of patients treated with long level fusion surgery

PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, SVA: Sagittal vertical axis postoperatively in the patients who underwent long-level fusion.

The preoperative sagittal vertical axis (SVA) values were significantly higher in the long-level fusion group than in the short-level fusion group. No difference in the postoperative SVA values was found between the groups. The SVA values of both the groups exhibited a significant decrease post-surgery.

The PT, PI, SS, TPA, T1 spino-pelvic inclination (T1SPI), and decompressive lumbar laminectomy values did not statistically differ between the groups before and after surgery (Table 2).

Revision surgery was performed in 4 (16%) patients with long-level fusion and 3 (15%) patients with short-level fusion due to the development of proximal junctional kyphosis (PJK) at the end of the second year of follow-up.

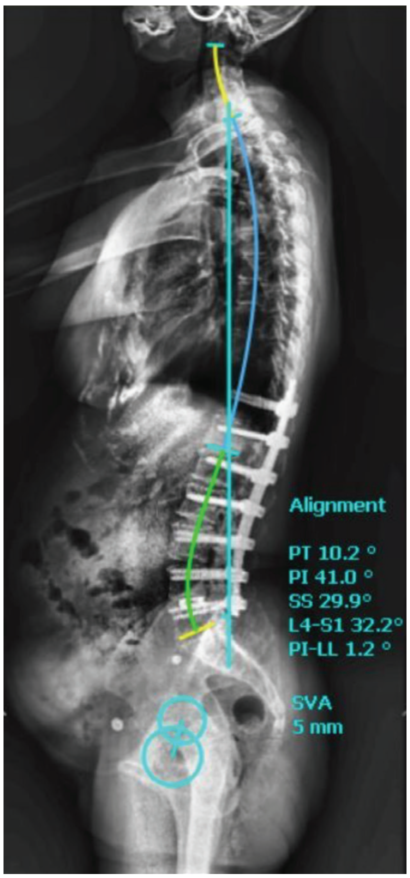

Figure 4. Postoperative lateral spine radiograph of patients treated with long level fusion surgery

PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, SVA: Sagittal vertical axis

DISCUSSION

TLIF in patients above the age of 65 years improved LL and SVA in both the long- and short-level fusion groups and TK and T9SPI improvement was observed in the long-level fusion group.

The prevalence of spinal surgeries increases with the aging population[12]. Although conservative treatments are preferred to minimize morbidity, surgical treatments are inevitable in some cases. Decompression alleviates neurological symptoms; however, it cannot optimally be performed alone due to its potential of increasing spinal instability[13,14]. Thus, most surgeons recommend the accompaniment of decompression with fusion and instrumentation[14,15]. Long-level fusion is preferred for multisegmental degeneration with high sagittal imbalance.

Previous studies have shown that the appropriate application of the TLIF technique accompanied with posterior instrumentation is effective in the restoration of global SB[16]. This study demonstrated a significant postoperative improvement in SVA in both the groups. Since long-level fusion was performed in the patients with multisegmental degeneration and instability, the preoperative SVA measurements were higher in them, which was an expected outcome. Long-level fusion significantly improved T9SPI, one of the global SB indicators, and corrected TK.

The restoration of LL is closely associated with patient satisfaction in degenerative spine conditions[17]. In addition, biomechanical and clinical studies have reported a reduction in the degeneration of the adjacent segments on LL restoration[18]. Previous studies provide indications about the expected increase in LL following TLIF surgery. Hsieh et al.[19] have shown that TLIF reduces LL. In contrary, other studies have reported an increase in LL between 1.5° and 17°[20,21]. The performance of bilateral facetectomy and the number of grafts used as per the surgeon's choice can account for the differences between the studies. In our study, an increase of 13° and 11.15° in the long- and short-level fusion groups were achieved in post-surgical LL. The postoperative increase in the LL values of both the groups was statistically significant compared with their preoperative LL values.

Glattes et al.[22] were the first to identify PJK. PJK is determined by measuring the proximal sagittal Cobb angle (proximal junctional angle) between the lower endplate of the uppermost instrumented vertebra and the upper endplate of the above two vertebrae of the uppermost instrumented vertebra[23]. This

Table 1. Distribution of age and follow-up duration of group

	Long-level fusion group		Short-level fusion group	
	Min.-max.	**($\bar{X}$ ± SD)**	**Min.-max.**	**($\bar{X}$ ± SD)**
Age	65-86	68.87±4.94	65-77	67.72±6.61
Follow-up duration	12-60 (Month)	26.96±15.53	12-48 (Month)	27.61±11.83

SD: Standard deviation, Min.: Minimum, Max.: Maximum turkishspine

Table 2. Comparison of preoperative and postoperative data

		Preoperative	Postoperative		
		Median (min.-max.)	Median (min.-max.)	Za	p-value
PT	Long-level fusion (n=25)	22.00 (0.30-33.40)	23.90 (2.70-241.00)	-1.338	0.181
	Short-level fusion (n=20)	23.30 (3.10-274.00)	22.95 (1.00-44.10)	-0.218	0.828
Zb		-0.368	-0.512		
p		0.713	0.608		
PI	Long-level fusion (n=25)	54.40 (28.20-97.40)	53.80 (28.60-90.40)	-0.503	0.615
	Short-level fusion (n=20)	58.95 (34.30-473.00)	58.05 (30.00-81.00)	-0.327	0.744
Zb		-1.090	-0.552		
p		0.276	0.581		
SS	Long-level fusion (n=25)	32.00 (14.00-68.30)	29.10 (17.70-48.00)	-1.384	0.166
	Short-level fusion (n=20)	36.50 (19.90-74.00)	35.60 (22.00-53.80)	-0.588	0.557
Zb		-1.064	-2.299		
p		0.287	**0.022***		
LL	Long-level fusion (n=25)	30.00 (1.00-75.90)	43.00 (18.80-59.90)	-0.548	**0.019***
	Short-level fusion (n=20)	41.40 (16.00-73.60)	52.55 (7.00-82.80)	-0.370	**0.036***
Zb		-2.378	-2.654		
p		**0.017***	**0.008***		
DLL	Long-level fusion (n=25)	27.30 (8.70-64.10)	29.00 (17.20-52.70)	-1.266	0.205
	Short-level fusion (n=20)	30.55 (11.00-62.00)	32.55 (18.00-58.50)	-0.044	0.965
Zb		-1.656	-0.342		
p		0.098	0.733		
TLK	Long-level fusion (n=25)	14.20 (1.50-52.90)	14.00 (1.20-29.50)	-0.365	0.715
	Short-level fusion (n=20)	5.75 (0.60-28.50)	7.85 (1.00-29.00)	-0.181	0.856
Zb		-1.840	-1.774		
p		0.066	0.076		
TK	Long-level fusion (n=25)	26.50 (1.80-44.20)	35.00 (0.60-51.40)	-2.829	**0.005***
	Short-level fusion (n=20)	33.80 (8.00-48.30)	31.55 (7.00-63.30)	-0.497	0.619
Zb		-2.141	-0.736		
p		0.432	0.462		
T1SPI	Long-level fusion (n=25)	3.10 (0.30-9.60)	4.00 (0.10-11.20)	-1.050	0.294
	Short-level fusion (n=20)	4.90 (1.00-11.20)	3.70 (0.00-15.00)	-1.111	0.266
Zb		-0.868	-0.657		
p		0.385	0.511		
T9SPI	Long-level fusion (n=25)	6.80 (0.20-20.10)	9.90 (0.90-21.10)	-2.370	**0.018***
	Short-level fusion (n=20)	9.50 (2.00-16.40)	10.25 (3.70-16.30)	-0.022	0.983
Zb		-1.695	-0.026		
p		0.090	0.979		
TPA	Long-level fusion (n=25)	21.00 (0.00-41.10)	22.50 (5.80-64.50)	-0.763	0.445
	Short-level fusion (n=20)	18.00 (0.50-32.60)	19.65 (2.40-36.90)	-0.719	0.472
Zb		-0.460	-0.473		
p		0.646	0.636		
SVA (mm)	Long-level fusion (n=25)	44.90 (5.00-152.70)	18.30 (0.70-110.30)	-1.612	**0.028***
	Short-level fusion (n=20)	26.40 (1.70-112.60)	16.15 (2.90-82.50)	-0.936	**0.048***
Zb		-1.997	-0.762		
p		**0.046***	0.446		

[a]Wilcoxon test; a: 0.05;* statistically significant difference
[b]Mann-Whitney U test; a: 0.05;* statistically significant difference
PT: Pelvic tilt, PI: Pelvic incidence, SS: Sacral slope, LL: Lumbar lordosis, DLL: Decompressive lumbar laminectomy, TK: Thoracic kyphosis, T1SPI: T1 spino-pelvic inclination, T9SPI: T9 spino-pelvic inclination, TPA: T1 pelvic angle, SVA: Sagittal vertical axis, TLK: Thoracolumbar kyphosis

condition is defined by an increase in the proximal junctional angle ≥10° and at least 10° more than the preoperative values[23]. The incidence of PJK varies between 17% and 61.7% in the literature[24,22]. In our study, revision surgery was performed in 4 (16%) patients with long-level fusion and 3 (15%) patients with short-level fusion due to the development of PJK at the end of the second year of follow-up.

In a study investigating the effects of long- and short-level fusion techniques on the radiological parameters in the treatment of degenerative scoliosis, patients who underwent long-level fusion had greater improvement in the spine-pelvis parameters, but no significant difference regarding PJK was observed between the two groups[25]. Another study showed no difference between long- and short-level fusions regarding LL restoration. In this study, the postoperative LL increased significantly in both the groups and TK and T9SPI were improved in the patients with long-level fusion.

Study Limitations

This study had a few limitations. The preoperative SB parameters were not similar between the two groups. An increase in PJK incidence was observed with the elongation of the follow-up duration, which may have impaired the radiological and clinical outcomes. Previous literature has reported on the impact of intervertebral cavity cage positioning on LL, which was not factored in for this study[10]. Future studies examining patient groups with higher homogeneity and with longer follow-up periods may further contribute to the literature.

CONCLUSION

Spine diseases in the elderly are complicated and require greater attention to decide the appropriate surgical treatments and fusion levels. TLIF contributes to the improvement of the SB parameters in both short- and long-level fusions in patients above the age of 65 years with degenerative spine conditions.

Ethics

Ethics Committee Approval: This study was performed after obtaining the institutional review board approval (2022/02) from İstanbul University, İstanbul Faculty of Medicine, Department of Orthopedics and Traumatology committee.

Informed Consent: Written informed consent was obtained from all patients before the study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: T.A., Concept: M.A.Ö., Design: M.A.Ö., Data Collection or Processing: Ş.K., T.F.Y., Analysis or Interpretation: M.K., D.T., Literature Search: T.P., M.K., Writing: M.A.Ö., T.A.

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