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Effect of TLIF on the Regional Lumbar Alignment of Patients with Lumbosacral Spinal Fusion in Comparison with PLF

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Abstract

This study aimed to evaluate the effects of transforaminal interbody fusion (TLIF) on the preservation or correction of regional lumbar alignment in patients with lumbosacral fusion surgery in compare with posterolateral intertransverse process fusion surgery (PLF). A total of 200 patients with severe low back pain and radicular pain were randomly selected for either posterolateral lumbar fusion by [titanium polyaxial pedicle screw] or transforaminal lumbar interbody fusion by [titanium polyaxial pedicle screw)] with intervertebral support by PEEK cage. The primary outcome scores were obtained using the visual analogue score (VAS) for Pain, Oswestry disability Index (ODI). All measures were assessed as follow-up after surgery. We included in this study 200 patients who fulfilled the inclusion criteria and underwent TLIF or PLF operation. The blood loss (250 cc) and duration of the procedure (2h) were better in PLF compared to TLIF (350cc; 2.5h) groups. However, the complications in PLF seem to be more sensitive to the presence of compiling chronic diseases (hypertension and diabetes mellitus). Analysis of pre- or post-operative follow-up parameters has indicated a non-significant difference between PLF and TLIF regarding all measured parameters except PRE-OP SS and POST OP LL which has shown a significant (P<0.05) higher in TLIF compared to PLF. Moreover, comparing results within the PLF group in PRE-OP versus POST-OP has shown significantly (P<0.05) higher PRE-OP PT over POST-OP PT. Additionally, comparing results within the TLIF group in PRE-OP versus POST-OP has shown significantly (P<0.05) higher POST-OP LL over PRE-OP LL alongside significantly (P<0.05) higher PRE-OP PI-LL over POST-OP PI-LL. TLIF get higher improvement in lumbar parameters, especially lumbar lordosis, sacral slope, pelvic tilt and PI-LL mismatch. Improvement of local spinopelvic parameters (LL, SS and PT) contributes to improved post-operative functional scores (ODI and VAS).

Keywords: *Low Back Pain, Lumbosacral Spinal Fusion, Oswestry Disability Index, Posterolateral Intertransverse Fusion, Regional Lumbar Alignment, Transforaminal Interbody Fusion, Visual Analogue Score.*

Introduction

Most adults will experience low back pain during their lifetime, with most of these instances resolving or improving without sequelae in, 6 weeks. For a small number of patients with severe, recalcitrant pain, lumbar fusion may be required, particularly when concomitant leg pain or deformity is present. Compelling prospective, randomized studies have demonstrated that spinal fusion produces improved clinical results compared with nonoperative treatment of chronic low back pain due to a variety of diagnoses [1]. Multiple studies have demonstrated an increase in the rate of lumbar fusion surgery over the past 20 years [2, 3]. This trend examined concerning specific surgical techniques and reported that, between 2004 and 2009, the majority of this

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growth was in the utilization of posterior interbody procedures, predominantly transforaminal lumbar interbody fusion (TLIF). TLIF has become a mainstay of surgical treatment for lumbar degenerative disorders, replacing instrumented posterolateral spine fusion (PSF) as the most commonly used fusion technique [3]. Lumbar spine fusion is the most common type of spine fusion and this is performed for several indications, most commonly related to symptoms thought to arise from degenerative conditions such as intervertebral disc disease, degenerative scoliosis and spinal canal stenosis. Less commonly, lumbar fusion is used for spondylolisthesis, traumatic conditions (fractures and dislocations) and tumours (most commonly metastases) [4].

Interbody fusion techniques allow for some degree of correction in the sagittal plane without the need for more extensive osteotomies. Various approaches, such as transforaminal, anterolateral, anterior lumbar interbody fusion (ALIF) and extreme lateral approaches augment the tools the surgeon can use to perform inter-body fusion and correct sagittal balance. Open transforaminal lumbar interbody fusion (TLIF) is a mainstay approach. In recent years, however, the rationale of less-invasive approaches such as MIS TLIF and OLIF is to reduce blood loss and tissue debridement, increasing the tolerability of such surgeries [5, 6].

Theoretical advantages of TLIF include increased fusion rate, more indirect foraminal decompression, better correction of lordosis, and more effective treatment of discogenic pain, foraminal stenosis. Importantly, TLIF also facilitates the use of minimally invasive strategies. Despite these multiple potential benefits, prior studies have often failed to document improved clinical outcomes with TLIF versus PLF [1].

Materials and Methods

Study settings: Single centre retrospective study hold in the neurosurgical department in Mosul Teaching Hospital with minimal period of follow-up for 6 months. From June 2020 through June 2023, a total of 200 patients (group A) n=100 who were treated by TLIF with an average age of 48.98 years and (group B) n=100 who were treated by PLF with an average age of 47.7 years) were included in this study (Figure 1).

Inclusion Criteria

1. Patients with clinical and imaging diagnoses of lumbar spine instability who underwent posterior lumbar fusion surgery.
2. All patients had good bone density evaluated by DEXA study preoperatively.

Exclusion Criteria

1. Patients with previous fusion surgeries (revision operations),
2. Patients with trauma, tumours and infection surgery.
3. Patients who fail to follow up for at 6 months.
4. Deformity patients (scoliosis and kyphosis).

All patients suffered from severe chronic BP and/or leg pain, static or dynamic, resulting from localized lumbar or lumbosacral segmental instability, spinal stenosis or disc prolapse at levels L2–S1 or caused by isthmic and degenerative spondylolisthesis (grade 1 and 2).

Baseline characteristics concerning demographic, clinical and surgical data were collected from the patient's database in the neurosurgery department.

All patients had MRI and plan x ray preoperative and all of them had followed by plane x-ray within 6 months in the follow-up period.

The preoperative standard imaging study adopted in all patients is the following:

1. Lumbosacral x ray plane.
2. Dynamic x-ray.
3. Magnetic resonance imaging (MRI).
4. Follow-up LSS x-ray.

The regional lumbar alignment parameters pre and postoperative adopted in this study were as follows

1. Pelvic Incidence Angle (PI)
2. Lumbar Lordosis Angle (LL)
3. Pelvic Tilt (PT)
4. Sacral Slope (SS)
5. PI-LL

These parameters are calculated by use of plane x-ray of the lumbosacral region the functional status for all patients scaled by using the Oswestry disability index (ODI). The pain severity assessment depended on a digital visual analogue score.

In the TLIF group, the size of the cage was assessed according to imaging measurements plus intraoperative measuring TLIF size and in all patients autologous bone graft was implanted inside the cage. In the PLF group, the harvested autologous bone graft was used in between decorticated intertransverse processes.

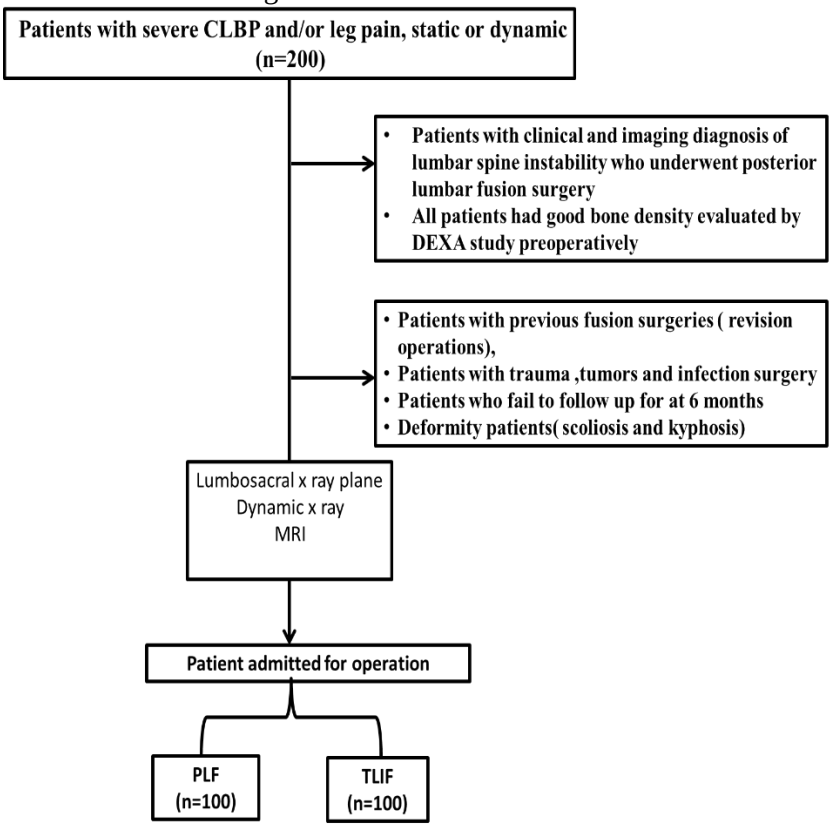

Figure 1. Flowchart Diagram of the Study Design

Study Design and Patient Data: Single centre retrospective study hold in the neurosurgical department of Mosul Teaching Hospital.

Radiographic Evaluation: Standing anteroposterior and lateral radiographs were obtained preoperatively, postoperatively, and at the latest follow-up. Measurements were made on 36 in. long-cassette radiographs, with the patient standing, knees fully extended and arms folded at 45_ to avoid superposition with the spine. Patients were asked to hold their breath during the acquisition.

All images included both the external auditory ducts and the superior third of the femurs. All lateral films were digitalized using a VIDAR VXR8 scanner and analyzed by the same investigator using validated software (microdicom). The parameters measured were, as described by Mac-Thiong et al. [7]:

1. Pelvic incidence (PI) is defined as the angle between the line joining the centre of the upper endplate of S1 to the bicoxo-femoral axis and a line perpendicular to the upper endplate of S1.
2. Pelvic tilt (PT) is the angle between a vertical line and the line joining the middle of the sacral plate and the bicoxo-femoral axis.
3. Sacral slope (SS), the angle between the endplate of S1 and a horizontal line.
4. Lumbar lordosis (LL), is the angle between the upper endplate of L1 and S1.

Surgical Technique: During surgery, the patients were placed in the prone position. We used controlled general or spinal anaesthesia. The patients first underwent the insertion of pedicle screws by a midline sub-periosteal approach. When indicated, hemilaminectomy or laminectomy for neural decompression was performed. In case the patients were randomized to the transforaminal procedure (TLIF), the facet joint of the intended levels was identified and the inferior and superior facets were resected to gain access to the disc space, and by that procedure, an indirect neurolysis or decompression of the nerve was performed. The pedicle screws were used to distract. The upper nerve was identified and protected. The PEEK cage with small pieces of bone graft was placed after cleaning the disc space and curating the superior and inferior endplates. Compression over the disc space was done after placement of the cage to create lordosis and to enhance the fusion rate according to Wolf's law. In PLF the same steps were done but the fusion by Cancellous bone from a local bone graft was used as bone graft and placed on the transverse process of the vertebrae fused. A careful preparation of the posterolateral region was performed before positioning the graft. Before that, the decompressed neural structures were covered with a gel foam (Spongostan) to avoid damage. Before that, the decompressed neural structures were covered with a gel foam (Spongostan) to avoid damage (Figure 2).

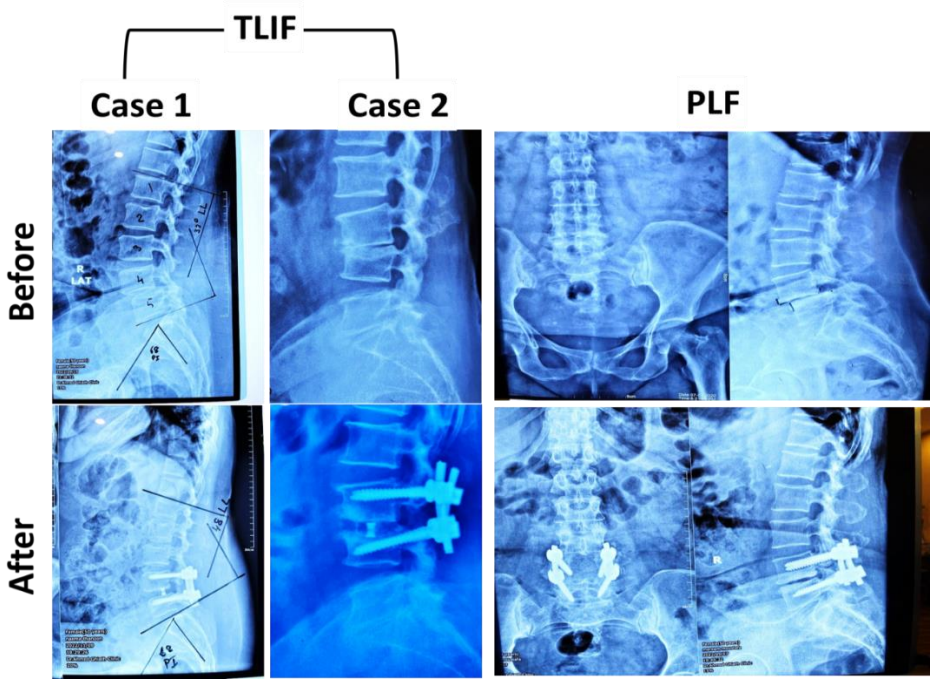

Figure 2. A representative Images of TLIF and PLF Before and After Operation

Statistical Analysis Data expressed as descriptive statistics or mean±SD for non-parametric or parametric variables, respectively. Chi-square or T-test is used to compare non-parametric or parametric variables, respectively. The differences were

considered significant at p value of less than 0.05.

Results

The demographic characteristics of the patients enrolled in the present study are outlined in Table 1. The results demonstrated non-significant (p>0.05) differences in age and BMI between PLF versus TLIF. Nearly two-fold more smokers were enrolled in TLIF versus PLF. Patients in TLIF have shown one-fold higher presentation with past medical surgery.

Table 1. Demographic Parameters of PLF versus TLIF group

Demographic Characteristics		**PLF**	**TLIF**	**P value**	**Chi-square**
Age (years) mean±SD (min. to max.)		52±12.8 (26 to 75)	49.8±11.4 (27 to 75)	0.2	
Sex (M/F)		31/69	38/62	0.3	1.1
BMI (kg/m2) mean±SD		31±4.3	30.2±6	0.3	
Smoking status	Yes	14	35*	0.0006	11.9
	No	86	65		
Chronic Diseases	HT	38	34	0.6	1.02
	DM	8	12		
	other	6	6		
Past-related surgery		14	27*	0.02	5.2
t-test used for parametric values and Chi-square used for non-parametric values *indicates the significantly higher group					

All patients in both groups suffered from back pain. Parasthesia has shown non-significant differences (p=0.25) in both groups. Almost all patients presented with radiation pain, with more unilateral (70%) in TLIF than PLF (60%) and more bilateral (40%) in PLF than TLIF (30%) and no significant differences existed between the groups (p=0.14). Claudication presentation was high in rate in both TLIF and PLF (Table 2) with no significant differences existing between both groups (p=0.65). Sphincter disturbances were mostly normal (98%) in both groups with no significant differences (p=1). No muscle weakness existed in most patients (95%) in both groups and no significant differences existed (p=0.73) (Table 2).

Table 2. Clinical Findings Presented PLF versus TLIF group

Sign and Symptoms		**PLF**	**TLIF**
Back pain	yes	100	100
	No	0	0
Radiating pain	Unilateral	60	70
	Bilateral	40	30
Claudication	Yes	90	88
	No	10	12
Sphincter disturbance	Normal	98	98
	Abnormal	2	2
Muscle weakness	Yes	4	5
	No	96	95

Paresthesia	Unilateral	52	60
	Bilateral	48	40

The results of the X-ray findings indicated that Most patients in the PLF group have Degenerative changes and instabilityB, L4-L5 Listhesis, L5-S1 Listhesis, and L3-L4 Listhesis. While TLIF suffers from L4-L5 Listhesis and L5-S1 Listhesis alongside other slight presentation of other findings in some cases of either group outlined in Table 3.

Table 3. X-Ray Findings of the Presented Cases for Operation

X-Ray Findings		**PLF**	**TLIF**
L4-L5	Degenerative Disc and Listhesis	42	40
L5-S1	Degenerative Disc and Listhesis	16	18
L3-L4	Degenerative Disc and Listhesis	16	14
L3-L4-L5	Degenerative Disc and Listhesis	12	18
L4-L5-S1	Degenerative Disc and Listhesis	10	4
L2-L3-L4-L5	Degenerative disc and instability	4	4
L2-L3-L4-L5-S1	Degenerative disc and instability	0	2

The results of MRI findings indicated that most patients in the PLF and TLIF group presented with L4-L5 Disc prolapse and Listhesis compared to other levels. Disc prolapse and Listhesis were also typical at L5-S1 and L3-L4 in both studied groups. Degenerative Disc and Listhesis highly presented in L3-L4-L5 in both studied groups compared to L4-L5-S1. Degenerative discs and instability are the less frequent and present at L2-L3-L4-L5 and L2-L3-L4-L5-S1 (Table 4).

Table 4. MRI Findings of the Presented Cases for Operation

MRI Findings		**PLF**	**TLIF**
L4-L5	disc prolapse and Listhesis	42	40
L5-S1	disc prolapse and Listhesis	16	18
L3-L4	disc prolapse and Listhesis	12	14
L3-L4-L5	Degenerative Disc and Listhesis	16	18
L4-L5-S1	Degenerative Disc and Listhesis	10	4
L2-L3-L4-L5	Degenerative disc and instability	0	4
L2-L3-L4-L5-S1	Degenerative disc and instability	4	2

A comparison of surgical outcomes between PLF and TLIF based on the level of operation has indicated that TLIF has reduced the early and late complications compared to

PLF (Table 5). The number of cases with no complications in total of early POST OP was [88] in the TLIF group versus [89] in the PLF group. However, In the TLIF group, the number of cases with no complications in total of late POST OP were [98] compared to [91] in the PLF group (Table 5 and Table 6).

Table 5. Comparison of Surgical Outcomes between PLF and TLIF Based on Level of Operation

Postoperative Complications		**PLF**		**TLIF**	
		Early POST OP	**Late POST OP**	**Early POST OP**	**Late POST OP**
No complications		89	93	90	100
Intraoperative Durotomy		6		6	
leg pain		2	1	4	
Left foot weakness		1			
Delay wound healing			2		
Wound infection			2		
CSF Leak			1	4	
DVT				3	
Sphincter abnormality				2	
Surgery time		2 h		2.5 h	
Blood loss		250 cc		350 cc	
Screw problems	One screw head deattached	1			
	Extra pedicle screw	1			
	One screw broken		1		

Table 6. Association of Complications with Chronic Diseases

Comorbid Diseases	**PLF**		**TLIF**	
	Early POST OP	**Late POST OP**	**Early POST OP**	**Late POST OP**
HT	7	2+2	1	
DM	4	2	1	
Other				
Total	7	4	1	
	Intraoperative Durotomy	CSF leak Delayed wound healing	DVT and urine retention	

Analysis of pre- or post-operative follow-up parameters has indicated a non-significant difference between PLF and TLIF regarding all measured parameters except PRE-OP SS and POST OP LL which has shown a significant ($P<0.05$) higher in TLIF compared to PLF (Table 7). Moreover, comparing results within the PLF group in PRE-OP versus POST-OP has shown significantly ($P<0.05$) higher PRE-OP PT over POST-OP PT.

Additionally, comparing results within the TLIF group in PRE-OP versus POST-OP has shown significantly (P<0.05)) higher POST-OP LL over PRE-OP LL alongside significantly (P<0.05) higher PRE-OP PI-LL over POST-OP PI-LL

Table 7. Follow-Up Parameters in Pre- or Post-Operative PLF and TLIF Groups

Timepoint Analyzed	**Follow-up Parameters**	**PLF (min. to max.)**	**TLIF (min. to max.)**
PRE-OP	SS	28.02±5.6 (5 to 45)	26.63±7.7 (5 to 42)
POST-OP	SS	31.95±6.3 (5 to 50)	33.43±7.4 (15 to 51)
PRE-OP	PT	26.86±5.3$ (14 to 36)	31.2±8.8* (20 to 60)
POST-OP	PT	23.27±5.8 (8 to 56)	24.3±7.5 (12 to 50)
PRE-OP	PI	54.69±6.3 (35 to 67)	52.6±17 (5 to 70)
POST-OP	PI	54.69±6.3 (35 to 67)	52.6±17 (5 to 70)
PRE-OP	LL	37.85±9 (5 to 73)	35.7±9.7 (0 to 50)
POST-OP	LL	40.33±8.4 (5 to 73)	45±8*^ (15 to 60)
PRE-OP	PI-LL	16.84±8.9 (-14 to 44)	16.9±20^ (-35 to 61)
POST-OP	PI- LL	14.36±8 (-14 to 36)	7.7±18.4 (-45 to 28)

Data expressed as mean±SD,

*$^indicates significant differences at a p-value of 0.05

* Comparison between PLF versus TLIF

$ comparison between PRE-OP versus POST-OP in the PLF group

^ Comparison between PRE-OP versus POST-OP in the TLIF group

The percentage of the level of involvement revealed similarity in both groups (Figure 3).

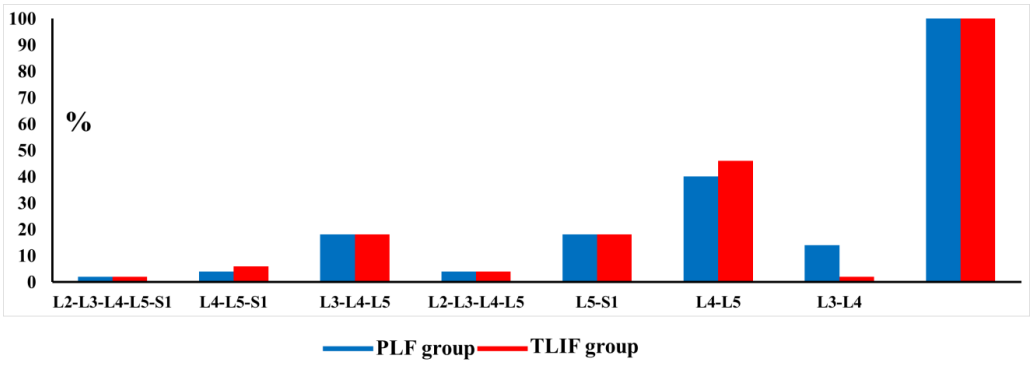

Figure 3. Percentage of the Level of Involvement in PLF versus TLIF Group

The percentage of DOI declined in the postoperative period compared to the preoperative time and continued afterwards over different time points until steadily stopped at 3 to 6 months postoperative, moreover, the decline was slightly better in TLIF compared to the PLF group (Figure 4)

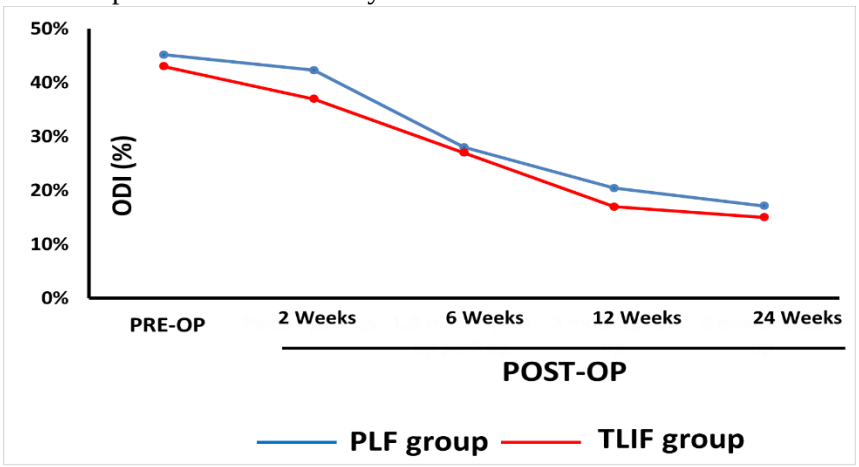

Figure 4. Percentage of the DOI in PLF versus TLIF Group

The VAS declined in the postoperative period compared to the preoperative time and continued afterwards over different time points until steadily stopped at 3 to 6 months postoperative, moreover, the decline was slightly better in TLIF compared to the PLF group (Figure 5).

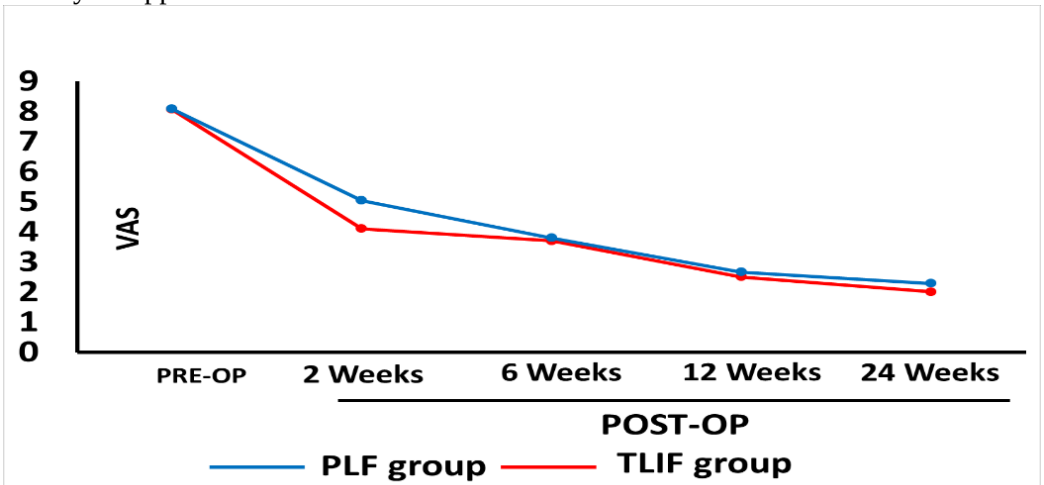

Figure 5. The VAS in PLF versus TLIF Group

Discussion

Open fusion and instrumentation have traditionally been the mainstay treatment of unstable lumbar degenerative diseases and isthmic spondylolisthesis. Sagittal plane balance and lumbar lordosis correction have become very important goals in spinal fusion surgery, as these have been shown to greatly impact outcomes [8]. Significant benefits in both lumbar lordosis and lumbar regional alignment angles were seen following TLIF and PIF which reflected in improvement of all functional scores and neurological improvement had been observed in many studies and this study [9]. TLIF have the opportunity for correction of local spinopelvic indeses when done in a manner that respects many factors including the appropriate prone positioning, optimizing disc space preparation, maximizing disc space height, anterior interbody cage placement, and reducing the spondylolisthesis [10]. Sagittal plane balance and lumbar lordosis correction have become very important goals in spinal fusion surgery, as these have been shown to greatly impact outcomes [11].

Patients enrolled in the present study were middle-aged around 50s years old, previous studies enrolled different age groups, younger [11] or older [12, 13] than our study or same age group [38, 39], presented with lumbosacral spinal fusion. Most patients were female and were reported in previous studies [35-39]. Most patients were obese, similarly, Tang et al (2023) reported that patients enrolled were overweight, nonetheless [12], Fujimori et al (2015) study enrolled normal-weight patients [14].

Smoking was presented in both groups with being more prevalent in the TLIF group versus the PLF group similarly Fujimori et al (2015) study reported a higher prevalence of smokers in the TLIF group than the PLF group [14]. Patients presented with other chronic diseases, such as diabetes, hypertension, or ischemic heart diseases with nearly no differences between TLIF and PLF groups. Similarly, no differences existed between TLIF and PLF groups in a study conducted by Fujimori et al (2015) study [14]. More patients in the TLIF group were presented with past surgery than in the PLF group. All patients presented with lower back pain and lower limb pain with only a few also associated with lower limb weakness and sphincter dysfunction. Back pain has been reported by nearly all lumbosacral spinal fusion patients in previous studies [11, 15-17].

Most patients with 2-3 disc levels involved presented with disc prolapse and listhesis on X-ray and MRI findings with only a many of them presenting with degenerative disc and instability when more disc levels involved. Similar findings were reported in different studies reported in one level [18-21] versus multiple levels of disc [22-20].

Most early POST-OP complications were similar except that TLIF operations were longer than PLF and associated with more blood loss and DVT, while screw problems were associated with PLF only. Similar results achieved by Eladawy et al. (2022) were TLIF compared to the PLF group [31]. TLIF group are free from late POST-OP, while in the PLF group the presence of screw problems which is related to PLF operation and a few delayed wounds and wound infections. Similar results were reported in a study conducted by Rezk et al. (2019) [32].

Chronic diseases were associated with more early and late POST-OP complications in PLF compared to TLIF, with no late POST-OP complication present in the TLIF group. Overall result of the present study revealed that TLIF has induced improved follow-up parameters compared to PLF. The percentage of ODI and VAS scores reduced in the TLIF group compared to PLF. Similar results were obtained in a study conducted by Etemadifar et al. (2016), who have performed a randomized controlled trial where 25 patients underwent PLF and 25 patients underwent TLIF [33]. At

24-month follow-up, the TLIF group reported significantly lower scores for back pain, leg pain and ODI ($p<0.05$). VAS back pain improved by 5.3 in the PLF group and 6.2 in the TLIF group, VAS leg pain improved by 6 in the PLF group and 6.7 in the TLIF group, and ODI improved by 53.2 in the PLF group and 56.7 in the TLIF group. The infection rate was not significantly different between the two groups ($p=0.37$) [33].

In a randomized controlled trial, Challier et al. (2017), have performed single-level PLF on 30 patients and TLIF on 30 patients for degenerative lumbar spondylolisthesis [34]. At 24-month follow-up, 17/30 (57%) PLF patients and 29/30 (97%) TLIF patients were fused according to grade A or B Lenke & Bridwell classification ($p<0.001$) on anteroposterior x-ray (XR) [35]. However, both the PLF and TLIF groups made similar improvements in clinical outcomes: VAS back pain improved by 3.8 in the PLF group and 3.3 in the TLIF group ($p=0.65$), VAS leg pain improved by 3.4 in the PLF group and 4 in the TLIF group ($p=0.65$), ODI improved by 19 in the PLF group and 30 in the TLIF group ($p=0.08$), SF-36 MCS improved by 3 in the PLF group and 9 in the TLIF group ($p=0.08$), and SF-36 PCS improved by 10 in the PLF group and 12 in the TLIF group ($p=0.12$). Outcomes such as ODI and S F-36 trended towards significantly greater improvement in the TLIF group, however, this study was likely underpowered to detect a significant difference in clinical outcome measures. TLIF was also associated with significantly longer mean operative time (106 minutes versus 82 minutes, $p<0.01$) than PLF. Infection rate and mean blood loss were not significantly different between the PLF and TLIF groups [35].

Carreon et al. (2016), have performed a retrospective, propensity-matched comparison of 101 patients who underwent PLF and 101 patients who underwent TLIF for either ischemic or degenerative lumbar spondylolisthesis (36). Operative time and blood loss were similar between the two groups. At 12-month follow-up, VAS back pain improved by an average score of 3.5 in the PLF group and 4.2 in the TLIF group, VAS leg pain improved by 3.7 in the PLF group and 4.6 in the TLIF group. The TLIF group made significantly greater improvements in ODI (21.1 in the PLF group versus 30.4 in the TLIF group; $p=0.001$) and HRQOL as measured by SF-6D (0.11 and 0.16 in the PLF and TLIF groups, respectively; $p=0.001$).

Fujimori et al. (2015) have performed a retrospective cohort study on 32 patients who underwent PLF and 24 patients who underwent TLIF for degenerative lumbar spondylolisthesis, 27/32 (84%) PLF patients and 23/24 (96%) TLIF patients were designated as fused on anteroposterior and lateral XR, although no statistically significant difference was found ($p=0.30$) [14]. At 24-month follow-up, the TLIF group made significantly greater improvements in VAS left leg pain and VAS back pain. For our meta-analysis, improvements in left and right leg pain were combined into a single outcome measure – VAS leg pain. VAS back pain improved by 2.2 in the PLF group versus 3.8 in the TLIF group ($p=0.03$), VAS leg pain improved by 1.6 in the PLF group and 10 3.3 in the TLIF group, ODI improved by 14.0 in the PLF group and 15.0 in the TLIF group and HRQOL as measured by SF-12 improved by 6.0 in the PLF group and 6.0 in the TLIF group.

Ghasemi (2016) has performed a retrospective cohort study on 65 PLF and 80 TLIF patients treated for grade I and II degenerative lumbar spondylolisthesis [37]. Blood loss, operation time and fusion rate were significantly greater in the TLIF group ($p<0.05$). At 24-month follow-up, TLIF patients had significantly less back pain and disability as measured by ODI ($p<0.05$). VAS back pain improved by 4.6 in the PLF group

and 5.6 in the TLIF group, VAS leg pain improved by 2.2 in the PLF group and 2.8 in the TLIF group, ODI improved by 13.6 in the PLF group and 20 17 in the TLIF group.

Owens et al. (2014) have performed a retrospective, propensity-matched study to determine the relative benefit of TLIF versus PLF stratified by diagnostic indication [38]. In a subgroup analysis of patients with degenerative lumbar spondylolisthesis, 50 patients underwent PLF and 50 patients underwent TLIF. At 24-month follow-up, no better clinical outcomes were observed for the TLIF group compared to the PLF group. VAS back pain improved by 2.5 in the PLF group and 2.6 in the TLIF group, VAS leg pain improved by 2.7 in the PLF group and 2.2 in the TLIF group, ODI improved by 17.2 in the PLF group and 18 in the TLIF group, and HRQOL as measured by SF-36 improved by 5.2 in the PLF group and 6.2 in the TLIF group.

Pooswamy et al. (2017), have performed a retrospective cohort study comparing 21 PLF patients to 19 TLIF patients who underwent surgery for grade I or II spondylolisthesis with three-year follow-up [39]. One case of failed fusion due to screw breakage was reported in the PLF group. No significant differences were found in ODI scores preoperative, 1-month postoperative, and at 6, 12, 24 and 36 months follow-up. At 24-month follow-up, ODI improved by an average of 22 in the PLF group and 22.1 in the TLIF group, and LBPRS improved by 55.4 in the PLF group versus 56.5 in the TLIF group. The only significant difference observed was in operative time, which was on average 50 minutes longer in the TLIF group ($p=0.02$).

The results of follow-up parameters have revealed that TLIF has been associated with improved postoperative LL and SS and PILL mismatch compared to PLF. Postoperative parameters which were improved compared to preoperative include PI-LL and LL, versus PT only in the PLF group. In Ould-Slimane et al. (2012) study, have reported improved sagittal parameters upon follow-up with significant ($p<0.01$) improvement of PT [17]. The study also revealed that the TLIF procedure improved disc height ($p<0.05$), lordosis at the level fused ($p<0.001$), and maximum lumbar lordosis ($p<0.01$) [8]. Consistent with the present study, an earlier report by Guigui et al. postoperative measures obtained in the current series are lower but the mean age of the group studied by Guigui et al. was younger (34 years), and their subjects did not suffer from degenerative lumbar disorders [40].

LL improvement found in our study had been achieved by Sembrano et al. (2015), who found that the operative level lordosis change in TLIF produced significantly greater segmental lordosis change compared to PSF [41]. The same was concluded by Watkins et al, who found an insignificant 0.8° change after TLIF [42]. The SS observed high improvement in the TLIF group (<0.05) reflecting an improvement of lumbar lordosis and hence better lumbar alignment. This is shown by other studies like Mourad Ould-Slimane et al who concluded that the reduction of the pelvic tilt (and increase of the sacral slope) observed at the last follow-up in their series confirms is an adaptive parameters [17, 43].

Conclusion

Lumbar disc disease with instability is a common disease in the adult group. Preoperative diagnosis of instability and sagittal balance and alignment parameters evaluation is crucial for the postoperative functional status improvement. TLIF get higher improvement in lumbar parameters, especially lumbar lordosis, sacral slope, pelvic tilt and PI-LL mismatch Improvement of local spinopelvic parameters (LL, SS and PT) contributes to improved post-operative functional scores (ODI and VAS).

References

[1]. Glassman, S. D., Carreon, L. Y., Ghogawala, Z., Foley, K. T., McGirt, M. J., Asher, A. L., 2016. Benefit of transforaminal lumbar interbody fusion vs posterolateral spinal fusion in lumbar spine disorders: a propensity-matched analysis from the national neurosurgical quality and outcomes database registry. *Neurosurgery*, 79(3), 397-405. Doi:10.1227/NEU.0000000000001118.

[2]. Deyo, R. A., Gray, D. T., Kreuter, W., Mirza, S., Martin, B. I., 2005. United States trends in lumbar fusion surgery for degenerative conditions. *Spine*, 30(12), 1441-1445. doi:10.1097/01.brs.0000166503.37969.8a.

[3]. Ciol, M. A., Deyo, R. A., Howell, E., Kreif, S., 1996. An assessment of surgery for spinal stenosis: time trends, geographic variations, complications, and reoperations. *Journal of the American Geriatrics Society*, 44(3), 285-290. Doi:10.1111/j.1532-5415.1996.tb00915.x.

[4]. Harris, I. A., Traeger, A., Stanford, R., Maher, C. G., Buchbinder, R., 2018. Lumbar spine fusion: what is the evidence?. *Internal medicine journal*, 48(12), 1430-1434. Doi:10.1111/imj.14120.

[5]. Khoury, N. N., Champagne, P. O., Kotowski, M., Raymond, J., Roy, D., Weill, A., 2017. Unexpected complications with head and neck hydrogel microsphere particle embolization: a case series and a technical note. Interventional Neuroradiology, 23(1), 107-111. Doi:10.1177/1591019916668840.

[6]. Blizzard, D. J., Gallizzi, M. A., Sheets, C., Smith, B. T., Isaacs, R. E., Eure, M., Brown, C. R., 2016. Sagittal balance correction in lateral interbody fusion for degenerative scoliosis. *International Journal of Spine Surgery*, 10. Doi:10.14444/3029.

[7]. Mac-Thiong, J. M., Labelle, H., Berthonnaud, E., Betz, R. R., Roussouly, P., 2007. Sagittal spinopelvic balance in normal children and adolescents. *European Spine Journal*, 16, 227-234. Doi:10.1007/s00586-005-0013-8.

[8]. Jagannathan, J., Sansur, C. A., Oskouian Jr, R. J., Fu, K. M., Shaffrey, C. I., 2009. Radiographic restoration of lumbar alignment after transforaminal lumbar interbody fusion. *Neurosurgery*, 64(5), 955-964. Doi:10.1227/01.NEU.0000343544.77456.46.

[9]. Dibble, C. F., Zhang, J. K., Greenberg, J. K., Javeed, S., Khalifeh, J. M., Jain, D., Ray, W. Z., 2022. Comparison of local and regional radiographic outcomes in minimally invasive and open TLIF: a propensity score–matched cohort. *Journal of Neurosurgery: Spine*, 37(3), 384-394. Doi:10.3171/2022.1.SPINE211254.

[10]. Tanasansomboon, T., Robinson, J. E., Anand, N., 2023. Minimally Invasive Transforaminal Lumbar Interbody Fusion: Strategies for Creating Lordosis with a Posterior Approach. *Neurosurgery Clinics*, 34(4), 643-651. Doi:10.1016/j.nec.2023.06.014.

[11]. Ohtori, S., Koshi, T., Yamashita, M., Yamauchi, K., Inoue, G., Suzuki, M., Takahashi, K., 2011. Surgical versus nonsurgical treatment of selected patients with discogenic low back pain: a small-sized randomized trial. *Spine*, 36(5),347–54. Doi: 10.1097/BRS.0b013e3181d0c944.

[12]. Tang, A. R., Chanbour, H., Steinle, A. M., Jonzzon, S., Roth, S. G., Abtahi, A. M., Zuckerman, S. L., 2023. Which Approach Leads to More Reoperations in Single-Level, Open, Posterior Lumbar Fusion: Transforaminal Lumbar Interbody Fusion or Posterolateral Fusion Alone?. *International Journal of Spine Surgery*, 17(2), 292-299. Doi:10.14444/8424.

[13]. Levin, J. M., Tanenbaum, J. E., Steinmetz, M. P., Mroz, T. E., Overley, S. C., 2018. Posterolateral fusion (PLF) versus transforaminal lumbar interbody fusion (TLIF) for spondylolisthesis: a systematic review and meta-analysis. *The Spine Journal*, 18(6), 1088-1098. Doi:10.1016/j.spinee.2018.01.028.

[14]. Fujimori, T., Le, H., Schairer, W. W., Berven, S. H., Qamirani, E., Hu, S. S., 2015. Does transforaminal lumbar interbody fusion have advantages over posterolateral lumbar fusion for degenerative spondylolisthesis?. Global *spine journal*, 5(2), 102-109. Doi:10.1055/s-0034-1396432.

[15]. Tang, A. R., Chanbour, H., Steinle, A. M., Jonzzon, S., Roth, S. G., Abtahi, A. M., Zuckerman, S. L., 2023. Which Approach Leads to

More Reoperations in Single-Level, Open, Posterior Lumbar Fusion: Transforaminal Lumbar Interbody Fusion or Posterolateral Fusion Alone?. *International Journal of Spine Surgery*, 17(2), 292-299. Doi:10.14444/8424.

[16]. Tuse, S. S., Matin, A., 2022. Comparison of early clinico-radiological outcome of posterolateral fusion and transforaminal lumbar interbody fusion techniques. *International Journal of Research in Orthopaedics*, 8(2), 165. Doi:10.18203/issn.2455-4510.IntJResOrthop20210602.

[17]. Ould-Slimane, M., Lenoir, T., Dauzac, C., Rillardon, L., Hoffmann, E., Guigui, P., Ilharreborde, B., 2012. Influence of transforaminal lumbar interbody fusion procedures on spinal and pelvic parameters of sagittal balance. *European spine journal*, 21, 1200-1206. Doi:10.1007/s00586-011-2124-8.

[18]. Bassani, R., Morselli, C., Querenghi, A. M., Nuara, A., Sconfienza, L. M., Peretti, G. M., 2020. Functional and radiological outcome of anterior retroperitoneal versus posterior transforaminal interbody fusion in the management of single-level lumbar degenerative disease. *Neurosurgical Focus*, 49(3), E2. Doi:10.3171/2020.6.FOCUS20374.

[19]. Gala, R. J., Bovonratwet, P., Webb, M. L., Varthi, A. G., Daubs, M. D., Grauer, J. N., 2018. Different fusion approaches for single-level lumbar spondylolysis have similar perioperative outcomes. *Spine*, 43(2), E111-E117, Doi:10.1097/BRS.0000000000002262.

[20]. Lee, N., Kim, K. N., Yi, S., Ha, Y., Shin, D. A., Kim, K. S., 2017. Comparison of outcomes of anterior, posterior, and transforaminal lumbar interbody fusion surgery at a single lumbar level with degenerative spinal disease. *World neurosurgery*, 101, 216-226, Doi: 10.1016/j.wneu.2017.01.114.

[21]. P Pradhan, B. B., Nassar, J. A., Delamarter, R. B., & Wang, J. C., 2002. Single-level lumbar spine fusion: a comparison of anterior and posterior approaches. *Clinical Spine Surgery*, 15(5), 355-361.

[22]. Adogwa, O., Elsamadicy, A. A., Han, J. L., Cheng, J., Karikari, I., Bagley, C. A., 2016. Do measures of surgical effectiveness at 1 year after lumbar spine surgery accurately predict 2-year outcomes?. *Journal of Neurosurgery. Spine*, 25(6), 689-696. Doi:10.3171/2015.8.SPINE15476.

[23]. Barnes, B., Rodts, G. E., McLaughlin, M. R., Haid, R. W., 2001. Threaded cortical bone dowels for lumbar interbody fusion: over 1-year mean follow up in 28 patients. *Journal of Neurosurgery. Spine*, 95(1), 1-4. Doi:10.3171/spi.2001.95.1.0001.

[24]. Bozzio, A. E., Johnson, C. R., Fattor, J. A., Kleck, C. J., Patel, V. V., Burger, E. L., Cain, C. M., 2018. Stand-alone anterior lumbar interbody, transforaminal lumbar interbody, and anterior/posterior fusion: analysis of fusion outcomes and costs. *Orthopedics*, 41(5), e655-e662, Doi:10.3928/01477447-20180711-06.

[25]. Freudenberger, C., Lindley, E. M., Beard, D. W., Reckling, W. C., Williams, A., Burger, E. L., Patel, V. V., 2009. Posterior versus anterior lumbar interbody fusion with anterior tension band plating: retrospective analysis. *Orthopedics*, 32(7), 492-496, Doi:10.3928/01477447-20090527-12.

[26]. Glassman, S., Gornet, M. F., Branch, C., Polly Jr, D., Peloza, J., Schwender, J. D., Carreon, L., 2006. MOS short form 36 and Oswestry Disability Index outcomes in lumbar fusion: a multicenter experience. *The Spine Journal*, 6(1), 21-26, Doi:10.1016/j.spinee.2005.09.004.

[27]. Kuang, L., Wang, B., Lü, G., 2017. Transforaminal lumbar interbody fusion versus mini-open anterior lumbar interbody fusion with oblique self-anchored stand-alone cages for the treatment of lumbar disc herniation: a retrospective study with 2-year follow-up. *Spine*, 42(21), E1259-E1265, Doi:10.1097/BRS.0000000000002145.

[28]. Madan, S. S., Boeree, N. R., 2003. Comparison of instrumented anterior interbody fusion with instrumented circumferential lumbar fusion. *European Spine Journal*, 12, 567-575, Doi:10.1007/s00586-002-0516-5.

[29]. Peng, B., Chen, J., Kuang, Z., Li, D., Pang, X., Zhang, X., 2009. Diagnosis and surgical treatment of back pain originating from endplate. *European Spine Journal*, 18, 1035-1040, Doi:10.1007/s00586-009-0938-4.

[30]. U Udby, P. M., Bech-Azeddine, R., 2015. Clinical outcome of stand-alone ALIF compared to

posterior instrumentation for degenerative disc disease: a pilot study and a literature review. *Clinical neurology and neurosurgery*, 133, 64-69, Doi:10.1016/j.clineuro.2015.03.008.

[31]. Eladawy, A., Youssef, E. M., Abdeen, M., 2022. Transforaminal Lumbar Interbody Fusion Versus Posterolateral Fusion for Surgical Treatment of Segmental Lumbar Spinal Instability. *Advanced Spine Journal*, 41(1), 5, Doi:10.57055/2314-8969.1002.

[32]. Rezk, E. M. A., Elkholy, A. R., & Shamhoot, E. A., 2019. Transforaminal lumbar interbody fusion (TLIF) versus posterior lumbar interbody fusion (PLIF) in the treatment of single-level lumbar spondylolisthesis. *Egyptian Journal of Neurosurgery*, 34, 1-8, Doi:10.1186/s41984-019-0052-9.

[33]. Etemadifar, M. R., Hadi, A., Masouleh, M. F., 2016. Posterolateral instrumented fusion with and without transforaminal lumbar interbody fusion for the treatment of adult isthmic spondylolisthesis: a randomized clinical trial with 2-year follow-up. *Journal of Craniovertebral Junction and Spine*, 7(1), 43-49, Doi:10.4103/0974-8237.176623.

[34]. Challier, V., Boissiere, L., Obeid, I., Vital, J. M., Castelain, J. E., Bénard, A., Gille, O., 2017. One-level lumbar degenerative spondylolisthesis and posterior approach: is transforaminal lateral interbody fusion mandatory?: a randomized controlled trial with 2-year follow-up. *Spine*,42(8),531–9, Doi:10.1097/BRS.0000000000001857.

[35]. Bridwell, K. H., Lenke, L. G., Cho, S. K., Pahys, J. M., Zebala, L. P., Dorward, I. G., Kang, M. M., 2013. Proximal junctional kyphosis in primary adult deformity surgery: evaluation of 20 degrees as a critical angle. *Neurosurgery*, 72(6), 899-906. Doi: 10.1227/NEU.0b013e31828bacd8.

[36]. Carreon, L. Y., Glassman, S. D., Ghogawala, Z., Mummaneni, P. V., McGirt, M. J., Asher, A. L., 2016. Modeled cost-effectiveness of transforaminal lumbar interbody fusion compared with posterolateral fusion for spondylolisthesis using N2QOD data. *Journal of Neurosurgery: Spine*, 24(6), 916-921, Doi:10.3171/2015.10.SPINE15917.

[37]. Ghasemi, A. A., 2016. Transforaminal lumbar interbody fusion versus instrumented posterolateral fusion in degenerative spondylolisthesis: an attempt to evaluate the superiority of one method over the other. *Clinical neurology and neurosurgery*, 150, 1-5, Doi:10.1016/j.clineuro.2016.08.017.

[38]. Owens, I. I., Carreon, L. Y., Djurasovic, M., Glassman, S. D., 2014. Relative benefit of TLIF versus PSF stratified by diagnostic indication. *Clinical Spine Surgery*, 27(3), 144-147, Doi:10.1097/BSD.0b013e3182867470.

[39]. Pooswamy, S., Muralidharagopalan, N. R., Subbaiah, S., 2017. Transforaminal lumbar interbody fusion versus instrumented posterolateral fusion in Grade I/II spondylolisthesis. *Indian Journal of Orthopaedics*, 51, 131-138, Doi:10.4103/0019-5413.201703.

[40]. Guigui, P., Levassor, N., Rillardon, L., Wodecki, P., Cardinne, L., 2003. Physiological value of pelvic and spinal parameters of sagital balance: analysis of 250 healthy volunteers. *Revue de chirurgie orthopedique et reparatrice de l'appareil moteur*, 89(6), 496-506.

[41]. Sembrano, J. N., Yson, S. C., Horazdovsky, R. D., Santos, E. R. G., Polly, D. W., 2015. Radiographic comparison of lateral lumbar interbody fusion versus traditional fusion approaches : analysis of sagittal contour change. *International journal of spine surgery*, 9, Doi:10.14444/2016.

[42]. Watkins IV, R. G., Hanna, R., Chang, D., Watkins III, R. G., 2014. Sagittal alignment after lumbar interbody fusion: comparing anterior, lateral, and transforaminal approaches. *Clinical Spine Surgery*, 27(5), 253-256, Doi:10.1097/BSD.0b013e31828a8447.

[43]. Andreyeva, T. O., Stoyanov, O. M., Chebotaryova, G. M., Kalashnikov, V. I., Vastyanov, R. S., Mashchenko, S. S., 2023. Densitometric correlates of degenerative-dystrophic processes in cervical vertebrae of humans and domestic animals, *Regulatory Mechanisms in Biosystems*, 14(3), 386-392, Doi:10.15421/10.15421/022357.