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Safety and Effectiveness of Two Surgical Interventions in Treatment of Grade I and II Lumber Spondylolisthesis

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ABSTRACT

Background: There are different techniques and technologies available for fusion, and each operative technique has its inherent benefits and disadvantages.

Objective: To assess safety and effectiveness of two surgical interventions in grade I and II lumbar spondylolisthesis.

Patients and Methods: A Randomized Controlled Clinical Trial of 42 patients aged 18-60years with grade I and II isthmic or degenerative lumber spondylolisthesis attending the Neurosurgery Department, Zagazig University hospitals were recruited to either posterolateral fusion (PLF) or posterior lumbar interbody fusion (PLIF) techniques. Perioperative and postoperative complications were assessed and dealt with appropriately. Radiological investigation, pain score scale (VAS) and Oswestry disability index (ODI) pre- and post-operative were measured.

Results: The main complaint was low back pain in all patients and leg pain in 85.71%; 73.81% had degenerative and 26.19% had isthmic spondylolisthesis. L4-5 listhesis (64.29%) and L5/S1 (33.33%). First degree spondylolisthesis (64.29%) and 2nd degree (35.71%). The mean duration of surgery was 157.14±23.04minutes in PLF group and 190.74±25.62minutes in PLIF group (p=0.0001). The mean amount of blood loss in PLF group was 615±142milliliter, while 730±105milliliter in PLIF group (p=0.028). The mean length of hospital stay was 5.81±1.47days in PLF group compared with 7.1±2.55days In the PLIF group. In PLIF group, complete reduction occurred in 61.9% compared with 38.1% in PLF one. VAS and ODI had significantly decreased postoperative.

Conclusion: better results of fusion rate in PLIF surgery in spite of more blood loss, longer duration of surgery and lengthy hospital stay. Similar results for VAS and ODI in both surgeries.

Key words: Spondylolisthesis, PLF, PLIF, VAS, ODI.

INTRODUCTION

Spondylolisthesis is forward slipping of upper vertebra in relation to its lower one, which is classified by **Wiltse and Rothman**[(1)] into dysplastic, isthmic, degenerative, traumatic, pathologic and iatrogenic. Spondylolisthesis is a condition characterized by a failure of the three-column support with severe complex instability requiring reconstruction of the altered supporting structures[(2)]. The degree of slip is measured with Meyerding Grades into I, II, III, IV and V or spondyloptosis[(3)]. Of its 5 subtypes, degenerative and isthmic spondylolisthesis are the most common in adults. Both can lead to compression and instability, which result in radicular and low back pain[(4)]. Conservative treatment often fails to provide relief.

In the past decades, a wide variety of spinal instrumentation was developed for treating spondylolisthesis. The surgical procedures that have been advocated include anterior interbody fusion, posterior interbody fusion, posterolateral fusion, repair of the pars interarticularis, and reduction and fusion[(5-9)]. Posterolateral fusion (PLF) and posterior lumbar interbody fusion (PLIF) are common choices among the various techniques available for the treatment of lumbar spondylolisthesis. The fusion rate was found to improve with the use of internal fixation using transpedicular screw fixation that allowed segmental fixation of the spine for treating spondylolisthesis[(10)]. The use of posterior lumbar pedicle screw instrumentation is now the standard for reconstruction of the affected segment; its widespread application introduced the era of segmental spinal fixation[(11)]. The success of every spine fusion procedure depends on bone healing that in turn depends on many factors, including host factors, technique, type of graft and the rigidity of the particular surgical construct[(12)].

Posterolateral inter-transverse fusion is a useful procedure with acceptable fusion rates for most degenerative conditions[(13)]. Complete neural decompression, solid fusion and restoration of normal inter-segmental alignment in addition to preservation of normal spinal function are the goals of PLIF in the treatment of spinal instability[(14)]. During the last decades, PLIF has been widely used in arthrodesis for segmental instability of the lumbar spine[(15)]. In both interventions the outcomes of the studies shows that there is no evidence of the superiority of one approach over another one in terms of the fusion rate. The choice amongst surgical management is in debate now[(Ref)].

Certain studies show that PLF is effective[(8,10,11)], whereas in other studies, PLIF had been proved to be superior to PLF [(6,7,9)]. Hence, it is essential to assess safety and effectiveness of both techniques which is the objective of the present study.

PATIENTS AND METHODS

A randomized Controlled Clinical Trial of two different interventions for treatment of low-grade lumbar spondylolisthesis was applied on 42 patients aged 18-60 years old with isthmic or degenerative spondylolisthesis attending the Department of

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Neurosurgery, Zagazig University hospitals from 1st of September 2021 till 28th February 2022.

Inclusion criteria:

1- Adults aged 18-60 years old.
2- Patients with grade one or two degenerative or ischemic spondylolisthesis.
3- Failed conservative treatment.
4- Willing to participate in the study.

Exclusion criteria:

1- Patients lower than 18 years or higher than 60.
2- Significant osteoporosis.
3- Acute spinal fracture.
4- Immune suppression.
5- Malignancy.
6- Active local and/or systemic infection.
7- Spondylolisthesis higher than grade II.
8- History of previous fusion surgery to the lumbar spine.
9- Concomitant deformities of the spine (scoliosis, tumor or trauma).
10- Patients with BMI ≥ 40 (morbid obesity).

Methods of the study:

Complete history taking included personal history; socio-demographic characteristics, complaint and present history, past history of previous diseases and operations, family history of similar conditions and chronic diseases, general examination and neurological examination were done. Straight leg raising test, femoral stretch test, gait, back examination for deformity (Kyphosis, exaggerated lumbar lordosis and scoliosis) and visible or palpable step, paravertebral muscle spasm and tenderness were assessed. Severity of pain was measured using visual analogue pain score scale (VAS)[16]. Degree of disability was assessed using Oswestry disability Index[17]. Radiological investigation included plan radiographs antero-posterior, lateral, oblique and dynamic views, CT lumbosacral spine, MRI lumbosacral spine and DEXA scan. Routine laboratory workup included complete blood count, fasting and post prandial blood sugar, renal and liver function tests and prothrombin time and activity.

Assessment of the degree of spondylolisthesis: The degree of spondylolisthesis was measured as a percentage of the distance from the posterior border of the caudal vertebra to the posterior border of the rostral vertebra, normalized to the superior end plate diameter of the former.

Surgical intervention: The patient was positioned in prone position on the operating table. General anesthesia was applied. The C-arm was used to gain a lateral fluoroscopic image to determine the location of pathology and to plan incision. The incision was made longitudinally midline over the spinous processes. The goal was to obtain a trajectory that was parallel to end plate. An appropriately sized pedicle screw was inserted into pedicle and vertebral body along the predetermined trajectory. Then the pedicle screws connected to a rod. After facet scarification, and transverse processes and pars decortication, the bone grafts were placed to promote fusion at pars and transverse processes.

Specific for Posterior Lumbar Interbody Fusion (PLIF)

DISC SPACE PREPARATION:

After decompression the pedicle screws were inserted and a discectomy was done. Finally, disc material was removed, and endplates prepared. The pedicle screws connected to a rod, allowing for sequential distraction of intervertebral space. The nucleus of disc was then removed. Further distraction of the disk space may be done by placing an intrvertebral distractor reducing strain on pedicle screws.

Lumber interbody fusion: After performing a wide laminectomy and bilateral partial facetectomy, special distractor instruments were used to restore the normal height of the disc, as well as to determine the appropriate size spacer to be placed. A bone spacer was used for widening of the intervertebral disc space, then the peek cage also carefully placed in the disc space. The Lumbar Cage is radiolucent and allows visualization of bony healing by normal plane radiographs. The cages were tightly packed with autologous bone graft and inserted into the disc space.

Outcome: Perioperative results related to the operative procedure such as blood loss, operation time, hospital stays and complications postoperatively were assessed. Assessment of safety; any complications or adverse events during and/or after surgery were recorded and dealt with accordingly. Assessment of effectiveness; using pain score scale (VAS) pre and post-operative, Oswestry disability Index questionnaire pre- and post-operative, plan radiographs Antero-posterior and lateral views, CT lumbosacral spine and slip reduction assessed. CT lumbosacral spine and plan radiographs Antero-posterior and lateral views follow up after 3 months were done.

Ethical consent:

Ethics approval was provided by the local Ethical Committee of the Faculty of Medicine, Zagazig University. Informed consent was signed by each patient. Confidentiality of data was ensured. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data presented and statistically analyzed using SPSS Statistical Package for Windows, Version 20.

Quantitative data presented in range, mean and standard deviation. Qualitative data presented in frequency and percentage. The two groups compared using Student "t" test and Chi square or Fisher Exact test. Level of significance (5%) was used. P value < 0.05 was considered significant.

RESULTS

Socio-demographic characteristics:

The mean age in PLF group was 43.62±9.39 years and 42.48±10.84 years in PLIF one. In the PLF group, 61.9% were females and 57.14% in the PLIF group. Heavy workers were 47.26% and 66.67% in PLF and PLIF group respectively. 28.57% were smoker in the PLF group compared with 23.81% in the PLIF one. There was statistical insignificant association between both groups as regards socio-demographic characteristics (p>0.05) (Table **1**).

Table (1): Sociodemographic characteristics in PLF and PLIF groups.

	PLF (n = 21)	**PLIF (n = 21)**	**p**
Age			
Range	20 - 59	18 - 60	0.717
Mean± S.D.	43.62±9.39	42.48±10.84	
Gender	**n (%)**	**n (%)**	
Female	13 (61.90)	12 (57.14)	0.753
Male	8 (38.10)	9 (42.86)	
Occupation			
Sedentary	7 (33.33)	3 (14.29)	0.322
Office work	4 (19.05)	4 (19.05)	
Manual work	10 (47.26)	14 (66.67)	
Smoking			
Non smoker	15 (71.43)	13 (61.9)	0.727
Smoker	6 (28.57)	8 (38.1)	

Complaint and clinical examination:

Low back pain (LBP) was reported in all patients. Right lower limb pain (Rt LLP) reported by 23.81% in PLF group compared with 28.57% in the PLIF one. Left lower limb pain (Lt LLP) and bilateral lower limb pain (Bil. LLP) reported by 42.86% and 14.29% respectively in PLF group compared with 33.33% and 28.57% in the PLIF group respectively.

In the PLF group, 80.95% were chronic patients with a mean duration of 3.95±2.2 years while in the PLIF group 85.71% chronic patients with a mean duration of 4.41±1.96 years. In the PLF group, 66.67% had numbness and 9.52% had claudication compared with 85.71% and 9.52% respectively in the PLIF group. The mean preoperative straight leg was 38.81±7.05 and 40.48±17.74 in PLF and PLIF groups respectively. The difference between both groups as regards complaint and present history was statistically insignificant (p>0.05) (Table 2). 66.67% had L4-5 lysthesis and 33.33% had L5S1 lysthesis in the PLF group while 61.9% had L4-5 lysthesis, 33.33% had L5S1 lysthesis and 4.76% had L3-4 lysthesis in the PLIF group. In the PLF group, 61.9% had 1st degree spondylolisthesis compared with 38.1% had 2nd degree spondylolisthesis. In the PLIF group, 66.67% had 1st degree spondylolisthesis compared with 33.33% had 2nd degree spondylolisthesis. In the PLF group, 76.19% had degenerative spondylolisthesis and 23.81% had isthmic one.

In the PLIF group, 71.43% had degenerative spondylolisthesis and 28.57% had isthmic one. There was statistical insignificant association between both groups as regards imaging findings (p>0.05) (Table **2**).

Table (2): Complaint and examination of studied patients in PLF and PLIF groups.

C/O	**PLF (n = 21)**	**PLIF (n = 21)**	**p**
	n (%)	**n (%)**	
LBP	21 (100.0)	21 (100.0)	0.14
Rt LL pain	5 (23.81)	6 (28.57)	
Lt LL pain	9 (42.86)	7 (33.33)	
Bilateral LL pain	3 (14.29)	6 (28.57)	
Onset			
Chronic	17 (80.95)	18 (85.71)	0.679
Subacute	4 (19.05)	3 (14.29)	
Duration in years			
Range	1 - 10	2 - 10	0.769
Mean ± S.D.	3.95±0.50	4.14±0.96	
Symptoms associated with pain			
Numbness	14 (66.67)	18 (85.71)	0.367
Claudication	2 (9.52)	2 (9.52)	
None	5 (23.81)	1 (4.76)	
Straight leg test			
Mean± S.D.	38.81±7.05	40.476±8.74	0.691
Range of walking in meters			
Mean± S.D.	204.64±48.62	228.57±52.32	0.407
Type of spondylolisthesis			
Isthmic	5 (23.81)	6 (28.57)	0.726
Degenerative	16 (76.19)	15 (71.43)	
Degree of spondylolisthesis			
1st degree	13 (61.9)	14 (66.67)	0.747
2nd degree	8 (38.1)	7 (33.33)	
Image findings			
L4-5 Lysthesis	14 (66.67)	13 (61.9)	0.556
L5S1 Lysthesis	7 (33.33)	7 (33.33)	
L3-4 Lysthesis	0 (0.00)	1 (4.76)	

Table (3): VAS and ODI pre and postoperative among studied patients in both PLF and PLIF groups.

	PLF (n = 21)	PLIF (n = 21)	p
VAS preoperative			
Range	7 - 10	7 - 9	0.717
Mean± S.D.	7.76±0.83	7.67±0.86	
VAS postoperative			
Range	2 - 4	1 - 3	0.043*
Mean± S.D.	2.57±0.5	2.14±0.43	
P (Pre vs Post)	0.000*	0.000*	
ODI preoperative			
Range	10 - 18	10 - 17	0.332
Mean± S.D.	13.57±2.77	12.81±2.23	
ODI postoperative			
Range	2 - 5	3 - 6	0.239
Mean± S.D.	4.00±1.00	3.67±0.6	
P (Pre vs Post)	0.000*	0.000*	

*** Means significant**

Outcome:

In PLF group, 38.1% had complete reduction, 33.33% had partial reduction and 28.57% had fixation in sito. In the PLIF group, 61.9% showed complete reduction, 14.29% partial reduction and 23.81% fixation in sito (figure 1). The mean preoperative VAS (table 3) was 7.76±0.83 in PLF and 7.67±0.86 in the PLIF group.

The mean postoperative VAS was 2.57±0.6 and 2.14±0.73 in PLF and PLIF group respectively. The difference between both groups as regards VAS postoperative was statistically significant (p=0.043). The VAS preoperative versus postoperative was statistically significant in each group (p=0.000).

The mean preoperative ODI was 13.57±2.77 and 12.81±2.23 in PLF and PLIF group respectively. It was 4.00±1.00 and 3.67±0.8 in PLF and PLIF group respectively. The difference between both groups as regards ODI pre and postoperative was statistically insignificant (p>0.05). The ODI preoperative versus postoperative was statistically significant in each group (p=0.000).

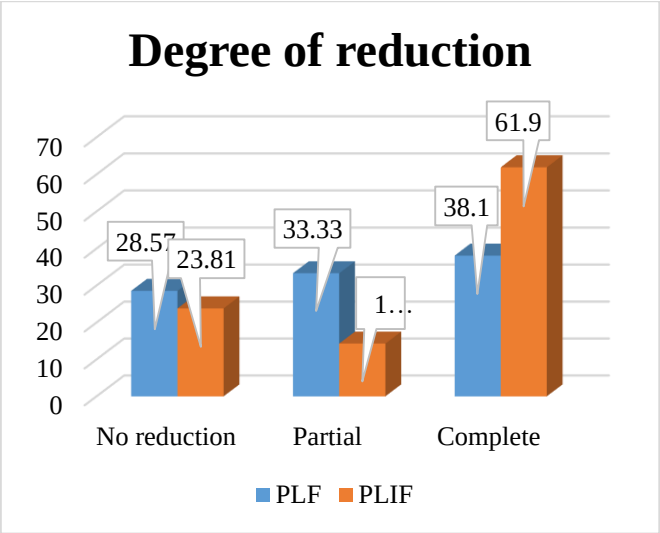
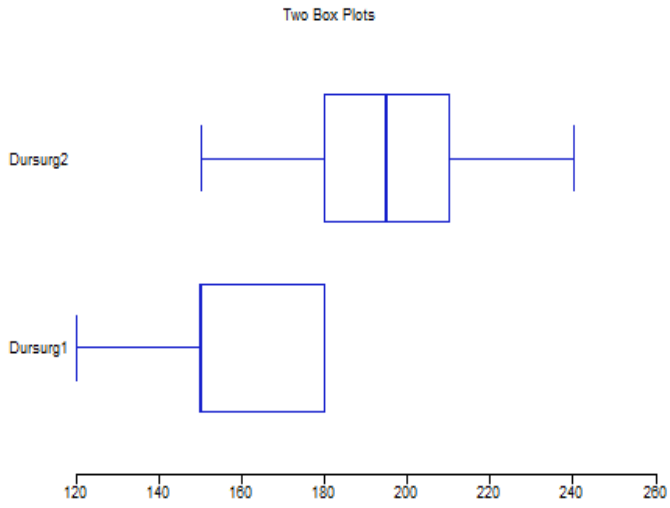


Figure (1): Postoperative reduction according to X-ray and CT.

Perioperative data:

The mean duration of surgery was 157.14±23.04 and 190.74±25.62 minutes in PLF and PLIF group respectively with statistically significant difference (p=0.0001*) (figure 2). The mean amount of blood loss was 615±142 and 730±105 milliliter in PLF and PLIF group respectively with statistically significant difference (p=0.028*) (figure 3). The length of hospital stay was 5.81±1.47 and 7.1±2.55 days in PLF and PLIF group respectively with statistically insignificant difference (p=0.052) (figure 4). In the PLF group, 90.49% showed clean wound and 9.51% inflamed wound. In the PLIF group, 85.71% showed clean wound, 9.51% inflamed wound and one patient had infected wound (figure 5).



(Dursurg1 = Duration of surgery in PLF)
(Dursurg2 = Duration of surgery in PLIF)

Figure (2): Two Box Plots of Duration of surgery in PLF and PLIF groups.

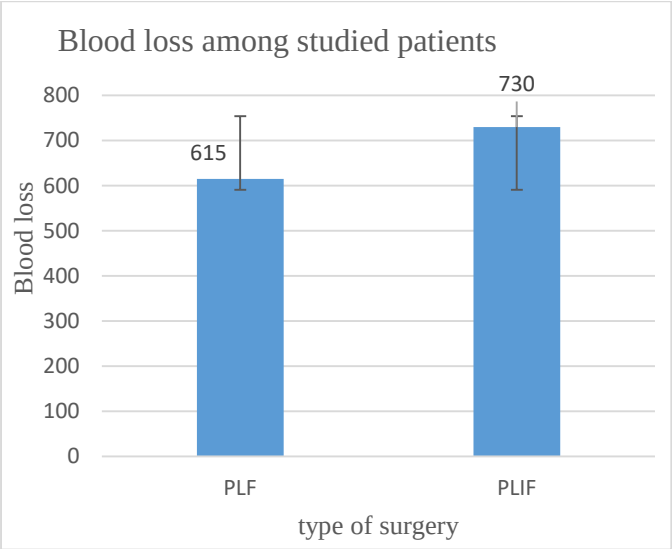
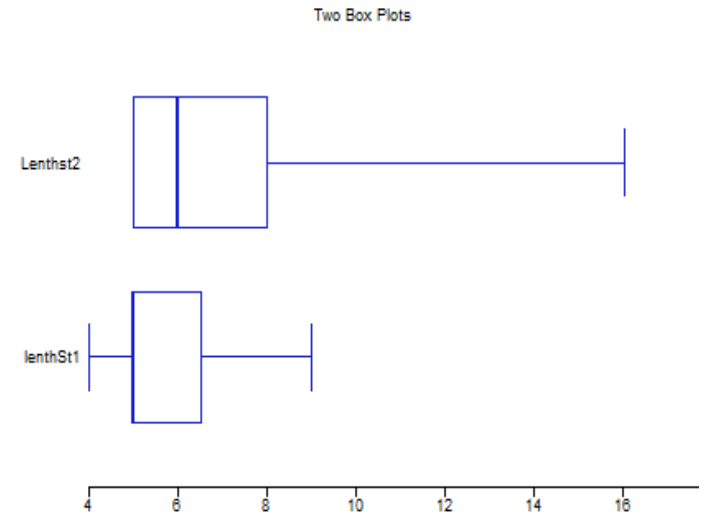


Figure (3): Mean Blood loss during surgery in PLF and PLIF groups.



(lenthSt1 = length of hospital stay in PLF)
(Lenthst2 = length of hospital stay in PLIF)

Figure (4): Two Box Plots of Length of hospital stay in PLF and PLIF groups.

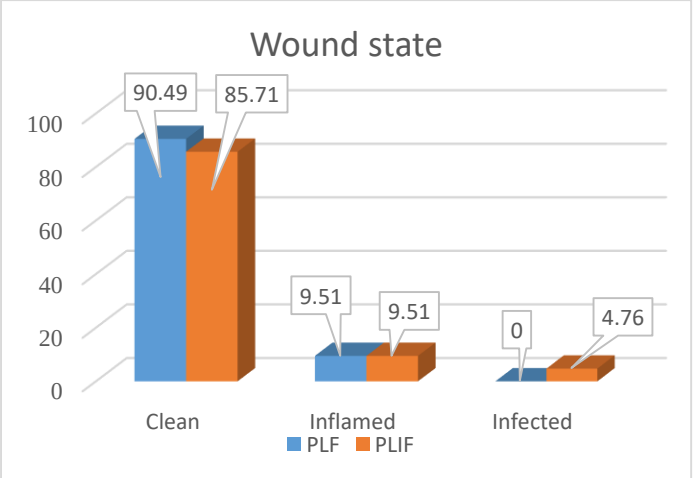


Figure (5): Wound state distribution among studied patients in both PLF and PLIF groups.

DISCUSSION

Pterolateral fixation for lumbar spondylolisthesis by using pedicle screw has been for years the standard procedure for treatment of lumbar spondylolisthesis. For increasing fusion and anterior support, the interbody fusion, either with cage or bone, were used by many surgeons. The mean age in the present study (43 years) is comparable to previous studies, reported that, the age ranged from 29.8 to 53.4 years in patients with spondylolisthesis[12]. The majority of patients in our study were females (59.52%) similar to other studies[18-20]. Tendency to obesity, repeated birth trauma, weak musculature, osteoporosis and early degenerative changes may be the cause [19]. Conversely, **Abdelaziz *et al.*[21]**, reported only 34% of their patients were females.

Similar to our study, many studies reported low back pain and leg pain were the main complaint[21,22]. Three fourths of our patients had degenerative spondylolisthesis and 26.19% had isthmic one. Similarly, **Amin *et al.*** [18] reported degenerative spondylolisthesis double those with isthmic spondylolisthesis. On the contrary, **Li *et al.*** [23] and **Smorgick *et al.*[24]** reported patients with isthmic spondylolisthesis nearly double those with degenerative spondylolisthesis. Many studies [19,24] reported the most affected vertebral level was L4-5 followed by L5/S1. This is similar to our results. On the contrary, **Csecsei *et al.*[22]** and **Lee *et al.*** [25] recorded affected level L5-S1 in most of their patients. Increased slippage at L4-5 and L5-S1 levels may be due to these segments are subjected to greatest forces and undergo the most motion[20], and presence of spina bifida at the lumbosacral junction that predispose for slippage [26]. Similar to the present study, most studies recorded grade I spondylolisthesis ranged from 60-65% [22,24,36]. Other studies reported more than 85% had grade I spondylolisthesis[25]. On the contrary, **La Rosa *et al.*[20]** reported grade I in 28.6% and **Singh *et al.*[19]** reported 25% were grade I. This may be due to early seeking medical advice before slip progression.

The mean VAS in the present study did not differ significantly pre and postoperative - between PLF and PLIF groups. Similarly, **Lee *et al.*[25]**, **Farrokhi *et al.*[28]**, **Taha and Youssef[29]** and **Singh *et al.*[19]** reported the same results. The mean ODI had significantly decreased from 13.19±2.51 preoperative to 3.83±0.91 postoperative. These results are similar to **Kim *et al.*[15]**, **Dantas *et al.*[7]**, **Musluman *et al.*[5]**, **Habib[27]**, **Farrokhi *et al.*[28]** and **Taha & Youssef[29]**. Similar results were achieved in the two groups. This similarity not only explained by solid bone fusion but also the decompressive procedure that preceded the implantation, the effect on the mechanical pain and the restoration of the neural space created by the system. The success of spine fusion procedure depends on host factors, technique, type of graft and the rigidity of the particular surgical construct that in turn affect bone healing[15].

In the present trial, the mean duration of surgery was 157.14±23.04 and 190.74±25.62 minutes in the PLF and PLIF group respectively. **Abdu *et al.* [30]** and **Abdelaziz *et al.*[21]**, reported similar results. Whereas, **Gottschalk *et al.*[31]** recorded opposite results with longer duration for PLF group than PLIF group. The long surgery duration could be considered a risk factor for superficial or deep infection of the wound. The length of hospital stays in the present study is longer in the PLIF group 7.1±2.55 days than in the PLF group 5.81±1.47 days. These results were in agreement with **Abdu *et al.* [30]** and **Vivien *et al.*[32]**. Conversely, **Lee *et al.*[25]**, and **Gottschalk *et al.*[31]** recorded opposite results. In this trial, perioperative blood loss was larger in PLIF than in PLF group. In agreement with our results, **Habib[27]** and **Mahmoud *et al.*[33]** reported similar results. On the other hand, **Abdelaziz *et al.*[21]**, reported little mean blood loss in PLF group 457±193.8 and in PLIF group 515±100.3 milliliter. More blood loss in PLIF may be due to more extensive operation and much more time of this technique. Tear of the dura occur in only one case in each surgical procedure in the present study compared with one case in PLF group and 2 cases in PLIF group in **Habib[27]**. Only one patient in the present study showed infected wound in PLIF group and two patients in each group showed inflamed wound. In accordance with these results, **Abdelaziz *et al.*[21]**, reported one case of wound infection in PLF group.

In both interventions the outcomes of the studies shows that there is no evidence of the superiority of one approach over another one in terms of the fusion rate. **Ekman *et al.*[13]** after 2 year follow up reported both PLF and PLIF shown equal results. In long term cohort study by **Cunningham *et al.*[6]**, PLIF has shown superior results compared to PLF. Complete neural decompression, solid fusion, restoration of normal inter-segmental alignment and preservation of normal spinal function are the goals of PLIF in the treatment of spinal instability[34]. Restoration of native anatomy; disc height and foraminal height are the prime success reasons behind PLIF. Primarily PLIF is done when there is gross instability or severe canal stenosis requiring extensive laminectomy and decompression. The radiological and clinical results demonstrated in this study agree with those reported by another authors and support the view that a rigid segmental fixation combined with interbody fusion is the treatment of choice for segmental lumbar instabilities[35].

Limitation and Strength of the Study:

Among limitations in the present study; limited number of patients and hence the applicability and generalizability of the results and short follow up period. Strong points in our study include; similar baseline characteristics between the two groups, homogeneous preoperative clinical and radiological findings and random distribution of patients to either PLF or PLIF surgery. There were no graft-related or serious neurological complications or implant failure was reported.

CONCLUSION

In the present controlled trial, we compared pedicle screw fixation with lateral fusion alone (PLF) with pedicle screw fixation with inter body fusion (PLIF). Results indicate better results of fusion rate in PLIF with more blood loss, longer duration of surgery and lengthy hospital stay. Similar results for VAS and ODI. PLIF is considered a difficult procedure with more complications. However, in the hands of trained surgeons, it should not cause more technical problems than PLF. Moreover, longer follow-up periods are needed to establish the comparison between both procedures on the long term. Future studies with greater number of patients for long follow-up period to establish the long term outcomes of these two techniques is essential.

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Author contribution: Authors contributed equally in the study.

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