Influence of the Posterior Lumbar Interbody Fusion on the Spine-Pelvic Parameters in High Grade Spondylolisthesis: Clinical and Radiological Outcomes

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Abstract

Background: The relationship of the pelvis to the spine has previously been overlooked, and its importance in sagittal balance has been underestimated. **Purpose:** To evaluate the sagittal balance improvement in surgically treated patients with high grade Lytic Spondylolisthesis treated with PLIF and its relation to clinical outcome. **Patient sample:** Prospective case study of 30 patients with high grade Lytic Spondylolisthesis with follows up of at least 12 months. **Methods:** It consisted of a prospectively collected consecutive series of 30 patients with high grade Lytic Spondylolisthesis who met the inclusion criteria treated between September 2019 and August 2022. All cases were managed by posterolateral fusion (PLF) added to posterior interbody fusion (PLIF) in Cairo University hospital, and Alharam hospital. **Results:** All patients achieved satisfactory results as regards the back pain, radicular pain and neurologic deficits. ODI significantly improved from mean 69.37±5.49 SD to 10.97±2.14 at 12 months (P <0.001). Mean Back pain VAS decreased significantly from mean 7.76 ±0.71SD to 0.93±0.37 at 12 months (P <0.001). Fusion improved from mean 4.17±0.83 SD by 6th month to 4.70±0.60by one year. Two patients were complicated by dural tear (6.7%), two patients had superficial infection (6.7%) and three patients complicated delayed fusion (10%). None had undergone a revision surgery. **Conclusions:** Clinical outcomes are in direct relation to radiological outcome after sagittal balance correction using posterior fusion.

Keywords: High grade Lytic Spondylolisthesis; Sagittal Balance; Spinopelvic Parameters& posterior fusion.

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Introduction

Spondylolisthesis refers to the forward translation of one vertebral body relative to another directly below. Most often, spondylolisthesis results secondary to an anatomic defect in the pars interarticularis of the lumbar spine. High-grade spondylolisthesis (HGS) is an uncommon cause of lower back pain in adults **(1)**.

The patient typically complains of progressive back pain in the lumbar region, exacerbated by extension or twisting of the spine. Radicular pain and urinary disturbances are uncommon unless nerve root compression has occurred. The common diagnostic work-up consists of conventional x-ray imaging and Magnetic resonance imaging (MRI) **(2)**.

In the past, the treatment for spinal disease was focused on a regional prospective, as neural decompression and obtaining bony fusion. As spinal surgery techniques have developed, a concept about whole spinal alignment has been emphasized as important for managing spinal disease. Spino-pelvic (lumbosacral pelvic junction) alignment is very important in understanding the overall alignment of the spine. It is a considerable factor, especially when performing lumbar fusion surgery. Sagittal alignment of the spine has been investigated in many studies, primarily in the normal population **(2)**.

In the normal population, the correlation between pelvic incidences, sacral slope and lumbar lordosis have been well documented. Also, several studies have reported sagittal alignment in populations of patients with low back pain, degenerative spondylolisthesis (DSPL), and isthmic spondylolisthesis (ISPL). Recent studies suggested a predominant role of spinopelvic parameters to explain lumbosacral spondylolisthesis pathology **(3)**.

Aim of Work was to evaluate spino-pelvic parameters after interbody fusion of high grade spondylolisthesis clinically and radiologically and their correlation to one another.

Patients and Methods

A total number of thirty consecutive patients with high grade Lytic Spondylolisthesis were selected for instrumented Posterior Lumbar Inter-body Fusion (PLIF) technique between September 2019 and September 2020 in Kasr Al Ainy hospital, Cairo University and Al Haram hospital after approval of the Ethical Committee of the Orthopedic Department Council, Cairo University and after taking a detailed informed Conscent from the patients .

All cases tried conservative measures for at least three months of active physiotherapy program, non-steroidal anti-inflammatory medications & lumbosacral brace before going to surgical treatment.

Patient selection involved the inclusion criteria: Age group between 20-50 years, patients with high degree of spondylolisthesis (Myerding Grade 3 and 4), isthmic spondylolytic patients and patients with low back pain and/or sciatica after failure of routine conservative management for 3 months.

Patient exclusion criteria: Patients below age of 20 years and above age of 50 years, marked Obesity (Body mass index more than 40), patients having osteoporosis, previous surgery at the lumbar spine and unwillingness to participate in the study.

Indications of PLIF:

Grade 3, and grade 4 lytic (High grade) spondylolisthesis. Thirty patients had an interbody fusion, most commonly affecting level L4/5 (24 patients) which is not common in the literature; all of them had sacralized L5, followed by L5/S1 (3 patients) & L4-5 and L5-S1(3 patients). The 30 patients included 13 men, 17 women with long-term low back pain and bilateral radiculopathy, Patients were postoperatively evaluated after 1, 3, 6, and 12 months. Back pain was the main complaint of all patients followed by radicular pain which was bilateral. It was severe on the right side in 17 patients and on left side in 13 patients.

General and Local Spine Assessment: A detailed history was taken from all patients. Precise pain analysis was done, location, duration, relation to various activities, severity of low back pain and radiation to lower extremity. Claudication distance was documented and bowel & bladder incontinence was questioned. It aimed also at defining the degree of pain and patient disability.

This was carried out using the **Visual Analog Scale (VAS)** and the **Oswestry Disability Index questionnaire (ODI)**. An Arabic translation of the VAS and ODI was used to be answered easily by all patients.

Local Examination: Complete local examination of the lumbar spine was routinely performed with particular emphasis on the range of motion, deformities, exact site of tenderness or scars of previous operations. Neurologic examination: A careful neurologic examination of lower extremity motor strength, sensory abnormalities, knee and ankle reflexes were performed. Any neural tension signs of the sciatic or femoral nerves was checked and noted. The ability to heel and toe walk produces a visual and functional assessment of lumbar nerve root functions.

Preoperative Radiological investigation:

A. Plain radiographs

B. MRI: Allowed a non-invasive evaluation of the spine and spinal canal, including the spinal cord.

Laboratory evaluation: Complete blood picture, ESR, C-reactive protein, blood sugar, urine analysis, liver and kidney function, hepatitis markers and bleeding profile

Surgical Technique: Patient received general hypotensive anesthesia and was placed in the prone position, maintaining the lumbar lordosis by position on a padded spinal frame, the surgical site was sterilized by betadine and addressed level was checked by image intensifier. The PLIF procedure began with a posterior, midline exposure that was centralized directly on palpable spinous process (fig:1).

Figure 1: Posterior midline approach.

Fixation of unstable level was done . Polyaxial pedicular screws were inserted and in few cases reduction pedicular screws were used. Position was checked by image intensifier then longitudinal rods were connected on one side then distraction was done to address correction and maintain the disc space and longitudinal rods were connected on the other side after decompression was done.

The complete exposure for the exiting root was achieved by removing laminae and the facet joint over the affected level and release of compression. At this stage, the medial thecal sac, exiting nerve root, and disc space were visible (fig: 2).

Figure 2: Removal of loose laminae and deroofing.

The exiting nerve root should be identified. If possible, it was preferred to maintain the fatty tissue sleeve around the exiting ganglion to avoid injury or irritation to this sensitive structure. To prepare the disc space for fusion, a nerve root retractor was often placed medially to protect the thecal sac, although minimal retraction of the sac was utilized. At the lower lumbar levels the use of this medial retractor may not be necessary owing to the wide lateral approach to the disc space (fig: 3).

Figure 3: Exposure of disc with nerve root.

Provisional discectomy was then performed using punches. Disc incision was made mainly at the side of maximum leg pain or at the side of bigger disc protrusion for proper decompression of affected nerve root especially exiting root.

Autogenous cancellous bone graft harvested from the posterior spinal elements during decompression, was then packed into the anterior portion of the disc space to promote interbody fusion. The interbody space was then reconstructed by selecting an appropriately sized interbody cage.

At last, Lumbar cage filled with autogenous bone graft was put after taking exact size using trials in order to obtain inter-body fusion using image intensifier (fig: 4), then compression on lumbar cage was done. The rest of autogenous cancellous bone graft were placed in the posterolateral gutter behind the rods in order to achieve posterolateral fusion, to ensure 360 degrees fusion.

Drain was put, and closure in layers was done after assurance of good hemostasis, then sterile compressive dressing was applied.

Figure 4: Proper position of lumbar cage checked.

Post op/ Follow up: Ambulation was allowed on day one after a complete neurological examination. IV antibiotics and analgesics were given. Drain was removed after 48 hours, Hospital stay ranged from 3-5 days. Patients were instructed to avoid leaning forward, or lifting heavy objects. Wound care instructions were given and sutures are removed 2 weeks post op. Clinical assessment and follow up was done at 1, 3, 6, and 12 months using VAS and ODI scores. Radiological assessment by plain x-rays to assess: Fusion (using Brantigan score). Spino-pelvic parameters(sacral slope, pelvic incidence, and pelvic tilt)which were measured on lateral standing x-rays at immediate post op, 3 months, 6 months, 12 months post-operatively , and compare the radiological with clinical results and the direct proportionality of them to each other and to the pre-operative findings.

Statistical analysis: Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). Data was summarized using mean and standard deviation in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. For comparison of serial measurements within same patient, repeated measures ANOVA was used in normally distributed quantitative variables while non-parametric Friedman test was used for non-normally distributed quantitative variables (Chan, 2004). P-values less than 0.05 were considered as statistically significant (4).

Case Presentation

Female patient, 50 years old, suffered from Low back pain of 2 years duration, radiating to Right lower limb, preoperative ODI was 60, VAS Back was 9, VAS leg was 8, PI was 71, PT was 30, SS was 42. PXR (fig: 44) revealed grade 3 L5/S1 spondylolisthesis. MRI (fig: 45) revealed L5/S1 disc prolapse. PLIF L5/S1 was done on 12/12/ 2019 (fig: 46), operative time was 90 min. ODI at 1 month was 26, and at one year was 14. VAS Back immediately postoperative was 5, and at one year was 1. VAS Leg immediately postoperative was 2, and at one year was 0. PI immediately postoperative was 42, and at one year was 37. PT immediately postoperative was 10, and at one year was 8. SS immediately postoperative was 33, and at one year was 25, and fusion was complete at 6 months (fig: 5-8).

Preoperative Radiographs

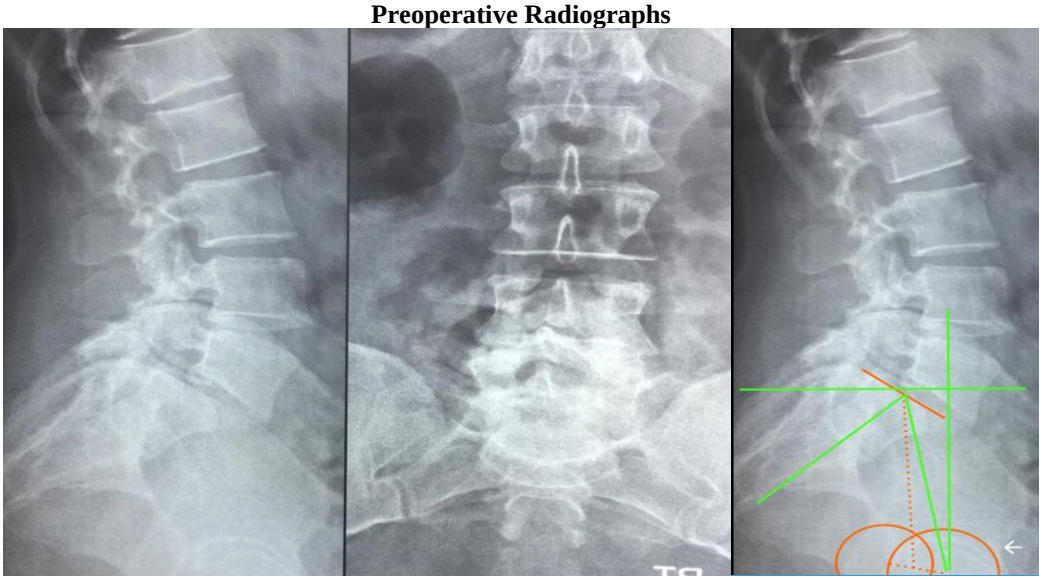

Figure 5: Preoperative PXR, AP and lateral views, showing L5/S1 instability

Postoperative Radiographs

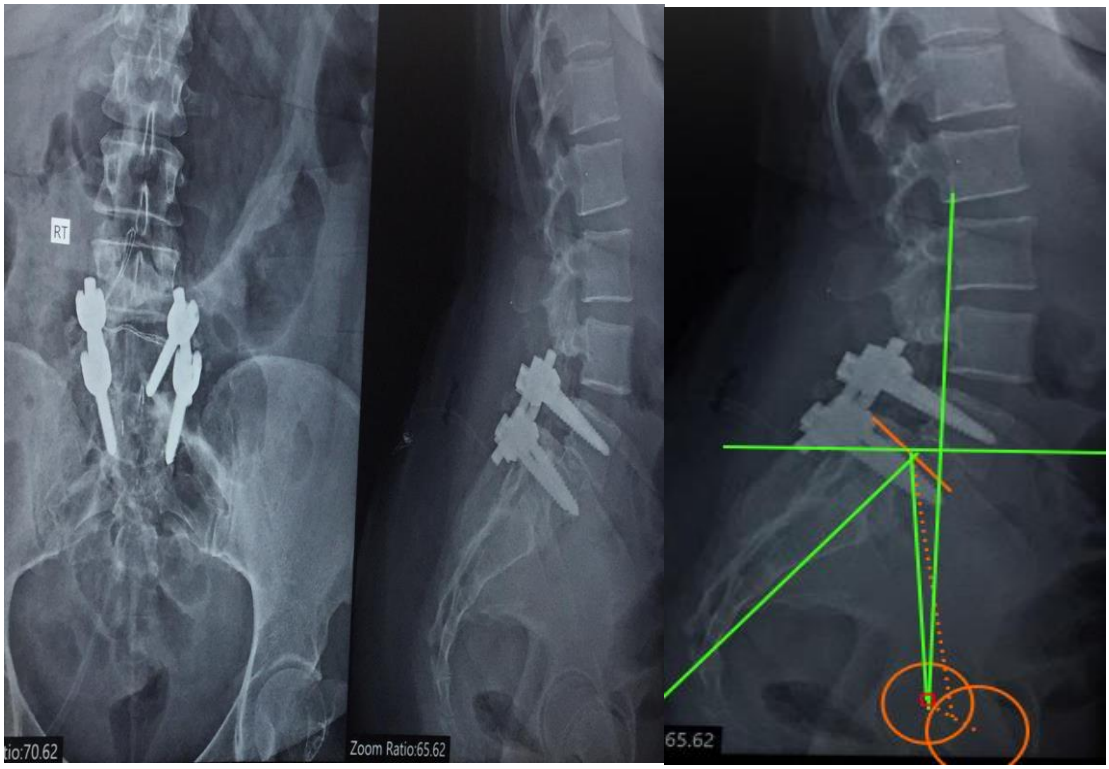

Figure 61: Early post-operative PXR A-P and lateral views, showing PLIF of L5/S1 level

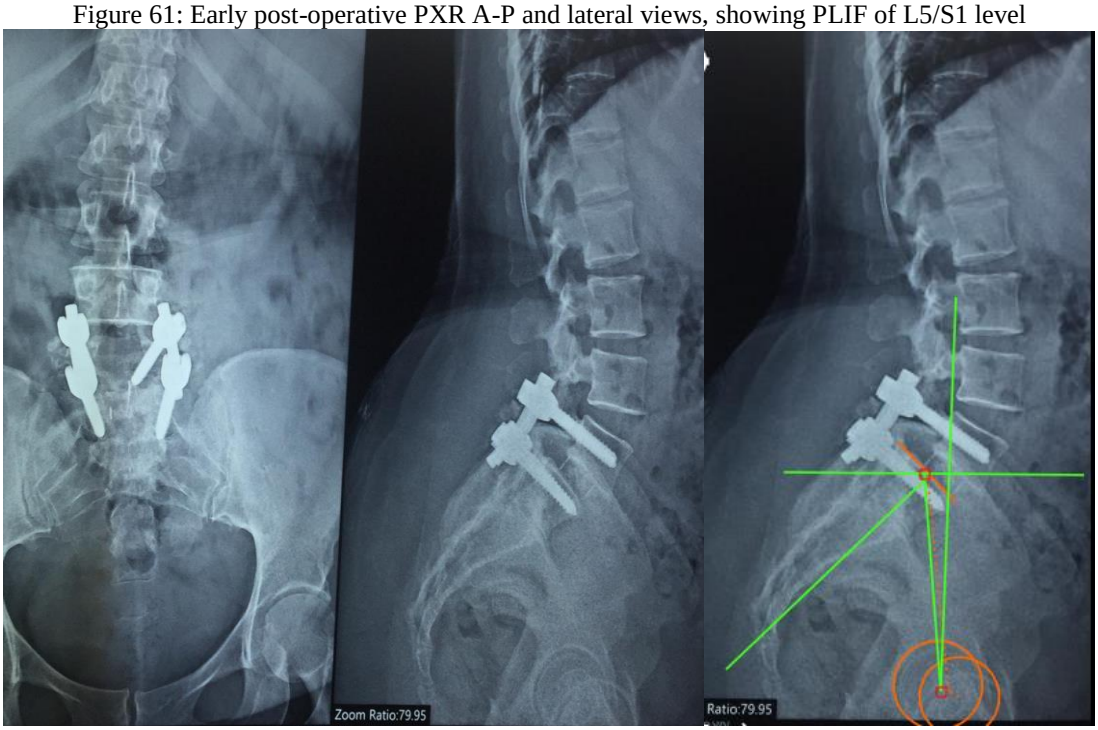

Figure 7: PXR 6months postoperative, showing bone bridging around cage

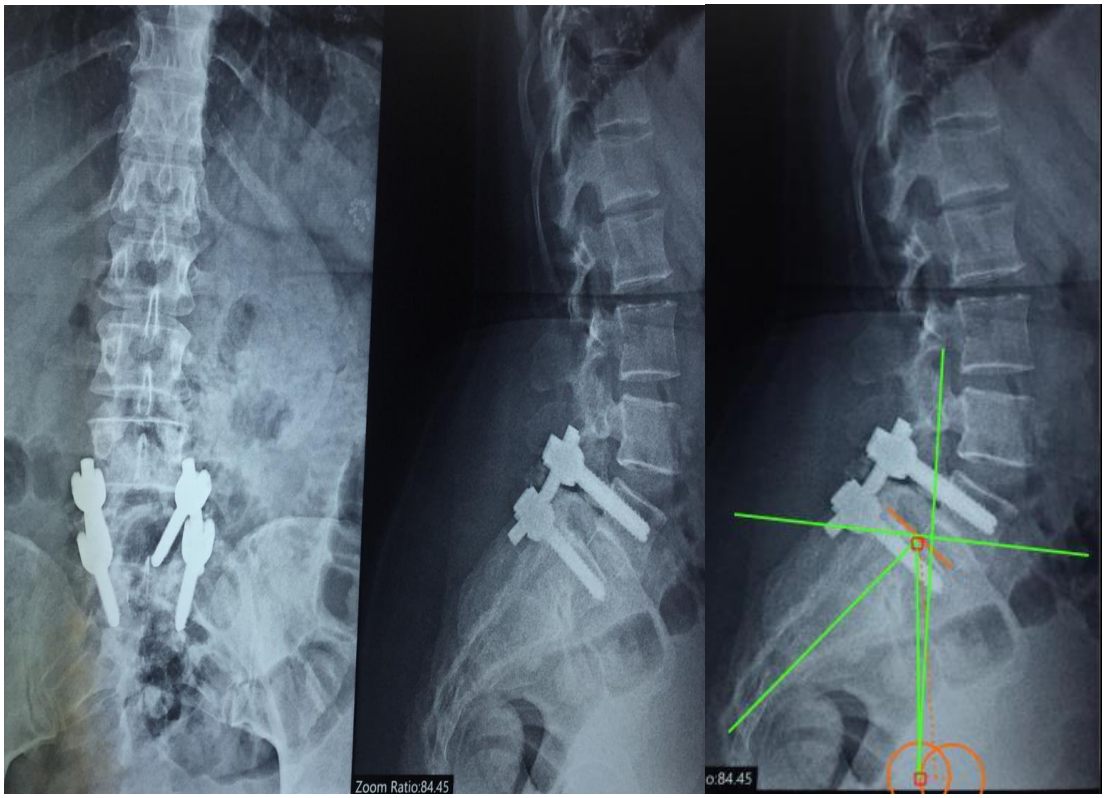

Figure 8: PXR 12 months postoperative

Results

This was a prospective case study includes 30 patients with high grade lytic spondylolisthesis underwent decompression, correction of the spino-pelvic parameters and fusion with posterior instrumentation. Early postoperative results data were obtained before hospital discharge, while late postoperative results data were obtained during follow up starting from 1st to 12th month. Follow up duration lasted for 12 months at least.

Age: Range between 20 - 50 years (mean 43.1± 5.82 SD), Hospital stay: 3 - 5 days (mean 3.30± 0.65 SD). Table *1*.

Table 1: Descriptive statistics

	Mean	Standard Deviation	Minimum	Maximum
Age	43.10	5.82	32.00	51.00
Hospital stay	3.30	0.65	3.00	5.00

Levels of vertebral segments affected: Three cases were affected at the level L4-5 and L5-S1, twenty four cases at L4-5 and three cases at L5-S1 (Figure 9).

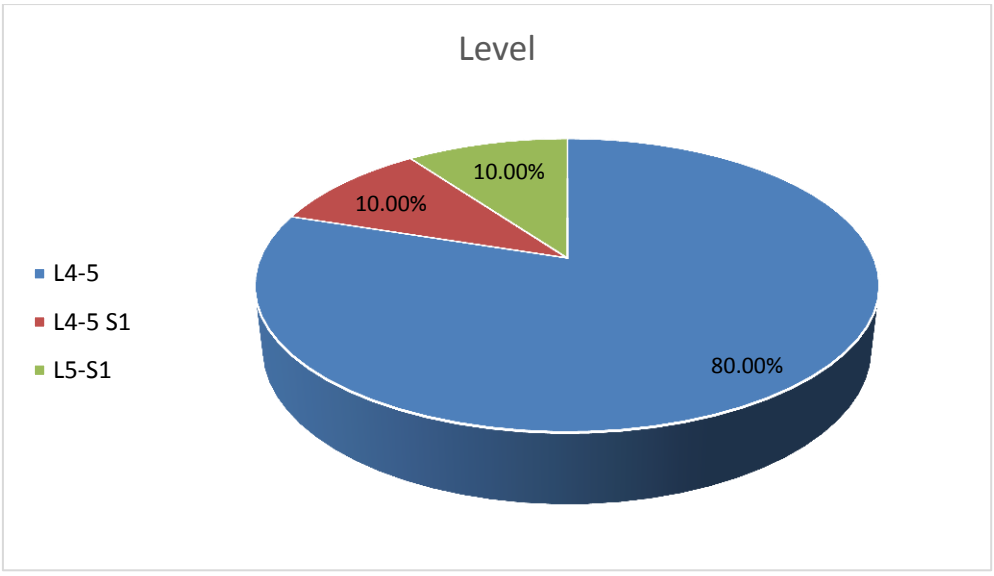

Figure 92: Level of affected vertebral segment

Operative time: Ranges from 90-140 min (mean 110.33± 17.32 SD). Blood loss: Ranges from 400 - 1000 cc (mean 551.67± 131.62 SD) (Table 2).

Table 2: Operative time and blood loss

	Mean	Standard Deviation	Minimum	Maximum
Op time	110.33	17.32	90.00	140.00
Blood loss	551.67	131.62	400.00	1000.00

VAS Back pain decreased significantly from mean 7.76 ±0.71SD, preoperatively to 5.43±0.57 SD at 1 month, 2.77±0.43 SD at 6 months and 0.93±0.37 at 12 months (Table 3). There was significant improvement of VAS Back pain over different time periods (p< 0.001).

Table 3: VAS Back pain pre, 1, 6& 12 months postoperative

	Mean	Standard Deviation	Minimum	Maximum
VAS BACk pre	7.67	0.71	7.00	10.00
VAS BACk 1m	5.43	0.57	4.00	6.00
VAS BACk 6m	2.77	0.43	2.00	3.00
VAS BACk 12m	0.93	0.37	0.00	2.00

Statistically P-value <0.001 was significant between results in VAS Back follow-up.
Comparison among different values of VAS Back pain at different two times showed that difference was statistically significant over time (P>0.001) (Figure *10)*

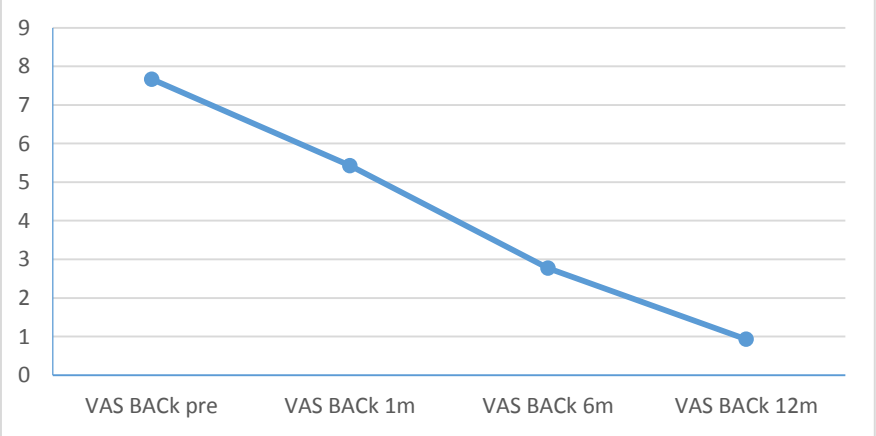

Figure 103: Pair wise comparisons among different values of VAS Back

VAS Leg pain decreased significantly from mean 7.83±0.P SD preoperatively to 2.23±0.43 SD at 1 month, 0.20±0.41 SD at 6 months and 0.07±0.25 SD at 12 months. There was significant improvement of VAS Leg pain over different time periods (p< 0.001) (Table 4).

Table 4: VAS Leg pain follow up pre, 1, 6& 12 months postoperative

	Mean	Standard Deviation	Minimum	Maximum
Vas Leg pre	7.83	0.65	7.00	10.00
Vas Leg 1m	2.23	0.43	2.00	3.00
Vas Leg 6m	0.20	0.41	0.00	1.00
Vas Leg 12m	0.07	0.25	0.00	1.00

Statistically P-value <0.001 was significant between results in VAS Leg follow-up.
Comparison among different values of VAS Leg pain at different two times showed that difference was statistically significant in many time periods (P> 0.001) (Figure *11*).

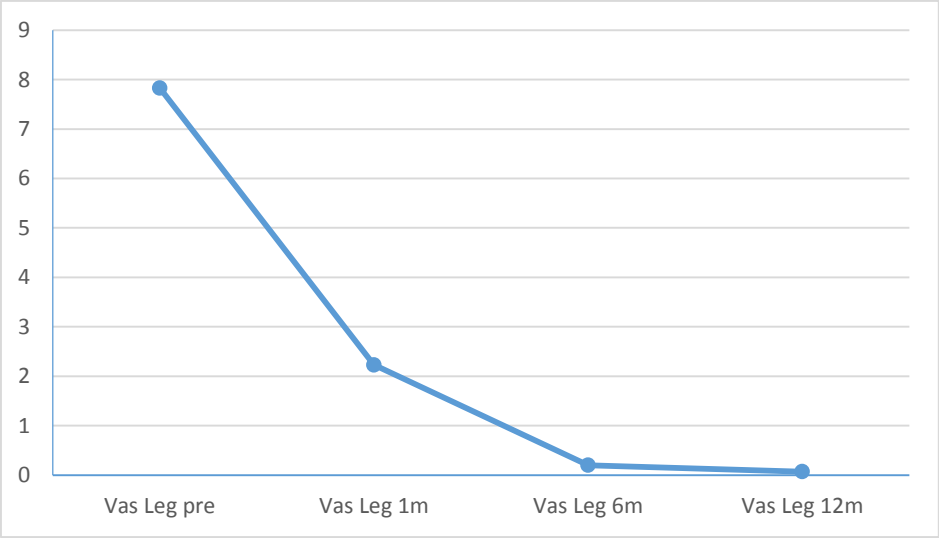

Figure 11: Pair wise comparisons among different values of VAS Leg pain

• ODI improved from mean 69.37±5.49 SD preoperatively to 31.07±4.49, 15.20±2.02 & 10.97±2.14 at 1, 6& 12 months postoperatively respectively (Table 5).

Table 5: ODI follow up pre-op and at 1, 6& 12 months postoperative.

	Mean	Standard Deviation	Minimum	Maximum
ODI pre	69.37	5.49	60.00	80.00
ODI 1m	31.07	4.49	24.00	40.00
ODI 6m	15.20	2.02	11.00	20.00
ODI 12m	10.97	2.14	7.00	16.00

Comparison among different values of ODI at different two times showed that most difference was statistically significant (P> 0.001) (Table 6).

Table 6: Pair wise comparisons among different values of ODI.

	Mean	Standard Deviation	P value compared to pre
ODI pre	69.37	5.49	----
ODI 1m	31.07	4.49	<0.001
ODI 6m	15.20	2.02	<0.001
ODI 12m	10.97	2.14	<0.001

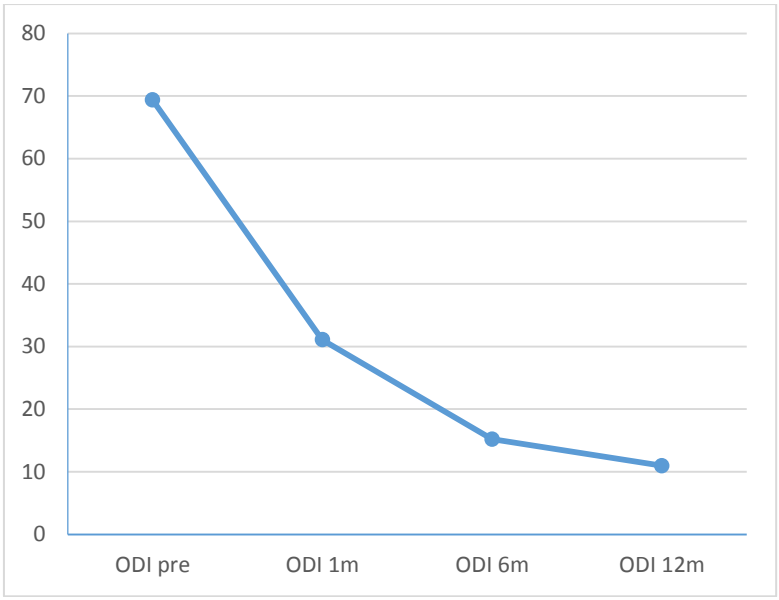

Figure 12: Pair wise comparisons among different values of ODI.

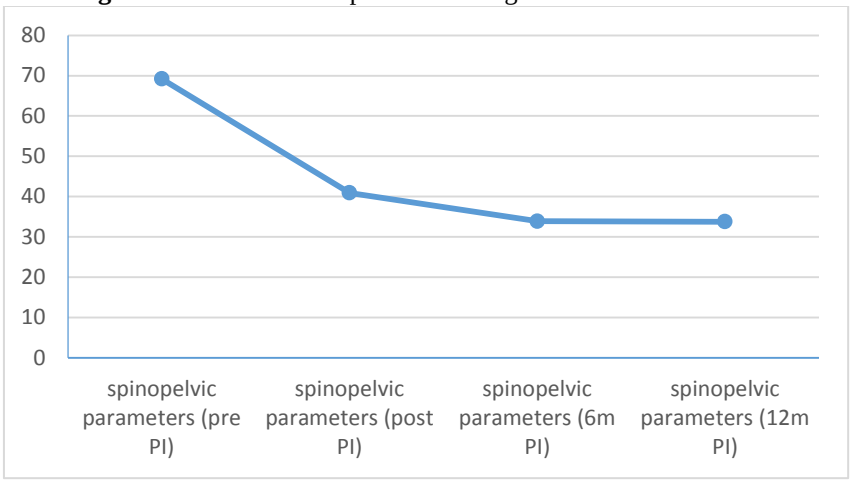

Figure 13: Pair wise comparisons of different values of PI follow-up.

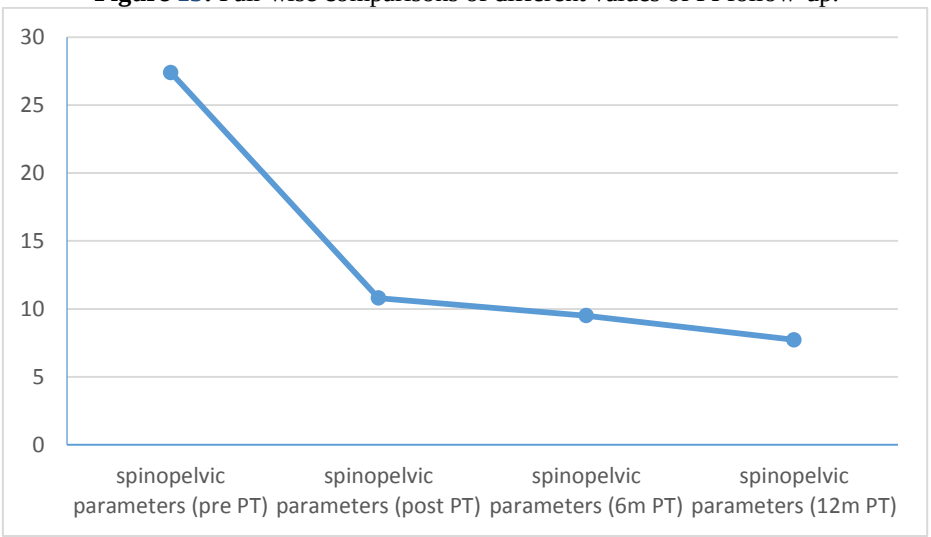

Figure 14: Pair wise comparisons of different values of PT follow-up.

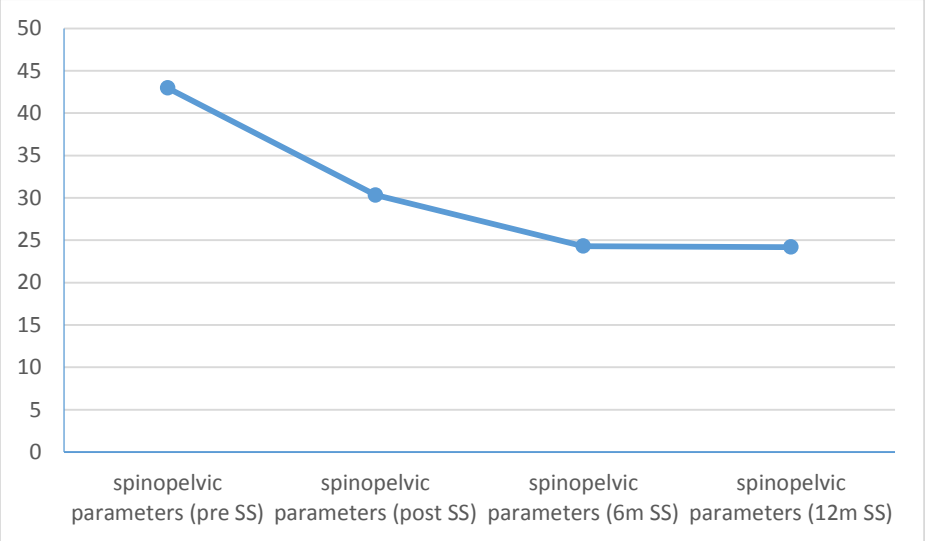

Figure 15: Pair wise comparisons of different values of SS follow-up.

Table 7: Correlation among fusion values and pelvic parameters.

		PI (pre)	PI (post)	PI (1y)	SS (pre)	SS (post)	SS (1y)	PT (pre)	PT (post)	PT (1y)
Fusion (6m)	**Correlation Coefficient**	**0.038**	**0.142**	**0.207**	**0.021**	**0.089**	**0.063**	**0.122**	**0.299**	**0.181**
	P value	**0.858**	**0.499**	**<0.001**	**0.920**	**0.671**	**<0.001**	**0.562**	**0.147**	**<0.001**
	N	**25**	**25**	**25**	**25**	**25**	**25**	**25**	**25**	**25**
Fusion (1y)	**Correlation Coefficient**	**0.102**	**0.156**	**0.157**	**0.109**	**0.093**	**0.071**	**0.032**	**0.245**	**0.026**
	P value	**0.629**	**0.455**	**<0.001**	**0.603**	**0.659**	**<0.001**	**0.878**	**0.237**	**<0.001**
	N	**25**	**25**	**25**	**25**	**25**	**25**	**25**	**25**	**25**

Statistically P-value >0.05 was considered insignificant.

Two patients were complicated by dural tear (6.7%) and managed intra-operatively by direct repair, two patients had superficial infection that managed by daily dressing and oral antibiotics (6.7%) and three patients complicated delayed fusion (10%) improved during twelve months of follow up. None had undergone a revision surgery (Figure 16).

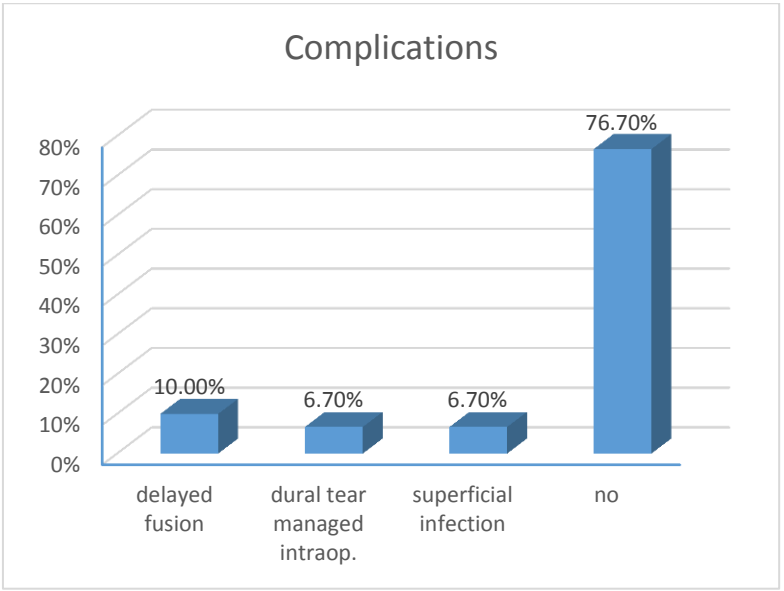

Figure 16: Complications

Discussion

In this study, thirty patients (100%) were diagnosed as having high grade lytic spondylolisthesis (LS) and foraminal stenosis (FS) underwent posterior surgical fusion and posterior instrumentation by poly-axial pedicular screws and rods after receiving sufficient decompression for the roots during the operation in addition to postero-lateral fusion. The patients were 13 males & 17 females, Age ranges between 20 and 50 years. All patients were clinically evaluated using the Visual Analog Scale (VAS) for LBP and LP, the Oswestry Low Back Pain Disability Questionnaire (ODI) and were assessed with standing X-ray 12months at least. Pelvic parameters were measured preoperative, postoperative and at 12th month.

Hao-Chun Chuang et al. (5), have included in the study 45 patients with high grade lytic spondylolithesis, with mean age was 30.

Rohit Amritanand et a., (6), have retrospective case series of 35 patients done, with Meyerding grades III, IV, or V spondylolisthesis who underwent surgical treatment in the institution, with mean age was 35.

Konstantinos Martikos et al., (7) (based on inclusion criteria in the study), enrolled in their study 28 patients selected for retrospective analysis, 19 female and 9 male. Mean age at surgery was 15.6 years.

In this study, the operative time of the studied patients was found to be mean 110.33±17.32 SD minutes. The longest operative time was 140.00 minutes and the shortest was 90.0 minutes. The operations that exceeded 120 min were double level operations. The blood loss mean was 551.67±131.62 SD cc. Hospital stay mean was 3.30±0.65 SD days.

Konstantinos Martikos et al., (7), reported that operative time (minutes) was 146.9. Blood loss (ml) was 244.1. Hospitals stay (days) 7.5.

Jabłońska-Sudoł et al., (8), have mentioned that the average surgical time for lateral procedure only was 103 min .The average time of divarication was 24 min. The mean intraoperative blood loss was 132 ml. All the patients were able to walk the first day after surgery, and the mean length of hospital stay was 3.4 days.

In this study, VAS Back pain decreased significantly from mean 7.67±0.71 SD preoperatively to 5.43±0.57 immediately postoperative, 2.77±0.43at 6 months and 0.93±0.37 at 12 months. VAS Leg pain decreased from mean 7.83±0.65SD preoperatively to 2.23±0.43immediately postoperative, 0.20± 0.41 at 6 months and 0.07±0.21 at 12 months. ODI also improved from mean 69.37±5.49 SD preoperatively to 31.07±4.49, 15.20±2.02, &10.97±2.14 at 1, 6& 12 months of follow-ups respectively.

Rohit Amritanand et al., (6), reported that SS and PT have no significant changes. Slip grade improved from an average 74.0%±13.2% to 30.0%±14.0% ($p<0.05$).

Konstantinos Martikos et al., (7), showed pelvic incidence (PI) 72,8°, 72,1°, 73,1° ,Pelvic tilt (PT) 28,2°25,6°, 28,8°,Sacral slope (SS) 43,9°, 45,9°, 43,9° Mean pre-op, post-op and final end of study respectively.

Jabłońska-Sudoł et al., (8), stated that there was a statistically significant improvement**,** mean preoperatively of PI, PT, and SS were 76, 28, 47respectively. And at the end of study were 4, 6, and 0.16 respectively.

In this study, fusion improved from mean 4.17±0.83 SD by 6th month to 4.70±0.60 by one year.

Konstantinos Martikos et al., (7) showed mechanical complications occurred, with loss of correction were observed in 4 patients (14.2%). Revision surgery was performed in each case, with the objective to obtain satisfactory listhesis stabilization, not necessarily reduction.

Lengert a et al., (9) found 7 symptomatic non-unions (17%) at last follow-up, accounting for the deterioration in slip found in certain patients. There was only 1 case of HMA screw breakage associated with non-union; 2 other patients showed fibular graft fracture.

In this study, two patients were complicated by dural tear (6.7%) and managed intra-operatively by direct repair, three patients had delayed fusion (10%) and two patients complicated with postoperative superficial infection that managed by oral antibiotics (6.7%) and improved during three months of follow up.

Compared to other studies in literature on doing PLIF in high grade isthmic spondylolisthesis patients, and **Rohit Amritanand et al., (6)** whom stated their findings indicate avenues for further research on how the radiological changes impact clinical outcomes, this study revealed impact of radiological outcomes on clinical outcomes and their direct correlation to one another. All studies highlighted radiological outcomes as a primary outcome and few mentioned clinical outcomes as a secondary outcome with no correlation between radiological and clinical outcomes.

Conclusion

This study found immediate postoperative significant improvement of the clinical outcomes when radiological improvement of pelvic parameters happened. Hence proving the influence of the posterior lumbar underbody fusion on the spine-pelvic parameters in high grade spondylo-listhesis, and study revealed impact of radiological outcomes on clinical outcomes and their direct correlation to one another.

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