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Original article

Management of Degenerative Lumbar Spine Disease by Posterior Lumbar Interbody Fusion and Percutaneous Pedicular Fixation

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Abstract

Background: Management of degenerative lumbar spine by percutaneous pedicle screw fixation and posterior interbody fusion is another technique instead of standard open techniques. **This study aimed to** evaluate outcome of using percutaneous fixation and interbody fusion in management of symptomatic spondylolisthesis. **Methods:** Once these methods are known, though, they provide a secure, minimally invasive, and trauma-free way to conduct fusion. Patients and Methods: This paper has illustrated in detail how to do this surgery, including ten patients, 2 males and 8 females, nine patients were L5-S1 and one was L4-L5 .7 patients were grade 2 spondylolisthesis and 3 patients were grade 3 Spondylolisthesis with follow up three months, six months and one year. **Result:** Comparison of preoperative VAS of back pain, VAS of leg pain and ODI among the operated patients (N=10) with 6 weeks, 6 months and final outcome, there was significant change among them with follow, as measured by the ODI. In the study the SVA showed a change from the range of (-65.1 to 110) to (-29 to 35) mm. there was 2 patients with SVA more than 50mm pre-operative. All patients were balanced post-operative. The fusion rate was about 95.8% with only one case showed non-union. **Conclusion:** For the treatment of spondylolisthesis, percutaneous pedicular fixation and interbody fusion is a promising alternative. The majority of surgeons prefer less invasive techniques, using minimally invasive pedicle screw systems, due to the morbidity caused by excessive paraspinal muscle stripping.

Key Words: Degenerative lumbar spine, Posterior lumbar interbody fusion, Percutaneous Pedicle screw fixation.

Introduction

Due to injury to the erector spinae muscles, conventional procedures for posterior lumbar spine fusion required considerable stripping, big incisions, and retraction of the paraspinal musculature, as well as severe postoperative pain and a delayed recovery (1). The benefits of posterior interbody fusion and percutaneous pedicle screw fixation provide more stable structures that enable early mobilization and allow for appropriate deformity correction. The operative exposure, in open technique increase the surgical dissection and muscle damage in contrast to percutaneous fixation which is mini-invasive technique. Follow-up MR imaging have illustrated degeneration in paraspinal musculature after such exposures, which lead to worse clinical results (2).

Posterior lumbar interbody fusion and percutaneous fixation use small-muscle splitting technique to place the screws and cage under C arm images. The appropriate implantation of this hardware at various levels is made possible by approaches, which prevent the more severe trauma associated with an open approach. In this article, we focus on a method for inserting pedicle screws percutaneously and offer instructions for setting up images, using a surgical approach, and inserting pedicle screws (3).

This technique is one of mini-invasive techniques which include the first is use of microsurgical techniques using of the microscope and also more recently of the endoscope for visualization and magnification of the intraoperative field, the second is the access strategies for the spine using percutaneous mini-open and tubular dilator access strategies to avoid muscle injury. The third is the imaging/navigation technology (4). The final which is illustrated in this paper is a special instrumentation and implants like Specific retractor systems to provide small incision. The treatment method at the target site itself should not be impacted by the size of the access corridor, and these approaches must be effective in a manner similar to macro-surgical operations (5).

This study aimed to evaluate outcome of using percutaneous fixation and interbody fusion in management of symptomatic spondylolithesis.

Patient and method

This prospective study was conducted at orthopedic departments at Benha university hospital and governmental hospitals in Cairo from January 2021 to January 2022 involved 10 patients with low grade spondylolithesis that underwent

posterior interbody fusion and percutaneous fixation of one level or two level of degenerative lumbar spine. Ten case series including 2 males and 8 females, nine patients were L5-S1 and one was L4-L5.7 patients were grade 2 Spondylolithesis and 3 patients were grade 3 Spondylolithesis with follow up including three month, six month, and one year.

Inclusion criteria were low grade isthmic spondylolisthesis with low back pain and/or leg pain not responding for the medical treatment for at least 6 months (rest, drugs in the form of analgesic drugs, muscle relaxant, physiotherapy and lumbosacral support).

Exclusion criteria were high grade spondylolisthesis, presence of severe osteoporosis, spinal tumor pathologies, spinal trauma and spinal infections.

Methods:

I. Clinically

Assessment in terms of Oswestry Disability Index (ODI) and visual analogue scale scores (VAS) for back and leg pain were evaluated before operation. Demographic data such as: sex, age, smoking, occupation and BMI were collected from all the patients. General examination to assess the patient general fitness for operation.

Local examination to the lumbar spine to evaluate any deformity, scar of previous operation, tender points and degree of movement of the lumbar spine was done to all patients.

Neurological examination of motor, sensory and reflexes of both upper and lower limbs was performed to all the patients .

Following the procedures outlined earlier, ten patients had 1- or 2-level posterior interbody fusion and percutaneous pedicular fixation for symptomatic spondylolisthesis. Participants had preoperative, 3-month, 6-month, and 1-year follow-up VAS and ODI assessment. There were 8 female patients and 2 male patients in this study, with a mean age of 60. This method consists of percutaneous pedicular fixation, posterolateral interbody fusion, and decompression of neural components at the location of the spondylolisthesis. For all patients, the average length of surgery was 140 minutes (range 90–300 minutes). 95 ml was the average amount of blood lost across all cases (range 50–60 ml). These patients stayed in hospital for an average of 2.44 days (range 1–5 days). Preoperatively, the mean pain score using the VAS assessment was 7.9 (range 6-10); at three months, it was 2.9 (range 0-7); and at twelve months, it was 2.1 (range 0-4At the 12-month mark, posterior interbody fusion is characterized as the absence of lucency surrounding the

hardware, with bone graft consolidation bridging the fused level's transverse processes on PA and lateral x-ray images, and without obvious mobility on flexion and extension lumbar spine X-ray images. All patients who have this procedure experience effective interbody fusion. In just one instance where the L-4 and L-5 did not fuse, the patient did not require revision surgery for their clinical complaints.

II. Technique percutaneous fixation and posterior interbody fusion

After taking general anesthesia, the patient is placed prone on a radiolucent table. Skin preparation is done. The C-arm is prepared and true PA views of the levels of interest are performed. When obtaining these views, proper alignment of the C-arm is very important to gain a successful technique. PA image of a vertebra should show a flat superior endplate with no “double endplate shadow” visible. The pedicles should be just below the superior endplate and the spinous processes should be centered between the pedicles.

Doing MIS-TLIF:

We used the quadrant system of Medtronic; we began with the non-symptomatic side with insertion of two percutaneous guide wire into the pedicles and then performing facetectomy, then insertion of pedicular screws rod insertion and doing distraction on that side. On the symptomatic side, we do not place the screws until preparing of the disc space and the TLIF cage is inserted; otherwise, the screw heads might hinder our access to the disk space, so we insert the guide wires in the pedicles, doing facetectomy of the facet, preparing the disc space and cage insertion, after that insertion of the screws and doing compression on the screws bilateral.

B. Bony Decompression

A guide wire was used to define the site of the facet joint by using a lateral fluoroscopy to confirm the level. Sequential tubular dilators were put until the final expandable retractor was placed with the flexible retractor arm between the K-wires. Bipolar or monopolar cautery was used to coagulate the soft-tissue inside the edges of the retractor. The lateral border of the facet, with special focus on the pars, was identified. The facet joint was resected with osteotomes and a hemi-laminotomy was performed with Kerrison rongeurs.

C. Exposure of the Thecal Sac and Disc Space

The ligamentum flavum was removed to see the thecal sac, the traversing nerve root

D. Discectomy, Correction and Interbody Fusion

The disc was opened and the discectomy is done using curettes and pituitary rongeurs. Nerve-root retractor was placed medially to carefully retract the traversing nerve root and thecal sac to see the disc. Careful removal of the cartilaginous endplates to obtain the largest surface area available for bony fusion was done. Sequentially disc space shavers were used to help the discectomy. Blunt dilators were used to distract collapsed disc spaces and to gain the intervertebral height.

This combined maneuver of ipsilateral disc space dilatation and contralateral screw distraction with reduction as needed has been effective at correction of the slippage and restoring the lordosis in cases of low-grade spondylolisthesis cases .

The interbody cage and the disc space were then packed with bone graft. The insertion of the cage was done under guidance of AP and Lateral image to make sure that the cage rest just behind the anterior longitudinal ligament in the center of the disc to decrease the risk of subsidence through the softer central cancellous endplate.

The working portal was then carefully removed to avoid removal of the guide wires from within the pedicles. The pedicle screws with their sleeves were placed over them and inserted into the vertebral bodies. The rod is then inserted after performing the needed lordosis in it. When both rods were placed, bilateral compression was done over the screws to increases the lordosis and improve overall sagittal balance, before final locking of the set screws. AP and lateral radiographs are done. The MIS pedicle screw sleeves were then all removed, leaving the final construct in place. The wounds were irrigated and closed in layers. At this point, reinjection of local anesthetic (ie, 0.25% Marcaine with 1:200,000 epinephrine) into the skin and underlying muscle will decrease post-operative pain was done to all patients .

Statistical analysis.

All data were analyzed SPSS 18.0 for windows (USA) Continuous variables were expressed as the mean ± SD & median (range), and the categorical variables were expressed as a number and percentage. Repeated measurements ANOVA test was used to compare more than two groups of normally distributed variables.

Research ethics committee: M S.10.3.2021

Results

Patient demographics were shown in **Table 1**.

The VAS for back decreased significantly from 8.42 preoperative to 1.79 and VAS for leg pain from 7.46 to 1at final follow up. The ODI also decreased significantly from severe disability (52.21%) to mild disability (15.71%) and continued like that till our final follow up. There was a statistically significant difference in VAS for back pain, leg pain and ODI, $\chi 2(2) = 62.074,66.792$ and 59.484 respectively, $p<0.001$. Post hoc analysis with Wilcoxon signed-rank tests was conducted. There were significant differences between the preoperative and postoperative VAS for back pain, leg pain and ODI. However, there was no statistically significant difference in changes after 6 months postoperatively which was maintained till final follow up ($Z= -1.806$, $p= 0.071$) for back pain, ($Z= -2.337$, $p= 0.019$) for leg pain and ($Z= -0.241$, $p= 0.809$) for the ODI. **Figure 1**

Regarding radiological outcome: Significant statistical differences ($p< 0.05$) were found between preoperative and postoperative measurements for each parameter. The pelvic incidence did not change throughout the follow up as it is a constant value. The mean Pelvic Tilt decreased significantly from 21.07(8-32.9) to 19.84 (12.3-27). The Sacral Slope also increased significantly from 40.72(25.9-54) to 41.98 (32.1-52.9). The lumbar lordosis increased significantly also from 57.23 (40-73) to 57.94 (47.4-68.90). The slip percentage showed significant reduction from 23.13% to 6.48%. There was a statistically significant difference in L1-L4, $\chi 2(2) = 12.602$, $p = <0.001$. Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at $p < 0.008$. Regarding the L4-S1 lordosis, there was a statistically significant difference, $\chi 2(2) = 12.602$, $p = <0.001$. Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at $p < 0.008$. There were significant differences between the preoperative and both 6 months and final postoperative. Regarding the segmental lordosis, there was a statistically significant difference, $\chi 2(2) = 49.034$, $p = <0.001$. **Table 2**

Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied to the previous radiological results, resulting in a significance level set at $p < 0.008$. **Table 3**

In the study the SVA showed a change from the range of (-65.1 to 110) to (-29 to 35) mm. there was 2 patients with SVA more than 50mm pre-operative. All patients were balanced post-operative.

The fusion rate was about 95.8% with only one case showed non-union. **Table 4**

Table 1: Patient demographics

	The operated patients (N=10)	
	No.	**%**
Sex		
• Male	2	20 %
• Female	8	80 %
Age (years)		
• Mean ± SD	40.42 ± 4.65	
• Median (Range)	42 (32 – 47)	
BMI (kg/m^2)		
• Mean ± SD	28.12 ± 7.82	
• Median (Range)	29 (19 – 44)	
Comorbidity		
• HCV	9	90%
• Absent		
• Present (HCV)	1	10%
• Smoking		
• Smoker	0	0 %
• Non-smoker	10	100 %
Follow up period (months)		
• Mean ± SD	19.42 ± 6.26	
• Median (Range)	16 (13 – 24)	
Level of spondylolithesis		
• L5-S1	9	90 %
• L4-L5	1	10 %
SDSG		
• SDSG grade 2	7	70 %
• SDSG grade 3	3	30 %

Table 2: Radiological outcome measures

	preoperative (N=10)	6 weeks (N=10)	Postoperative 6months (N=10)	final (N=10)	Test	p-value(Sig.)
PI						
Mean ± SD	61.83±8.77	61.78±8.88	61.61±8.90	61.61±8.99	1.654*	0.196
Median (Range)	62.15(50.2-77.9)	62.15(50.3-78)	62.15(49.7-78.1)	62.15(49-78.1)		(NS)
PT						
Mean ± SD	21.07±8.74	26.42±5.99	21.12±5.20	19.84±4.20	36.620•	<0.001
Median (Range)	20.6(8-32.9)	28.35(15-35)	19.25(13-31.5)	19.45(12.3-27)		(HS)
SS						
Mean ± SD	40.72±7.03	35.62±6.01	40.69±5.73	41.98±6.19	22.410*	<0.001
Median (Range)	40.70(25.9-54)	34.90(23-45.9)	40.90(32.2-50)	42.6(32.1-52.9)		(HS)
LL						
Mean ± SD	57.23±9.23	54.87±6.88	57.78±7.20	57.94±6.83	7.213•	0.047
Median (Range)	56.35(40-73)	57.15(42-65.1)	58(44.9-68.4)	59(47.4-68.9)		(S)
Slip (%)						
Mean ± SD	23.13±8.09	5.13±3.97	5.98±4.71	6.48±5.58	53.276•	<0.001
Median (Range)	23.5(5-42)	4(1-16)	4.5(1.8-18)	4.5(1.8-23)		(HS)

* Repeated measures ANOVA test, • Friedman's test, p< 0.05 is significant and Sig.: Significance.

	Baseline (N=10)	Post-operative 6 weeks (N=10)	6 months (N=10)	final (N=10)	Test•	p-value (Sig.)
Mis-match						
Mean ± SD	10.33±7.48	7.67±4.90	6.31±2.85	6.21±2.85	4.513•	0.211 (NS)
Median (Range)	8.55(0-23.7)	7.20(0.1-18)	7.30(1-9.9)	7.10(0.1-9.9)		
L1-L4						
Mean ± SD	30.10±8.02	27.41±7.21	27.88±7.29	27.65±6.56	12.443•	0.006
Median (Range)	30.80(15.6-41)	28.95(13.7-34.2)	28.80(15.7-41.1)	27.50(17.2-38.6)		(S)
L4-S1						
Mean ± SD	35.07±6.47	37.55±5.09	37.92±4.2	38.88±4.24	12.602*	<0.001
Median (Range)	34.15(23.8-45)	38(27.9-44.5)	38.50(32-45)	39.15(31.2-45.2)		(HS)
Segmental lordosis						
Mean ± SD	16.30±6.52	22.23±7.10	21.12±6.50	20.70±6.49	49.034•	<0.001
Median (Range)	14.40(4.2-30)	19(14.8-38.9)	19.40(13.9-38)	19.10(13.9-37)		(HS)

•Friedman's test, *repeated measures ANOVA test p< 0.05 is

Table 3: post-hoc test of radiological parameters

	Preop. Vs 6 weeks	Preop. Vs 6 months	Preop. Vs final	6 weeks Vs final	6weeks Vs 6 months	6months Vs final
			L1-L4			
Test‡	-2.430	-1.629	-1.515	-0.314	-0.685	-0.763
p-value (Sig.)	0.015 (NS)	0.103 (NS)	0.130 (NS)	0.753 (NS)	0.493(NS)	0.44(NS)
			L4-S1			
Test‡	-2.903	-2.802	-3.330	-2.100	-0.375	-0.963
p-value (Sig.)	0.004 (NS)	0.005 (S)	0.001 (S)	0.036 (NS)	1.000(NS)	0.020(NS)
			Seg. lordosis			
Test‡	-4.288	-3.830	-3.687	-3.250	-3.619	-3.367[c]
p-value (Sig.)	<0.001(HS)	<0.001(HS)	<0.001(HS)	<0.001 (HS)	<0.001 (HS)	0.002(S)

‡ Wilcoxon singed ranks test, p< 0.008is significant and Sig.: Significance.

Table 4: SVA change (mm)

	Baseline	6weeks	6months	final
Minimum	-65.10	-30	-29	-29
Maximum	110	38	35	35

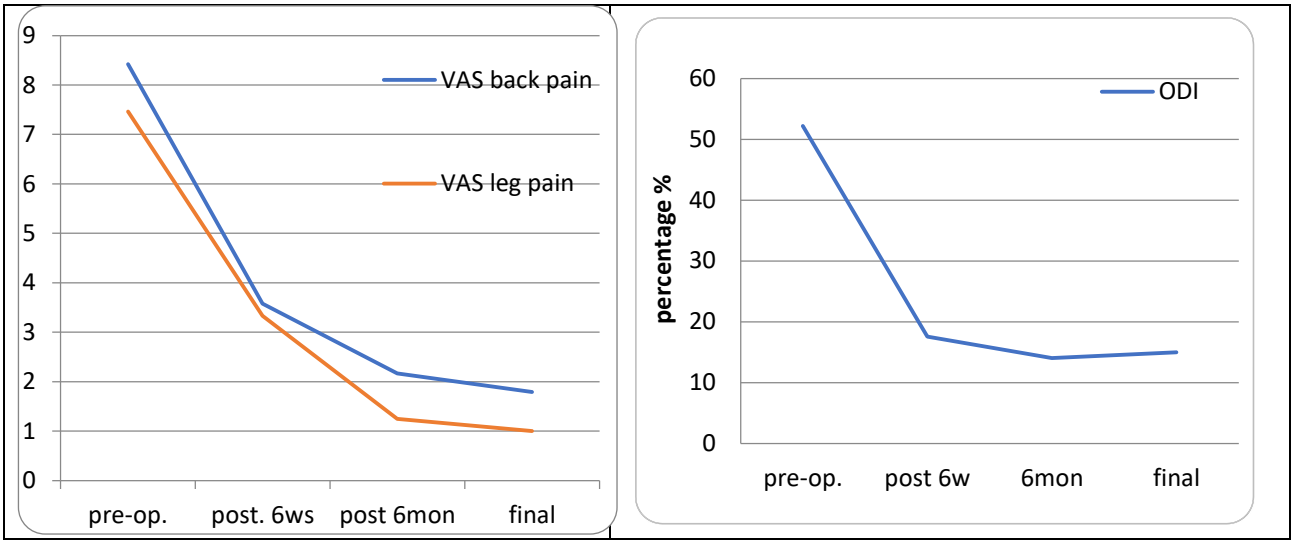
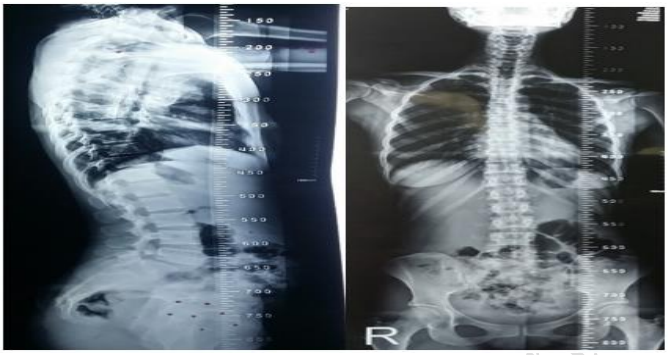


Figure 1: Changes in VAS for back and leg painon the left figure and Changes of ODI on the right figure.

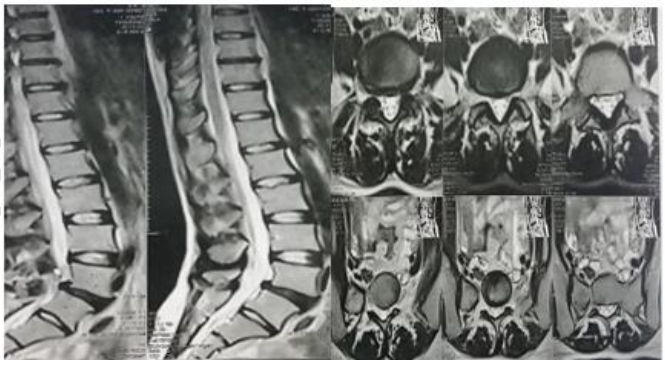
Case presentation

I. Preoperative data: Female patient 44 years, C/O: Back pain 2 years duration, radiating to left lower limb. Painful flexion and extension of the back with. paresthesia on the left side was expressed. Past history: negative

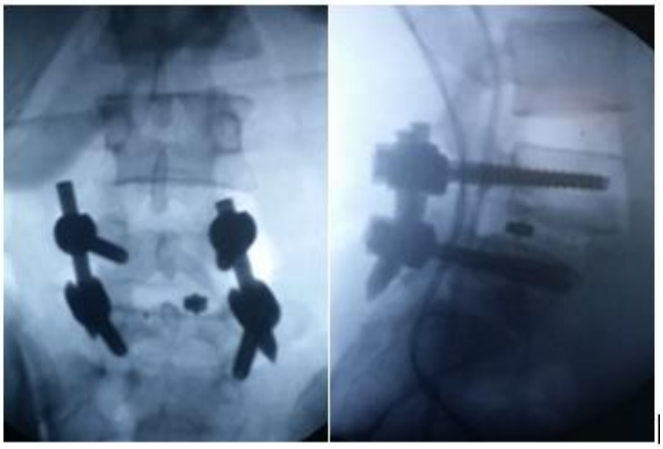
Imaging study: Plain x-rays revealed L5-S1 isthmic spondylolisthesis grade 2. MRI revealed L5-S1 isthmic spondylolisthesis with pseudo disc prolapse. CT revealed L5-S1fusion follow up. Failed conservative treatment for 6 months. Preoperative VAS leg pain = 6, Preoperative VAS back pain = 8, ODI = 44%. II. Operative data: Posterolateral Lumbar Interbody fusion L5-S1 augmented by posterior spinal fixation with percutaneous screws. Postoperative data after 6 months: Postoperative VAS leg pain= 1, Postoperative VAS back pain= 3, ODI = 12%, III. Postoperative data at the last follow up: Postoperative VAS leg pain= 1, postoperative VAS back pain= 3, ODI = 12%. **Figure 2**



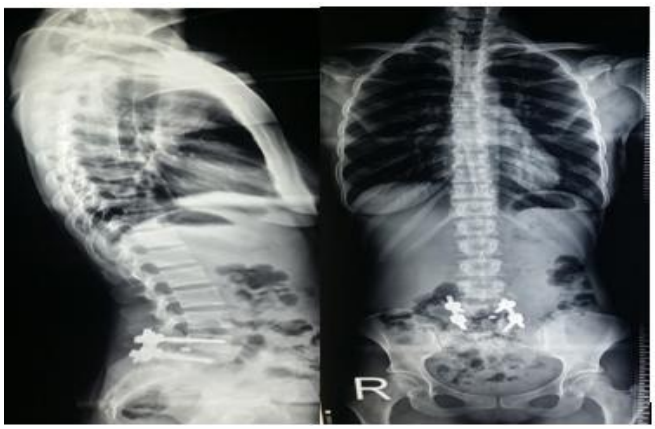
AP & Lat. View of the patient with L5-S1 isthmic spondylolisthesis



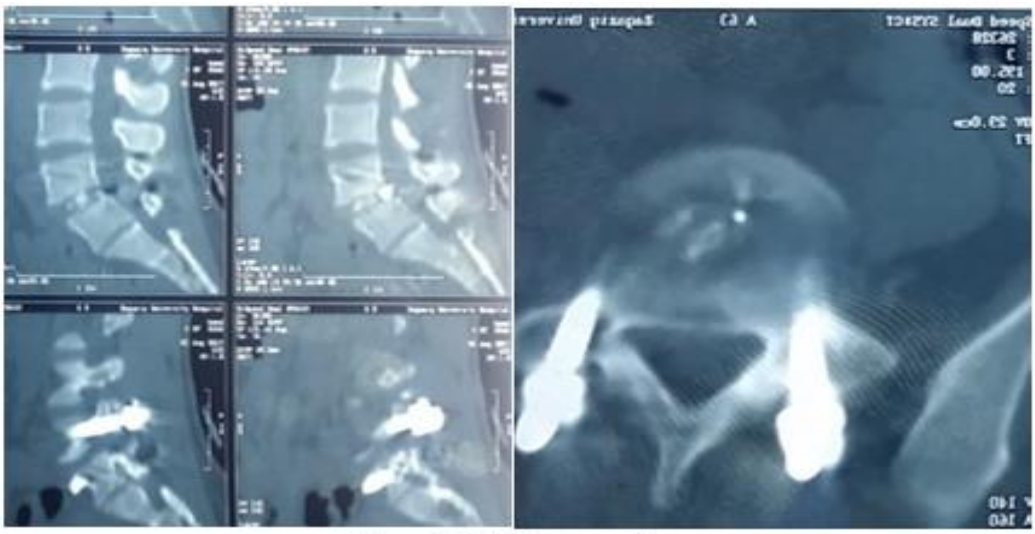
MRI of the patient



C-Arm photo intra-operative AP and Lateral view



Final follow up x ray AP and Lateral view with cage migration backward



CT scanning

Figure 2: Female patient 44 years, C/O: Back pain 2 years duration. Radiating to left lower limb. Painful flexion and extension of the back. Paresthesia on the left side. Past history: negative, Imaging study: Plain x-rays revealed L5-S1 isthmic spondylolisthesis grade 2. MRI revealed L5-S1 isthmic spondylolisthesis with pseudo disc prolapse. CT revealed L5-S1fusion follow up.

Discussion

Isthmic spondylolisthesis is found in nearly 6% of the population and occurs most often at L5–S1 level (85 and 95%) and then L4–L5 level (5–15%). It is associated with the stress or fatigue fracture of pars and is characterized by the loss of disc height across the affected segment with translational and rotational instability in the sagittal plane, where the spine-pelvic articulation is disrupted in those patients (6).

The cumulative effects of radiation exposure on the operating team and the patient should not be under-estimated. A study suggested that with greater surgical experience, radiation exposure time could be reduced. This explains the increased radiation exposure in early cases and its reduction in late cases. The mean radiation exposure was about (3.79±0.83 min) which was more than that reported in the literature in MISS. But as experience was gained with time, exposure time decreased in the last cases and was comparable to most of the literature (7).

The improvement of the learning curve in MIS-TLIF also had a great effect on the operative time. It had been reported that with the increase in experience the operative time decrease. The mean operative time in this study was (110±13.39 min) which was less than what was reported by a study (8), which examined the difference in operative time in relation to the learning curve in 64 patients, of which 30 patients underwent MIS-TLIF. The overall mean operative time in his study was (127±25 min), and the surgical time was longer for MIS-TLIF. However, there was a statistically significant

difference in operative time between the initial 15 MIS-TLIF patients (mean time, 192 min) and the latter 15 patients (mean time, 108 min). This confirm that with MIS-TLIF the operative time decreases with the increase in experience and that MIS-TLIF requires a learning curve, which was demonstrated in the current study.

The early improvement in clinical outcomes was in favor of MIS-TLIF, as evidenced by the early ambulation, early return to work and reduced hospital stay. Spondylolisthesis reduction may help to re-establish a correct balance of the spinal column by correcting the lumbosacral kyphosis, resulting in a lower risk of degenerative evolution of adjacent segments and improving the altered biomechanics of the spine. Moreover, the reduction maneuver may improve the healing process, placing bony segment in a more anatomical position. Indeed, reducing the lumbosacral kyphosis by decreasing the slip angle, may improve the biomechanical environment for a fusion by converting the shear forces to compressive forces (9).

A study found on 214 (L5-S1) spondylolisthesis patients that the pelvic incidence (PI) (71.6±7.7) was significantly greater than the control subjects in patients without spondylolisthesis (10). Additionally, a study demonstrated that patients with lumbosacral low-grade spondylolisthesis had significantly higher PI (average 65.5) than the control population (average 51.9). These results were the same in our study, where the average value for PI was 61.83(50.20-77.90) (11).

In this study, there was a significant decrease in the PT value from 21.07 to 19.84in the final follow-up. Keeping in mind that the patients showed an initial increase of PT post-operatively that improved after 6 weeks, this may be due to the relieve of hamstring spasm as a compensation for the slippage. The improvement and maintenance of PT in physiological ranges might be one of the reasons why MIS-TLIF could improve the low back pain in Isthmic spondylolisthesis. Also, **SS** increased from 40.72 to 41.98. This finding confirms the results previously reported by a trial which found that PT decreased from 41 to 30, and SS increased significantly (from 36 to 47) with surgery (12).

A trial studied the correlations between spinopelvic parameters and health-related quality of life (HRQoL) scores in patients with adult spinal deformity. The authors stated that PT, PI-LL and SVA can guide the prediction of the disability and guide patient assessment for good decision making. He stated that patients with values of PT of 22° or more, SVA of 47 mm or more, and PI − LL 11° or more will have a negative impact on the HRQoL (13).

A trail encourages surgeons to carefully achieve sagittal spino-pelvic alignment and

avoid post-operative PI-LL mismatch in particular. That is called that pelvic tilt reduction should increase the adaptive capacities of patients with lumbar pathologies. Moreover, its reduction is associated with less postoperative pain; this explains the improvement of ODI and VAS scores with PT reduction in our study (14).

The complication rate with TLIF is controversial. The most common complications are wound infection, nerve root injury, and durotomy. Cage migration, screw misplacement and implant failure were also reported. A study retrospectively examined 74 obese patients (BMI > 30 kg/m^2) and showed significantly higher complication rates with Open-TLIF than those with MIS-TLIF (15).

Conclusion

For the treatment of spondylolisthesis, percutaneous pedicular fixation and interbody fusion is a promising alternative. The majority of surgeons prefer less invasive techniques, using minimally invasive pedicle screw systems, due to the morbidity caused by excessive paraspinal muscle stripping. Historically, cases undergoing this technique have had well to excellent results compared to cases undergoing standard surgical procedure. Smaller incisions, less muscle stripping, less blood loss, and superior fusion rates and results are key benefits of percutaneous methods. Long radiation exposure times and longer operating hours than with open surgery are disadvantages of this procedure. Once the tips and tricks of the operation are understood, it provides a less stressful, more aesthetically pleasing, and equally effective approach to standard fusion.

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