

Clinical and Radiological Outcomes in Patients of Isthmic Spondylolisthesis Treated with Transforaminal Lumbar Interbody Fusion - A Retrospective Cohort Study, New Delhi

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ABSTRACT

BACKGROUND

Operative treatment and fusion for isthmic spondylolisthesis can be achieved by various fusion techniques such as posterolateral fusion (PLF), anterior lumbar interbody fusion (ALIF), posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF) and circumferential fusion. The purpose of this study is to evaluate the clinical outcome and radiological correction achieved after TLIF and assess the correlation between them if any.

METHODS

This is a retrospective cohort study analysing 30 cases of adult isthmic spondylolisthesis who failed conservative treatment and were then treated with transforaminal lumbar interbody fusion between 2011 and 2013. The clinical follow-up was done with the modified Oswestry disability index (ODI) and visual pain analogue score (VPAS). For the radiological follow-up radiographs were taken and several radiographic parameters were noted and analysed.

RESULTS

The mean of the Oswestry disability index scores in all patients decreased from 67.73 to 13.1 at final follow up. Similarly, visual pain analogue score reduced from mean 8.43 to 1.76 at final follow up. The average anterolisthesis was significantly reduced from the preoperative $27.1 \pm 14\%$ to $7.1 \pm 5\%$ at final follow-up radiographs ($P < 0.001$). Segmental lordosis increased from a mean of 11.5 degrees to 15.7 degrees. The difference in slip angle was significant from preoperative -4.87 ± 4.8 degrees and -7.23 ± 4.63 degrees on the initial postoperative and -7.2 ± 4.57 degrees at final follow-up radiographs ($P = 0.14$ and 0.13 respectively).

CONCLUSIONS

Thus, adult isthmic spondylolisthesis can be safely and effectively treated by TLIF with significant clinical relief and decrease in disability. TLIF procedure in isthmic spondylolisthesis is capable of reducing the sagittal translation and restoring disc height. Also, sagittal alignment and lordosis can be restored to a large extent.

KEYWORDS

Spondylolisthesis, Pelvic Incidence, Sagittal Balance, TLIF

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BACKGROUND

Spondylolisthesis is defined as anterior slippage of cephalad segment of the spine on the caudal segment. Spondylolysis is described as a defect in pars interarticularis without slippage which may lead to slippage and isthmic spondylolisthesis. Isthmic spondylolisthesis has a multifactorial origin; mechanical, hereditary, and hormonal factors are all believed to play a role. Both gravitational and postural forces acting upon the upright spine, place stress on the pars interarticularis, making it susceptible to injury.^{1,2,3} Patients with spondylolysis and low-grade spondylolisthesis demonstrate increased pelvic incidence than in a normal population. Patients with high pelvic incidence and sacral slope would have increase shear stress at lumbosacral junction causing more tension on the pars interarticularis. An association between global sagittal alignment of the spine and pelvis and spondylolysis and spondylolisthesis exists.^{4,5,6} The angular relationships expressed as the slip angle are the best predictors of instability or progression of the spondylolisthesis deformity. The natural history of spondylolysis and spondylolisthesis in general is benign.^{7,8} Non-operative treatment is successful in the majority of cases with surgical intervention being reserved for those in whom symptoms are refractory to these measures. Minority of patients in whom non-operative treatment fails, require surgical intervention.

Gill et al.⁹ first described decompression surgery without fusion in 1955. Decompressions with fusion have shown superior results as compared to decompression alone. The operative options are many from posterior in situ fusion with or without instrumentation, posterior decompression, partial reduction, instrumentation and fusion, posterior decompression, complete reduction and fusion, posterior lumbar interbody fusion (PLIF), anterior lumbar interbody fusion (ALIF), combine anterior and posterior approach and transforaminal lumbar interbody fusion (TLIF).

The goals of surgery are

1. Fusion between two vertebrae,
2. Decompression of neural structures,
3. Reconstitution of disc space,
4. Prevention of further progression of disease,
5. Restoration of sagittal balance.^{10,11}

Reduction of listhesis can increase susceptibility to iatrogenic neurologic dysfunction.⁷ Advocates of reduction propose that reducing the slip angle decreases post-surgery progression rates, followed by a more normal sagittal alignment with improvements in gait and cosmetic appearance. A partial reduction will theoretically correct slip angle enough to decrease slippage and minimize the risk of developing neurologic deficits.^{12,13}

The purpose of our study is to determine whether TLIF is an effective and safe procedure in treatment of spondylolisthesis.

Objectives

1. To evaluate clinical outcomes in patients of isthmic spondylolisthesis treated with transforaminal lumbar interbody fusion (TLIF) by ODI and VAS.

2. To assess the radiological correction after surgery among study subjects.
3. To evaluate the correlation of radiological correction with clinical outcomes.

METHODS

This is a retrospective cohort study. For sample size calculation, we had defined a relative difference of 50 percent from pre-operative to post-operative values using a two tailed alpha value (0.05) and beta value (0.2). A minimum of 30 cases were sufficient to detect a significant difference. All cases treated within the study period matching the inclusion criteria were selected. Between 2011 and 2013, 30 adult patients with isthmic spondylolisthesis who failed conservative treatment and underwent transforaminal interbody fusion at the listhetic level at Sir Gangaram Hospital, New Delhi were enrolled in the study group after taking informed consent.

Inclusion Criteria

1. Age of patient 18 - 70 years. Either sex.
2. All patients of isthmic spondylolisthesis all grades treated with transforaminal lumbar interbody fusion (TLIF).

Exclusion Criteria

1. Age of patient not between 18 -70 years.
2. Patients of spondylolisthesis other than isthmic spondylolisthesis.
3. Patients of isthmic spondylolisthesis treated with surgery other than transforaminal lumbar interbody fusion (TLIF).

Clinical and radiological parameters were observed and evaluated by an independent observer. Pre-operative and follow-up were performed clinically using the modified Oswestry disability index (ODI). Modified Oswestry disability index (ODI) consists of a questionnaire of 10 questions of daily living activities and the responses as functional limitation arising in those due to the back pain. Each response has a score of 0 to 5 which is then added and a total score is calculated indicating the degree of disability due to pain. In addition, the patients had to assess their pain on a 10 cm visual pain analogue scale between 0 (no pain) and 10 (maximal pain). Before the operation informed consent was taken, radiographs of the lumbar spine were performed in antero-posterior (AP) and lateral views, also an erect whole spine radiograph was taken in AP and lateral view. Magnetic resonance imaging was done in all cases.

Patient positioning was standard prone position with linear bolsters over chest and abdomen with intra-operative sequential compression devices to both the legs. A standard transforaminal approach was used. Bilateral subperiosteal dissection was done. The side which the patient had maximum symptoms was chosen for approaching the disc. Inferior facet of that side was removed. Following this,

portion of superior facet was excised to get access into the disc space. The exiting and traversing nerve root were identified and protected with cotton patties. A nearly complete discectomy was performed and the endplates were scraped but without complete decortications. Distraction was then done from the opposite side and spacers were introduced to check the exact size. Thereafter locally harvested bone graft was placed in the disc space. Bean shaped cage with autologous local bone graft was then introduced in the disc space. In an attempt to enhance physiologic lordosis of the reduced motion segment, the interbody cages were preferentially positioned in the anterior third of the disc space. After this, compression was achieved and final fixation was done. Reduction achieved in process of distraction was accepted and no further attempts for reduction were done. Surgical wounds were closed in layers over a suction drain which was removed after 48 hours.

Post-operative outcome scoring was done at 6 weeks and 6 months and maximum follow up at 18 months. The radiographic follow-up was conducted at 6 weeks and around 6 months. The minimum follow-up was 6 months. On lateral radiographs, the following parameters were noted and record was kept

1. Increase in disc space height ratio.
2. Reduction of anterolisthesis.
3. Correction in slip angle.
4. Change in sacral inclination.
5. Change in segmental lordosis.
6. Pelvic incidence

For variations in the pre-operative and post-operative films, disc space height and the anterolisthesis of the vertebrae were measured as a ratio with respect to the superior end plate diameter of the cephalad vertebrae to minimize magnification error as described by Kwon et al.¹⁴ Disc height was measured from the distance between the inferior end plate of cephalad vertebrae and superior end plate of caudal vertebrae at the midpoint of the superior end plate of caudal vertebrae. Anterolisthesis was graded in percentage according to Meyer ding grading. Slip angle was measured between lines drawn along the superior end plate of rostral vertebral body cutting the line perpendicular to a line drawn along the posterior body of S1. Angle of sacral inclination was measured as angle subtended by tangent to posterior border of S1 and vertical axis. Segmental lordosis was measured by the Cobb method in which intersecting perpendicular lines from the superior surface of the superior end vertebra and from the inferior surface of the inferior end vertebra are drawn and the angle of deviation of these perpendicular lines from a straight line is the angle of the curve also known as Cobb's angle.¹⁵ Pelvic incidence^{15,6} is the angle subtended between a line drawn from the centre of femoral head to the midpoint of sacral end plate. The sacral end plate is defined by the line segment down from poster superior corner of the sacrum and the anterior tip of S1 vertebrae. For situations when the femoral head are not superimposed, the centre of each femoral head are marked and the centre of the line joining the two head is taken as

reference point to calculate the pelvic incidence. Sacral slope^{5,6} is calculated as the angle subtended by the line tangent to superior end plate of S1 vertebrae and the horizontal. Pelvic tilt^{5,6} is the angle between the vertical axis and the line joining the centre of femoral head and the midpoint of sacral end plate (Figure 1 and 2). The obtained data was compiled and comparison were performed and results were obtained.

Statistical Analysis

Statistical testing was conducted with the statistical package for the social science system version SPSS 17.0. Continuous variables were presented as mean \pm SD, and categorical variables were presented as absolute numbers and percentage. The comparison of normally distributed continuous variables from pre intervention to post intervention was done using paired t test. Nominal categorical data between the groups were compared using chi-squared test or Fisher's exact test as appropriate. For non-normal data, Wilcoxon signed rank test was used. Spearman correlation was also used among various variables. For all statistical tests, a P value less than 0.05 will be taken to indicate a significant difference.

RESULTS

There were 23 women and 7 men with an average age of 51.9 years (SD \pm 11.604). 15 patients had isthmic spondylolisthesis of the L5 over S1, 13 had isthmic spondylolisthesis identified at L4 – L5 and 2 had isthmic spondylolisthesis identified at L3 – L4. 13 patients had grade I slip, 15 had grade II slip and 2 patients had grade III slip according to Meyer ding grading.

The average anterolisthesis was 27.1 ± 14 % preoperatively, 7 ± 4.8 % on first postoperative follow up, and 7.1 ± 5 % at final follow-up. The average forward translation was significantly reduced from the pre-operative and the final follow-up radiographs ($P < 0.001$) (Table 1). The average disc height ratio normalized to the superior endplate diameter was 0.18 ± 0.06 preoperatively, 0.33 ± 0.054 on first postoperative follow up, and 0.3 ± 0.055 at final follow-up. The average disc height was significantly larger than the pre-operative measure ($P < 0.001$). The final follow-up measures of disc height were less than first post-operative measure and the difference was found to be significant.

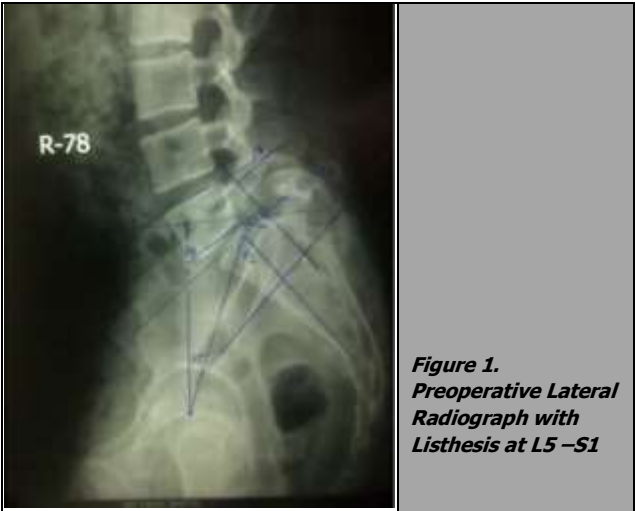
Average slip angle pre-operatively was -4.87 ± 4.8 deg and -7.23 ± 4.63 deg on the initial post-operative and -7.2 ± 4.57 deg at final follow-up radiographs, a trend toward an average increase in lordosis was observed. The difference in slip angle was significant from pre-operative to initial post-operative and final post-operative measurement ($P = 0.14$ and 0.13 respectively) (Table 1). No significant difference was found between the two post-operative measurements. The average segmental lordosis had increased as measured on the pre-operative radiographs and final follow up radiographs and the difference was significant ($P < 0.001$). The average segmental lordosis, was 11.5 ± 7 deg

preoperatively, 15.3 ± 6.8 deg on first post-operative follow up, and 15.7 ± 6.2 deg at final follow-up (Table 1). The post-operative and final follow-up measures of segmental lordosis were not significantly different. Average sacral inclination from the pre-operative measure to the initial post-operative and final follow-up measures were not significantly different ($P < 0.56$). Pelvic incidence as already known is constant for an individual. On comparing pelvic incidence with the grades of slip we have noted an increase in the percentage of slip with higher values of pelvic incidence. The correlation between the grade of slip and pelvic incidence was thus found to be significant. ($r = 0.4$)

	Average Percentage of Slippage (Mean \pm SD)	Disc Height Normalized to Superior End Plate Diameter. (Mean \pm SD)	Slip Angle (Degrees). (Mean \pm SD)	Segmental Lordosis. (Mean \pm SD)
Pre-operative.	27.1 \pm 14	0.18 \pm 0.06	-4.87 \pm 4.8	11.5 \pm 7
Initial Post-operative.	7 \pm 4.8	0.33 \pm 0.054	-7.23 \pm 4.63	15.3 \pm 6.8
P value	$P < 0.001^*$	$P < 0.001^*$	$P = 0.14$	$P < 0.001^*$
Final Post-operative.	7.1 \pm 5	0.3 \pm 0.055	-7.2 \pm 4.57	15.7 \pm 6.2
P value	$P < 0.001^*$	$P < 0.001^*$	$P = 0.13$	$P < 0.001^*$

Table 1. Results of Radiological Assessment

*indicates statistically significant P value



Clinical outcome was taken by modified ODI and VPAS. Average maximum follow-up being 16 months, with a maximum clinical follow-up of 24 months. Maximum patients experienced relief of pre-operative symptoms, 2 reported increase in pain and disability as noted by increase in VPAS and ODI scores. For the remaining patients, mean ODI and VPAS score had significant improvement. The average pre-operative ODI scores were 67.73 which had reduced to 24.6 on first post-operative visit and further reduced to 17.4 on second post-operative follow-up and further slight reduction to 13.1 at final-follow up. The score was significantly reduced in the initial follow-up ($P < 0.001$), with further significant reduction at the second follow-up ($P < 0.001$). There was no further significant reduction in the pain and disability after 6 months as noticed at maximum follow-up. Mean VPAS pre-operatively were 8.43, which had reduced on initial follow-up to 2.77 and on second post-operative follow-up was 2.23, a further slight reduction in pain score and decrease in disability was reported at the maximum available follow-up and the mean scores at maximum follow-up were 1.76

Improvement in ODI and VPAS were compared with the number of corrections achieved in radiological parameters. We have found that decrease in pain as measured by VPAS to be highly correlated to improvements in ODI scores.

Correlation of improvement in ODI scores with

- Reduction of grade of slip ($r = 0.857$),
- Increase in segmental lordosis ($r = 0.599$) were not found to be significant.

On comparing correlation of VPAS scores with

- Reduction of grade of slip ($r = 0.860$),
- Increase in segmental lordosis ($r = 0.162$).

we have found no significant correlation between clinical outcome with respect to reduction of listhesis or the increase in segmental lordosis.

DISCUSSION

Spectrum of treatment of isthmic spondylolisthesis ranges from conservative management in form of restricted activities, physiotherapy to various modalities of surgical treatment. In a prospective randomized study, Moller and Hedlund¹⁶ studied 111 adult patients and compared conservative and operative management of spondylolisthesis. The group treated with PSF had statistically significant reductions in disability and greater pain relief as compared to the group treated with non-operative management. The literature does support operative intervention in the patient with spondylolisthesis who has failed conservative management.

The surgical reduction of spondylolisthesis was first described in 1936 by Jenkins.¹⁷ Suggested indications for reduction include back pain, leg pain, slip progression, and the inability to stand upright with the knees fully extended.¹⁸ Cited advantages of instrumented reduction include normalization of spine biomechanics, improvements in posture, increased fusion rates, a reduction of lumbosacral

kyphosis, and or the restoration of lordosis, at the involved motion segment. These advantages come with high rate of surgically related complications with reduction procedures that have previously been described in the literature.¹⁶ Which operative technique results best balances the benefits of operative reduction with the risks has been controversial and remains debatable. Analysis of literature regarding surgical management of adult isthmic spondylolisthesis suggests that combined approaches that include an anterior interbody fusion with a posterolateral fusion provide superior results to isolated anterior or posterior procedures alone. Other studies have demonstrated both clinical and radiographic benefits of adding interbody support to posterior instrumentation constructs when reducing listhetic vertebrae. Which operative technique results best balances the benefits of operative reduction with the attendant risks has been and remains debatable. The transforaminal lumbar interbody fusion (TLIF) technique described by Harms and Jeszenszky¹⁹ seems to be an ideal procedure for isthmic spondylolisthesis.

Kwon et al.¹⁴ in his study reported radiological outcome in adult patients with low-grade isthmic spondylolisthesis treated with TLIF. The authors found reduction in anterolisthesis and increase in disc height with no significant change in slip angle. Clinical outcomes were not analysed. The ability to reduce forward translation, increase disc height, and restore sagittal alignment with the TLIF procedure has been analysed in our study. We have noticed similar results in our series of 30 adult patients with isthmic spondylolisthesis in relation to reduction of anterolisthesis and restoration of disc height. We have also noticed and increase in the slip angle post-operatively showing a trend towards increasing lordosis at the listhetic segment. A similar increase in slip angle was also noted in their studies but it was not statistically significant. We have also compared the segmental lordosis at the affected vertebrae and found an increase in the segmental lordosis which is consistent with our other findings.

Nitin et al.²⁰ had done a similar study in 13 patients in which radiological parameters and clinical outcome was measured in patients of isthmic spondylolisthesis managed with TLIF. They had found a significant decrease in grade of slip and improvement in disc height ratio with changes in slip angle that were not significant. Clinical outcome was measured by Odom's grading with excellent results in 3 good in 8 and fair in 1. We have used modified Oswestry disability index and visual pain analogue score for comparison of pain and disability. We have found a significant difference in pain and disability among 28 patients with a poor outcome in 2 patients. The average ODI scores reduce from 67.7 pre-operatively to 13.3 at final maximum follow-up. The average VPAS reduced from 8.4 to 1.76 at final follow-up. One of the patients who had a haemorrhagic stroke was bed ridden, the other patient continued to have significant disabling back pain but was relieved of leg pain. Also 1 of our patients had screw breakage after one year of operation and was re-operated but the outcome after both surgeries was good.

There has been a recent interest in the association of sacral morphology in development or at least in the risk of progression of spondylolisthesis. We were able to observe a

correlation between the pelvic incidence angle and the percentage of slip. We found that pelvic incidence was on the higher sides in individual who had higher grades of slip. These finding is consistent with the observations made by Roussouly et al. Labelle et al. and Mac-thoing et al. in their studies.^{4,5,6,21,10,22,23}

Clinical outcomes were not significantly found to be correlated to the correction in all radiological parameters. This suggests that the amount of reduction or decrease in grade of slip, or correction in lordosis does not have much effect on the relief of symptoms. Out of the 30 patients, in a total of 24 patients with sufficient follow-up of more than a year, 22 had radiographic evidence of solid bony union at the time of final radiographic examination. Solid union was defined as no evidence of hardware loosening or failure and bridging trabeculae spanning the interbody space. In the remaining 6 patients the maximum follow-up was less than a year at the time final analysis.

CONCLUSIONS

The results of our series clearly demonstrate the ability of this technique to correct deformity, evident by the statistically significant ($P < 0.001$) reduction of anterolisthesis. Also, significant improvements in disc height ($P < 0.001$) were identified. We have also noticed a statistically significant increase in slip angle ($P = 0.13$) and increase in segmental lordosis ($P < 0.001$) suggesting the correction of the kyphosis at the listhetic vertebrae and hence improvement in the sagittal alignment. We have also found a significant decrease in pain and disability with an improvement in the quality of life as measured by ODI and VPAS scores. Transforaminal lumbar interbody fusion (TLIF) is a safe and effective treatment for isthmic spondylolisthesis. Reduction in anterolisthesis and restoration of disc height can be effectively achieved with this procedure. Also, the sagittal alignment and segmental lordosis can be restored to some extent. Clinical improvement is not related to the reduction of deformity. An excellent to good clinical outcome and solid bony fusion can be expected in patients treated with TLIF with relatively low risk of complication.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.

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