Posterior Fixation with Transforaminal Lumbar Interbody Fusion for Single Level Isthmic and Degenerative Lumbar Spondylolisthesis in Adults Causes Less Complication

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ABSTRACT

BACKGROUND
Lumbar interbody fusion has long been considered the "gold standard" technique for surgical treatment of adult spondylolisthesis. Superior results have subsequently been reported with interbody fusion with cages and posterior instrumentation. The objectives of the study were to determine the functional outcome after one year following surgery and evaluate the fusion rate.

METHODS
In this prospective, non-randomised study, 26 patients (average age 37.1 yrs) with isthmic spondylolisthesis (IS), who suffered for an average of 12.08 months and 14 patients with degenerative spondylolisthesis (DS) (average age 58.6 yrs), who suffered for 13.2 months on average were collected in out-patient department basis. They underwent an interbody fusion with cages with posterior instrumentation (TLIF or PLIF). Clinical outcome was measured using VAS and Oswestry Disability Index. Foraminal dimensions and disc heights were measured in standard digital radiographs. Radiographic fusion was confirmed with CT scans at 1 year.

RESULTS
In the IS group, a mean spondylolisthesis slip of 33.3 % was reduced to 6.7 % at 1 year. Vertical foraminal distance(C) was improved from 11.2 mm to 12.0 mm. The fusion rate was 78.2 % with TLIF and 66.7 % with PLIF. In the DS group, a mean spondylolisthesis slip of 32.7 % was reduced to 7.4 % at 1 year. C distance was improved from 11.8 mm to 13.2 mm. The fusion rate was 66.7 % with TLIF and 100 % with PLIF. The mean ODI scores at baseline and 1 year, were improved from 48 to 9.8 and from 49.5 to 18.4 in the IS and DS groups respectively. VAS score was improved from 6.4 to 0.8 and from 6.6 to 2.5 in IS and DS groups respectively.

CONCLUSIONS
Interbody fusion for low-grade spondylolisthesis requiring reduction results in excellent to good functional outcomes in 90 % of patients with a good fusion rate. TLIF procedure of spinal fusion requires less time, causes less bleeding, and has less chance of damage to the neural structures than PLIF.

KEY WORDS
Spondylolisthesis, Isthmic, Degenerative, VAS
BACKGROUND

Spondylolisthesis is defined as the forward slippage (subluxation) of a vertebra on the one below. Wilks, Newman, and Macnab (1976), first classified spondylolisthesis into dysplastic, isthmic (where there is a defect in a portion of the vertebra called the pars interarticularis), degenerative (due to arthritic changes in the joints of the vertebrae due to cartilage degeneration), pathological & traumatic variety.[1]

Marchetti and Bartolozzi (1997) reclassified that into developmental and acquired forms for the feasibility of prognosis and response to surgery.[2] Meyerding's (1932) radiological grading system is based on the percentage of slippage of the vertebra.[3] This classification shows good prognostic value & also guides treatment procedures. DeWald (1981) recommended a modification of the Newman system to better define the anterior roll of L5.[4] In symptomatic patients with a P.I. defect, direct repair of the pars defect is generally considered after a period of conservative treatment. The principle of repair of the pseudoarthrosis is the same as any long bone: debridement of the defect and autologous bone grafting with compression of the fracture site is done during the reduction and fixation procedure. Kalucho M (1997) described better results in follow-up with patients having pars defect where the fusion of the defect was achieved by bone grafting along with pedicle screws and rod fixation. The extra stability of the vertebrae is provided by the inter-body fusion.[5-9]

Traditionally the surgical management of the degenerative spondylolisthesis is laminectomy and decompression alone. Herkowitz and Kurz (1991) published better outcomes and less chance of recurrence of slippage and instability found in those patients, who received arthrodesis along with decompression together.[10] An alternative method of reconstructing the anterior column is via posterior lumbar interbody fusion. The original technique of posterior lumbar interbody fusion was described by Cloward R(1953).[11] It was again modified by some surgeons like Lerat et al.(1996).[12] In 1990, Brantigan et al.(1996) proposed a new surgical technique using inter-somatic carbon cages, which has given safe and reproducible results.[13]

The transforaminal posterior lumbar interbody fusion (TLIF) technique developed by Dr Harms involves a transforaminal approach to the anterior interspace, though being a useful alternative to the PLIF, acute effects of both the procedures and long term clinical outcomes are quite comparable.[14] Most surgeons now either use TLIF or PLIF techniques according to their expertise. The minimally invasive lateral transsposa approach to the lumbar and thoracic spine, also known as extreme lateral interbody fusion (XLIF) or direct lateral interbody fusion (DLIF) was first described in 2001.[14-16] This technique has become an increasingly popular approach for achieving interbody fusion. The reported advantages include minimally invasive access to the spine, less blood loss compared to open procedures, decreased operative times, shorter hospital stays, and less postoperative pain. Even after much advancement in operative procedures for spondylolisthesis, the ideal surgical treatment of spondylolisthesis remains controversial. Devkota et al. (2011) analyzed a total of 72 patients with different types of spondylolisthesis.[17-20] These patients were having a different kind of spondylolisthesis and they showed that posterior lumbar interbody fusion (PLIF) was one of the most effective and reliable techniques for the management of spondylolisthesis.

Steven R, Koreckij TD and many authors suggest that stand-alone cage insertion has some degree of slip reduction and restoration of disc height.[21-25]

However, compared with stand-alone cage insertion, additional posterior fixation provides better segmental alignment improvement in terms of slip reduction and segmental lordosis in TLIF procedures in the treatment of lumbar degenerative spondylolisthesis.[26-30]

METHODS

This is a prospective, non-randomised interventional study. Patients who had presented with symptomatic spondylolisthesis at the spine and orthopaedics outpatient department in Vivekananda Institute of Medical Sciences, Kolkata and fulfilled the inclusion criteria were included in this study. The patients were from various parts of West Bengal, especially from Kolkata and surrounding districts. They mainly belonged to the urban community.

Sample Size & Sample Technique

The sample size in this study population is 40. We have studied the previous years’ OPD registers to evaluate the trend of spondylolisthesis patients in OPD. After analyzing the numbers and the trend of patient inflow, we have calculated the sample size.

Data Collection Technique and Tools

We have collected all the clinical and radiological parameters with the help of pre-set questionnaire and validated measurements in the radiographs. We measured clinical outcomes by using the VAS score and ODI score.[16-18] We measured all radiological parameters using X-rays of L-S spine standing AP and Lateral views and CT scan.

Data Analysis

SPSS version 20 software was used for data analysis. Categorical variables were expressed as several patients and the percentage of patients and compared across the 2 groups using Pearson’s chi-square test for independence of attributes.

Continuous variables were checked for normality using Shapiro–Wilk and Kolmogorov-Smirnov. Since most of the parameters were not normally distributed, non-parametric tests were applied. Continuous variables were expressed as mean ± standard deviation and compared across the 2 groups using the Mann-Whitney U test.

Comparisons between pre-operative and post-operative values for each parameter for both the groups were done separately using Wilcoxon Signed Ranks Test.

Correlation among the change in different parameters between pre-operative and post-operative values for both the
groups separately were captured using Kendall’s Method of correlation and a test of significance of the correlation was used to capture the significance of the correlation.

**RESULTS**

This study included 40 patients from the out-patient department of Vivekananda Institute of Medical Sciences. There were 26 patients (average=37.1 yrs; age range 16-48 years) with isthmic spondylolisthesis (IS) and 14 patients (average=58.6 yrs; age range 50-66 years) with degenerative spondylolisthesis (DS). In the IS group, the level of listhesis was more common at L5/S1 (22 patients) and L4/5 (4 patients) whereas in the DS group, 12 patients were having listhesis at L5/S1 and, the other 2 were at L4/5. Most patients had major complaints of low back pain and/or leg pain and in higher grades of spondylolisthesis, complained of instability. Features of radiculopathy and low back pain caused restriction of daily activities. Incidence of neurogenic claudication was less in the case of an isthmic variety of spondylolisthesis, due to relative decompression as caused by pars break.

Among these patients in the isthmic group, 10 patients presented with only back pain and the rest 16 had both back and leg pain. The ratio was 5: 9 in case of degenerative variety.

7 patients (27 %) had grade I listhesis, 14 (54 %) had grade II and 5 patients (19 %) had grade III spondylolisthesis in an isthmic group. Similarly, in the degenerative group the no. of patients was 3 (21 %), 8 (54 %) and 3 (21 %) respectively.

These patients were treated with conservative therapy for at least 6 months. In IS group, they had suffered for an average of 12.1 months (range: 6 to 21 months) and in the DS group, the mean period of conservative treatment was found to be 13.2 months (range: 6 to 21 months).

On admission, a questionnaire containing VAS & ODI was filled by the patient under the supervision of a resident.

In the operation room, all patients were positioned prone. After a midline incision and complete bony exposure, transverse processes were exposed. The decompressive procedure was done through a laminectomy, medial facetectomy and extensive foraminotomy. Then after pedicle screw fixation, all patients underwent interbody fusion using identical pedicle screw and rod instrumentation (MB-Medtronic Sofomor Danek) and interbody cages (TLIF/PLIF-Capstone/Crescent-Medtronic Sofomor Danek) introduced through standard posterior or transforaminal route. An autologous bone graft from the spinous process was used for fusion.

23 patients in the IS group underwent decompression, transforminal interbody fusion (TLIF) with pedicle screw system (posteriorlateral fusion) and the rest 3 had posterior lumbar interbody fusion (PLIF) with pedicle screw system (posteriorlateral fusion). 12 patients in the DS group underwent TLIF with pedicle screw system (posteriorlateral fusion) and 2 had PLIF with pedicle screw system (posteriorlateral fusion).

![Table 1. Chart Showing a Correlation Between Clinical and Radiological Parameters in IS and DS Group](https://example.com/table1.png)

<table>
<thead>
<tr>
<th>Radiological Parameters</th>
<th>Statistical Analysis</th>
<th>Change in ODI</th>
<th>Change in VAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Lissilethsis distance (mm)</td>
<td>Correlation Coefficient</td>
<td>0.040</td>
<td>0.339</td>
</tr>
<tr>
<td>Change in Lissilethsis %</td>
<td>Correlation Coefficient</td>
<td>-0.058</td>
<td>0.183</td>
</tr>
<tr>
<td>Change in Anterior disc height (mm)</td>
<td>Correlation Coefficient</td>
<td>-0.445</td>
<td>0.234</td>
</tr>
<tr>
<td>Change in Posterior disc height (mm)</td>
<td>Correlation Coefficient</td>
<td>-0.892</td>
<td>0.137</td>
</tr>
<tr>
<td>Change in C distance (mm)</td>
<td>Correlation Coefficient</td>
<td>0.359</td>
<td>0.420</td>
</tr>
<tr>
<td>Change in F diameter (mm)</td>
<td>Correlation Coefficient</td>
<td>-0.221</td>
<td>-0.331</td>
</tr>
</tbody>
</table>

**Complications**

Perioperative dural tear was noticed in 2 patients in the DS group. On table, dural repair was done with 5-0 Prolene and reinforced with fat graft. Both of them were kept in the prone position for the first 48 hours. No postoperative headache or CSF leakage was observed.

2 patients in IS group and 2 patients in the DS group (all were operated on with PLIF) had temporary unilateral numbness in the limbs which recovered within an average of 6 weeks.

**Clinical & Radiological Outcome**

Radiographs and clinical outcome scores were analyzed at baseline, at 6 weeks and 1 year after surgery. All patients had visual analogue scores (VAS) and Oswestry Disability Index (ODI) recorded at a fixed point of time. Foraminal dimensions and disc heights were measured in digital radiographs. These changes in the radiographic parameters were correlated with the VAS and ODI Radiographic fusion was confirmed with CT scans at one year.

In the IS group, a mean spondylolisthesis slip of 33.3% was reduced to 6% at 6 weeks and a loss of reduction to 6.7% at 1 year. Anterior disc height had improved from 9.7 mm (range 8 to 12) to 11.7 mm (range 10 to 14). Posterior disc height had risen from 4.4 mm (range 3 to 6) to 5.8 mm (range 4.5 to 7). C distance was improved from 11.2 mm (range 9 to 14) to 12.4 mm (range 9 to 16). The F diameter had improved.

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from 18.5 mm (range 14 to 21.5) to 20.0 mm (range 16 to 23). The fusion rate was 66.7 % with PLIF and 78.2 % with TLIF. Whereas in the DS group, a mean spondylolisthesis slip of 32.7 % was reduced to 7 % at 6 weeks and a loss of reduction to 7.4 % at 1 year. The anterior disc height was improved from 9.8 mm (range 8 to 12 mm) to 11.9 mm (range 10 to 14 mm). Posterior disc height had risen from 4.6 mm (range 4 to 6) to 5.9 mm (range 5.5 to 7). C distance was improved from 11.9 mm (range 9.5 to 13) to 13.2 mm (range 10 to 16). The F diameter had improved from 12.6 mm (range 12.6 to 15.5) to 14.9 mm (range 13 to 17). The fusion rate was 66.7 % with PLIF and 100 % with TLIF.

At the baseline and one year postoperative, the mean ODI scores were 48 (range 34-58) and 9.8 (range 4-22) respectively. In the DS group, the mean ODI scores were 49.5 (range 40-62) and 18.4 (range 10-22) respectively in the baseline and at one year postoperative. VAS score was improved from 6.4 (range 5 to 7.5) to 0.9 (range 0 to 2) in IS group and from 6.6 (range 5 to 8) to 2.5 (range 1 to 4) in the DS group.

### DISCUSSION

#### Radiological Outcome

Yan et al. (2008) showed that the average percentage of spondylolisthesis was 30.1 % (range 22.9 to 37.3) in PLIF and 31.4 % (range 23.1 to 39.7) in TLIF pre-operatively and 8.1 % (range 5.3 to 10.9) and 8.2 % (range 5.6 to 10.8) on the final follow-up at one year respectively. In the PLIF group, the average preoperative disc height was 6.8 mm (range 4.5 to 9.1) which improved to 11.24 mm (range 10 to 12.24) at final follow up. The foraminal diameter was also improved from 14.2 mm (range 9.9 to 15.9) to 18.1 mm (range 16.3 to 19.9) at the final follow up. Similarly in the TLIF group, the average preoperative disc height was improved from 6.7 mm (range 5.0 to 8.4) to 11.3 mm (range 9.9 to 12.7) at 2-year follow up. The foraminal diameter was also improved from 14.1 mm (range 12.3 to 15.9) preoperatively to 18.2 mm (range 16.5 to 19.9) at the final follow-up.

Femke Hagenmaier et al. (2013) showed a mean listhesis of 10.6 mm (range 6.3 to 14.9) which was reduced to a mean of 8.1 mm (range 6.0 to 11.0) after 1 year. Average foraminal diameter significantly reduced from 21.1 mm (range 17.8 to 24.4 mm) preoperatively to 19.3 mm (range 15.2 to 23.4) and 19.0 mm (range 14.7 to 23.3) at 6 weeks and one year, respectively (P < 0.001). No significant changes in anterior or posterior disc height were encountered, whereas average distance C decreased from 14.3 mm (range 11.2 to 17.4) preoperatively to 13.1 mm (range 9.6 to 16.6) and 13.0 mm (range 9.3 to 16.7).

The above two studies are showing two different outcomes. Yan et al. (2008) showed significant improvement in the disc height, foraminal dimensions and the slip reduction. In contrast, Femke Hagenmaier et al. (2013) showed no change in disc height but decreased foraminal dimensions. This difference in outcome is due to the different surgical procedures in the two studies i.e. Yan et al. (2008) had performed TLIF or PLIF along with posterolateral fusion, which improved the neural foraminal dimensions but the other study performed only posterolateral fusion.

#### Clinical Outcome

Ziad M Audat et al. (2011) had shown at the last follow-up evaluation at one year, that the mean ODI had decreased from the preoperative value of 50 to 4 (P < 0.005) in IS group (P < 0.005) and from 52 to 15 in DS group.\(^6\)

Yan et al. (2008) showed that the mean pain index (VAS) had improved from 7.08 (range 5.95 to 8.21) to 2.84 (range 1.95 to 3.73) (P < 0.001) in PLIF patients and improved from 7.18 (range 6.09 to 8.27) to 2.84 (range 1.93 to 3.75) (P < 0.001) in TLIF patients.\(^21\)

Femke Hagenmaier et al. (2013) suggested that both the VAS for leg and ODI improved significantly at both follow-ups after surgery (P < 0.001). The preoperative VAS for leg pain decreased from a median of 69.0 points (range 2.0-98.0) to 7.5 points (range 0.0-82.0) and 5.5 points (range 0.0-93.0) at 6 weeks and one year, respectively. The ODI improved from a preoperative score of 44.4 (range 8.9-73.3) to a median of 37.8 (range 0.0-84.4) and 11.1 (range 0.0-77.8) at 6 weeks and 1 year, respectively.

Zagra et al. (2009) have shown an improvement in the mean preoperative VAS of 6.2 (range 5-8) for back pain and 5.5 (range 4-7) for leg pain to a mean VAS back pain of 1.3 and the mean VAS leg pain of 0.7.\(^27\)

In our study, in the IS group, the baseline and at one year postoperative, the mean ODI scores were 48 (range 34-58) and 9.8 (range 4-22) respectively. In the DS group, at the baseline and one year postoperative, the mean ODI scores were 49.5 (range 40-62) and 18.4 (range 10-22) respectively. In IS group, the VAS score was improved from 6.4 (range 5 to 7.5) to 0.9 (range 0 to 2), whereas in the DS group, VAS score was improved from 6.6 (range 5 to 8) to 2.5 (range 1 to 4).

Compared with the previous studies, the patients from this series had a similar clinical outcome.

#### CT Evidence of Fusion

Femke Hagenmaier et al. (2013) had shown in 46 patients (64 %) that the one-year CT scan revealed bony fusion and a

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non-union or doubtful fusion in 26 patients (36%). The latter consisted of 19 non-union and 7 doubtful fusion patients.

Benli IT et al. (2006) had operated on 41 patients with degenerative spondylolisthesis, 21 patients with TLIF and 20 patients with PLIF. Most of the patients, 17 from group I and 19 from subgroup II, had solid fusion after two years.31

Yan et al. (2008) had shown all patients achieving spinal fusion with no cases of cage extrusion at the end of 2 years of follow-up.29

In our study, in the IS group, the fusion rate was 66.7% with PLIF and 100% with TLIF at the end of one year. In the DS group, the fusion rate was 66.7% with PLIF and 78.2% with TLIF.

Correlation of Clinical Outcome & Radiological Improvement

In the current study, an interbody fusion along with reduction and decompression was performed in all cases. The maintenance of structural integrity of the interbody cages allowed one to hypothesize that the clinical outcome may have a relationship with the radiological outcome. This hypothesis failed after the results suggested that there was only a moderate correlation between the VAS score and spondylolisthesis reduction distance (r=0.46) and C diameter (vertical foraminal dimension) (r=0.44). All other parameters did not correlate with VAS or ODI scores. This could mean that there may be a moderate improvement in pain in patients who undergo a reduction of slip. Overall, the reduction of slips does not influence the clinical outcome scores of ODI. Therefore, no correlation could be established statistically between the slip reduction and clinical outcome. This supports the views of a previous study by Femke Hagenmaier et al. (2013).

CONCLUSIONS

Surgical decompression followed by interbody fusion and posterolateral fusion is recommended for symptomatic in isthmic as well as degenerative low-grade lumbar spondylolisthesis.

Both the types of posterior approaches for spinal fusion i.e. TLIF and PLIF procedures produce almost similar statistically significant clinical outcomes and maintain radiographic reduction of slip.

TLIF procedure of spinal fusion requires less time, causes less bleeding and has less chance of damage to the neural structures than PLIF.

The reduction of spondylolisthesis is appealing since it improves the radiological parameters as well as improves the pain esp. leg pain in symptomatic patients.

There is no correlation between clinical outcomes esp. ODI and radiological parameters of slip reduction.

Recommendations

The functional outcomes of TLIF in patients with isthmic spondylolisthesis were significantly better relative to degenerative ones. Therefore, we recommend TLIF as a safe and effective treatment for both types and to prevent neural complications of PLIF.

We recommend TLIF with posterolateral fusion with pedicle screw fixation and bone grafting for low-grade lumbar spondylolisthesis (for both isthmic and degenerative types).

REFERENCES


