Transforaminal Lumbar Interbody Fusion (TLIF) for Revision of Failed Posterolateral Spinal Fusion

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Abstract

Introduction: Posterolateral fusion is commonly used for managing many degenerative spinal problems. Reported pseudarthrosis rate varies between 5-56%. Several approaches have been used for revision, including re-grafting, ALIF, PLIF, and TLIF.

Purpose: The aim of this work is to evaluate the radiographic and functional results of TLIF for the management of symptomatic lumbar pseudarthrosis and to compare between revising posterolateral fusion by re-grafting and by TLIF using autogenous iliac bone graft.

Study Design: This is prospective comparative study

Methods: Forty-three patients with symptomatic pseudarthrosis after previous posterolateral fusion were revised using TLIF technique and were prospectively evaluated and followed for a minimum of 2 years (Range=2-5.6 years). The clinical and radiological outcomes were recorded and compared to a different group of another 21 patients treated earlier with refreshing the same fusion bed and re-grafting. Only autogenous iliac grafts were used in all cases. VAS and Oswestry Disability Index (ODI) were used for the clinical assessment. Radiographs were obtained at 2, 6, 12 and 24 months.

Results: There was no significant difference in the mean amount of blood loss between both groups. However, the mean operative time for TLIF was significantly shorter than the revision PLF. At 2 years follow-up, the TLIF group showed significantly better improvement in the mean VAS score and ODI scores (42 and 43 in TLIF group versus 8 and 21 in the PLF group) and the fusion rate was also significantly higher. Complications included incidental dural tear (2 patients) in the TLIF group that was recognized intraoperatively and successfully repaired, superficial infection (1 patient) in the posterolateral group, and donor site discomfort (2 patients in each group).

Conclusion: The significantly higher success of TLIF for revising pseudarthrosis after posterolateral fusion is attributed to the fact of placing the graft in a wide fresh bed under compression. The approach is relatively easy and safe for the neural tissue because it avoids any fibrosis from previous surgery and its use is therefore encouraged.

(2012ESJ014)

Key Words: Pseudarthrosis, TLIF, Instrumentation, Posterolateral Fusion, PLF, Autograft.
Introduction

Lumbar spine fusion is commonly used for managing many degenerative problems; nevertheless, reported pseudarthrosis rates varied between 5–56% for fusions of the lumbar spine. Nonunion of the spine is difficult to diagnose at an early stage because not all patients are symptomatic. The rate of nonunion increases with increasing the number of fusion levels. Factors contributing to pseudarthrosis include excessive motion at the fusion site, metabolic abnormalities such as osteoporosis, vitamin D deficiency, excessive alcohol use, and malabsorption syndrome, smoking, trauma, infection, insufficient graft material at the time of operation and poor surgical technique. The etiology of most spinal fusion failures, however, is unclear.

Patients may present with localized pain and tenderness at the site of surgery or pain with motion in the affected segments. For symptomatic patients, a thorough evaluation should be conducted, including a search for other causes of pain such as mechanical problems or chronic radiculopathy. Patients who have instability or intractable pain from the nonunion are candidates for surgical intervention.

Diagnosis, however, is a challenge because, currently, there is no diagnostic imaging modality that can detect spinal pseudarthrosis with 100% accuracy. Despite the various techniques described, plain radiography is accurate in only 59-82% of the cases. Surgical exploration, therefore, is considered by many authors to be the gold standard in diagnosing nonunion.

Management and avoidance of lumbar pseudarthrosis are among the most common and challenging tasks faced by reconstructive spine surgeons. Several approaches have been used for revising pseudarthrosis, including posterior fusion with no instrumentation, posterior fusion with instrumentation, and anterior fusion. Reported results of lumbar pseudarthrosis repair are poor. Fusion rates range from 30-70%, with only a 30-50% rate of functional success. Very few reports in the English literature have offered a specific analysis of the results of surgical management for symptomatic lumbar pseudarthrosis. Most of the information available exists in series with multiple causes of failed back surgery reported or with different techniques of pseudarthrosis repair grouped together.

The aim of this study is to evaluate the radiographic and functional the results of transforaminal lumbar interbody fusion (TLIF) for the management of a homogenous group of patients with symptomatic lumbar pseudarthrosis and to compare between revising instrumented posterolateral fusion (PLF) by re-grafting or by TLIF using autogenous iliac bone graft.

Methods

Between January 2000 and December 2009, more than 102 patients with failed fusion surgery for lower lumbar degenerative problems were revised and prospectively followed-up by the authors. Causes of failure included inadequate decompression or recurrence of stenosis, development of pseudarthrosis, implant failure or mal-position, development of infection, adjacent segment degeneration, and or iatrogenic flat-back syndrome. The commonest cause for revision was pseudarthrosis, which was suspected clinically and/or radiographically and confirmed by surgical exploration in 75 symptomatic patients.

Out of the 75 patients with surgically confirmed pseudarthrosis, 64 patients, which constituted the material of this report, had an instrumented posterolateral fusion (PLF) supplemented with internal fixation. The other 11 patients had non-instrumented posterolateral fusion and were excluded from this study. The study protocol was approved by the institutional ethics committee and all patients gave an informed consent.

There were 25 females and 39 males with a mean age at time of revision surgery of 43 years ±12.5. The reason for the index attempt at lumbar arthrodesis was painful isthmic or degenerative spondylolisthesis, painful degenerative instability, and continuing low-back pain after a previous discectomy or decompression. All patients had had iliac crest autograft used during the first surgery.

Detailed history was obtained; particular attention was given to smoking habits and working status. Forty four patients (68.7%) were heavy smokers. The remaining twenty patients (31.3%) were occasional or non-smokers. Twenty one
patients (32.8%) were housewives, 37 patients (57.8%) were manual workers, and 6 patients (9.4%) were retired. Most of the manual workers were self employed; only 6 patients (16.2%) were eligible for workmen’s compensation.

The Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) were used for pain and functional assessment. All patients had persistent severe low back pain that was aggravated by movement, preventing or severely limiting their activity and ability to work. All patients had failed conservative measures and medication. In addition to the back pain, twenty nine (32.8%) patients also suffered from sciatic pain on one or both legs. Physical examination along with a detailed neurologic examination was done. None of the patients suffered from motor weakness or sphincteric disturbance.

Radiographic assessment included standing antero-posterior, lateral, flexion/extension views as well as oblique views. In suspected cases without conclusive findings in x-rays, CT was also used. Radiological findings used for diagnosis of pseudarthrosis included: 1) Bilateral graft resorption, 2) Bilateral pseudarthrosis line across the fusion mass, 3) Radiolucent zones around the screws, 4) Implant breakage, 5) Pulling out of screws and loss of sagittal alignment, 6) detection of motion across the fused segments in dynamic views. Pseudarthrosis was radiologically diagnosed in 56 patients (87.5%). In eight patients (12.5%) with persistent back pain and negative radiological findings, pseudarthrosis was only diagnosed after surgical exploration. Before attempting revision fusion, every effort was made (including a recent MRI) to exclude other causes of failure such as infection, adjacent segment degeneration, or incorrect initial diagnosis.

Revision fusion surgery was performed at a mean of 33.5±5.9 months from the index surgery. The level affected was L3-4 level in 2 patients, at L4-5 level in 25 patients, at L5-S1 level in 34 patients and at L4-5-S1 levels in 3 patients. Two operative techniques were used; Twenty one consecutive patients were revised by PLF and 43 consecutive patients were revised by TLIF using only autograft harvested from the intact iliac crest. The TLIF group included 10 patients who had failed regrafting revision. In all patients, surgery started by documenting the presence of pseudarthrosis. This was done by removing the rods on both sides, confirming strong screw purchase in the vertebrae, and then by applying distraction and compression forces, one could detect movement across the previously fused segment, which is considered a sure sign of pseudarthrosis. Broken or loose screws were replaced by thicker and longer ones before testing for pseudarthrosis. In PLF group, the pseudarthrosis site was then explored and refreshed with sharp curettes and burrs and then ample amount of cancellous autograft chips harvested from the intact iliac crest were added. In TLIF group, the inferior facet and part of the superior facet were excised to reach the interbody disc space, where two pieces of tricortical iliac crest graft as well as cancellous chips were packed inside after doing complete discectomy. All patients were allowed out of bed on the first postoperative day without any external support.

At each follow-up visit, patients were evaluated both clinically and radiographically. VAS and ODI were recorded preoperatively, 2 months postoperatively and at 2 years follow-up. Radiographs were obtained at 2, 6, 12 and 24 months and every year thereafter. Fusions were considered solid when consolidation and/or a trabeculation pattern was seen across the disc/endplate interface in TLIFs or between the transverse processes and across the facet joints in PLFs. Table 1 summarizes the demographic and clinical data of the patients and stratifies them into the two operative groups and Figures 1-2 show 2 illustrative cases.

Statistical analysis of the data was performed using SPSS 17.0 software (SPSS Inc., Chicago, IL). Continuous variables (such as age, body mass index, number of previous back surgeries, duration between fusion and revision, VAS, ODI, blood loss, operative time, and follow-up duration) were compared using a two-sample t-test. Probability values of less than 0.05 were considered to be significant. Grouped variables such as gender, smoking habits, type of work, compensation claim, fusion level, and radiological outcome) were evaluated using a Pearson chi-square test; values of less than 0.05 were considered significant. Statistical evaluation of all the demographic data of patients was performed and showed no statistical difference between the two groups (table 1).
Table 1. Demographic and clinical data of the patients.

<table>
<thead>
<tr>
<th>Operative Technique</th>
<th>TLIF N=43</th>
<th>PLF N=21</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (Male/Female)</td>
<td>26/17</td>
<td>13/8</td>
<td>0.912</td>
</tr>
<tr>
<td>Mean Age/years</td>
<td>43.1 ± 12.7</td>
<td>43.2 ± 12.7</td>
<td>0.955</td>
</tr>
<tr>
<td>Smoking Habits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None (or Occasional)</td>
<td></td>
<td></td>
<td>0.409</td>
</tr>
<tr>
<td>Heavy</td>
<td>12 (27.9%)</td>
<td>8 (38.1%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31 (72.1%)</td>
<td>13 (61.9%)</td>
<td></td>
</tr>
<tr>
<td>Working Status</td>
<td></td>
<td></td>
<td>0.808</td>
</tr>
<tr>
<td>Housewife</td>
<td>13 (30.2%)</td>
<td>8 (38.1%)</td>
<td></td>
</tr>
<tr>
<td>Manual Worker</td>
<td>26 (60.5%)</td>
<td>11 (52.4%)</td>
<td></td>
</tr>
<tr>
<td>Retired</td>
<td>4 (9.3%)</td>
<td>2 (9.5%)</td>
<td></td>
</tr>
<tr>
<td>Workmen’s Compensation Claim</td>
<td></td>
<td></td>
<td>0.833</td>
</tr>
<tr>
<td>Legible</td>
<td>4/26 (15.4%)</td>
<td>2/11 (18.2%)</td>
<td></td>
</tr>
<tr>
<td>Illegible</td>
<td>22/26 (84.6%)</td>
<td>9/11 (81.8%)</td>
<td></td>
</tr>
<tr>
<td>Pseudarthrosis/Revision Level</td>
<td></td>
<td></td>
<td>0.778</td>
</tr>
<tr>
<td>L3-4</td>
<td>2 (4.7%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>L4-5</td>
<td>16 (37.2%)</td>
<td>9 (42.9%)</td>
<td></td>
</tr>
<tr>
<td>L5-S1</td>
<td>23 (53.5%)</td>
<td>11 (52.4%)</td>
<td></td>
</tr>
<tr>
<td>L4-5-S1</td>
<td>2 (4.7%)</td>
<td>1 (4.8%)</td>
<td></td>
</tr>
<tr>
<td>Fusion/Revision fusion interval/months</td>
<td></td>
<td></td>
<td>0.888</td>
</tr>
<tr>
<td></td>
<td>33.6 ± 5.7</td>
<td>33.4 ± 6.4</td>
<td></td>
</tr>
<tr>
<td>Preop. VAS</td>
<td>7.5 ± 1.07</td>
<td>7.3 ± 1.06</td>
<td>0.646</td>
</tr>
<tr>
<td>Preop. ODI score</td>
<td>76.8 ± 8.2</td>
<td>74.6 ± 6.01</td>
<td>0.277</td>
</tr>
</tbody>
</table>

Results

This study involves only those symptomatic patients, who were revised for confirmed pseudarthrosis and who have completed a minimum of 2 years follow-up. The mean follow-up period for the whole group was 4.3 years ± 1.5 years (range, 2-7 years). The mean follow-up duration for the TLIF group was 3.9 ± 1.1 years and for the PLF group was 4.7 ± 1.5 years (P=0.009).

Table 2 summarizes the results. The mean operative time for the TLIF group was 160 ± 30 minutes, significantly shorter (P=0.005) than the mean operative time for the PLF group (182 ± 22 minutes). The mean amount of blood loss was 765 ± 215 ml. for the TLIF and 785 ± 201 ml. for the PLF, with no statistical difference.

Table 2. Outcome difference between the two operative techniques used.

<table>
<thead>
<tr>
<th>Operative Technique</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up Duration</td>
<td></td>
<td>3.94</td>
<td>1.10</td>
<td>0.009</td>
</tr>
<tr>
<td>Operative Time</td>
<td></td>
<td>4.81</td>
<td>1.63</td>
<td>0.005</td>
</tr>
<tr>
<td>Blood Loss</td>
<td></td>
<td>160.23</td>
<td>30.18</td>
<td>0.715</td>
</tr>
<tr>
<td>Postop. VAS</td>
<td></td>
<td>181.90</td>
<td>22.05</td>
<td>0.413</td>
</tr>
<tr>
<td>2 years follow-up VAS</td>
<td></td>
<td>765.12</td>
<td>215.62</td>
<td>0.944</td>
</tr>
<tr>
<td>Postop. ODI</td>
<td></td>
<td>18.93</td>
<td>5.84</td>
<td>0.001</td>
</tr>
<tr>
<td>2 years follow-up ODI</td>
<td></td>
<td>15.02</td>
<td>3.69</td>
<td>0.001</td>
</tr>
</tbody>
</table>

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All patients showed significant improvement of their VAS pain score (2 or more grades) and ODI scores at 2 months follow-up and at 2 years follow-up. The mean preoperative VAS score decreased from 7.4 ± 1 to a mean of 2.39 ± 0.9 at 2 months postoperative follow-up (P=0.001) and was maintained at a mean of 3.3 ± 2.4 at 2 years follow-up (P=0.001). Likewise, the mean preoperative ODI decreased from 76.1 ± 7.6 to a mean of 18.9 ± 6.2 at 2 months postoperative follow-up (P=0.001) and was maintained at 27.3 ± 25.4 at 2 years follow-up (P=0.001). At 2 months follow-up, there was no significant difference in the degree of improvement in VAS (P=0.413) and ODI (P=0.944) between the two operative groups. However, at 2 years follow-up, the TLIF group showed significantly better mean VAS score (P=0.001) and ODI (P=0.001) scores.

A strong positive correlation was found between clinical success and radiologically proven fusion regardless of the operative technique. Forty two patients (97.7%) in the TLIF group achieved solid fusion, while only 8 patients (38.1%) in the PLF group showed solid fusion (P=0.001). The TLIF group included ten patients who had failed regrafting. The remaining 3 pseudarthrosis patients from the PLF group refused any further surgical management. Pseudarthrosis group showed significantly higher mean VAS (P=0.001) and ODI (P=0.001) scores when compared to the fusion group regardless of the fusion technique used.

At 2 years follow-up, 45 patients (90%) of the 50 patients who had achieved solid fusion returned to their pre-disease activity level or work and 5 patients (10%) resumed a lighter work. Out of the 14 patients who developed pseudarthrosis, only 2 (14.2%) patients, one from each operative group, resumed their pre-disease activity level and the remaining patients could not work at all. Ten of them were successfully re-revised by TLIF.

Complications included incidental dural tear (2 patients) in the TLIF group that was recognized intraoperatively and successfully repaired, superficial infection (1 patient) in the posterolateral group, and donor site discomfort (2 patients in each group). Three patients in the TLIF group suffered from temporary nerve root irritation that was successfully managed medically and relieved within 3 weeks. Thirteen patients in the PLF group developed pseudarthrosis.

Figure 1. 1 A 39 years old farmer had had L3-5 PLF 12 months earlier in another hospital. He was suffering from recurrence of severe back pain and bilateral sciatica and inability to work. a. Erect lateral X-ray shows pulling out of screws, loss of alignment suggesting pseudarthrosis. b. & c. Two years follow-up X-rays after TLIF revision of L3-4-5 levels show solid fusion and restoration of normal lumbar lordosis.
Management of lumbar pseudarthrosis begins with its avoidance. If a pseudarthrosis does occur, careful analysis should be given to its cause before considering revision. In revision surgery the surgeon may fix any technical errors of the first procedure, place new, better graft material in the best possible biological environment for fusion, and correct the biomechanical environment to yield the best chance for success.

Reviews of repeat fusion for failed surgery in the lumbar spine show a 50-65% fusion rate and a clinical failure rate as high as 40-70% in patients with symptomatic lumbar pseudarthrosis. Although some authors have contended that a pseudarthrosis after an attempted arthrodesis cannot automatically be assumed to be the principal cause of continuing symptoms and that operative repair is therefore not always mandatory, it is our experience, as well as that of others, that a pseudarthrosis after an attempted arthrodesis in the lumbar spine does result in continuing pain and impairment and that patients may be helped by successful pseudarthrosis repair.

Functional outcome of lumbar pseudarthrosis repair has rarely been reported in the literature. Cleveland et al. reported the results for 119 patients who had had a pseudarthrosis repair. The patients who had a solid fusion were generally free of disability. Rothman et al assessed the results for thirty-nine patients who had had a repair of a pseudarthrosis; thirty-two said that the operation had been worthwhile. In this study, successful revision of symptomatic pseudarthrosis patients was associated with significant pain reduction and functional improvement regardless of the fusion technique used. Ninety percent of the patients who achieved fusion returned to their pre-disease job or activity level, while only 14% of the pseudarthrosis group could return to their job.

The gold standard for spinal fusion graft material remains autologous iliac crest. In accordance with the Wolf law, anterior-column grafts are in a much better fusion environment than those in the posterior lateral transverse process. Anterior (structural) grafts load share with the rest of the construct absorbing up to 80% of the axial load, decrease the flexion strain, which could lead to implant-related loosening, pullout, and ultimately construct failure and pseudarthrosis.

Very few reports in the English literature have offered a specific analysis of the results of surgical management for lumbar pseudarthrosis. The current report is a detailed prospective analysis of treatment outcomes for 64 consecutive patients with symptomatic lumbar pseudarthrosis who were treated by using two different revision fusion techniques. In this difficult patient population (64 patients with previous failure of fusion surgery, 68.8% with a smoking history, 57.8% manual workers), TLIF achieved 97.5% fusion rate and significantly higher improvement in VAS and ODI scores than the PLF, which achieved only 38% fusion rate.

Figure 2. A 43 years old housewife presented 15 months following PLF done in another hospital with recurrence of back pain and marked limitation of her activities. a. & b. X-rays show breakage of S1 screws suggesting pseudarthrosis. c. & d. Two years follow-up X-rays after TLIF revision show solid fusion.
A combined anterior and posterior approach for the management of symptomatic lumbar pseudarthrosis is a viable alternative to posterior fusion alone. In fact, this procedure affords a higher fusion rate based on radiographic assessment. However, anterior surgery is not without risks and complications. In their series of 37 anterior pseudarthrosis repair with the assistance of an access (vascular) surgeon, Albert et al reported three vascular perforations. Additionally, 4 patients experienced wound infections and one patient had an ileus. In young men, the anterior L5–S1 approach may also damage the presacral plexus, leading to retrograde ejaculation.

On the other hand, the use of transforaminal lumbar interbody fusion seems practical and intuitive as it combines the advantages of fusing the virgin anterior column through the same incision necessary to revise the posterior fusion and instrumentation. It can simultaneously address issues of nerve root decompression, spondylolisthesis reduction, and deformity correction. It is cost-effective, and eliminates the need for an additional surgeon to approach the anterior spine. Only a single incision is required, and 360° stabilization can be accomplished. Comparative studies has proved that TLIF is associated with shorter operating time, less blood loss, shorter hospital stay, and lower incidence of complications and achieved higher fusion rate than anteroposterior lumbar fusion.

The radiologic and clinical results reported in this study are superior to those previously reported with the use of instrumented posterolateral pseudarthrosis repairs or with an anterior approach alone. West et al reported a 35% pseudarthrosis rate and 47% clinical failure rate in patients with pre-existing pseudarthrosis in whom posterior fusion and pedicle screw fixation were performed, whereas Lauerman et al reported a 50% pseudarthrosis rate and 50% clinical failure rate in patients in whom a variety of instrumentation systems was used, including some non-instrumented fusions and anterior interbody fusions in the management of lumbar pseudarthrosis. When comparing these series, one should take into account that patient demographic variables and clinical and radiographic assessments may have been different. For example, most patients in this study were high demands manual workers or housewives, yet those who can qualify for workman’s compensation represent a minority.

Most recently, several newer approaches and implants targeting the interbody space have been introduced. These include the mini ALIF, the XLIF (Extreme Lateral Interbody Fusion), DLIF (Direct Lateral Interbody Fusion), and AxiaLIF or TranSL. All of them aim at minimizing the morbidity of the anterior surgery, and achieving better mechanical and biological environment for fusion. All of them, however, share many disadvantages including a steep learning curve, newer and costly implant to acquire, not addressing the posterior pathology or previous instrument related problems through the same approach, and finally, all have been associated with many serious complications as well.

Lumbar pseudarthrosis remains a common and challenging complication in the field of reconstructive spinal surgery. By following fundamental principles, the success rate of repair and stabilization can be maximized. Surgical exploration is the only sure method to confirm or exclude pseudarthrosis in symptomatic patients in the absence of other radiological signs. TLIF is highly successful for revising pseudarthrosis after posterolateral fusion. The approach is relatively easy and safe because it avoids any fibrosis from previous surgery. The reported morbidity of this approach is less than ALIF and its use is therefore encouraged.

**Conclusion**

The significantly higher success of TLIF for revising pseudarthrosis after posterolateral fusion is attributed to the fact of placing the graft in a wide fresh bed under compression. The approach is relatively easy and safe for the neural tissue because it avoids any fibrosis from previous surgery and its use is therefore encouraged.

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