Posterolateral Fusion for Degenerative Spondylolisthesis Performed with Local Bone Graft Alone versus Posterior Iliac Crest Graft and Local Bone versus Beta Tricalcium Phosphate and Local Bone Graft

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ABSTRACT:
INTRODUCTION: There are studies evaluating the clinical efficacy of various bone grafts used for instrumented posterolateral fusions for low grade degenerative spondylolisthesis. Purely radiological studies based on two year follow-up CT scans are scarce. We studied the quality of the fusion mass with three types of bone graft materials.

METHOD: Between Jan 2008 and September 2010, 30 patients (male =12, female=18) with degenerative low grade lumbar spondylolisthesis with stenosis randomly underwent decompressive laminectomy and posterolateral instrumented fusion with either of three graft materials. Each group consisted of 10 patients and were followed for a minimum of two years after which a CT scan was done to evaluate the status of the fusion mass. Lenke et al., classification was used to grade the fusion mass.

RESULT: At the end of two years, no pseudoarthrosis was observed in any of the three groups. In the local bone (LB) graft group; 5 patients (50%) had definite fusion (Lenke A) and 50% had a probable solid fusion mass (Lenke B). 9 patients (90.0%) in the iliac crest group had a Lenke A fusion while 1 patient (10.0%) had a Lenke B fusion. In the beta tri-calcium phosphate group; 6 patients (60.0%) had a Lenke A fusion while 4 patients (40.0%) had Lenke B fusion mass.

CONCLUSION: Although iliac crest bone graft continues to remain as the gold standard in fusion procedures, its usage is limited by the donor site morbidity. However, the chance of radiologically demonstrable dense fusion mass is enhanced with the usage of iliac crest graft. Further, there seems to be no significant advantage using beta tricalcium phosphate as far as the quality of fusion mass is concerned when compared to local bone graft in single level instrumented posterolateral fusion.

KEY WORDS: Spondylolisthesis, Degenerative, Fusion, Grafts, CT scan

INTRODUCTION
Posterolateral lumbar fusion (PLF) is one of the common fusion procedures performed in the lumbar spine. The goal of spinal fusion is to achieve a solid arthrodesis. Spinal arthrodesis is achieved with autograft, allograft or substitutes. Local autograft harvested from the laminectomy site provides a substantial amount of graft for fusion. However, the extent of solid fusion produced by local bone remains doubtful.1

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Graft harvested from the iliac crest is commonly used when the local graft is limited in quantity. Iliac crest graft is considered to be the “gold standard” in lumbar fusion procedures. It provides both the osteogenic factors and scaffold necessary for fusion. The disadvantage of iliac crest graft is the donor site morbidity.2 To obviate the problems of limited local bone graft quantity and donor site morbidity, bone graft substitutes are used in conjunction with the autograft. Hydroxyapatite (HA) and tricalcium phosphate (TCP) bone graft substitutes are widely used for spinal fusion. These are biocompatible and osteo-conductive materials which offer a conducive surface for new bone formation.3 TCP is biodegradable and replaced by bone tissue.4 When combined with
autograft, osteogenic and osteo-inductive properties are also added.

The goal of this study is to compare the radiological rate of fusion using local bone graft alone versus iliac crest graft and local bone versus beta TCP and local bone. Evaluation of the solidity of fusion mass is difficult.\textsuperscript{5,6,7,8,9} A number of radiological techniques have been used to measure the bony fusion. Plain radiographs and CT scans are used frequently in the evaluation of the fusion mass. The intertransverse continuous trabeculated fusion mass bilaterally, less than two degrees of angular motion without any increase in the amount of slip or fresh instability defined a solid fusion.\textsuperscript{10} The presence of instrumentation makes the evaluation of fusion difficult in plain films and hence the necessity of CT scans. Surgical exploration of the fusion mass is the definite method of evaluation of solid arthrodesis and is considered the gold standard. However, it is impractical because of the cost involved and associated morbidity.\textsuperscript{11,12}

**METHOD**

This prospective study was conducted at a neurosciences hospital in West Bengal, India and approved by the Hospital Review Board and Ethics Committee. From January 2008 and September 2010, 30 patients with symptomatic degenerative low grade listhesis with stenosis posted for surgery were randomized into one of the three groups based on the type of graft used for fusion:

- **Group I**: local autograft derived from the spinous process and the laminectomy
- **Group II**: local autograft and posterior iliac crest bone graft
- **Group III**: local autograft combined with beta TCP

Pedicle screw and rod instrumentation from the same company was performed in all the patients and the senior author performed all the surgeries so as to maintain uniformity of the procedure. All patients in this study were followed for a minimum of two years and CT scan was performed at the end of two years.

**INCLUSION CRITERIA**

All the 30 patients had low grade degenerative spondylolisthesis at L4/L5 with spinal stenosis manifested by back pain with neurogenic claudication in the legs. Plain radiographs and MRI were used to confirm the diagnosis. Degenerative changes were manifested as desiccated and decreased disc height, disc herniation, facet hypertrophy, synovial or facetial cyst, hypertrophied ligamentum flavum, osteophytes, angular motion ≥ 5 degrees, translation ≥ 4mm. All the patients included in the study, failed to respond favorably to conservative management for a minimum period of 3 months.

**Exclusion Criteria**

Patients were excluded from the study if they had any or more of the following: high grade spondylolisthesis; lytic, dysplastic, traumatic or pathological listhesis; listhesis other than L4/L5; smokers or consumers of nicotine in any form; history of chronic drug intake especially steroids, chemotherapy and immunosuppressants; previous spine surgery at the involved level or multiple levels; patients with inflammatory spondyloarthopathies and on anti-inflammatory analgesics; active malignancy or receiver of chemotherapy or radiation therapy; local or systemic infections and anesthetically deemed unfit for surgery. History of diseases specific to osteogenesis (Paget’s disease, Osteogenesis Imperfecta, Renal Osteodystrophy) were excluded.

**Surgical Technique**

A midline subperiosteal approach was used to expose the posterior elements of the cranial and caudal respective vertebrae. Pedicle Screws were placed and then decompressive laminectomy, medial facetectomy, foraminotomy and removal of all compressive elements were done. The bone obtained from this procedure was used as the local autograft and placed in the decorticated intertransverse area and lateral aspect of the facet joints. The iliac crest graft was obtained via a separate incision and mixed with the local bone and placed in a similar fashion. For the third group, 5 cc of TCP (chronOS, Synthes) in granule form was mixed with local bone and placed. A suction drain was kept in a sub-fascial plane and removed 48 hours later. For post operative pain relief all patients were prescribed paracetamol intravenously for 48 hours and then orally when required. No external immobilization was used postoperatively.
Radiological Evaluation

All patients were followed up for a minimum two years. At the end of two years, CT evaluation was done to determine the status of fusion. 64 slice CT machine was used and 2mm thickness images were obtained with axial, sagittal, coronal and 3D reconstruction images at the instrumented fusion level. Contiguous reformatted sagittal and coronal images were obtained. In all the sections obliteration of the facet joints, continuous bony trabeculae lateral to the facet joints and in the intertransverse area, new vertebral translation or increase in the listhesis as compared to pre operative picture were evaluated. Also, implant loosening / back out and rod breakage / disengagement were looked for. The fusion pattern was categorized, using the Lenke et al classification system:

Grade A: definitely solid (solid big trabeculated bilateral fusion masses)
Grade B: possibly solid (unilateral large fusion mass with contra-lateral small fusion mass)
Grade C: probably not solid (bilateral small, thin fusion masses with apparent crack)
Grade D: definitely not solid (bilateral graft resorption or fusion mass with obvious bilateral pseudoarthrosis)

The fusion status was evaluated from the CT scan by a senior spine fellow who was blinded to the study.

### Table 1. Patient demographics in the randomized 3 groups according to the type of graft used for fusion.

<table>
<thead>
<tr>
<th>Group</th>
<th>Type of Graft Material</th>
<th>Number of patients</th>
<th>Male/Female</th>
<th>Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>Local Bone Graft</td>
<td>10</td>
<td>3/7</td>
<td>38-73</td>
</tr>
<tr>
<td>Group II</td>
<td>Iliac Crest Bone Graft and local bone</td>
<td>10</td>
<td>6/4</td>
<td>53-70</td>
</tr>
<tr>
<td>Group III</td>
<td>Beta TCP Graft and local bone</td>
<td>10</td>
<td>3/7</td>
<td>40-73</td>
</tr>
</tbody>
</table>

### Table 2. Type of Fusion Mass based on CT scans according to the Lenke classification

<table>
<thead>
<tr>
<th></th>
<th>Lenke A</th>
<th>Lenke B</th>
<th>Lenke C</th>
<th>Lenke D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>5 (50%)</td>
<td>5 (50%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Group II</td>
<td>9 (90%)</td>
<td>1 (10%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Group III</td>
<td>6 (60%)</td>
<td>4 (40%)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 1. Lenke A fusion mass with iliac crest bone graft
Figure 2. Lenke A fusion mass with local bone graft
Figure 3. Lenke A fusion mass with tri calcium
Figure 4. Lenke B fusion mass with iliac crest bone graft
Figure 5. Lenke B fusion mass with local bone graft
RESULT

There were 10 patients in each of the three groups. Local bone graft group had 3 male and 7 female patients, the ICBG and local bone graft group had 6 male and 4 female patients while the beta TCP group had 3 male and 7 female patients. In the local bone graft only group, 5 patients had a definite solid fusion (Lenke A) while the remaining 5 had a possible solid fusion mass. In the posterior iliac crest group, 9 patients had a Lenke A fusion mass while 1 patient had a Lenke B fusion mass. 6 patients in the TCP and local bone graft had a Lenke A fusion and 4 patients had a Lenke B fusion mass. At the end of two years, no pseudoarthrosis was seen in any of the three groups. No implant failure or increase in the amount of slip was observed.

DISCUSSION

The objective of any spinal fusion procedure is a stable and painless spine. The status of a fusion becomes important especially in a patient who has undergone fusion presents with new or recurrent symptoms or progressive spinal deformity. Numerous studies have been described in the literature evaluating the efficacy of different types of graft materials however, purely radiological studies are scant and two year CT scan studies are not present. Through this study, we have presented the first randomized, prospective study comparing the fusion status using the CT scan for three different types of graft materials in single level instrumented posterolateral lumbar fusion.

Lumbar laminectomy provides a substantial amount of local bone for grafting purpose. Moller et al14 in their prospective study have shown improved outcome using autologous bone graft in posterolateral fusion compared to conservative treatment. In their retrospective study, Sengupta et al1 compared the clinical and radiological outcome of instrumented posterolateral lumbar fusion using local bone graft versus ICBG in seventy six cases of spinal stenosis. They found a higher fusion rate in the ICBG group than the local bone group, but, when analyzed separately for a single level instrumented fusion the local bone group achieved a similar fusion rate. Schizas et al15 have reported that the use of local bone alone would achieve a similar fusion rate compared to autogenous iliac crest autograft mixed with local bone in single level instrumented posterolateral lumbar fusion. In our study, at the end of two years, using only local bone graft material 50% patients achieved a definitive fusion while the remaining 50% achieved a possible solid fusion mass.

Iliac crest autograft has been used extensively for lumbar fusions.16 The most common complication following fusion with iliac crest graft is pseudoarthrosis and donor site morbidity. The rate of pseudoarthrosis has been reported up to 55% following posterolateral, un-instrumented fusion.17 Pseudoarthrosis rate still remains significant in spite of rigid instrumentation.18 Morbidity associated with the donor site such as: pain, paraesthesias, hematoma, and infection are frequently reported.19,20,21 2% to 5% of patients require surgery for wound complications and up to 60% of patients complain of persistent pain.19 To eliminate these complications a variety of bone graft substitutes have been used in posterolateral lumbar fusion. In this study the quality of the fusion mass was better in the iliac crest group with 90% showing a definite fusion while only 10% showed a possible solid fusion mass. Compared to the local bone graft only group and the beta TCP group, the status of fusion was much higher with the iliac crest group.

Synthetic bone graft materials such as beta TCP are commonly used in spinal fusion procedures. The calcium phosphate compound provides a scaffold for bony in-growth and development of a fusion mass. However, it is gradually reabsorbed over a period of several months as the fusion procedure occurs. Gunzburg and Szpalski22 in 11 cases used autogenous bone on one side and TCP on the opposite side for single or multilevel, instrumented or non-instrumented posterolateral fusion with or without interbody fusion reported no adverse effects. This may have been the first clinical trial of TCP in spinal fusion. Muschik and Ludwig23 compared the instrumented posterolateral fusion rates in adolescent idiopathic scoliosis using either TCP mixed with autograft or autograft mixed with...
Posterolateral Fusion for Degenerative Spondylolisthesis Performed with Local Bone Graft Alone... allograft. They found similar fusion rates and clinical results. They also observed that the TCP granules took an average range of 6 to 10 months to be completely substituted by bone on plain films. However, Le Huec and Lespirit et al\textsuperscript{8} observed that the TCP resorbed after 2 years when using TCP and allograft for spinal fusion in idiopathic scoliosis. In our study, the 60% of patients in the beta TCP group achieved a Lenke A fusion status while 40% had a Lenke B fusion mass. The beta TCP granules were resorbed at the end of two years and the fusion mass was more hyperintense on CT scans.

All the 30 patients had a solid fusion (Lenke A and Lenke B) mass and none showed signs of pseudoarthrosis or implant breakage. The type of fusion based on the Lenke classification was also relatively similar in all the three groups. Dai and Jiang\textsuperscript{25} in their prospective randomized study compared the fusion rate between beta TCP combined with local autograft to iliac crest autograft in single level instrumented posterolateral found no difference in the fusion rate between the two groups. The fusion rate was 100% in both the groups at 3 years follow-up period. They also concluded that TCP could be used as an ideal bone graft substitute in combination with autograft for instrumented posterolateral lumbar fusion. However, their study lacked a control group which would consist of a group of patients that received only local bone autograft. Our study, consists of three groups of patients out of which one group received only local bone autograft.

CT scan provides the greatest amount of information in assessing the bony anatomy and the status of the fusion mass.\textsuperscript{7} A study by Zinreich\textsuperscript{26} demonstrated that CT scan with sagittal, coronal and 3D reconstructed images were more informative than axial section only. Sengupta et al, in their study also mention that CT scan with 2mm slices and sagittal reconstruction is superior to conventional skiagrams in evaluating the fusion status. Dai and Jiang also evaluated their fusion mass based on plain radiographs which could have been a limitation of their study. Based on these authors, CT scan assessment of the fusion mass is superior to plain radiographs. At the end of our study period, the fusion status of all patients was evaluated with CT scans.

The relatively small sample size may be a limitation of our study. We are of the opinion that further studies with more number of patients are required. Our study is purely based on the radiological evaluation of the fusion status; we have not considered the clinical outcome of a successful fusion nor the complications associated with donor site morbidity. Both clinical and radiological outcomes are important for a successful spinal fusion.

**CONCLUSION**

Based on the results of our study, all the patients in the three groups achieved radiological solid fusion mass (Lenke A and Lenke B) with no pseudoarthrosis or implant breakage. The quality of the posterolateral fusion was better observed with iliac crest graft. However, the use of iliac crest graft is limited by the donor site morbidity. Therefore bone graft substitutes are increasingly used to avoid this complication. But the rate of fusion with beta TCP combined with local bone versus local bone only is similar. Hence, for a single level posterolateral lumbar fusion the use of the more expensive beta TCP needs to be justified.

**REFERENCES**

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