A Radiological Evaluation of Allografts (Ethylene Oxide Sterilized Cadaver Bone) and Autografts in Anterior Cervical Fusion

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Summary

Serial roentgenograms of 40 patients who had 70 cervical intervertebral spaces grafted with ethylene oxide sterilized cadaver bone and 28 patients who received 44 iliac crest autografts for anterior cervical spine fusion, were studied. The radiological evaluation was made on the basis of settlement of intervertebral spaces, fusion rate, delayed union, non-union, graft collapse and extrusion of the graft. Indigenous methodologies were designed for the assessment of settlement of grafted intervertebral spaces in percentage. Disc space settlement was more common in autografts (93% cases) than in allografts (80% cases). The average percentage of settlement of intervertebral disc space (S%) was 22 in autografts and 28 in allografts during the first four months. By the end of eight months, allograft disc spaces settle more. No significant difference was noted in fusion rate at the end of one year viz. allografts (90% cases) and autografts (93% cases). Autograft and allograft (ethylene oxide sterilized cadaver bone) are equally useful in anterior cervical spine fusions.

Key words: Cervical spine, Allograft, Autograft, Settlement.

Introduction

Anterior interbody fusion after the removal of intervertebral disc material and osteophytes is an accepted mode of treatment for cervical disc prolapse and degenerated discs.1 Since the advent of the anterior approach by Smith-Robinson and Cloward,2 many modifications have been undertaken by spinal surgeons to achieve better results.3-5 The patient’s own bone (tricortical iliac crest) is considered the best graft for anterior cervical fusion. Literature shows long term good results achieved by it.3 Allografts came into the picture to reduce the patients morbidity at the harvest site.6-8 Cadaver bones are sterilized before use by different methods.9-11 Research works and reports comparing the autografts and allografts are encouraging.12,13

Since the establishment of a bone bank in November...
1986 at L.T.M.G. Hospital, Bombay, India, a large number of anterior cervical fusions were performed using ethylene oxide sterilized cadaver bone by the senior author (PSR). During the process of fusion at the grafted site, an element of settlement of the intervertebral disc space was obvious while following the serial lateral roentgenograms of the cervical spine. The settlement was obviously more in the allografts. Indigenous methodologies were designed to assess the settlement of the grafted intervertebral disc spaces.

### Material and Methods

Serial lateral roentgenograms of 40 patients who had 70 cervical intervertebral spaces grafted with ethylene oxide sterilized cadaver bone (allograft) and 28 patients who received 44 iliac crest autografts during August 1992 at the department of Neurosurgery, L.T.M.G. Hospital, Bombay, were studied. Lateral cervical X-rays taken at the same institution using a constant technique during immediate post operative day, 4 months, 8 months, 12 months and 24 months following surgery were available. Sixteen cases of single level, eighteen cases of two levels and six cases of three levels were available with allograft fusion, while there were twelve cases of single level and sixteen cases of two levels with autograft. The radiological changes were studied in four phases viz. phase I (immediate postoperative-4 months), phase II (4 months-8 months), phase III (8 months -12 months) and phase IV (12 months -24 months).

To assess the settlement of the grafted intervertebral spaces in percentage, methodologies ‘A’ and ‘B’ were designed. In methodology ‘A’, the settlement is calculated from the difference between the intervertebral space heights of two consecutive lateral X-rays, ie. \((AB-CD)\). The height of the graft is not taken into account since key-stone technique was followed. The percentage of settlement \((S\%)\) is calculated as \(\frac{AB-CD}{AB} \times 100\) (Fig. 1). Methodology ‘B’ provides an arbitrary settlement study. The difference between two fixed points in the vertebral bodies \((A_1B_1-A_2B_2)\) gives an idea of settlement and the percentage of arbitrary settlement \((Arbitrary\ S\%)\) is calculated as \(\frac{A_1B_1-A_2B_2}{AB} \times 100\) (Fig. 1). The radiological fixed point in the vertebral body is marked. A line crossing the body of the vertebra horizontal to the upper border of the upper vertebra and the lower border of the lower vertebra, or parallel to one of them in multilevel fusion, is drawn from the point where the inferior border of the pedicle joins the posterior border of the vertebra. The center of this line is taken as the fixed point. Methodology B was used in all phases keeping the immediate post operative X-ray as a constant with X-rays taken at 4, 8, 12 and 24 months separately. Methodology A was used only in the first phase, since the radiological delineation at the graft-body site was less in the second phase, especially in the autografts.

<table>
<thead>
<tr>
<th>Settlement in</th>
<th>Allograft (levels)</th>
<th>Autograft (levels)</th>
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<tbody>
<tr>
<td>Phase I</td>
<td>56/70 (81%)</td>
<td>38/44 (86%)</td>
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<tr>
<td>Phase II</td>
<td>30/70 (43%)</td>
<td>10/44 (23%)</td>
</tr>
<tr>
<td>Single level</td>
<td>06/16 (38%)</td>
<td>12/12 (100%)</td>
</tr>
<tr>
<td>Two levels</td>
<td>32/36 (89%)</td>
<td>26/28 (81%)</td>
</tr>
<tr>
<td>Three levels</td>
<td>18/18 (100%)</td>
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</table>

### Table I

**Disc Space Settlement**

![Immediate post operative](image1)

Methodology A - Settlement % = \(\frac{AB-CD}{AB} \times 100\)

![4 months post operative](image2)

Methodology B - Arbitrary Settlement % = \(\frac{A_1B_1-A_2B_2}{AB} \times 100\)

**Fig. 1**: Methodology
Using these methodologies, settlement was assessed and compared between the allografts and autografts.

Good fusion was judged with disappearance of the marginal line between the graft and the host vertebral body and increase in the density of vertical trabeculae of the graft. Abrupt loss of height in the graft with fracture and partial resorption of the mid portion of the graft was termed as collapse of the graft. Persistent clear zone at one junction at the end of second phase was taken as non-union. Union seen after phase II was included in delayed union.

Results

Thirty two out of 40 cases (80%) grafted with ethylene oxide cadaver bone (allograft) showed settlement of the intervertebral disc space as compared to 26 out of 28 cases (93%) in autograft group. All the three level fusions in allograft had settled (18/18 levels) while only six out of sixteen levels settled in single level. However, all single level autografts (12/12) showed settlement. Many allografts settle in the second phase (30/56) as compared to the autografts, (28 allografts as compared to 22 autografts). Arbitrary settlement study showed settlement in the second phase also in both groups, but more in allograft (10% more than the I phase). No settlement was noticed in the III and IV phases. This study shows the increased tendency of the allograft to settle in height more than the autografts (Table II) (Fig. 2).

Non-union, delayed union and graft collapse were equally represented in both the groups in this series. The fusion at the end of one year was seen in 36 out of 40 patients (90%) with allografts (94% levels) when compared to 26 out of 28 patients (93%) with autografts (95% levels) (Table III). Changes in spinal contour were found in patients who had laminectomy and anterior cervical fusion (4 cases) (Fig. 3) and in four cases where three level fusion was done. Extrusion of the graft was seen in four cases. Other findings elicited during this study included the cortex of allografts being more opaque and prominent, and the margin between the graft and body could possibly be made out at 4 months. However, at the end of one year no difference could be made out between allograft and autograft fusion.

Discussion

Since the advent of anterior approach in cervical disc prolapses and degenerative osteophytes with radiculopathy and myelopathy, the use of bone grafts

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Phase</th>
<th>Allograft</th>
<th>Autograft</th>
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<tbody>
<tr>
<td>A Settlement %</td>
<td>I</td>
<td>28%</td>
<td>22%</td>
</tr>
<tr>
<td>B Arbitrary Settlement %</td>
<td>I</td>
<td>47%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>57%</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>57%</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>57%</td>
<td>33%</td>
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Using these methodologies, settlement was assessed and compared between the allografts and autografts.
for interbody fusion has gained momentum among the spinal surgeons all over the world. Patient’s own bone (autograft) is considered best for grafting as it contains bone, osteoinductive bone, morphogenic protein and live osteogenic cells. However, the morbidity at the harvest site is significant in the form of pain, numbness and, in rare cases, fracture of iliac crest bone. Grafts other than autogenic, like kiel bone, polymethyl methacrylate (PMMA), A1203 ceramic and human cadaver bones (allografts), were brought in to achieve better results. Preservation and storage of allografts date back to the experimental studies of Bauer in 1910 and the clinical efforts of Inclan in 1942. Cloward, in 1946, used frozen cadaver bone for spinal fusion. Ethylene oxide sterilised cadaver bone is used in many centres for spinal fusion. We found some amount of settling of the disc space in large number of cases in which ethylene oxide sterilized cadaver bone was used, and in some patients with own iliac crest bone. Other authors have also experienced the settling in different forms. However, the settling of disc height and collapse are reported irrespective of the techniques used viz. Cloward, Smith-Robinson, modified Smith-Robinson, Key Stone, T-graft etc. The designed methodologies could standardize the measurement of the settlement in percentage and could be used to assess the nature of settlement during fusion process. Methodology A, particularly in the first phase (upto 4 months), provides a near normal study. In the present study, 28% of the height of allograft disc space settled as compared to 22% in autograft in the phase I, which helped to assess the nature of the grafts used. Brown et al and Zdeblick and Ducker, reported increased graft collapse in allografts. Brodke and Zdeblick reported no disc space collapse in all the 51 patients reported, using a modified Smith-Robinson technique, by placing the tricortical graft cortex posterior in the middle column. However, the measurements were not given.

Key stone technique was followed by the senior author using the tricortical graft cortex anteriorly placed with sufficient decortication. Since different surgeons use different types and shapes of grafts with different techniques, it is presumed that this methodology could provide an international standard to the study of the settlement of disc space height.

### Table III

<table>
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<tr>
<th>Fusion Study</th>
<th>Allograft (Levels)</th>
<th>Autograft (Levels)</th>
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<tbody>
<tr>
<td>Fusion rate (1 year)</td>
<td>66/70 (94%)</td>
<td>42/44 (95%)</td>
</tr>
<tr>
<td>Single level</td>
<td>16/16 (100%)</td>
<td>12/12 (100%)</td>
</tr>
<tr>
<td>Two level</td>
<td>32/36 (89%)</td>
<td>30/32 (95%)</td>
</tr>
<tr>
<td>Three level</td>
<td>18/18 (100%)</td>
<td>-</td>
</tr>
<tr>
<td>Non Union</td>
<td>4/70 (06%)</td>
<td>2/44 (05%)</td>
</tr>
<tr>
<td>Delayed Union</td>
<td>8/70 (11%)</td>
<td>6/44 (14%)</td>
</tr>
<tr>
<td>Graft Collapse</td>
<td>12/70 (17%)</td>
<td>8/44(18%)</td>
</tr>
</tbody>
</table>

*Fig. 3 : A Three level fusion with allograft in a patient with previous laminectomy shows significant disc space collapse at C5/6 and settlement at C4/5 and C6/7. (A) Immediate post operative (B) 8 months post operativeshowing progressive kyphosis with solid fusion.*
However, methodology ‘A’ could be used until the graft host interface is prominent or faint, hence it is useful in the phase I. Methodology ‘B’ is useful in assessing the settling at different phases. In the present study the progressive settling after 4 months in both groups was well appreciated. Moreover, the tendency of the allograft to settle more in the second phase highlights the delayed union of the grafts. However, this methodology does not provide the near normal result since the measurements $A_1B_1-A_2B_2$ include not only the disc space but also host-graft interface and portion of body of adjacent vertebrae. The difference between two phases gives an idea of settlement and facilitates the comparison between the two groups.

Cloward, in his clinical experience, has shown that the percentage of union in interbody fusions with allografts is the same or higher than autografts, when the grafting technique is performed correctly. Gore reported 100% union rate in dovetail technique with autograft. Hohmann also opines that poor technique leads to poor results. Zdeblick and Ducker reported higher incidence of graft collapse, delayed union and nonunion in freeze dried allografts. However, their clinical results were similar in both. Brown found no difference in fusion rate among allograft (94%) and autograft (97%) despite the increased collapse rate in allografts in multi level fusions. In all three level fusions with allograft in our series, fusion occurred with significant settlement. No significant difference was noticed in the fusion rate in this series (94% of allograft and 95% of autograft levels). Delayed union and graft collapse were equally represented. Despite the difference in settlement among the allograft and autografts, fusion rate is equal in this study. Hence, the increased settlement among the allografts is an acceptable fact in the process of fusion, unless and until a clinical deterioration occurs.

**Conclusion**

Autograft and ethylene oxide sterilized allografts are equally useful in anterior cervical fusions. It is presumed that the methodologies designed could standardize the study of settlement of intervertebral disc height during the process of fusion. Methodology ‘A’ is possible until the graft-host interface is demarcated or faint which is usually seen upto four months in both allo and autografts. Methodology ‘B’ is possible in all phases but does not provide the exact settlement result.

**References**

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Accepted for publication: 22nd August, 2001.