Does Donor Site Reconstruction Following Anterior Cervical Surgery Diminish Postoperative Pain?

*Nancy E. Epstein and †Renee Hollingsworth

*Department of Neurologic Surgery, Albert Einstein College of Medicine, Bronx, New York, and the †Department of Neurosurgery, North Shore-Long Island Jewish Health System, Manhasset, New York, U.S.A.

Summary: Many attempts have been made at donor site reconstruction to reduce postoperative pain following anterior cervical surgery. This study is a comparative analysis of the outcome of 46 patients undergoing single-level anterior corpectomy and fusion using iliac crest autograft performed by one surgeon (N.E.E.). Twenty-three patients had no donor site reconstruction, whereas the more recent 23 patients had iliac crest reconstruction using a MacroPore sheet (MacroPore, Inc., San Diego, CA) and Inductive Conductive Matrix (ICM, Sofamor Danek, Memphis, TN). Bodily Pain, assessed on the Short Form-36, obtained up to 12 months postoperatively, failed to demonstrate better pain relief following donor site reconstruction. Multiplanar CT studies obtained 6 months postoperatively documented 100% donor site fusion for the 23 reconstructed patients. Although iliac crest reconstruction failed to reduce Bodily Pain, it did result in 100% fusion. Key Words: Iliac crest reconstruction—MacroPore ICM—Anterior cervical surgery—Multiplanar CT—Bodily Pain SF-36.

INTRODUCTION

Iliac crest autograft remains the gold standard for anterior cervical fusion (ACF) demonstrating the highest fusion and lowest complication rates (1–4). However, to alleviate hip pain (17.3%), one of the major sources of donor site morbidity, attempts have been made to reconstruct the donor site (5–9). In this study, 46 patients had identical single-level anterior cervical corpectomy and fusion (ACF) performed by one surgeon using nonreversed iliac crest strut autografts and dynamic plates. The first 23 patients had no donor site reconstruction performed, whereas the more recent 23 individuals did undergo iliac crest reconstruction. Reconstruction was completed with MacroPore sheet (MacroPore, Inc., San Diego, CA), a resorbable mesh, and Inductive Conductive Matrix (ICM, Sofamor Danek, Memphis, TN), a form of demineralized bone matrix. Clinical outcomes were assessed using the Medical Outcomes Trust Short Form 36 (SF-36) questionnaire administered preoperatively and 1 week, 6 weeks, and 3, 6, and 12 months postoperatively. Particular attention was paid to the Bodily Pain scale of the SF-36 because it most closely correlated with hip discomfort. All 23 patients undergoing iliac crest reconstruction had multiplanar CT examinations performed 6 months postoperatively to assess the extent of donor site fusion. Additionally, 6 of 23 patients not undergoing donor site reconstruction were randomly selected to undergo CT studies 6 months postoperatively to evaluate the extent of myositis ossificans at the donor site.

METHODS

Operative Procedures

Forty-six single-level ACFs were performed using nonreversed iliac crest strut autografts, averaging 3 cm in length (Table 1). Grafts were harvested atraumatically with an oscillating saw and curved osteotome. Dynamic ABC plates (Aesculap, Tuttingen, Germany) were applied in all patients, averaging 45–46 mm in length.
Donor Site Reconstruction

Donor site reconstruction was not performed in the initial 23 patients where bone wax was applied to the exposed cancellous surface, followed by routine closure. In 23 additional patients, donor sites were reconstructed utilizing MacroPore sheet (MacroPore, Inc.) and Inductive Conductive Matrix (ICM, Sofamor Danek). MacroPore sheet is comprised of a L-lactide (70%) and D,L-lactide (30%) polymerized into a noncrystalline sheet, which when warmed to 70°C becomes moldable. Over 1–3 years, the polymer fully resorbs, being degraded by hydrolysis to H₂O and CO₂. ICM, a form of demineralized bone matrix, includes 30% cortical and 70% cancellous morcellated bone fragments suspended in a non-water soluble gel containing a very low concentration of bone morphogenetic protein (BMP). Iliac crest reconstruction required the molding 9 cm of warmed ICM applied into the iliac crest defect followed by immediate application of a contoured MacroPore sheet measuring 5 cm long × 5 cm wide and 0.5 mm thick. Care was then taken to ensure a 1-cm overlap of mesh at each end of the construct to facilitate the placement of two, 2 mm × 10 mm resorbable screws on either side of the apex of the cortical shelf.

Clinical Data

Clinical data for the nonreconstructed (23 patients) and reconstructed (23 patients) patient populations were comparable (Table 1). Nonreconstructed patients averaged 42 years of age, and the reconstructed patients averaged 46 years of age. Both groups exhibited moderate myelopathic preoperative deficits (Nurick scores of 2.6 and 3.0) and improved to the same degree postoperatively, exhibiting mild residual radiculopathy (Nurick grade 0.2 and 0). Preoperative MRI and CT studies demonstrated similar contiguous disc disease, spondylosis, stenosis, and ossification of the posterior longitudinal ligament extending behind intervening vertebrae, warranting single-level anterior cervical corpectomy with fusion rather than two-level discectomy and fusion. Postoperative radiographic and CT studies documented fusion 3.6 and 3.8 months following nonreconstructed and reconstructed procedures. Surgery for patients in the nonreconstructed group were performed earlier, and they were therefore followed for a longer average interval of 3 years compared with the reconstructed patients’ shorter average follow-up interval of 2 years (Table 1).

Short Form 36 Assessment of Outcome

Patient-based outcomes were assessed using the Short Form (SF-36) administered preoperatively and 1 week, 6 weeks, and 3, 6, and 12 months postoperatively (Tables 2–4). Of the eight outcome scales, Bodily Pain was considered the most likely to reflect postoperative donor site pain. Transformed Bodily Pain scores were graded on a scale of 0–100, with the higher scores indicating less pain.

Multiplanar CT Documentation of Donor Site Fusion

Fusion at the iliac crest donor site was evaluated on multiplanar bone-window and soft tissue-window CT

<table>
<thead>
<tr>
<th>TABLE 1. Clinical data for single-level ACF with and without donor site reconstruction</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td><strong>Nonreconstructed iliac crest graft site with ACF (23 patients)</strong></td>
</tr>
<tr>
<td>Average age [yr (range)]</td>
</tr>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Males</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>Average follow-up (yr)</td>
</tr>
<tr>
<td>Average dynamic plate length (mm)</td>
</tr>
<tr>
<td>Single-level ACF C5–C7</td>
</tr>
<tr>
<td>C4–C6</td>
</tr>
<tr>
<td>C3–C5</td>
</tr>
<tr>
<td>C2–C4</td>
</tr>
<tr>
<td>Average Nurick Status Preoperatively</td>
</tr>
<tr>
<td>Postoperatively</td>
</tr>
<tr>
<td>Average days in hospital</td>
</tr>
<tr>
<td>Average operative time (hr)</td>
</tr>
<tr>
<td>Average time to CT documented fusion (mo (range)]</td>
</tr>
<tr>
<td>Average plate migration Cephalad (mm)</td>
</tr>
<tr>
<td>Caudal (mm)</td>
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</table>

<table>
<thead>
<tr>
<th>TABLE 2. Mean and median postoperative SF-36 bodily pain scores with and without donor site reconstruction</th>
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<tr>
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<tr>
<td><strong>Donor site reconstruction</strong></td>
</tr>
<tr>
<td>Preoperative values Average</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>1-week postoperative Average</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>6-week postoperative Average</td>
</tr>
<tr>
<td>Median</td>
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<tr>
<td>3-month postoperative Average</td>
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<tr>
<td>Median</td>
</tr>
<tr>
<td>6-month postoperative Average</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>12-month postoperative Average</td>
</tr>
<tr>
<td>Median</td>
</tr>
</tbody>
</table>

scans obtained 6 months postoperatively in the 23 patients undergoing donor site reconstruction (Figs. 1–8). The extent of accompanying myositis ossificans was also recorded for each patient. Six of the 23 patients not undergoing donor site reconstruction had been randomly chosen to undergo 6-month postoperative CT assessment of iliac crest donor sites to assess the extent of myositis ossificans or other changes.

**RESULTS**

**SF-36 Outcome: Bodily Pain**

Postoperative SF-36 Bodily Pain scores indicated that donor site reconstruction failed to provide pain relief when compared with the scores for the nonreconstructed population (Tables 2–4). Although average Bodily Pain scores were comparable preoperatively and 1 week postoperatively, the nonreconstructed patients showed somewhat greater improvement 6 weeks and 3 months following surgery. Six and 12 months following surgery, average scores for the two groups showed a trend toward convergence but at this point demonstrated no significant differences. Median scores for the two groups were identical preoperatively but were also somewhat higher for the nonreconstructed group throughout the postoperative course except at 6 weeks postoperatively.

Although SF-36 data were available for both populations throughout the postoperative course, assessment of the 12-month postoperative SF-36 results revealed similar or identical results on five health scales, with differences noted on only two (Tables 3 and 4). Identical results were observed for the Role–Physical, General Health, and Role–Emotional Scales, with similar responses noted for Mental Health and Vitality. Reconstructed patients showed higher scores on Physical Function, whereas nonreconstructed patients demonstrating higher scores on Social Function.

**Multiplanar CT Documentation of Fusion**

For the 23 patients undergoing donor site reconstruction, the 6-month postoperative multiplanar CT studies documented 100% fusion within the reconstruction site. Myositis ossificans was additionally demonstrated to a mild degree in 56% of patients (Fig. 1 and 2), to a moderate degree in 35% of patients (Figs. 3–5), and to a severe degree in 9% of individuals (Figs. 6–8). Nevertheless, the extents of ectopic bone formation did not correlate with increased Bodily Pain scores. Comparatively, the 6-month postoperative CT studies for the six randomly chosen patients not undergoing iliac crest reconstruction revealed no significant calcification within the donor site defects, with all showing only mild myositis ossificans.

**Hospital Stay and Operative Time**

Donor site reconstruction did not shorten the average hospital stay, observed to be 3.6 days for the nonreconstructed and 3.2 days for the reconstructed groups. However, to perform iliac crest reconstruction, the average operative time of 3.0 hours was lengthened by an average of 24 minutes. Donor site reconstruction resulted in immediate cosmetic recontouring of the iliac crest, which was maintained 12 months postoperatively.

### Table 3. Complete SF-36 outcome data for single-level ACF with donor site reconstruction

<table>
<thead>
<tr>
<th>Reconstruction group</th>
<th>Physical function</th>
<th>Role–physical</th>
<th>Bodily pain</th>
<th>General health</th>
<th>Vitality</th>
<th>Social function</th>
<th>Role–emotional</th>
<th>Mental health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative</td>
<td>37</td>
<td>6</td>
<td>22</td>
<td>63</td>
<td>40</td>
<td>53</td>
<td>48</td>
<td>67</td>
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<tr>
<td>1-week postoperative</td>
<td>13.6</td>
<td>0</td>
<td>28.9</td>
<td>63.3</td>
<td>35.7</td>
<td>7.1</td>
<td>28.5</td>
<td>51.4</td>
</tr>
<tr>
<td>6-week postoperative</td>
<td>26</td>
<td>0</td>
<td>26.1</td>
<td>66</td>
<td>44</td>
<td>31.3</td>
<td>43.3</td>
<td>57.6</td>
</tr>
<tr>
<td>3-month postoperative</td>
<td>16</td>
<td>0</td>
<td>23.2</td>
<td>63</td>
<td>26</td>
<td>29.2</td>
<td>57</td>
<td>69</td>
</tr>
<tr>
<td>6-month postoperative</td>
<td>34</td>
<td>14</td>
<td>39</td>
<td>69</td>
<td>47</td>
<td>55</td>
<td>68</td>
<td>75</td>
</tr>
<tr>
<td>12-month postoperative</td>
<td>80</td>
<td>25</td>
<td>51</td>
<td>90</td>
<td>60</td>
<td>56</td>
<td>50</td>
<td>80</td>
</tr>
</tbody>
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### Table 4. SF-36 outcome data for single-level ADF without donor site reconstruction

<table>
<thead>
<tr>
<th>No reconstruction group</th>
<th>Physical function</th>
<th>Role–physical</th>
<th>Bodily pain</th>
<th>General health</th>
<th>Vitality</th>
<th>Social function</th>
<th>Role–emotional</th>
<th>Mental health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative</td>
<td>54</td>
<td>11</td>
<td>19</td>
<td>53</td>
<td>39</td>
<td>43</td>
<td>53</td>
<td>52</td>
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<tr>
<td>1-week postoperative</td>
<td>12.7</td>
<td>0</td>
<td>27.9</td>
<td>63.3</td>
<td>29.5</td>
<td>21.6</td>
<td>18.1</td>
<td>56</td>
</tr>
<tr>
<td>6-week postoperative</td>
<td>31.6</td>
<td>0</td>
<td>45.3</td>
<td>65.6</td>
<td>42.2</td>
<td>45.3</td>
<td>50</td>
<td>71</td>
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<tr>
<td>3-month postoperative</td>
<td>44</td>
<td>9</td>
<td>48</td>
<td>67</td>
<td>46</td>
<td>42</td>
<td>39</td>
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<tr>
<td>6-month postoperative</td>
<td>56</td>
<td>19</td>
<td>54</td>
<td>73</td>
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<td>70</td>
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<tr>
<td>12-month postoperative</td>
<td>69</td>
<td>25</td>
<td>74</td>
<td>90</td>
<td>55</td>
<td>78</td>
<td>50</td>
<td>82</td>
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DISCUSSION

Autograft: Gold Standard for Fusion

The “gold standard” for ACF remains autogenous bone graft as higher rates of fusion are achieved with a lower incidence of graft collapse or pseudarthrosis (1–4). Nevertheless, high frequencies of major (25%) and minor (24%) complications follow iliac crest graft harvesting, some reporting up to a 17.3% incidence of iliac crest donor site pain (5–9). To minimize donor site morbidity, rib, ceramics, and methylmethacrylate have been used to fill autogenous donor site defects (10–13). When Wang et al. used MacroPore alone to reconstruct the anterior iliac crest following different anterior cervical procedures in 15 patients and compared them with 15 nonreconstructed controls, postoperative pain was reduced 1 week and 3 months following surgery based on a postoperative 10-point questionnaire (14).

Bioengineered Gels

Bioengineered gels containing different osteogenic growth factors are increasingly used to reconstruct bony defects and to promote or enhance fusion. Demineralized...
bone matrix (15,16), recombinant human bone morpho-
genetic protein (rhBMP-2) (17), recombinant human os-
teogenic protein-1 applied to a bone collagen carrier
rhOP-1 (18), transfected marrow cells encoded with
cDNA osteoinductive protein (19), and BMP (20) have all
contributed to fusion in different in vivo animal models.

Healos, an osteoconductive matrix (21), and hydroxyapa-
tite supplemented with osteoinductive growth factor (22)
have also added to successful fusions, but only in the
presence of autogenous bone graft.

In clinical settings, bioengineered gels have also suc-
cessfully supplemented fusions. Demineralized bone ma-
trix has been useful in filling calvarial defects (23,24) and
for supplementing posterolateral lumbar fusions, which
include autogenous grafts (25). When Boden et al. per-
formed radiographic and CT studies to assess fusion in 14
patients undergoing posterior lumbar interbody fusion,
higher fusion rates were observed for grafts filled with
rhBMP-2 collagen, whereas only two of three cylindrical
cages filled with autologous bone alone (three patients)
fused (26). Additionally, patients treated with rhBMP-2
collagen exhibited superior outcomes documented on both

FIG. 4. Case 2. The 6-month postoperative multiplanar soft tis-
sue-window CT scan in the same patient as Figure 3 confirmed fusion (single arrows) at the donor site along with moderate myositis ossificans (double arrows). Despite moderate ectopic ossification, this asthenic patient had no complaints referable to the donor site.

FIG. 5. Case 3. The 6-month postoperative multiplanar bone-window CT scan in a 59-year-old man again demonstrated fusion at the iliac crest graft site (single arrow) with moderate but asymptomatic myositis ossificans (double arrows).

FIG. 6. Case 4. The 6-month postoperative multiplanar bone-window CT study in this slight 43-year-old man revealed fusion at the iliac crest graft site (single arrow) and marked myositis ossificans (double arrows).
SF-36 and Oswestry questionnaires administered between 6 and 24 months postoperatively. In the series presented, ICM and MacroPore resulted in 100% donor site fusion on 6-month postoperative multiplanar CT studies. Mild myositis ossificans, observed in the nonreconstructed group, was attributed to blood in the postoperative bed. The mild, moderate, and severe ectopic ossification noted for the reconstructed population was more likely attributed to ICM and would be better contained in the future by using a nonperforated MacroPore sheet.

Bodily Pain Scale on SF-36 Outcome Questionnaire

Between 6 weeks and 12 months postoperatively, iliac crest donor site reconstruction following single-level ACF failed to significantly reduce Bodily Pain. Of interest, myositis ossificans, seen in nearly proportionate numbers in both groups, did not adversely affect outcome. Nevertheless, these results are considered preliminary because only a small number of patients were included in either group and the 12-month follow-up interval is relatively short. Differences in outcome assessment between this study and the study by Wang et al. (14) include predominantly the use of different outcome measures. We used Bodily Pain from the SF-36 questionnaire, a generic instrument, which may not have been sufficiently specific to measure hip pain, whereas Wang et al. (14) used a 10-point scale, which although specific, was not part of a previously tested instrument.

CONCLUSION

Iliac crest donor site reconstruction with MacroPore and ICM resulted in 100% fusion at the donor site on the 6-month postoperative multiplanar CT study. However, using the Bodily Pain scale from the SF-36, iliac crest reconstruction did not reduce postoperative donor site pain. Because the Bodily Pain scale from the SF-36 may be too generic to accurately measure donor site pain, a more specific instrument or combined instruments may be required for future studies.

REFERENCES


