TECHNICAL NOTE

Extra-articular distal radius malunion: The phosphate cement alternative

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KEYWORDS
Malunion; Distal radius; Osteotomy; Calcium phosphate cements; Bone substitutes

Summary
Five consecutive patients (mean age: 40.4 yrs (range, 19–58 yrs)), with symptomatic distal radius malunion underwent corrective opening wedge osteotomy using phosphate cement as an alternative to bone autograft, at a mean 9 months (4–16 mo) of fracture. Internal fixation used a plate placed just above the distal radioulnar joint, with soft-tissue release. Radiographic and functional parameters were measured before surgery, and at 6 months and 1 year. At a mean 32.4 months (range, 16–47 mo), all patients were satisfied and all the osteotomies were united. At 1 year’s follow-up, wrist range of motion reached 75% compared to the contralateral side. Two biopsies performed during plate removal showed osteoid tissue at the cement–bone junction. It is reasonable to consider injectable phosphate cement as a viable alternative to bone grafting in conjunction with surgical correction of distal radius malunion.

Level of evidence: level IV.

Introduction

Untreated extra-articular distal radius malunion is liable to cause adaptive instability in the carpus of patients having a high level of functional demand [1]. Voche et al. [2] reviewed treatment options. In opening wedge osteotomy, the resultant defect is classically corrected by cortico-cancellous iliac graft, the cortical component playing the structural role and the cancellous bone it contains fulfilling the biological function. The type of osteosynthesis and the immobilization time are at the surgeon’s discretion [2–4].

Recently, Luchetti [5] demonstrated that correction could use injectable phosphate cement: union did not pose a problem in this metaphyseal location, iliac graft morbidity was avoided and the substitute showed better mechanical properties than did cancellous bone.

We here report five cases of extra-articular distal radius malunion, corrected using injectable phosphate cement, with the first published histological analysis performed on removal of the material.

Technique [3] (Fig. 1)

Treatment comprised opening wedge osteotomy with the defect corrected by an injectable substitute (JectOS®) and
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Figure 1  CT scan, dorsal tilt of radius. Peroperative aspect, with dorsal approach and posterior opening wedge osteotomy. Posterior cortical osteoclasia was performed, respecting the anterior cortex. Positioning of posterior plate, then bone substitute injection under image amplification. Peroperative aspect of substitute while setting. Postoperative X-ray aspect.

plate osteosynthesis. In all cases, the approach was on the same side as the opening. Osteotomy was followed by 3.5 non-locking screw titanium plate osteotomy, without rupture of the facing cortex but with osteoclasia at the side of the osteotomy. The defect was then filled with JectOS® cement, at end of surgery, under image intensification, 3—5 min after blending, so as to obtain a paste thick enough not to run forwards, while respecting the anterior cortex, or into surrounding soft tissue. Lateral release of the brachioradial muscle and medial release of interosseous membrane were required to mobilize the radial epiphysis and enable good correction. Closure was performed on a drain with intradermal continuous suture on the skin.

Phosphate cement

Arexbone® or JectOS® (Arexbone), produced by Kasios (Lunaguet, France), is a phosphate cement made of dicalcium phosphate dihydrate. The cement is obtained by blending a liquid and a solid (powder) phase with an acid base reaction. The solid phase comprises beta-tricalcium phosphate (> 97%) and sodium pyrophosphate, and the liquid phase 4 M orthophosphoric acid 0.1 M sulfuric acid. The powder—liquid mix is blended for 1 min; depending on the room temperature, approximately 4 min further thickening is required for injection. Hardening time is 9—10 min (at 23 °C): hardening kinetics is highly temperature-sensitive. The resultant porosity is 40%, with a mean < 5 μm pore size. Resistance on 12/10 mm test-tube compression is 37 MPa (at ground pressure), with a Young’s modulus of 900 MPa. X-ray assessment (Fig. 2) monitored progressive resorption of the substitute, which was never found to be complete during follow-up. Radiolucency was observed in four cases, but was not pathological. In the two cases with the longest follow-up, there was slight and very progressive disappearance of the substitute. There were no cases of correction loss. Two biopsies were performed at removal of the material at 6 months (patients BO and DA): in both cases, histology found that the JectOS® cement had been replaced by bone (Fig. 3). Biomaterial particles were either in contact with or had been included in poorly vascularized and poorly cellularized scar tissue, or else (in most cross-sections analyzed) bone tissue the maturity of which varied according to location. In some places, the bone tissue showed an osteoid aspect. Biomaterial included in bone or conjunctive tissue seemed not to be in contact with polynuclear giant cells.

Patients (Tables 1 and 2)

Five symptomatic patients, mean age 40.4 years (range, 19—58), were treated at a mean interval of 9 months (4—16 months) from initial fracture, and assessed prospectively by
### Table 1 Preoperative data.

<table>
<thead>
<tr>
<th>Patient - age</th>
<th>Type of malunion</th>
<th>Cause</th>
<th>Interval from fracture (months)</th>
<th>Pre-op flex /ext (◦)</th>
<th>Pre-op pro /sup (◦)</th>
<th>Pre-op frontal slope</th>
<th>Pre-op sagittal slope</th>
<th>Pre-op ulnar variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CU - 53</td>
<td>Palmar tilt</td>
<td>Defective conservative management</td>
<td>8</td>
<td>60</td>
<td>100</td>
<td>16</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>DA - 22</td>
<td>Dorsal tilt</td>
<td>Defective conservative management</td>
<td>12</td>
<td>100</td>
<td>120</td>
<td>12</td>
<td>−14</td>
<td>0</td>
</tr>
<tr>
<td>Da - 58</td>
<td>Dorsal tilt</td>
<td>Ext. fixator only</td>
<td>4</td>
<td>40</td>
<td>60</td>
<td>0</td>
<td>−26</td>
<td>−8</td>
</tr>
<tr>
<td>MA - 19</td>
<td>Dorsal tilt</td>
<td>Defective conservative management</td>
<td>16</td>
<td>80</td>
<td>100</td>
<td>20</td>
<td>−14</td>
<td>0</td>
</tr>
<tr>
<td>BO - 50</td>
<td>Palmar tilt</td>
<td>Insufficient K-wire fixation</td>
<td>6</td>
<td>38</td>
<td>70</td>
<td>26</td>
<td>20</td>
<td>−6</td>
</tr>
</tbody>
</table>

### Table 2 Postoperative data.

<table>
<thead>
<tr>
<th>Patient - age</th>
<th>FU (mo)</th>
<th>Flex/Ext 6 mo FU</th>
<th>Pro/Sup 6 mo FU</th>
<th>Wrist force 6 mo FU</th>
<th>Frontal slope 6 m FU</th>
<th>Sagittal slope 6 mo FU</th>
<th>Ulnar variance 6 mo FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>CU - 53</td>
<td>26</td>
<td>62◦ (56%)</td>
<td>140◦ (84%)</td>
<td>20 KgF (58%)</td>
<td>20</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>DA - 22</td>
<td>37</td>
<td>120◦ (86%)</td>
<td>160◦ (94%)</td>
<td>44 KgF (97%)</td>
<td>14</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Da - 58</td>
<td>36</td>
<td>52◦ (61%)</td>
<td>126◦ (94%)</td>
<td>28 KgF (76%)</td>
<td>14</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>MA - 19</td>
<td>16</td>
<td>116◦ (84%)</td>
<td>160◦ (94%)</td>
<td>44 KgF (74%)</td>
<td>20</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>BO - 50</td>
<td>47</td>
<td>68◦ (54%)</td>
<td>140◦ (87%)</td>
<td>23 KgF (68%)</td>
<td>20</td>
<td>14</td>
<td>0</td>
</tr>
</tbody>
</table>
an independent operator. In three cases, malunion showed dorsal tilt and in two cases palmar tilt. In all cases, there had been technical error in fracture management. Mean follow-up was 32.4 months (16—47). No complications related to the injectable cement were observed. One patient presenting with reflex sympathetic dystrophy secondary to the fracture required arthrolysis at 4 months postosteotomy, and conserved 54% motion as compared to the contralateral side. In the other four patients, flexion—extension ROM recovery reached 71% as compared to the contralateral side. All five patients recovered pronosupination, to a mean 80% as compared to the contralateral side. Force recovered in all patients as of month 3, reaching a mean 74% as compared to the contralateral side at 6 months.

Commentary

Luchetti [5] reported six cases of malunion managed by opening wedge osteotomy, K-wire and osteotomy defect correction by Norian® phosphate cement. There were no cement-related complications, and he reported complete integration, with bone replacing cement over time, at a minimum 22 months’ FU. Abramo et al. [6] managed a continuous prospective series of 25 cases of malunion with dorsal tilt by opening wedge osteotomy, with fixation by the Trimed® system plus Norian®. At a minimum 1 year’s FU, patients showed improved function, a 13-point gain in flexion—extension and pronosupination; there was no correction loss; only one case failed to show union. The authors state that not having recourse to grafting meant that patients could be managed on an ambulatory basis. Kruckhaug and Hove [7] encountered more complications, using grafts: in a continuous prospective series of 33 cases, graft lysis required a second look in five patients. Regarding the inconveniences of grafts, Zyluk and Niedzwiedz [8], in a prospective study of 25 cases, reported that, in all five cases using allograft, the graft showed resorption; he implicated K-wire fixation and allograft lysis as causes of failure. Lozano-Calderón reported six cases of malunion in patients aged more than 60 years, managed by locking plate and Norian® without loss of correction in osteoporotic subjects [9]. The positioning of a corticocancellous graft is not always as anatomical as the surgeon might wish: when it is positioned in the opening wedge osteotomy, there is a risk of the radius adapting to the graft. Such metaphyseal locations do not necessarily require the biological properties of autografts. Finally, as Gupta [10] points out, corticocancellous iliac graft harvesting entails a certain morbidity: his meta-analysis found a 31% complications rate at the harvesting site. The injectability of bone substitute gives perfect adaptation to the defect. JectOS® shows resistance on compression that is equal to or better than that of cancellous bone. Humid environment tests, closer to peroperative reality, are needed. Disappearance of the cement is not to be expected before 4—6 years, at best, and will be dose-dependent, replacement being centripetal. The essential precaution is to have a paste thickness compatible with injection at the moment of surgery, without risk of leakage into soft tissue.

Conclusion

Injectable phosphate cement is a logical option in extra-articular distal radius malunion in patients with a high degree of functional demand to correct the opening wedge osteotomy defect. It is merely a means of filling the defect, and replaces only the corticocancellous graft, avoiding iatrogenic effects at the harvesting site and the need for general anesthesia, but in no way replaces rigid fixation. It is essential to be fully cognizant of the mechanical properties of the injectable substitute being used. It is deployed in the final stage of the procedure, after fixation of the correction, and should be performed under image intensification.

Conflict of interest statement

None.

References


