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Tricalcium phosphate bone substitute in corrective osteotomy of the distal radius

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ABSTRACT

Aim: To evaluate the outcome of using tricalcium phosphate (TCP) as void filler and structural support in corrective opening-wedge osteotomy of the distal radius.
Methods: A consecutive series of 17 patients with malunited dorsally angulated distal radius fracture underwent corrective osteotomy using plates, screws and TCP blocks. Results were evaluated postoperatively with DASH at 6 months with radiography at 8–12 weeks and 0.5–3.5 years.
Results: Mean DASH score improved from 52 (S.D. 22) preoperatively to 30 (S.D. 22) postoperatively. There was one non-union. There was also a mean loss of radial length of 1.1 mm (S.D. 1.0 mm) between the first postoperative radiograph and final follow-up. Radiolucent zones were observed around the TCP grafts after 6–8 weeks in 10/14 cases, but could not be statistically correlated with the slight loss of reduction.
Conclusions: TCP seems to be an alternative to iliac crest bone grafting in corrective osteotomies of the distal radius. The shortening observed over time may be attributable to inflammation induced by the TCP.

Introduction

Residual symptoms after a fracture of the distal radius are relatively common, occurring in 20–40% of cases.[4,14,17] Malunion is a strong contributor to dysfunction. The typical deformity is axial shortening with dorsal angulation. This may cause secondary carpal malalignment, ulnocarpal abutment and incongruity of the distal radioulnar joint, leading to instability and loss of forearm rotation. In these circumstances a corrective osteotomy may be indicated.

Open-wedge osteotomy creates a bony defect of varying size in the metaphysis of the distal radius. Common practice is to fill this with autogenous iliac crest bone graft, either tricortical or non-structural cancellous.[16,25] Significant donor site morbidity persists 1 year after surgery in 8–30% of cases, resulting in both local discomfort and neurogenic pain, with or without walking impairment. These problems have been reported in similar frequencies after harvesting structural and non-structural grafts from either the anterior or the posterior iliac crest.[3,21,26,27] There is therefore need to find other ways of filling or spanning the osteotomy gap. The use of tricalcium phosphate (TCP) has mainly been studied in animals and in human dental surgery. In orthopaedic surgery, TCP has been used and described most frequently in high tibial osteotomies[30] and also in various procedures such as foot arthrodesis, hip prosthesis revision, treatment of non-union of the humeral shaft and in trauma cases (mainly tibial plateau osteotomies).[8] Different means of stabilising the osteotomy have been documented, including external fixation,[23] dorsal plating[7,25] and the use of stable angle volar plates.[24]

The purpose of this study was to evaluate the outcome of using TCP as void filler and structural support in corrective opening-wedge osteotomy of the distal radius.

Methods

A total of 17 consecutive cases of symptomatic malunion of a displaced, dorsally angulated fracture of the distal radius were treated with corrective osteotomy. Indications for surgery were a malunited distal radius fracture (>3 mm of shortening of the radius, as compared with the uninjured wrist, or >10° of dorsal tilt measured from 0°) causing pain from the distal radioulnar or radiocarpal joints or restricted forearm motion. During this study, each person scheduled at our department for elective surgery of the upper extremity underwent DASH (Disabilities of the Arm, Shoulder and Hand) scoring before surgery and 6 months postoperatively. Case records and radiographs were reviewed retrospectively.

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Mean patient age was 56 (21–79) years. Mean time from injury to correction was 1.3 years (0.75–1.75 years). Mean preoperative deformity was 4.0 (S.D. 1.8) mm of positive ulnar variance and 13 (S.D. 13) degrees of dorsal angulation (Table 1). None of the patients had any history of wrist disease or injury before the fracture. One had had a contralateral distal radius fracture that healed with slight shortening and loss of volar tilt, but without residual impairment. No patients had rheumatoid arthritis or osteoarthritis of the radiocarpal joint. Smoking was not noted, nor was hand dominance retrievable from the case files.

Radiographs were taken postoperatively and after 8–12 weeks, both an anteroposterior (AP) view and a lateral projection with the arm in neutral rotation. A follow-up radiograph was obtained 0.5–3.5 years postoperatively. Ulnar variance was determined on the AP radiograph[15] (numbers are positive when the ulna is distal to the radius). Positive dorsal angulation was measured with 0° as baseline. Measurements were taken using digitalised radiographs (SECTRA®, Linkoping, Sweden) independently by the two authors, one additional senior orthopaedic surgeon and one senior radiologist. Radiolucent zones were defined as a visible line between the whole TCP graft and the surrounding bone in either of the projections.

Stabilisation involved a dorsal conventional AO small-fragment T-plate (Synthes®, Solothurn, Switzerland) from a dorsal approach in the first ten cases. At the end of 2004 we changed from dorsal to volar plating, in the hope of reducing the need for hardware removal. Thus in the following seven cases, operation was through a volar incision and stabilisation with a volar stable angle plate (KönigSee®, Aschau, Germany) using three distal 3.5-mm screws. For both approaches, the bony defect created was then filled with pieces of TCP (Biosorb®, S.B.M., Lourdes, France) which were shaped to fit using a sharp rongeur and squeezed into the gap from the radial side to bear the load.

Surgical technique

For dorsal access, a standard approach through the extensor pollicis longus sheath was used and Lister's tubercle was removed. After applying distal plate screws, the osteotomy was created using an oscillating saw. Angulation and alignment were controlled fluoroscopically, and the plate was fixed with three distal and three proximal screws. TCP was fitted as described above, except in one case which required a single larger TCP graft. This case went on to non-union.

Volar access was through the flexor carpi radialis tendon sheath, incising the pronator quadratus distally in an L-shaped fashion. Distal plate screws were inserted before creating the osteotomy with an oscillating saw. Under fluoroscopic control, length, angulation and alignment were checked and the plate secured. Two blocks of TCP were inserted into the osteotomy after pronation of the forearm.

Two younger individuals also underwent simultaneous reattachment of the triangular fibrocartilage complex to the ulna, using a small suture anchor with non-absorbable sutures in the fovea of the ulnar head through a dorsal, horizontal incision over the ulnocarpal joint.

Rehabilitation

Patients were followed throughout by either one of the two authors. Postoperatively the wrist was supported with a dorsal wrist splint, and immediate unloaded hand therapy was started. The splint was removed after 4 weeks. Manual labour and activities against resistance were not permitted until 8 weeks postoperatively. One individual moved out of town and was lost to radiological follow-up, but completed and returned the DASH questionnaire.

Table 1
Patient data, injured side.

Case	Gender	Age (years)	Approach	Preoperative positive ulnar variance[a]	Preoperative dorsal angulation (°)	Preoperative pro./sup. (°)	Postoperative pro./sup. (°)	Preoperative DASH	Postoperative DASH	Zones[b]	Mean lost reduction[c]	Complications, more surgery
1	F	58	D	5	16	80/70	80/70	*	*	No	1.0	No
2	F	39	D	4	−5	65/50	80/80	*	*	Yes	1.2	Hardware removal, ulna shortening
3	M	64	D	7.7	20	80/80	80/80	62	18	Yes	1.0	No
4	F	62	D	4.4	12	80/70	–	64	21	**	**	No
5	F	79	D	2.2	21	60/80	–	72	0	**	0.5	No
6	F	60	D	2.7	9	80/40	80/70	58	46	Yes	0.5	No
7	F	49	D	4.2	22	70/80	80/80	*	18	Yes	2.3	Hardware removal
8	F	60	D	4	−9	70/20	80/70	22	1	Yes	Non-union	Revision, ulna shortening
9	F	64	D	4.4	6	40/80	60/80	36	9	No	1.2	No
10	F	50	D	3.1	−7	80/15	80/70	47	38	No	0	No
11	F	48	V	6	30	30/30	60/85	*	*	**	2.1	No
12	F	42	V	1.6	13	80/80	80/80	35	46	Yes	0.2	No
13	F	62	V	7	14	80/60	80/80	80	52	Yes	2.8	No
14	F	77	V	5	33	80/80	80/80	78	46	Yes	2.0	No
15	F	21	V	2	24	90/90	90/90	18	34	Yes	1.8	EPL-rupture, reconstruction
16	M	42	V	4	0	90/70	90/80	72	72	Yes	0.3	Osteoarthritis, arthrodesis
17	F	70	V	1	26	60/50	80/80	*	11	No	0.8	No

F, female; M, male; D, dorsal approach; V, volar approach; pro., pronation; sup., supination; DASH, Disabilities of the Arm, Shoulder and Hand score; EPL, extensor pollicis longus.

[a] Positive ulnar variance: ulna distal to radius in the anteroposterior projection (mm).

[b] Zones: radiolucent zones around the TCP at 8–12 weeks.

[c] Loss of reduction (mm) due to axial compression, from the immediate postoperative radiograph to the last follow-up, measurements being the mean of four independent observers.

* Incomplete DASH questionnaire (four or more unanswered items).

** Did not attend planned follow up.