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ORIGINAL ARTICLE

Use of bone graft substitute in the treatment for distal radius fractures in elderly

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Abstract
Introduction Fractures of the distal radius in elderly patients are often associated with metaphyseal defects that can lead to collapse, malunion and therefore decreased function. An alternative approach to simple reduction is to fill the defects with materials that can provide structural support.
Methods We used synthetic hydroxyapatite (HA) in unstable fractures of the distal radius in thirty-one elderly patients, of which four patients lost to follow-up, leaving twenty-seven patients for this study. All subjects underwent closed reduction with K-wire fixation and HA augmentation. They were followed up at 8- and 16-week intervals post-operatively to assess the functional outcome using patient-related wrist evaluation [PRWE], clinical outcome and radiological outcome.
Results At mean 16 weeks, our results show that patients treated with this method showed no metaphyseal defect, no collapse and had satisfactory clinical outcome as assessed by PRWE.
Conclusion We believe that fixation with hydroxyapatite augmentation for fractures of the distal radius in elderly patients is an attractive therapeutic option. This experience has changed our clinical practice.

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Keywords Distal radius fractures · Hydroxyapatite (HA) · Bone graft substitute

Introduction

Fractures of distal end of radius are common injuries treated by orthopaedic surgeons, accounting for approximately 1/6th of all fractures seen and treated in emergency rooms, and these fractures show a predilection for elderly females [1]. These injuries were described as early as in 1783 by Pouteau and later by Sir Abraham Colles in 1814 [2]. The term "fractures of distal end of radius" refers to fractures beginning at the proximal end of pronator quadratus and ending at the radio-carpal articulation [3].

The traditional treatment for such a fracture is closed reduction and application of cast although, in some cases, some form of fixation is desired [4]. Most of the complications associated with these fractures are sequelae of the treatment rather than the original fracture [5, 6]. To offset the major complications of malunion and subsequent functional disability, an alternative approach, as proposed by Charnley in 1970, is to fill the defect with bone or bone substitute to augment fracture stability, accelerate healing and decrease the duration of external fixation [7, 8]. Although autogenous bone graft is considered the gold standard for filling metaphyseal defects, it has inherent risks and morbidity [9]. Graft harvest carries risks, including iliac wing fracture, vascular injury, nerve injury, infection, hernia, haematoma and chronic pain in 6–25 % of cases and adds considerably to operative time, blood loss and cost [10, 11]. Bearing in mind these complications, recent years have seen an increased use of synthetic grafts for primary stabilisation of fractures of distal end of radius with encouraging results [12].

We used synthetic bone graft substitute (hydroxyapatite) in a group of patients with comminuted extra-articular fractures of the distal radius. The aim of the study was to assess the functional outcome in this group of patients following fixation and augmentation with hydroxyapatite.

Materials and methods

Appropriate permission from the institutional ethical committee was taken prior to starting the study. Thirty-one elderly patients were enrolled in this study between May 2009 and June 2011, of which four patients lost to follow-up, leaving twenty-seven patients. Patients of both sexes above the age of 50 with extra-articular, closed comminuted fractures of distal end of radius of Frykman's classification types I, II, V or VI were included in the study [13]. Patients were excluded from the study if they had simple, non-comminuted, intra-articular fractures, and those who meet Frykman's classification types III, IV, VII, VIII. All subjects underwent closed reduction with K-wire fixation and hydroxyapatite augmentation (G. Surgiwear Ltd., Shahjanpur, India) by a single surgeon. All patients were followed up at 8- and 16-week intervals post-operatively to assess the functional outcome, clinical outcome and radiological outcome as given below.

The functional parameters of the subjects included the patient-related wrist evaluation (PRWE) score. This score is based on a questionnaire, range being 0–100 where 100 being worst-case scenario [14]. The following parameters were studied, using a goniometer, for clinical measurement: dorsiflexion (DF), palmar flexion (PF), radial deviation (RD), ulnar deviation (UD), supination (S) and pronation (P) [15]. Radiological parameters were evaluated using X-rays taken at 8 and 16 weeks for radial inclination (RI), radial length (RL) and radial tilt (RT) [16].

Operative procedure

Preoperatively, the procedure was explained to the patient and informed consent was obtained. The affected arm was anaesthetised via brachial block or general anaesthesia. Under image intensifier guidance, the fracture was reduced using traction and counter-traction and fixed with two crossed percutaneous K wires passed from distal end radius to maintain reduction (Fig. 1a). Using minimal dorsal approach to distal end radius, the defect was noted and filled using hydroxyapatite bone granules. The wound was then closed in two layers. A below-elbow slab was applied, and a check X-ray was taken in the immediate post-operative period (Fig. 1b). The patient was allowed active mobilisation of thumb and fingers. On the tenth post-operative day, after suture removal, a full below-elbow cast was applied. The cast and K wires were removed 4 weeks from the day of cast application, and active wrist physiotherapy was started. Patients were subsequently followed up at 8 and 16 weeks for analysis of functional and radiological outcomes (Fig. 1c, d).

Statistical analysis

The statistical analysis was carried out using SPSS 16.0 and MS Excel 2003. Statistical analyses tested the null hypotheses of no differences in patients treated with this group, and a p value of <0.05 was considered significant. Chi-square test, t test and ANOVA test were carried out for statistical analysis.

Results

Of 31 patients enrolled in the study, a total of 27 patients were able to complete the follow-up.

Demography of data is shown in Table 1. It can be inferred that groups as per the gender distribution are comparable for the different characteristics like injured side, dominant hand, Frykmann type, associated injury and complications. Table 2 shows that PRWE score has improved at the 16th week compared to the follow-up at the 8th week. Table 3 shows functional analysis at 8 and 16 weeks. At 16 weeks, there is significant improvement in terms of dorsiflexion, palmar flexion, radial deviation, ulnar deviation, supination and pronation. Figure 2 shows that all the functional variables have shown considerable improvements over the period of 8 to 16 weeks. Table 4 indicates that the figure at 16 weeks is not different from that at 8 weeks, suggesting that there is no collapse. Figure 3 shows that all the radiological variables have shown very marginal changes over the period of 8–16 weeks.

Discussion

Fracture of the distal radius in the elderly results in a metaphyseal trabecular defect that leads to progressive displacement after initial reduction. Therefore, recognition of fracture pattern, reduction, fixation and prevention of collapse is the key to successful management.

Immobilisation in a cast, external fixation and internal fixation with either Kirschner wires or plates are the methods commonly used to try to hold the fracture in a good position until the trabecular defect is filled with new bone. In many cases, however, reduction is not maintained leading to an unsatisfactory outcome.

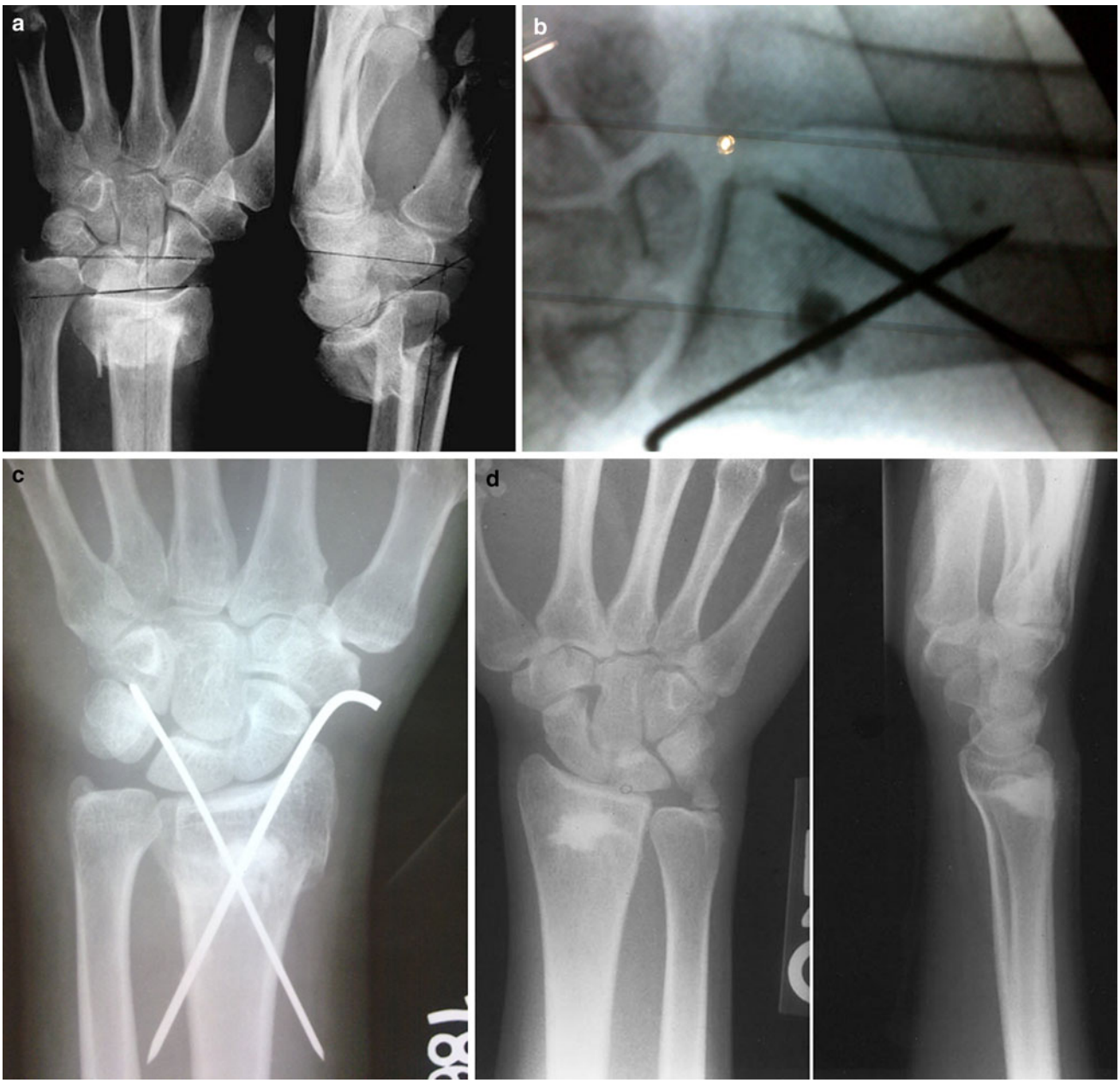

Fig. 1 **a** Preoperative radiograph. **b** Intra-operative image. **c** Immediate post-operative radiograph**. d** Follow-up radiograph at 16 weeks

Locking plate fixation being an open procedure, we wanted to be as minimal in our approach as possible, considering the age, morbidity and cost factors.

Fixation of comminuted extra-articular fractures of distal radius with multiple kirschner wires alone is insufficient to withstand forces across the fracture site and to prevent fracture collapse. Thus, these bone graft substitutes form a mode of solving this problem of collapse.

Interest in bone graft substitutes stems from the added morbidity associated with iliac crest bone graft harvest and the potential for disease transmission and variable antigenicity of allograft bone. An alternative approach to deal with the trabecular defect is to fill it primarily with a material, which provides immediate structural support. When bone graft or PMMA has been used for structural reinforcement, shorter times for immobilisation are achieved with satisfactory functional and anatomical results.

Currently, ceramics are available in variable forms in the market, which are broadly divided into hydroxyapatite, tricalcium phosphate, biphasic calcium phosphate, Norian SRS, chromos (synthes) and cementek. These products are mainly indicated in filling of an osseous cavity or augmentation of bone to enhance its mechanical strength. They also have faster speeds of resorption [17].

Table 1 Demographic analysis

Characteristics	Female *N*	Male *n*	Total *n*
Injured side			
Left	13	8	21
Right	4	6	10
Dominant hand			
Right	17	14	31
Frykmann type			
I	4	6	10
II	12	7	19
V	1	1	2
Associated injury			
DRUJ subluxation	0	3	3
Ulnar head fracture	1	0	1
Complications			
Nil	16	8	24
K wire loosening	1	0	1
Loss of reduction	0	1	1
Pin tract infection	0	3	3
Serous discharge	0	1	1
Shoulder hand syndrome	0	1	1
Total	17	14	31

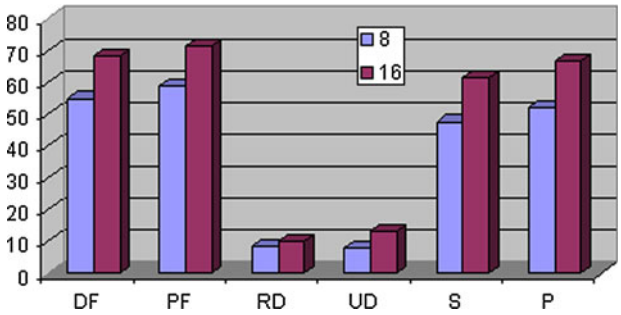

Fig. 2 Functional analysis characteristics over the weeks

Hydroxyapatite has two properties that make it attractive. First, it can be formed in a three-dimensional structure that is rigid and stable. Second, at a microscopic level, the building blocks of HA can be organised to form micropores of ideal size for osteogenesis and angiogenesis. The porosity formed into hydroxyapatite provides the essential scaffold design for proper bone ingrowth, thus creating a stable interface for new bone formation [18]. Synthetic grafts are readily available in different sizes and shapes and are supplied in sterile packet, thus preventing the spread of any kind of infection. The procedure can be performed

Table 2 PRWE analysis

	F		M		Total		*p* value
	N	Mean	*N*	Mean	*N*	Mean	
PRWE at 8 weeks	17	16.6	14	16.9	31	16.8	0.912
PRWE at 16 weeks	14	14.4	13	15.9	27	15.1	0.528

PRWE patient-related wrist evaluation

Table 3 Functional analysis

Weeks	F		M		Total		*p* value
	N	Mean	*N*	Mean	*N*	Mean	
8							
DF	14	55.4	13	54.5	27	54.9	0.703
PF	14	59.6	13	58.1	27	58.9	0.433
RD	14	8.2	13	9.2	27	8.7	0.245
UD	14	8.6	13	7.3	27	8.0	0.196
S	14	46.8	13	48.5	27	47.6	0.566
P	14	51.1	13	53.5	27	52.2	0.411
16							
DF	14	68.8	13	67.8	27	68.3	0.603
PF	14	72.5	13	70.2	27	71.4	0.206
RD	14	10.0	13	10.0	27	10.0	–
UD	14	13.6	13	12.7	27	13.1	0.364
S	14	61.8	13	61.5	27	61.7	0.918
P	14	67.1	13	66.5	27	66.9	0.762

DF dorsiflexion, *PF* palmar flexion, *RD* radial deviation, *UD* ulnar deviation, *S* supination, *P* pronation

Table 4 Radiological analysis

Weeks	F		M		Total		*p* value
	N	Mean	*N*	Mean	*N*	Mean	
8							
RI	14	23.5	13	23.6	27	23.6	0.901
RL	14	10.5	13	10.8	27	10.7	0.480
RT	14	11.1	13	13.0	27	12.0	0.132
16							
RI	14	22.8	13	23.6	27	23.2	0.195
RL	14	10.6	13	10.4	27	10.5	0.750
RT	14	11.1	13	12.6	27	11.8	0.206

RI radial inclination, *RL* radial length, *RT* radial tilt

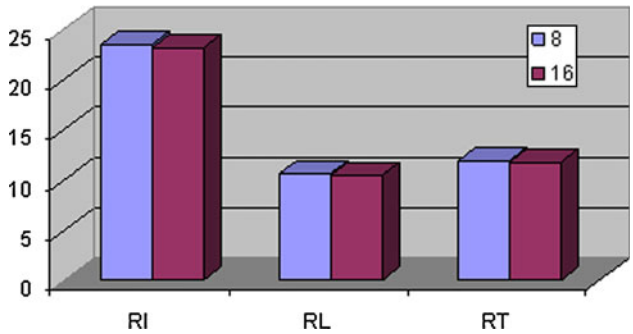

Fig. 3 Radiological analysis characteristics over the weeks

under axillary or intravenous regional anaesthesia and it offers a quick rehabilitation of the wrist and power of the grip.

Previous reports have shown varying radiological results following bone graft substitutes in distal radial fractures [19–23]. However, in our study the mean radial length was 10.8 mm, and there was no statistically significant decrease in radial length over the period of follow-up up to 16 weeks. Radial length was well maintained throughout the follow-up period. Besides, there was no statistically significant decrease in radial tilt over the period of follow-up up to 16 weeks. Radial tilt was also well maintained throughout the follow-up period.

The statistical analysis of our study shows that the p value was not significant in case of radial inclination, radial length and radial tilt, implying that hydroxyapatite augmentation prevented secondary collapse as the weeks progressed. Also, by the functional variables analysis, there has been a statistically significant improvement in the range of all the movements in and around the wrist joint. All patients grip power also increased on each follow-up visits and were able to do their daily activities.

Our study has clearly shown that there are distinct advantages of using synthetic bone in addition to fixation of distal radial fractures in the elderly. We agree that the sample size being small and no control group, there is a weakness in this study.

However, this study has changed our clinical practice and we, now, routinely use synthetic bone grafts in all extra-articular distal radial fractures in addition to fixation.

Conclusion

We believe that hydroxyapatite augmentation for fractures of the distal radius in elderly patients is an attractive, alternate therapeutic option in selected patients and should be routinely considered in distal radial fractures with metaphyseal defects.

Conflict of interest The authors declare that there is no conflict of interest regarding this article.

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