REDISPLACED UNSTABLE FRACTURES OF THE DISTAL RADIUS

A PROSPECTIVE RANDOMISED COMPARISON OF FOUR METHODS OF TREATMENT

M. M. MCQUEEN, C. HAJDUCKA, C. M. COURT-BROWN

From the Royal Infirmary of Edinburgh, Scotland

We performed a prospective, randomised trial on 120 patients with redisplaced fractures of the distal radius comparing four methods of treatment. The four treatment groups, each containing 30 patients, were remanipulation and plaster, open reduction and bone grafting, and closed external fixation with and without mobilisation of the wrist at three weeks.

The radiological results showed improvement in angulation of the distal radius for the open reduction and bone grafting group. Functional results at six weeks, three and six months and at one year, however, showed no difference between any of the four groups. The main influence on final outcome was carpal malalignment which had a statistically significant negative effect on function.

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Fractures of the distal radius are common and treatment depends on the type. The management of an unstable fracture which has redisplaced presents a particular problem. Many different methods have been advocated. The traditional one is closed remanipulation and application of a cast and this is still used in many centres, despite reports of poor results, particularly in older patients (McQueen, MacLaren and Chalmers 1986; Schmalholz 1989). Closed external fixation has been advocated (Cooney, Linscheid and Dobyns 1979; Jonsson 1983; Schuind, Donkerwolcke and Burny 1984; Jenkins et al 1987; Howard et al 1989; Kongsholm and Olerud 1989; Lennox, Page and Mandell 1989; Edwards 1991), but recent reports have described poor functional results even after an acceptable reduction (Roumen, Hesp and Bruggink 1991; McQueen, Michie and Court-Brown 1992). External fixators of the wrist with articulation which allows mobilisation of the joint have not been fully evaluated. Bone grafting has been used either with external fixation (Leung et al 1990) or for treating late malunion (Fernandez 1982; Jupiter and Masem 1988), and encouraging results have been reported with corticocancellous wedge grafting at an early stage when instability has been identified (McBirnie, Court-Brown and McQueen 1995).

We report a prospective, randomised study of four of these methods of treatment with reference to the anatomical and functional outcome.

Table I. Classification of 120 fractures according to the AO system (Müller et al 1990)

Group	A3.2	C2.1	C2.2	C2.3	C3.2
1	11	11	1	0	7
2	10	14	0	0	6
3	14	12	0	1	3
4	13	9	3	1	4
Total	48	46	4	2	20

PATIENTS AND METHODS

Between December 1991 and December 1993, 120 consecutive patients with unstable fractures of the distal radius were entered into the study. Instability was defined as the failure to hold a reduced position of the fracture within a forearm cast. Patients with redisplacement to dorsal angulation of more than 10° (van der Linden and Ericson 1981) or radial shortening of more than 3 mm (Melone 1984) were chosen. We excluded patients with an inadequate primary reduction, those in whom more than two weeks had elapsed from injury to the recognition of instability, and those with displacement of articular fragments requiring open reduction. We also excluded those with a previous malunion or physical or mental incapacity.

There were 107 women and 13 men; their average age was 63 years (16 to 86). The fractures were classified using

M. M. McQueen, MD, FRCS Ed(Orth), Consultant Orthopaedic Surgeon
C. Hajducka, RCN, ONC, Research Manager
C. M. Court-Brown, MD, FRCS Ed(Orth), Consultant Orthopaedic Surgeon
Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh NHS Trust, 1 Lauriston Place, Edinburgh EH3 9YW, UK.

Correspondence should be sent to Miss M. M. McQueen.

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Fig. 1

A distal radial fracture treated by open reduction and bone grafting. The bone graft can be seen filling the doral defect and held in place by a Kirschner wire.

the AO system (Table I) and 60% were intra-articular. They had been caused by either a simple fall (100), a fall from a height of more than three feet (7), sport (11) or road-traffic accidents (2).

Patients were randomly allocated by a closed-envelope method into one of four treatment groups. Group 1 consisted of 30 who had closed re-reduction under regional or general anaesthesia with application of a forearm cast which was retained for six weeks.

Group 2 comprised 30 patients who had open reduction and bone grafting (McBirnie et al 1995). We used a transverse dorsal skin incision at the level of the fracture with longitudinal division of the extensor retinaculum, taking care to protect the extensor pollicis longus tendon. The distal radius was exposed by subperiosteal dissection and the fracture was reduced. The resulting defect in the dorsal surface was filled with a wedge of corticocancellous bone from the iliac crest, held in place by a single Kirschner wire inserted diagonally across the fracture from the radial styloid (Fig. 1). A forearm cast was applied and retained for six weeks.

The 30 patients in group 3 had closed re-reduction and application of a Pennig external fixator, with two pins in the second metacarpal and two in the shaft of the radius, all inserted by an open technique. The ball joint was aligned with the axis of the wrist and then locked. Meticulous attention was given to the pin tracks during the post-operative period. The fixator was removed after six weeks.

The 30 patients in group 4 had closed re-reduction and application of a Pennig external fixator as in group 3, but at three weeks the ball joint was released to allow wrist movement. The fixator was removed after six weeks.

Table II. Details of the 120 patients with unstable fractures of the distal radius

	Group			
	1	**2**	**3**	**4**
Mean age in years (± SD)	64 ± 14.5	59 ± 17.9	63 ± 11.6	65 ± 14.7
Female (%)	*93*	*87*	*83*	*93*
Simple fall (%)	*83*	*87*	*87*	*77*
AO class A (%)	*37*	*33*	*47*	*43*
AO class C (%)	*63*	*67*	*53*	*57*

For each group, physiotherapy was prescribed for some patients on purely clinical indications. The groups were similar in age, gender, type of injury and fracture classification (Table II), although there were more extra-articular AO class-A fractures in the two groups treated by an external fixator.

All the operations in the four groups were carried out by two of the three authors (MMcQ and CCB). We performed a clinical, radiological and functional review at six weeks, three and six months and at one year after injury. Complications were recorded and a research physiotherapist made a detailed assessment of hand and wrist function (McQueen and Caspers 1988). The mass grip strength was measured with a Jamar dynamometer and expressed as a percentage of the opposite normal side, allowing 30% less for the non-dominant side (Bechtol 1954). Specialised grips (pinch, key, chuck, hook and cylinder) were measured using the Musur-Grieve spring balance (Musur-Grieve 1984) and again expressed as a percentage of that on the normal side. The ability to perform each of 11 unilateral and bilateral activities of daily living was scored on a scale of 0 to 2, where 0 is impossible, 1 possible with difficulty and 2 normal. We measured flexion, extension, radial and ulnar deviation, pronation and supination with a goniometer, expressing the results as a percentage of the opposite normal side. Pain was assessed from 0 to 10 using a visual analogue score.

Anteroposterior and lateral radiographs were taken of the wrist. We measured the dorsal angulation (van der Linden and Ericson 1981) radial shortening (Melone 1984) and carpal malalignment, defined as the displacement on a lateral view of the longitudinal axis of the capitate either dorsal or volar to the longitudinal axis of the radius (Taleisnik and Watson 1984) (Fig. 2).

Malunion was defined as more than 10° of dorsal angulation, more than 15° of volar tilt or more than 3 mm of radial shortening compared with the opposite normal side.

All the patients attended for review at six weeks. Nine failed to attend at three months leaving 27 in group 1, 28 in group 2, 29 in group 3 and 27 in group 4. Seven were not seen at six months leaving 27 in group 1, 29 in group 2, 30 in group 3 and 27 in group 4. Eleven patients did not attend for review at one year leaving 28 in group 1, 27 in group 2, 28 in group 3 and 26 in group 4.

Fig. 2

A fracture with doral malunion and carpal malalignment. The long axis of the capitate is displaced doral to the long axis of the radius on the lateral view.

We performed statistical analysis using the chi-squared test, the Spearman correlation coefficient, the Mann Whitney U test and the Wilcoxon rank test.

RESULTS

Radiological results. The mean dorsal angulation for all the patients was 7° at six weeks and 6° at one year. Table III gives the values for each group. We found no statistical differences between the two external-fixator groups and they were therefore merged for the purposes of statistical analysis.

Open reduction and bone grafting gave the best correction of dorsal angulation with a mean volar tilt of 4° at six weeks and 3° at one year, which was significantly better than that in group 1 or groups 3 and 4 (Table III). Ten of the 30 patients regained a normal volar tilt but seven were either overcorrected or collapsed into further volar tilt later. Three fractures, although initially reduced, had collapsed into recurrent dorsal angulation by six weeks.

The combined external-fixation groups showed a significantly better correction of the dorsal angle than the remanipulation group at six weeks and one year, but were significantly worse than group 2. Of the 60 fractures in these two groups, ten were not reduced fully by closed techniques and 14 had recurrence of the instability while the fixator was in place. Recurrent instability was equally distributed between groups 3 and 4.

Group 1 had the worst results in terms of dorsal angulation. Four fractures were not reduced adequately with closed remanipulation and 16 had recurrent instability. There were no statistically significant differences between the four groups for radial shortening (Table IV).

Table III. The mean dorsal angulation (degrees ± SD) for all groups at six weeks and one year

	Treatment group				p value			
	1	**2**	**3**	**4**	**1 *v* 2**	**3 *v* 4**	**1 *v* 3+4**	**2 *v* 3+4**
6 weeks	16 ± 8	-4 ± 13	7 ± 13	9 ± 9	<0.001	NS	<0.01	<0.001
1 year	13 ± 11	-3 ± 14	5 ± 14	8 ± 11	<0.001	NS	<0.02	<0.01

Table IV. The mean radial shortening (mm ± SD) for all groups at six weeks and one year

	Treatment group				p value			
	1	**2**	**3**	**4**	**1 *v* 2**	**3 *v* 4**	**1 *v* 3+4**	**2 *v* 3+4**
6 weeks	3 ± 3	2 ± 2	4 ± 3	2 ± 2	NS	NS	NS	NS
1 year	2 ± 3	2 ± 2	3 ± 3	2 ± 2	NS	NS	NS	NS

Table V. Mean mass grip strength expressed as a percentage (± SD) of the normal side for all groups at six weeks, three and six months, and at one year

	Group				
	1	**2**	**3**	**4**	**Whole**
6 weeks	7 ± 16	4 ± 10	0.1 ± 0.5	3 ± 7	4 ± 10
3 months	24 ± 21	28 ± 22	18 ± 21	23 ± 25	24 ± 22
6 months	46 ± 24	52 ± 32	53 ± 30	43 ± 32	49 ± 30
1 year	68 ± 28	65 ± 29	64 ± 27	54 ± 32	63 ± 29

Table VI. Mean recovery of the flexion/extension arc expressed as a percentage (± SD) of the normal for all groups at six weeks, three and six months, and at one year

	Group				
	1	**2**	**3**	**4**	**Whole**
6 weeks	43 ± 12	33 ± 15	39 ± 21	42 ± 14	39 ± 16
3 months	74 ± 15	66 ± 15	72 ± 13	73 ± 13	71 ± 14
6 months	80 ± 14	79 ± 14	82 ± 15	80 ± 14	80 ± 14
1 year	83 ± 14	81 ± 16	88 ± 13	85 ± 10	84 ± 13

Table VII. Mean recovery of range of motion expressed as a percentage (± SD) of the normal side for all groups at six weeks, three and six months, and at one year

	Group				
	1	**2**	**3**	**4**	**Whole**
6 weeks	63 ± 21	52 ± 23	50 ± 23	54 ± 21	55 ± 22
3 months	83 ± 13	82 ± 17	82 ± 15	81 ± 14	82 ± 14
6 months	87 ± 12	86 ± 17	86 ± 15	90 ± 12	87 ± 14
1 year	93 ± 11	93 ± 11	89 ± 13	89 ± 13	91 ± 12

Some carpal malalignment was evident after union in 50 wrists (42%). Thirty-one (62%) were malunited in either dorsal angulation (Fig. 2) or volar angulation, whereas of the 70 wrists with normal carpal alignment 17 (24%) showed malunion. Fourteen in group 1, 11 in group 2, 14 in group 3 and 11 in group 4 had carpal collapse after the fracture had healed or at final review. The small differences between the groups were not statistically significant (chi-squared test).

Functional results. The results for mass grip strength are shown in Table V. There was sequential improvement although this was not subjected to formal statistical analysis. There were no statistically significant differences between the groups for each time period. The recovery of specialised grip strength and the ability to perform unilateral and bilateral activities of daily living also showed sequential improvement without statistically significant differences between the groups.

The recovery of the ranges of flexion/extension and rotation are shown in Tables VI and VII, respectively. There was rapid improvement for up to three months which then slowed with further slow recovery until one year. There were no significant differences between the groups.

Using the Spearman rank correlation coefficient and the Wilcoxon rank test, the radiographs of all the patients were examined to see whether any specific feature had an effect on the functional outcome. Carpal malalignment had a significant association with diminished recovery of strength of mass grip (p 0.02), chuck grip (p 0.02) and key grip (p 0.05) after one year. There was a similar association with recovery of the range of rotation at three months (p 0.005), six months (p 0.002) and one year (p 0.01). After one year radial shortening had a significant negative association with recovery of chuck (p 0.005), key (p 0.01) and pinch (p 0.001) grip strengths.

Complications. Overall, 77 patients (64%) had a complication of either their fracture or of the operation (Table VIII). If malunion is excluded, 27 patients (26%) had 30 complications. Fifty-four patients (45%) had malunion. Infection occurred in 12 pin tracks in nine patients, that is in 12 of 240 pins (5%). Two of these patients required early removal of the fixator and one case of pin-track infection resolved only after curettage. All the others settled rapidly with oral antibiotics and local dressings. There was a trend to an increased rate of reflex sympathetic dystrophy in the fixator groups but this was not statistically significant.

Table VIII. Complications encountered in all groups, by number and *percentage*

	Group				
	1	**2**	**3**	**4**	**Total**
	(n = 30)	**(n = 30)**	**(n = 30)**	**(n = 30)**	**(n = 120)**
Malunion	20 (*67*)	10 (*33*)	11 (*37*)	13 (*43*)	54 (*45*)
Carpal collapse	14 (*47*)	11 (*37*)	14 (*47*)	11 (*37*)	50 (*42*)
Pin-track or K-wire infection	0	1 (*3*)	7 (*23*)	2 (*7*)	10 (*8*)
Reflex sympathetic dystrophy	1 (*3*)	1 (*3*)	4 (*13*)	3 (*10*)	9 (*8*)
Carpal tunnel syndrome	1 (*3*)	2 (*7*)	1 (*3*)	2 (*7*)	6 (*5*)
Dorsal medial neurapraxia	0	1 (*3*)	1 (*3*)	0	2 (*2*)
Wound infection	0	2 (*7*)	0	0	2 (*2*)
Extensor pollicis longus rupture	0	1 (*3*)	0	0	1 (*1*)

DISCUSSION

Our study has shown no differences in the functional outcome of unstable fractures of the distal radius treated by four different methods, despite disparity in the anatomical appearance as measured by deformity in the distal radius. The best anatomical results were obtained by open reduction and bone grafting and the next best by external fixation with or without early mobilisation of the wrist. Remanipulation and casting did not reliably achieve or maintain a good reduction, confirming previous retrospective studies (McQueen et al 1986; Schmalholz 1989). Howard et al (1989) reported a randomised study comparing external fixation with plaster in displaced fractures of the distal radius and showed a statistical improvement in the anatomical results but not in function, except in younger patients. In neither group was palmar tilt restored. Similar findings were described by Roumen et al (1991). These authors did not relate carpal malalignment to function.

The major influence on function in our patients was the degree of carpal malalignment. Despite differences in the final anatomical appearance of the distal radius the incidence of carpal malalignment between the groups was similar. Taleisnik and Watson (1984) believe that the carpal malalignment is due to loss of the normal palmar tilt of the distal radius and that only when this is restored will there be correction of carpal alignment. None of the four techniques which we used was reliable in restoring volar tilt even in the presence of conventionally acceptable radiological results. Restoration of palmar tilt is probably more important for recovery of wrist and hand function than has previously been realised. Open reduction and bone grafting is the best of the four techniques for regaining volar tilt because it depends on direct reduction of the distal fragment. It is a more difficult method than closed techniques and overcorrection may occur, especially in the presence of both volar and dorsal comminution (McBirnie et al 1995).

Closed techniques depend on ligamentotaxis to regain palmar tilt. Bartosh and Saldana (1995) believe that when closed reduction is performed the palmar ligaments are brought out to length and pull on the distal fragment before the thinner dorsal ligaments exert any traction, thus limiting the ability of any technique of closed reduction to restore palmar tilt.

Mobilisation of the wrist during the period of stabilisation of the fracture has recently become popular (Asche 1989). Our study has shown that mobilising the wrist at three weeks gave no improvement in the ranges of movement or of hand function. Loss of position was not seen, however, since all of the malunited fractures in the external fixation groups had either not been reduced successfully by closed means or had shown recurrent instability before three weeks had elapsed. These patients did not receive physiotherapy while the fixator was in place and it is likely that patients in this older group were not motivated to move the wrist. More benefit may accrue in more highly-motivated younger patients especially if they had considerable intra-articular damage.

Similar findings were noted by Sommerkamp et al (1994) in a randomised study of static versus dynamic external fixation in a young group of patients with generally higher-energy injuries than in our study. They saw no improvement in mobility or function with dynamic fixation. The results of early mobilisation in our study are similar to those reported by Stewart, Innes and Burke (1984) with early mobilisation using braces, but conflict with others (Dias et al 1987). These last authors agree, however, that early mobilisation does not influence the bony deformity.

We found recovery to approximately 80% to 90% of normal range of movement, similar to that in other reports (Cooney et al 1979; McQueen et al 1992; McBirnie et al 1995). The overall return of grip strength was disappointing: an average of 63% was regained at one year. Again, there was sequential improvement during the year and there may be further recovery (Yen, Hwang and Hwang 1991). Similar results, with significant weakness of grip, have been reported previously after treatment of the same type of fracture (Cooney et al 1979; Dias et al 1987; Yen et al 1991; McQueen et al 1992). Significant numbers of poor or fair results after unstable fractures of the distal radius have been described after assessments using scoring systems (Jonsson 1983; Howard et al 1989; Kongsholm and Olerud 1989).

Our complication rate in this series was high but very similar to that already noted by us and by others (Cooney et al 1979; Weber and Szabo 1986; Jenkins et al 1987; Kongsholm and Olerud 1989; Roumen et al 1991; McQueen et al 1992).

None of the four methods of management which we compared showed greater benefit to the patient in terms of functional outcome although there were significant differences in the alignment of the distal radius. No regime consistently restored palmar tilt and normal carpal alignment. These two related criteria are probably the most important influences on functional outcome. Until a method of treatment is found which reliably corrects palmar tilt the dilemma of how best to treat an unstable fracture of the distal radius will remain. We are currently evaluating closed metaphyseal external fixation with promising early results.

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