Redisplaced unstable fractures of the distal radius

A RANDOMISED, PROSPECTIVE STUDY OF BRIDGING *VERSUS* NON-BRIDGING EXTERNAL FIXATION

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A randomised, prospective study was carried out on 60 patients with unstable fractures of the distal radius to compare bridging with non-bridging external fixation using pins placed in the distal fragment of the radius.

The radiological results showed significant improvement in the non-bridging group at all stages of review. In particular, normal volar tilt and carpal alignment were regained and maintained. The functional results at six weeks, three months, six months and one year showed statistically better grip strength and flexion in the non-bridging group at all stages of review. Other ranges of movement showed an early advantage in the non-bridging group.

Non-bridging external fixation is the treatment of choice for unstable fractures of the distal radius which have sufficient space for the placement of pins in the distal fragment.

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Fractures of the distal radius are common; a significant proportion redisplace after initial reduction and management in plaster. Many different methods of treatment have been advocated. The traditional practice of remanipulation and further management in a cast is ineffective.[1-3] External fixation is a popular method which may improve the maintenance of reduction but not the functional outcome.[3] Function correlates closely with alignment of the carpus[3,4] and to regain this the volar tilt of the distal radius must be restored. It cannot be achieved reliably using bridging external fixation.[3]

A randomised, prospective study has been carried out to compare the effectiveness of non-bridging with bridging external fixation in restoring the normal anatomy, carpal alignment and function of the hand after unstable fractures of the distal radius.

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Patients and Methods

Between February 1993 and January 1995, 60 patients with unstable fractures of the distal radius were entered into the study. Instability was defined as a failure to hold the reduced position of the fracture within a forearm cast, and those with redisplacement to dorsal angulation[5] of more than 10° were chosen. Patients were excluded if there was still residual dorsal angulation after primary reduction, an interval of more than two weeks from injury to recognition of the instability, a displaced articular fracture or a fracture with less than 1 cm of intact volar cortex on the distal fragment. Those with a previous malunion or who were unable, physically or mentally, to perform the functional evaluation, were also excluded.

There were 55 women and five men with an average age of 61 years (31 to 85). The fractures were classified using the AO system.[6] Of the total number of fractures, 44 were AO class A3.2, 14 were AO class C2.1 and two were AO class A3.3; 23%, therefore, were intra-articular. The injuries were caused by a fall from a standing height in 52 cases, a fall from over three feet in two and by sport in six.

Patients were randomly allocated using closed envelopes into one of two groups. Group I consisted of 30 patients who had been treated by closed re-reduction and application of a Pennig external fixator. Two pins were inserted into the second metacarpal and two into the shaft of the radius using the open placement technique. The ball joint of the fixator was locked for the period of treatment. Meticulous attention was given to the pin tracks during the postoperative period. The fixator was removed after six weeks and physiotherapy was prescribed as clinically indicated.

The 30 patients in group II had closed reduction and application of a non-bridging Pennig fixator. A short transverse incision was made over the dorsum of the wrist just proximal to the radiocarpal joint. A 1 cm longitudinal incision was then made in the extensor retinaculum on either side of Lister's tubercle taking care to protect the tendon of extensor pollicis longus. Two fixator pins were then placed parallel to the surface of the joint in the distal radial fragment from the dorsal to the volar aspects and engaging the volar cortex (Fig. 1). Two pins were inserted into the radial shaft again using an open placement technique. The fracture was reduced using the distal pins as

Fig. 1

Placement of the pins in the distal fragment parallel to the joint surface and engaging the volar cortex.

levers. The postoperative care was the same as in group I and the fixator was removed after six weeks.

Some patients in each group had physiotherapy prescribed for purely clinical indications. The groups were similar in age, gender, type of injury, initial displacement and fracture classification although there were more intra-articular AO class-C fractures in group II (Table I).

All the operations were carried out by the author. A radiological review was undertaken at six weeks and one year after injury by measuring the dorsal angulation[5] and radial shortening[7] and assessing carpal malalignment. Dorsal angulation was measured using the same technique as van der Linden and Ericson[5] and expressed as the number of degrees from the neutral position. Radial shortening was measured as the vertical distance between the ulnar border of the distal radius and the most distal point of the head of the ulna,[7] and expressed as the difference between the normal and injured sides. Carpal malalignment was defined on a lateral view as the dorsal or volar displacement of the longitudinal axis of the capitate to the long axis of the radius.[3,4] Malunion was defined as more than 10° of dorsal angulation or more than 3 mm of radial shortening compared with the opposite normal side. Clinical and functional reviews were undertaken at six weeks, three and six months and one year after injury. The complications were recorded and an assessment of hand function was made by a research physiotherapist.[8] The mass grip strength was measured using a Jamar dynamometer and expressed as a percentage of the opposite normal side, allowing 30% less for the non-dominant side.[9] Flexion, extension, pronation and supination were measured with a goniometer, expressing results as a percentage of the opposite normal side. Pain was assessed on a range of 0 to 10 using a visual analogue scale and its site was recorded.

Table I. Details of the patients with fractures of the distal radius treated either by closed re-reduction and application of a Pennig external fixator (group I) or a non-bridging fixator (group II)

	Group I	Group II
Number of patients	30	30
Mean age in years (±SD)	61 (±13)	62 (±14)
Men	2	3
Women	28	27
Simple fall	26	26
AO classification		
A	25	21
C	5	9
Original dorsal angulation (degrees; ±SD)	25 (±8)	27 (±12)
Original shortening (mm; ±SD)	2.7 (±3.0)	1.9 (±3.0)

Table II. Mean dorsal angle (degrees; ± SD) and radial shortening (mm; ± SD) for the two groups immediately after surgery and at six weeks and one year

	Group I	Group II	p value
Mean dorsal angle			
After operation	3.6 (±5.7)	-5.0 (±5.7)	<0.001
Six weeks	9.5 (±13.2)	-6.6 (±6.2)	<0.001
One year	12.2 (±13.2)	-5.6 (±6.4)	<0.001
Mean radial shortening			
After operation	1.5 (±2.5)	-0.2 (±1.1)	<0.001
Six weeks	2.8 (±2.9)	0.2 (±1.8)	<0.001
One year	2.8 (±3.2)	1.4 (±1.8)	>0.05

Table III. Mean mass grip strength (%; ± SD) of the normal side for both groups at six weeks and three months, six months and one year

	Group I	Group II	p value
Six weeks	3 (±6)	14 (±16)	<0.01
Three months	30 (±16)	54 (±27)	<0.001
Six months	50 (±22)	75 (±21)	<0.001
One year	69 (±21)	87 (±16)	<0.001

Table IV. Mean ranges of flexion and extension (%; ± SD) for both groups at six weeks and three months, six months and one year

	Group I	Group II	p value
Flexion			
Six weeks	35 (±22)	38 (±20)	>0.05
Three months	61 (±20)	71 (±17)	<0.05
Six months	73 (±23)	86 (±14)	<0.05
One year	78 (±20)	88 (±15)	<0.05
Extension			
Six weeks	14 (±21)	26 (±22)	<0.01
Three months	65 (±23)	67 (±19)	>0.05
Six months	84 (±19)	79 (±14)	>0.05
One year	87 (±15)	86 (±13)	>0.05

Table V. Mean ranges of supination and pronation (%; ± SD) at six weeks and three months, six months and one year

	Group I	Group II	p value
Supination			
Six weeks	33 (±27)	59 (±31)	>0.05
Three months	72 (±24)	88 (±23)	>0.05
Six months	88 (±16)	93 (±24)	>0.05
One year	94 (±9)	97 (±7)	>0.05
Pronation			
Six weeks	42 (±27)	59 (±24)	<0.05
Three months	76 (±23)	88 (±17)	<0.05
Six months	91 (±9)	93 (±15)	>0.05
One year	95 (±7)	97 (±6)	>0.05

Table VI. Major complications for each of the two treatment groups

	Number of complications	
	Group I	Group II
Pin-track infection	2	7
Rupture of extensor pollicis longus	0	2
Reflex sympathetic dystrophy	2	0
Malunion	14	0

All patients were seen for review at six weeks. One in group II failed to attend at three months and two at six months and one year. All patients in group I were reviewed at three and six months but two did not come at one year.

Statistical analysis was performed using the chi-squared test with Yates' correction for categorised outcomes and the Wilcoxon rank-sum test for ordinal or continuous outcomes. Non-significance was defined as $p > 0.05$.

Results

Radiological. Immediately after re-reduction and application of the external fixator the mean dorsal angle in group I was 3.6° and in group two –5°, i.e. 5° of volar tilt (Table II). This difference was statistically significant ($p < 0.001$) using the chi-squared test with Yates' correction. All but five of the patients in group II were reduced to some volar tilt and these five all had a dorsal angle of less than 5°. By contrast, only five patients in group I regained volar tilt, but all except three were reduced to less than 10° of dorsal angulation.

Immediately after operation, non-bridging external fixation achieved significantly better radial length than bridging, with means of –0.2 mm and 1.5 mm of shortening, respectively (Table II).

By six weeks, the differences in the radiological outcome had increased for both the dorsal angle and the radial length (Table II). There was a mean increase of 5.9° of dorsal angulation and a mean loss of 1.3 mm of radial length in group II. The 25 fractures in the non-bridging group which had reduced to a volar tilt had maintained their position and none of the five which had not regained this tilt had more than 5° of dorsal angulation. By contrast, 13 of the fractures in group I had deteriorated to more than 10° of dorsal angulation.

One year after fracture, group II had maintained a mean volar tilt of 5.6° while the bridging group had deteriorated to a mean dorsal angle of 12.2° (Table II). A total of 23 fractures in group II maintained a volar tilt while the five with persistent dorsal tilt maintained positions of less than 5° of dorsal angulation. In group I, 15 fractures had more than 10° dorsal angulation at one year.

There was a mean loss of 1.2 mm of radial length in group II at one year. This was half the loss of length in group I, but the difference was not statistically significant (Table II).

Normal carpal alignment was regained after operation and maintained at one year in 13 patients in group I and 28 in group II. This difference was statistically significant ($p < 0.001$; chi-squared test).

Functional. The results for mass grip strength are shown in Table III. The strength was significantly better at all stages in group II compared with group I, with the final measurements being 87% and 69% of normal, respectively.

The range of flexion was similar at six weeks but significantly better in group II at three months, six months and one year (Table IV). Extension was significantly improved in group II at six weeks but similar at later stages (Table IV). Table V shows that the range of pronation was increased in group II at six weeks and three months, but was the same in the two groups at later review. There were no significant differences at any stage in the range of supination in the two groups (Table V).

At one year, 16 patients in group I and 14 in group II had residual pain, although the mean analogue scores were low at 1.3 and 1.2, respectively, with no differences in the earlier stages. Eight patients in group I and seven in group II localised their pain at the distal radioulnar joint. Seven patients in group I had carpal pain compared with three in group II.

Complications. Overall, 25 of the 60 patients (42%) experienced one or more complications (Table VI). Excluding malunion, 12 of the 60 patients (20%) had one or more complications. Of these, only five (8%) had major complications, defined as those which would be expected to have a significantly negative effect on outcome. There were no significant differences between the complication rates for the two groups if malunion was excluded. The specific complications are detailed in Table VI.

Discussion

Non-bridging external fixation achieves a better reduction of unstable distal radial fractures than the bridging method and this is maintained at one year. It restores carpal alignment, achieves a significantly better grip strength and the range of movement is significantly increased, especially in the early period of rehabilitation.

The key to the improved results is the ability of non-bridging external fixation to regain and maintain the normal volar tilt, allowing correction of the carpal alignment which is significantly related to better functional outcome.[3,4] The pins in the distal fragment permit the surgeon to have direct control which allows exact repositioning. It avoids the need to depend on ligamentotaxis which does not restore volar tilt with any degree of certainty.[5,10-13] On applying traction across the wrist the volar ligaments, which are short and tough, tighten first thus preventing the distal radius from inclining in a volar direction.[14] Closed bridging external fixation does not always achieve an adequate reduction especially if there is some delay between the fracture and recognition of instability, but a successful result may be achieved much later after fracture with the non-bridging technique which may be used in about 90% of unstable fractures of the distal radius. Other methods should be considered in those with less than 1 cm of volar cortex or with articular displacement.

Early mobilisation of the wrist during bridging fixation has been advocated[15,16] but has not been successful in improving the range of movement after treatment of a redisplaced fracture in the short or long term.[3,13] The patient may be reluctant to move a wrist which is restricted by a bridging external fixator, and the few degrees of dorsal inclination of the distal fragment which usually persists after bridging reduces the range of flexion. There is no mechanical restriction of wrist movement with a non-bridging fixator and this allows better movement during the period of fixation and after removal of the device. The better range of flexion persists after non-bridging fixation because of the restoration of volar tilt, and preservation of length is improved.

Other methods of treatment of unstable fractures of the distal radius have relative disadvantages. Remanipulation and application of another cast does not reliably regain or maintain position and should be abandoned.[1-3] Dorsal plating is a difficult technique and requires an extensive approach with stripping of soft tissue. A cast is usually used as well. Fixation with multiple Kirschner wires does not reliably maintain the re-reduced position even in younger patients[17,18] and is inappropriate in older patients with osteoporosis. It usually requires immobilisation in a cast with its attendant disadvantages.

The complication rate in this series was relatively low. Theoretical concerns about infection of distal pin tracks leading to septic arthritis of the wrist have been unfounded. It is likely that the excellent blood supply of the metaphysis minimises the risk of septic arthritis. Equally, the pins are separated from the joint by a physical barrier of metaphyseal bone, subchondral bone and articular cartilage. Infection in other sites remains localised around the pin tracks and in this respect the distal radius is no different.

Tendon rupture may occur due to imprecise placement of the pins in the distal fragment but can be avoided by careful technique. The two ruptures of the extensor pollicis longus which occurred in the non-bridging group were not related to the pins, and no further tendon ruptures have been seen in another 50 patients treated by this method since completion of this study.

Reflex sympathetic dystrophy is a disabling complication after fracture of the distal radius. The only two cases encountered were in the bridging group, perhaps related to the traction across the wrist.

Despite the osteoporotic nature of the fractures no pins lost their hold in the distal fragment. It is important to engage the volar cortex especially in the presence of extensive dorsal comminution. Reduction is achieved with such little force that the stresses on the pins are likely to be very low.

Non-bridging external fixation is a significantly better technique than bridging both anatomically and functionally and is the treatment of choice for unstable fractures of the distal radius in which external fixation is contemplated and there is sufficient space in the distal fragment.

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