Management of completely displaced metaphyseal fractures of the distal radius in children

A PROSPECTIVE, RANDOMISED CONTROLLED TRIAL

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In a prospective, randomised controlled trial, 68 children who had a completely displaced metaphyseal fracture of the distal radius were treated either by manipulation (MUA) and application of an above-elbow cast alone or by the additional insertion of a percutaneous Kirschner (K-) wire. Full radiological follow-up to union was obtained in 65 children and 56 returned for clinical evaluation three months after injury.

Maintenance of reduction was significantly better in the K-wire group and fewer follow-up radiographs were required. There was no significant difference in the clinical outcome measured three months after injury. Seven of 33 patients in the MUA group had to undergo a second procedure because of an unacceptable position compared with none of the 35 in the K-wire group (chi-squared test, p < 0.01). One patient in the K-wire group required exploration for recovery of a migrated wire.

We conclude that the use of a percutaneous K-wire to augment the reduction of the fracture in children who have a completely displaced metaphyseal fracture of the distal radius is a safe and reliable way of maintaining alignment of the fracture.

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Traditionally, fractures of the distal radius in children have been treated by closed reduction and immobilisation in a plaster cast. Maintenance of satisfactory alignment can be difficult, however, and redisplacement and malunion have been widely described.1-4 Haddad and Williams5 reported that 21% of fractures of the distal radius redisplaced early after reduction. The acceptable degree of residual deformity remains ill-defined. Even if such fractures heal in a mal-united position, they may remodel with little or no functional deficit,6,7 and up to 20° of residual dorsal angulation may be accepted with the expectation of satisfactory remodelling.1 Nevertheless, poor functional outcome after such fractures has been associated with both residual angulation and translation.5 Choi et al8 confirmed that translation of the radius had an unfavourable outcome. Roberts2 found that, in fractures of the distal third of the radius, loss of rotation was related to residual deviation of the radius, but not to dorsal angulation. Even a temporary restriction of movement or abnormal appearance may not be acceptable to the child or parents.

Loss of position in the cast has been shown to be the most important factor affecting the position at union.7 The use of properly fitting casts using three-point fixation has also been emphasised.3-5 Haddad and Williams5 felt that the outcome was related to the experience of the operator. Proctor, Moore and Paterson9 found that complete displacement of the fracture and failure to achieve a perfect reduction were both associated with a significant increase in the incidence of redisplacement.

The use of percutaneous Kirschner (K-) wire fixation has been recommended, but the indications vary. Proctor et al9 advocated fixation in all cases in which a perfect reduction could not be achieved, whereas Prevot et al17 recommended wires for instability or irreducibility. Gibbons et al10 proposed that fractures of the distal radius in the presence of an intact ulna should be wired. Our study was based on the radiological assessment of 23 patients and the functional outcome was not considered. Reported complications of K-wire fixation include pin-track infection, hypertrophic scarring and neurapraxia.8,10 Most studies are retrospective with considerable loss to follow-up.

We designed a prospective, randomised, controlled trial to determine whether K-wire fixation is a safe and reliable treatment giving better maintenance of reduction to union compared with closed manipulation (MUA) and immobilisation in a cast alone. We evaluated the radiological position at union, the clinical function at three months after injury, the requirement for additional treatment and the incidence of complications.
Patients and Methods

Between May 1997 and October 1999, we enrolled 68 children aged between four and 14 years into the trial. Approval had been given by the local Ethical Committee. All had a completely displaced metaphyseal fracture of the distal radius with or without a fracture of the ulna. One patient had a concomitant injury to his acromioclavicular joint and one had a grade-I open injury. Physeal injuries were excluded. During the period of the study the parents of seven children refused consent for entry into the trial and these children were treated by MUA and above-elbow casting.

There were 42 boys and 26 girls with an overall mean age of 7.9 ± 2.7 years. The boys were older than the girls (8.6 v 6.7). The right and left sides were equally involved with 34 cases each. Hand dominance was recorded in 51 patients and 27 injuries (53%) affected the non-dominant side. The two groups were matched for age and gender. There were 13 girls and 22 boys in the K-wire group, with a mean age of 8.1 years, and 13 girls and 20 boys in the MUA group with a mean age 7.6 years (p = 0.47). Most cases (53) had occurred in the summer months between May and September. The mechanisms of injury were a fall from a height in 30 patients, from standing height in 23, off roller blades in nine, at sport in five and in a pedestrian road-traffic accident in one. Eight children had an intact ulna (5 in the MUA group, 3 in the K-wire group).

The protocol for the study required that the fracture be reduced under general anaesthesia and checked using image intensification. A sealed envelope was then opened to determine whether it was to be managed in a long-arm cast alone or with an additional single percutaneous K-wire. If used, the wire was introduced across the fracture to the radial side of Lister’s tubercle, avoiding the extensor tendons.

The children who were treated by MUA and application of a cast alone were reviewed weekly for three weeks by anteroposterior (AP) and lateral radiographs. Those in the K-wire group returned three weeks later for removal of the wire and change of cast under general anaesthesia. The casts were removed between four and six weeks after injury depending on the age of the child. At three months after injury assessment of the function of the wrist was carried out independently by the same physiotherapist (BC) to avoid interobserver error. Function was compared with that of the non-injured side. Final radiographs, taken at the time of clinical assessment, were evaluated by one surgeon (GJM). A previous study had shown excellent intraobserver correlations for clinical assessment by this physiotherapist and radiological assessment by this surgeon.

Once enrolled into the trial, the patient was under the care of one of four consultants and any further management followed that consultant’s normal practice. Some patients in the MUA group subsequently underwent a further procedure and, in these, the final clinical and radiological assessment took place after this second procedure. Two analyses were therefore carried out, first with the reoperated patients excluded and secondly, on an intention-to-treat basis in which these patients were included.

Continuous data were analysed using Student’s t-test and categorical data by chi-squared analysis.

Results

All fractures were reduced within 18 hours of admission and in most cases within eight hours of injury. The patients were generally discharged by 24 hours. A satisfactory initial reduction was obtained in all patients. The mean angulation on the initial post-cast radiograph was 1.0 ± 7.7° of volar angulation in the K-wire group and 3.9 ± 7.7° of dorsal angulation in the MUA group.

Seven patients subsequently required a second procedure to correct an unacceptable deformity which developed during follow-up. In these children, the initial reduction had been undertaken by a consultant in two and by a specialist registrar in five. Six had dorsal angulation of greater than 20° (Fig. 1) and the seventh radial translation of the distal fragment of more than 50%. All of these were in the MUA group (chi-squared test, p < 0.01). Two of these patients had a further MUA, one had wedging of the cast and four had an MUA and percutaneous K-wire fixation. In the K-wire group, one wire was removed three days earlier than planned because of pain and two patients had a prominent scar at the site of the wire. In one patient the wire migrated and was removed.

Fifty-six patients (82%) returned for clinical review. Five complained of minor residual pain after strenuous activity, but none had a functional deficit. Three months after injury there were only minor differences in the range of movement between the injured and the normal limb (Table I). There were no differences in the clinical measurements between the two treatment groups (Table II), irrespective of whether those who required a second procedure were excluded or not.

Radiological records were incomplete for three patients (two in the MUA group and one in the K-wire group). They showed statistically significant differences in the quality of the reduction between the groups, initially and at union. These differences were present, with or without exclusion of the group requiring a second procedure (Table III).

In addition to the seven patients who required a second procedure, in a further seven in the MUA group the fracture united in more than 20° of dorsal angulation, but they did not require any further treatment during the trial period. Of these, four attended for clinical review. They had a mean loss of 7.5° of forearm rotation and 25° of flexion/extension at the wrist and 14° of radial/ulnar deviation compared with the uninjured side. One had a corrective osteotomy at six months and subsequently regained normal function. In the K-wire group, in one patient the fracture united in more than 20° of dorsal angulation. The K-wire had migrated...
Fig. 1a

Fig. 1b

AP and lateral radiographs of the radius and ulna of the same patient showing a) the position after initial reduction, b) one week later showing redisplacement and c) three months after remanipulation.

Fig. 1c

Table I. Clinical measurements (mean ± sd) at three months after injury for the uninjured and injured arms of 68 children with completely displaced distal radial metaphyseal fractures

<table>
<thead>
<tr>
<th></th>
<th>Flexion (degrees)</th>
<th>Extension (degrees)</th>
<th>Radial deviation (degrees)</th>
<th>Ulnar deviation (degrees)</th>
<th>Supination (degrees)</th>
<th>Pronation (degrees)</th>
<th>Grip strength (kg)</th>
</tr>
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<tbody>
<tr>
<td>Uninjured</td>
<td>83 ± 9.9</td>
<td>73 ± 13.6</td>
<td>30 ± 7.0</td>
<td>38 ± 8.9</td>
<td>89 ± 5.9</td>
<td>90 ± 2.8</td>
<td>22 ± 10.1</td>
</tr>
<tr>
<td>Injured</td>
<td>76 ± 13.7</td>
<td>71 ± 14.2</td>
<td>30 ± 9.2</td>
<td>35 ± 8.0</td>
<td>85 ± 10.0</td>
<td>89 ± 5.8</td>
<td>21 ± 10.6</td>
</tr>
<tr>
<td>p value</td>
<td>0.005</td>
<td>0.497</td>
<td>0.972</td>
<td>0.036</td>
<td>0.013</td>
<td>0.150</td>
<td>0.484</td>
</tr>
</tbody>
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Table II. Clinical measurements (mean ± sd) at three months after injury in the injured arm comparing both groups with and without exclusion of those requiring a second procedure

<table>
<thead>
<tr>
<th></th>
<th>Flexion (degrees)</th>
<th>Extension (degrees)</th>
<th>Radial deviation (degrees)</th>
<th>Ulnar deviation (degrees)</th>
<th>Supination (degrees)</th>
<th>Pronation (degrees)</th>
<th>Grip strength (kg)</th>
</tr>
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<tbody>
<tr>
<td>K-wire</td>
<td>77 ± 14.0</td>
<td>71 ± 13.5</td>
<td>30 ± 10.8</td>
<td>35 ± 9.0</td>
<td>85 ± 10.9</td>
<td>90 ± 6.1</td>
<td>22 ± 10.6</td>
</tr>
<tr>
<td>MUA (all)</td>
<td>76 ± 13.6</td>
<td>71 ± 15.1</td>
<td>29 ± 7.0</td>
<td>34 ± 6.8</td>
<td>85 ± 9.1</td>
<td>89 ± 5.6</td>
<td>21 ± 10.8</td>
</tr>
<tr>
<td>p value (v wire)</td>
<td>0.87</td>
<td>0.99</td>
<td>0.54</td>
<td>0.82</td>
<td>0.85</td>
<td>0.51</td>
<td>0.7</td>
</tr>
<tr>
<td>MUA (excluding re-operation)</td>
<td>75 ± 14.6</td>
<td>70 ± 12.5</td>
<td>29 ± 5.8</td>
<td>35 ± 6.4</td>
<td>84 ± 9.9</td>
<td>88 ± 5.1</td>
<td>21 ± 11.2</td>
</tr>
<tr>
<td>p value (v wire)</td>
<td>0.69</td>
<td>0.88</td>
<td>0.74</td>
<td>0.93</td>
<td>0.86</td>
<td>0.43</td>
<td>0.74</td>
</tr>
</tbody>
</table>
and, at follow-up after three months, this patient lacked 20° of wrist flexion and supination. There was no independent effect of age, gender or mechanism of injury on the clinical or radiological result.

Discussion

The traditional management of completely displaced fractures of the distal radius in children has been closed manipulation and casting. Although this has been shown to give good functional results in most cases,9,10 loss of reduction in the cast is a well-documented problem and a poorer outcome is associated with malunion.1-3 Our aim was to determine which of the two techniques produced better maintenance of reduction of the fracture until union.

We have shown that there was a statistically significant difference between the two groups in the quality of reduction on the immediate post-reduction radiograph after application of a cast. This was better in the K-wire group, suggesting that the wire prevented displacement during application of the cast. We are not aware of any other study which has considered this aspect. By the time of union, the mean dorsal angulation in the MUA group was 9.1 ± 11.5° compared with 2.7 ± 7.3° in the K-wire group, showing a further loss of position during immobilisation in the cast. We question the recommendation that wiring should be used for the incompletely reduced fracture. Although we accept that reduction can be difficult to achieve, our protocol required a satisfactory initial reduction, as defined by the treating clinician’s normal practice, and this was achieved in all patients. Occasionally, open reduction may be required and an incidence of 8% has been quoted,8 but we did not find this to be necessary in our study. Gibbons et al10 recommended that fractures of the distal radius in the presence of an intact ulna should be wired. In eight of our children the ulna was intact, but this had no significant influence on outcome.

It is accepted that good three-point fixation by a cast is important in order to maintain reduction.4,5 Haddad and Williams5 also thought that the experience of the operator was important when treating these fractures. In our study, one-third of the fractures was treated by a consultant orthopaedic surgeon, but this had no significant effect on the outcome. For the purposes of our study, all patients received an above-elbow cast to ensure conformity between the two groups.

A significant number of the fractures in the MUA group redisplaced. Seven patients received further treatment and, at the final radiological follow-up, seven other fractures in the MUA group had united in more than 20° of dorsal angulation. Subsequently, one of these had a corrective osteotomy six months after injury. Thus, a total of 14 of 33 fractures in the MUA group lost position. This is comparable to the series reported by Proctor et al9 in which 13 out of 25 completely displaced fractures redisplaced. Only one fracture in the K-wire group united in a displaced position. In this patient the wire had migrated causing loss of fixation.

The treatment of these injuries by percutaneous fixation had no observable detrimental clinical effect at assessment at three months. Inclusion or exclusion of the patients requiring further treatment did not affect this finding. The most notable difference between the groups was the incidence of remanipulation, seven in the MUA group and none in the K-wire group. This difference was statistically significant. The decision for further treatment was based on the treating consultant’s clinical judgement. Three months was set as the endpoint for the study when clinical recovery should be sufficient to allow objective assessment before remodelling occurred. It also avoided the inconvenience of having children return to hospital after recovery from the fracture. Some patients were followed beyond the three months, specified by the protocol because of persistent deformity. Assessment of their final outcome was beyond the limits of this study.

We have shown that K-wire fixation of completely displaced fractures of the distal radius is effective in preventing subsequent loss of position. Complications from the use of percutaneous wires were few and generally minor. One patient required an open operation to retrieve a wire which had migrated, one had a wire removed three days early for pain and in two there was a slightly prominent scar. These findings are in agreement with those of Choi et al.8

The study protocol required that we adhere to current hospital procedures, which meant that wires were removed as a day case under general anaesthesia. In practice, many children can tolerate removal of the wire in the outpatient department. The use of an above-elbow cast in all patients was to ensure uniformity between the groups. A forearm

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Table III. Radiological measurements (mean ± sd) by treatment group. All measurements correspond to radial deviation on the AP and dorsal angulation on the lateral film. A negative value indicates degrees of volar angulation.

<table>
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<tr>
<th></th>
<th>Initial reduction</th>
<th>Union</th>
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<tbody>
<tr>
<td></td>
<td>AP</td>
<td>Lateral</td>
</tr>
<tr>
<td>K-wire</td>
<td>0.6 ± 4.4</td>
<td>-1.0 ± 7.7</td>
</tr>
<tr>
<td>MUA (all)</td>
<td>3.2 ± 5.4</td>
<td>3.9 ± 7.3</td>
</tr>
<tr>
<td>p value (v wire)</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>MUA (excluding reoperations)</td>
<td>3.5 ± 6.4</td>
<td>3.5 ± 8.5</td>
</tr>
<tr>
<td>p value (v wire)</td>
<td>0.04</td>
<td>0.03</td>
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</table>
cast may be satisfactory in those patients whose fractures were held by a wire. Fewer radiographs were required in the K-wire group during follow-up.

We conclude that completely displaced fractures of the distal radius in children have a high propensity for redisplacement, despite satisfactory initial reduction. Supplementary percutaneous K-wire fixation resulted in a significantly better maintenance of the alignment of the fracture. It was safe and reduced the need for follow-up radiographs and further procedures to correct loss of position with no detrimental effect on the outcome.

We thank Mr M. F. Macnicol and Professor W. J. Gillespie for allowing their patients to be included in the study.

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References