Displaced fractures of the forearm in children are often treated conservatively, but there is a relatively high incidence of redisplacement, malunion and consequent limitation of function. We have performed percutaneous Kirschner (K) wire fixation in 72 such children under the age of 14 years, of which 57 were reviewed for our study. Both the radius and ulna were fractured in 45 (79%), the radius only in eight and the ulna only in four. The mean initial angulation was 19° in the lateral plane and 9° in the anteroposterior plane for the radius and 15° and 9°, respectively, for the ulna. In 42 patients (74%) we performed closed reduction. In the remaining 15 (26%) closed reduction failed and an open reduction, through a minimal approach, was required before K wiring.

At a mean follow-up of 20 months all patients had good functional results with an excellent range of movement. Only five had angulation of from 10° to 15° and none had nonunion, premature epiphyseal closure or deep infection. Percutaneous intramedullary K wiring for forearm diaphyseal fracture is a convenient, effective and safe operation, with minimal complications.

Fracture of the forearm is common in children both in Hong Kong and in Western countries. These injuries are usually treated conservatively by closed reduction and splintage. Perfect anatomical reduction is not always necessary since remodelling of malunion may correct any residual deformity. Work by Sarmiento et al, Matthews et al, and Tarr, Garfinkel and Sarmiento have shown that, except in very young children, residual angulation of the forearm greater than 10° should be corrected since remodelling is unpredictable. Angulation has been shown to affect the range of pronation and supination of the forearm. Fuller and McCullough concluded that the loss of pronation and supination is proportional to the degree of rotational malunion. Some authors have advocated surgical management of displaced forearm fractures in children using plating, intramedullary rods, pins and plasters and external fixation.

We present the results of percutaneous fixations using Kirschner (K) wires in 57 children treated between 1991 and 1995.

Patients and Methods

Between January 1991 and December 1995 at the Prince of Wales Hospital we treated 436 children under the age of 14 years with a unilateral acute displaced fracture of the diaphysis of one or both bones of the forearm. Of these, 72 had percutaneous intramedullary fixation using K wires. All were part of an ongoing study approved by the Ethical Committee for Research on Human Subjects of the Medical School of the Chinese University of Hong Kong.

Of the 72 patients, 15 were excluded: seven had been repatriated to other countries, three had emigrated and five could not be traced. All these had been followed up for at least 12 months and discharged with no symptoms and full function.

This left 57 patients available for review at 12 to 48 months after removal of the plaster and wires. There were 32 boys and 25 girls with a mean age of 7.6 ± 3.3 years (2 to 13). In 39 (68%) the left forearm had been injured. All but two had presented on the day of injury; the other two had been treated by Chinese bone-setters for three and four days, respectively, before being seen.

The indications for percutaneous pinning were completely displaced fractures of the shaft of one or both of the forearm bones and fractures of both radius and ulna with more than 10° angulation. Greenstick fractures of one or...
both bones which would be reduced and stabilised by closed
manipulation were not pinned.

Operative technique. The patient was anaesthetised and the
injured limb positioned on a radiolucent table. Closed reduc-
tion was attempted under image intensification. If closed
reduction failed an open reduction was done through a 2 cm
incision over the fracture site. At least 50% apposition of the
fractured bone ends is necessary to allow wiring.

We performed percutaneous K wiring under image-inten-
sifier control using wires of 1.6 mm in diameter. The wire
was inserted through Lister’s tubercle or the radial styloid
for fractures of the radius and through the tip of the
olecranon for fractures of the ulna (Fig. 1). When both
bones of the forearm were fractured, the radius was reduced
and wired first. If the ulna had then reduced spontaneously,
ulnar wiring was usually not performed, but where the
reduction was unstable, the ulna was also fixed. The K wire
was passed under direct vision using the image intensifier.

Radiographs of a ten-year-old boy with a fracture of the
midshaft of both the radius and ulna.

Figure 1a – There was angulation of 22° in both the
lateral and anteroposterior planes.

Figure 1b – After closed reduction percutaneous intra-
medullary K wiring was performed via the radial styloid
and the olecranon.

Figure 1c – Eight months later there was no displace-
ment, angulation or premature epiphyseal closure and a
full functional recovery.
across the fracture site as far as the distal metaphysis taking care not to breach its growth plate. The entry point on the skin was enlarged and the wire cut and bent to prevent migration.

The limb was then placed in an above-elbow cast with the elbow at 90° of flexion and the forearm at various degrees of rotation according to the level of the fracture. The cast and the wires were removed at four to six weeks after the operation, no anaesthesia being required in all but one case.

Assessment was undertaken by two of the authors (SHY, CYL) not involved in the initial management using a standard questionnaire, bilateral radiography, goniometry and measurement of grip strength.

Radiographs of the whole forearm, including the wrist and elbow on the same film, were reviewed to determine the site (proximal, middle or distal shaft) and pattern (transverse, oblique, spiral or comminuted) of the fracture, the amount of displacement and angulation, the status of the epiphysis and physeal plates and the presence of malunion.

**Handgrip strength.** The non-injured limb was tested first and then the injured one after a three-minute rest. The patient gripped the dynamometer (Grip D 5101, Takei & Co, Ltd, Tokyo, Japan) with the middle phalanges between the fingers and the palm. It was held clear of the body with the shoulder abducted about 30° and the elbow extended. The patient then squeezed the dynamometer with maximum force, sustaining the effort for three to five seconds. Three attempts were allowed and the best result used for analysis.

**Statistical analysis.** We used SPSS/PC+ V. 6.0 (SPSS Inc, Chicago, Illinois) for the analysis and p values of less than 0.05 were considered significant.

## Results

Both the radius and the ulna had been fractured in 45 children (79%), the radius only in eight and the ulna only in one. The initial angulation of the radius ranged from 10° to 50° in the lateral plane and 10° to 32° in the anteroposterior plane (Table I). For the ulna angulation was 12° to 67° in the lateral plane and 5° to 36° in the anteroposterior plane (Table II). There were no significant differences in angulation between patients with fractures of both bones and those with only one fracture (p > 0.5). Thirty-seven patients (65%) had transverse fractures and 20 had oblique fractures.

Of the 57 patients 42 had closed and 15 open reduction. Of the 45 children with fractures of both bones, 23 (51%) had only the radius fixed. The mean hospital stay was 2.5 days (1 to 5); 85% were discharged within three days.

All patients were followed up as outpatients for a mean of 25 ± 13.8 months. Physiotherapy for elbow and wrist mobilisation was required only in ten patients (18%) for a mean period of six weeks (3 to 12). One patient had a deficit of pronation of 20° and loss of supination of 10°. The remaining patients had a range of movement of the elbow, forearm and wrist within 5° of that of the normal side.

In 45 patients the hand grip strength was within 95% of the contralateral hand, but in 12 (21%) it was between 70% and 90% of the normal side.

Five patients (9%) had a residual angulation of 10° to 15°. All were less than ten years of age and none had any functional deficit.

**Complications.** No patient showed radiological evidence of premature epiphyseal closure but a two-year follow-up of a 12-year-old girl showed that the ulna was 1 cm short. It had not, however, had K wiring and shortening was probably related to the initial injury. No patient developed deep infection, but one had a superficial pin-track infection which was successfully treated with oral antibiotics and daily dressing for ten days. In one patient, the wire became subcutaneous and required removal under local anaesthesia. A seven-year-old girl had refracture of the radius at the same site six months after the first injury. She was treated successfully by closed manipulation and K wiring.

### Table I. Pre- and postoperative range of radial angulation (degrees) in fracture of the radius alone and in fracture of both radius and ulna

<table>
<thead>
<tr>
<th></th>
<th>Radius</th>
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<th>Radius and ulna</th>
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<td></td>
<td>Preop</td>
<td>Postop</td>
<td>Preop</td>
<td>Postop</td>
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<tr>
<td>Number of cases</td>
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<tr>
<td>Lateral angulation</td>
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<td>10 to 50</td>
<td>0 to 6</td>
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<td>Anteroposterior angulation</td>
<td>13 to 19</td>
<td>0</td>
<td>10 to 32</td>
<td>0 to 10</td>
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</table>

### Table II. Pre- and postoperative range of radial angulation (degrees) in fracture of the ulna alone and in fracture of both radius and ulna

<table>
<thead>
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<tr>
<td></td>
<td>Preop</td>
<td>Postop</td>
<td>Preop</td>
<td>Postop</td>
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<td>Lateral angulation</td>
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<td>12 to 67</td>
<td>0 to 15</td>
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<tr>
<td>Anteroposterior angulation</td>
<td>12 to 26</td>
<td>0</td>
<td>5 to 36</td>
<td>0 to 10</td>
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Discussion

The treatment of fractures of the forearm in children is tending to change: more authors now advocate surgical management. In the 1960s, closed reduction and immobilisation in plaster were recommended for all of these fractures, and the criteria of acceptable reduction varied. The maximal acceptable angulation should be no greater than 10°. Some authors believe that open reduction and internal fixation are rarely necessary recommending it only for older children after failed closed reduction.

Nielsen and Simonsen reported that 8% to 9% of their patients with fractures of the forearm shaft required open reduction and plate fixation with excellent functional outcomes. The technique is complicated by increased soft-tissue dissection, longer scars, increased risk of infection and occasionally a second operation for removal of the plate.

Amit et al. and Lascombes et al. all showed good results using intramedullary elastic nails. They reported few complications, but these included skin irritation from the tips of nails and sensory neuropathy.

The use of pins and plaster has been reported by Voto, Weiner and Leighly in 20 patients in whom satisfactory closed reduction could not be achieved. All had good results without complications. Schranz et al. reported their experience with external fixation, but its use is rare and it should probably be limited to compound fractures.

Although our technique requires immobilisation in a plaster cast for four to six weeks, we did not observe any significant joint stiffness in most children. The cast and the K wire(s) are removed in the outpatient clinic without anaesthesia, thus reducing costs and morbidity associated with the removal of plates and screws.

We conclude that percutaneous intramedullary K wiring with immobilisation in a synthetic cast is an easy, minimally invasive and safe method which gives a good functional outcome.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References