PERCUTANEOUS KIRSCHNER-WIRE PINNING FOR SEVERELY DISPLACED DISTAL RADIAL FRACTURES IN CHILDREN

A REPORT OF 157 CASES

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Distal radial fractures are common in children. Recent outcome studies have cast doubt on the success of treatment by closed reduction and application of plaster. The most important risk factor for poor outcome is translation of the fracture. If a distal radial fracture is displaced by more than half the diameter of the bone at the fracture site it should be classified as high risk.

We performed percutaneous Kirschner-wire pinning on 157 such high-risk distal radial fractures in children under 16 years of age. The predicted early and late failure rate was reduced from 60% to 14% and only 1.5% of patients had significant limitation of forearm movement of more than 15° in the final assessment at a mean of 31 months after operation. There were no cases of early physeal closure or deep infection.

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Distal radial fracture is common in children (Beekman and Sullivan 1941; Gandhi et al 1962; Worlock and Stower 1986) and this is also true in Hong Kong (Cheng and Shen 1993). Closed reduction and application of a plaster have been the mainstay of treatment and have been supported by classical studies which have demonstrated remodelling of malunion in children (Blount, Schaeffer and Johnson 1942; Gandhi et al 1962; Hughston 1962). This has sometimes led to the acceptance of poor reduction and loss of reduction (Davies and Green 1976).

Recent outcome studies have shown poor end-results in 15% to 29% of cases, particularly with regard to limitation of forearm rotation (Daruwalla 1979; Creasman, Zaleske and Ehrlich 1984; Mani, Hui and Cheng 1993). Loss of rotation has been correlated with angular deformity and residual malalignment at the time of the removal of the plaster (Roberts 1986; Younger et al 1994). By contrast, Fuller and McCullough (1982) reported a high percentage of complete remodelling after malunion of distal radial fractures but their study used non-randomised sampling and chose 180° as the normal range of forearm rotation instead of a comparison with the uninjured side (Roberts 1986). Limitation of forearm movement may persist despite apparently full remodelling (Högström, Nilsson and Willner 1976; Nilsson and Obrant 1977).

Translation of the fracture is the most important risk factor for poor outcome. Mani et al (1993) have shown a predicted failure rate of 60% if the radial fracture is displaced by more than half the diameter of the radius and 68% after complete displacement. Proctor, Moore and Paterson (1993) have also demonstrated a similar risk association with fracture redisplacement independent of the quality of the cast or the experience of the surgeon. Remanipulation may be safe and effective (Voto, Weiner and Leighley 1990), but these authors advise the addition of percutaneous Kirschner wires (K-wires) in high-risk cases.

Gibbons et al (1994) reported excellent early results in 12 completely displaced isolated distal radial fractures but there has been no large long-term study to validate the use of K-wires and to examine the potential risk of damage to the physis. Our aim was to analyse the efficacy and safety of percutaneous K-wires for treating 'high-risk' distal radial fractures in children.

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PATIENTS AND METHODS

From 1989 to 1992, 549 children under the age of 16 years with acute fractures of the distal third of the radius, with or without distal ulnar fractures, were admitted to the Prince of Wales Hospital, Hong Kong. Fracture dislocations and epiphyseal injuries were excluded. Of these, 157 with considerable displacement of fractures (translation greater

Fig. 1a

Fig. 1b

Fig. 1c

A 6-year-old boy with a completely displaced and translated distal radial fracture (a) was treated by closed reduction and percutaneous K-wire pinning (b) with a subsequent good result (c).

than half of the diameter of the radius at the fracture site) were treated by closed reduction and percutaneous K-wire pinning (Fig. 1).

From these 157 patients, 140 complete sets of records and radiographs were available for detailed study. Standard anteroposterior and lateral radiographs of the forearm were checked at each weekly follow-up until union. Detailed data were collected retrospectively from the medical records. All the radiographs were reviewed by one author (KYC) to determine the sites of the fractures, the amount of translation and angulation of the radius and ulna, redisplacement, malunion and time to union.

A final assessment by the same author (KYC) was made at 13 to 54 months after operation (mean 31) using standard questionnaires, radiographs and goniometry of wrist and elbow movement including supination and pronation. In all, 66 patients (47%) were available for the final assessment. In addition, 26 were contacted by phone and were all asymptomatic.

Failure was recorded for irreducibility, loss of reduction by more than 10° during K-wire stabilisation, limitation of movement in any plane by more than 15° compared with the normal side, and persistent pain or deformity at final assessment (Mani et al 1993).

Fig. 2a

Fig. 2b

Different methods of K-wire insertion. Figure 2a – K-wire inserted from the radial styloid through the fracture to the opposite cortex. Figure 2b – K-wire inserted from Lister's tubercle and passed up the medullary cavity, with an additional ulnar wire.

Operative technique. Consent was obtained for closed reduction and percutaneous K-wire insertion under general anaesthesia. This was performed under image-intensifier control; satisfactory reduction was defined as at least 70% of bony apposition across the fracture site and angulation of under 15° in patients under ten years of age, or 10° over this age. Rotational deformity was corrected. Distal ulnar fractures were also reduced but percutaneous K-wires were rarely used in this bone.

A 1.6 mm K-wire (1.1 mm in those under six years old) was inserted either from the radial styloid or Lister's tubercle to avoid injury to adjacent tendons or neurovascular structures. After passing through the fracture site, it was directed into the opposite cortex of the radius. For the more proximal fractures, the K-wire was passed up the medulla for at least 4 cm beyond the fracture site. An extra wire was inserted if the surgeon considered that the position was insecure with the first wire (Fig. 2).

After insertion the K-wire entry point was enlarged slightly to avoid tenting and the wire bent perpendicular to the skin. An above-elbow fibreglass cast was applied with the forearm and wrist in neutral position (Fig. 3).

The casts and K-wires were removed at three to six weeks depending on the patients' age and the radiographs. No anaesthesia was required.

RESULTS

The age distribution of the series was bimodal with peaks at 8 and 12 years. The male:female ratio was 5:1 and the left side was involved slightly more frequently (Table I). There was an associated fracture in 6.8%, usually a supracondylar fracture of the ipsilateral humerus (Table II).

Table I. Sex, age and side distribution of 140 patients who received percutaneous Kirschner-wire pinning for distal radial fracture

	Fracture translation	
	50% to 100%	> 100% (complete displacement)
Age in years		
1 to 5	2	12
6 to 10	17	47
10 to 15	24	38
Sex		
Male	37	80
Female	10	13
Side		
Right	18	55
Left	25	42

Table II. Analysis of the fracture pattern in 140 patients

	Fracture translation	
	50% to 100%	> 100%
Site of fracture*		
Distal 1/6	32	71
Between distal 1/6 and 1/3	8	29
Dorsovolar angulation		
Dorsal	28	69
Neutral	7	22
Volar	9	5
Radioulnar angulation		
Radial	15	46
Neutral	23	44
Ulnar	4	8
Ulnar involvement		
No fracture	18	15
Greenstick	16	23
Complete	12	56

* defined as the length of the distal fracture fragment over the overall length of the radius

Fig. 3a

Fig. 3b

Figure 3a – The cut end of the wire is bent away from the skin to avoid impingement due to later swelling. Figure 3b – A pin-track dressing is used before a fibreglass cast is applied.

Most operations were done on the day of admission, and the average hospital stay was two days. The average time of anaesthesia was 37 minutes (20 to 120), the longer periods being for multiple fractures.

Of the 140 patients, 20 (14.3%) had failures (Table III). In 11 (7.9%) failure was because open reduction was required. Although the operative time and hospital stay were prolonged, all these fractures united uneventfully within six weeks and all the children regained a normal range of movement.

Nine patients (6.4%) had loss of reduction of more than 10° on one plane on follow-up radiographs. Seven with angulation of less than 20° were kept under observation and all except one remodelled and regained a full range of movement. Two patients were revised by open reduction and plating because the angulation was more than 20° and they were close to skeletal maturity.

All the 66 patients who had a final assessment were

symptom-free. The patient mentioned above with redisplacement treated conservatively had a reduced range of pronation of more than 15°, with 10° residual angulation of the radius.

Other complications included superficial pin-track infection in eight patients (5.7%) and neurapraxia (one median and one ulnar nerve) in two (1.4%). There were no cases of osteomyelitis, vascular complications or premature physal closure.

DISCUSSION

Percutaneous Kirschner wires are widely used in the treatment of children's fractures such as a supracondylar fracture of the humerus and also in certain distal radial fractures in adults (Stein and Katz 1975; Kapandji 1976; Clancey 1984; Rayhack, Langworthy and Belsole 1989; Mah and Atkinson 1992), but their use in high-risk distal radial fractures in children has not been well documented.

Our study confirms that percutaneous K-wires have a place in the high-risk group of patients with over 50% translation of the fracture. Only two (1.4%) required revision and only one of the 66 reviewed patients (1.5%) had a poor outcome with loss of over 15° of forearm rotation. These three failures were all in boys of 15 years of age who were active and close to skeletal maturity. We consider that open reduction and internal fixation may be more advantageous in such cases.

The strict criteria which we adopted for reduction probably contributed to success. Bayonet apposition was unacceptable, and open reduction was therefore required in 8%. When perfect reduction is achieved, the incidence of redisplacement can be reduced from 73% to 20% with plaster treatment alone (Proctor et al 1993).

We saw no cases of premature physal closure. This complication has been reported sporadically (Boyden and Peterson 1991). Although traversing of the epiphyseal plate can be avoided by inserting the K-wire in the metaphyseal region, this may be difficult in a very distal fracture. We believe that the leverage against angulation is much strong-

Table III. Analysis of the failures

	Our series		Predicted*	
	Number	Per cent	Number	Per cent
Irreducibility (n = 140)	11	7.9	35	25
Loss of reduction (n = 140)	9	6.4	28	20
Poor final outcome (n = 66)	1†	1.5	10	15

* based on predicted failure rate of 60% in fracture of the distal radius with translation of more than one half of the diameter of the radius, in which 25% were due to irreducibility, 20% reduction loss and 15% poor outcome (Mani et al 1993)

† the patient with poor final outcome was also included in those with loss of reduction

er if the K-wire is inserted through the radial styloid or Lister's tubercle. For some fractures in which accurate reduction is difficult, the K-wire can help by acting as a lever to manipulate the distal fragment.

Conclusions. For fractures of the distal radius in children with a high risk of failure due to translation of the fracture by more than half the diameter of the bone, closed reduction with percutaneous K-wiring should be the preferred procedure. It is easy to perform and the associated risk is minimal. When there is failure to achieve satisfactory alignment and bony apposition, open reduction should be used to ensure a good result.

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