Fractures of the neck of the radius in children

EARLY EXPERIENCE WITH INTRAMEDULLARY PINNING

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The treatment of fractures of the neck of the radius in children is difficult, particularly if the angulation of the fracture exceeds 60°. Since 1994 we have used closed reduction and stabilisation with an intramedullary Kirschner wire in patients with grade-IV fractures according to the classification of Judet et al. In a retrospective analysis of a two-year period (1994 to 1996), 324 children with fractures of the elbow were treated in our department. Of these, 29 (9%) had a fracture of the neck of the radius; six were grade-IV injuries (1.9%). Five of the latter had an excellent postoperative result with normal movement of the elbow and forearm. One patient with a poor result had a concomitant dislocation of the elbow.

Our results suggest that closed reduction and intramedullary pinning of grade-IV fractures allows adequate stabilisation while healing occurs.

J Bone Joint Surg [Br] 2001;83-B:536-41.

Received 2 February 2000; Accepted after revision 4 July 2000

Injuries to the elbow in children are common and fractures of the neck of the radius represent 5% to 10%.¹⁻³ The anatomical complexity of the elbow and its blood supply makes treatment difficult. The head of the radius and its blood supply can be damaged by the injury itself and by surgical manipulation such as in open reduction.²⁻¹¹ As a result, closed techniques using percutaneous Kirschner (K-) wires have been developed.^{12,13} Satisfactory reduction may not be achieved consistently, and because the K-wires are removed immediately after, dislocation can recur.^{7,14-16} Formal fixation of these fractures is preferable, and closed intramedullary pinning (CIMP), as proposed by González-Buendia et al¹⁷ and Métaizeau et al,⁷ combines non-invasive closed reduction with internal fixation fulfilling both requirements.

We report our results obtained since November 1994 when we began to use CIMP instead of open reduction and transcondylar fixation.

Patients and Methods

We grade fractures of the neck of the radius according to the classification of Judet, Judet and Lefranc¹⁸ (Fig. 1). Grade-I and grade-II fractures are treated by a cast with no reduction, grade-III by closed reduction and a cast, and grade-IV by CIMP, if necessary using percutaneous K-wires to aid reduction. Between November 1994 and October 1996, we treated 324 children with fractures at the elbow, 29 (9%) of whom had fractures of the neck of the radius. Six (1.9%) presented with a grade-IV fracture. The relevant information regarding the mechanism of injury, the angulation of the fracture, other injuries, and the time of surgery are given in Table I.

Under general anaesthesia, the entire upper limb is prepared, draped, and placed on a hand table. Under guidance of an image intensifier, a small incision is made about 1.5 cm above the epiphyseal plate on the radial side of the distal radial metaphysis. The soft tissue is dissected under direct vision taking care not to injure the cutaneous branch of the radial nerve, muscles or tendons. The cortex is exposed and perforated using a Pfriem-type trocar. A K-wire (1.6 to 2.0 mm in diameter, depending on age) with a slightly bent end is introduced into the intramedullary canal and gently pushed cranially until it reaches the inferior

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0301-620X/01/411060 \$2.00

Fig. 1

Diagram illustrating the classification of fractures of the radial neck by Judet et al.¹⁸: grade I, undisplaced fracture; grade II, $\alpha < 30^\circ$ (angulation of radial neck), $S < 1/2$ diameter of radial shaft (translation $< 50\%$); grade III, $\alpha = 30^\circ$ to 60° , $S < 1/1$ diameter of radial shaft (translation $< 100\%$); grade IV $\alpha = 60^\circ$ to 90° , $S > 1/1$ diameter of radial shaft (translation $> 100\%$).

Fig. 2

Diagram showing reduction of the head of the radius by the leverage method and intramedullary pinning with a K-wire. Note the slightly bent tip, first pointing laterally. Once placed in the radial head it is rotated 180° along its axis.

Table I. Mechanism of injury, angulation of the fracture, concomitant injuries, time of surgery, and outcome in the six patients with grade-IV fractures

Age (yr mth)	Gender	Mechanism of injury	Fracture angulation (degrees)	Concomitant injuries	Time between injury and surgery	Results
7	M	Fall, 1 m	60	None	4 days	Excellent
10 9	F	Fall over a ball	75	Elbow dislocation	2 days	Poor
9 6	F	Fall, 0.6 m	60	None	1 day	Excellent
6 7	M	Tripping	65	None	5 days	Excellent
9 8	F	Fall, 0.4 m	80	None	3 hours	Excellent
7	F	Fall from a bar	45, $S > 1/1$	Fracture of the shaft of the ulna	4 days	Excellent

Fig. 3a

Fig. 3b

Fig. 3c

Radiographs showing anteroposterior (left) and lateral (right) views of the elbow of a 9.5-year-old girl. Figure 3a – Preoperative radiographs showing a grade-IV fracture with an angulation of 60°. Figure 3b – Intraoperative radiographs after closed reduction and intramedullary pinning with a K-wire. Figure 3c – Follow-up radiographs showing an excellent outcome 12 months after the operation.

aspect of the displaced epiphysis. Then, with the elbow under a moderate varus stress, the fracture is reduced by external manipulation. If this manoeuvre fails, i.e., the intramedullary K-wire does not reach the fragment or does not achieve acceptable reduction of the angulation to 20° to 30° in younger and 10° to 15° in older children, further reduction is achieved by percutaneous leverage of the head with a K-wire as described by Akatsu¹² and Feray¹³ (Fig. 2). The intramedullary K-wire is then pushed into the head, with the tip still pointing radially. In order to reduce the remaining

radial-lateral displacement, the wire is rotated through 180° so that the tip points towards the ulna, thereby forcing the fragment to shift medially and facilitating anatomical reduction of the radial head within the joint (Fig. 3). Finally, the elbow is immobilised in a cast mainly to control pain.

The mean operating time was 35 minutes (25 to 45), with the exception of the patient with an additional fracture of the ulna (90 minutes). We did not feel that there was a significant learning curve because of our extensive experience of pinning fractures of the shaft. We now use 1.6 mm

Table II. Grading of results after treatment of fractures of the neck of the radius

Grade	Elbow movement	Radiological features	Symptoms
Excellent	Normal range of movement	Anatomical position of head of the radius	None
Fair	< 10° restriction in one plane or < 20° restriction in all planes	Minor irregularities	Intermittent and/or minimal pain
Poor	> 20° restriction in all planes	Disproportion and deformity of the head of the radius	Permanent and/or severe pain

Fig. 4a

Fig. 4b

Fig. 4c

Radiographs showing anteroposterior (left) and lateral (right) views of the elbow of a 10-year-old girl. Figure 4a – Preoperative radiographs showing a grade-IV fracture with an angulation of 75° and concomitant dislocation of the elbow. Figure 4b – Intraoperative radiograph after closed reduction and intramedullary pinning with a K-wire. Figure 4c – Follow-up radiographs 18 months after the operation. Note the angulated, hypertrophic radial head and the radio-ulnar synostosis.

K-wires for all patients because they are much easier to insert. The mean radiation time was 3 minutes 30 seconds (2 minutes 47 to 4 minutes 10), except in the patient with an ulnar fracture in whom the radiation time was 10 minutes. The patient, the surgeon, and all operating theatre personnel wore prescribed protection garments and were exposed to $< 0.01 \mu\text{Gy/s}$.

All patients were followed up clinically and radiologically at four weeks, at three months, and thereafter at six-monthly intervals. Mobilisation of the elbow started after removal of the cast, i.e., four weeks after the operation. The

K-wire was removed when healing of the fracture had occurred clinically and radiologically.

Results

The results were graded as excellent, fair or poor as shown in Table II. Normal pronation/supination was defined as $85^\circ/0^\circ/90^\circ$, and normal flexion/extension as $160^\circ/0^\circ/0^\circ$ in boys and $160^\circ/0^\circ/5^\circ$ in girls. Pronation/supination and flexion/extension were compared with those of the uninjured elbow.

In all six patients, the postoperative course was uneventful. Radiological signs of consolidation were noted at four weeks and healing of the fracture was complete at three months after the injury. After removal of the pin at a mean of 4.25 months (6 weeks to 8 months) five of the six patients (83.3%) showed complete clinical and radiological recovery with a normal range of movement of the elbow and forearm with the head in the anatomical position on the radiograph. The oldest patient in our series, who had also suffered dislocation of the elbow, showed unsatisfactory clinical and radiological recovery and was graded as poor. Severe impairment of pronation/supination ($25^{\circ}/0^{\circ}/10^{\circ}$) and mild restriction of flexion/extension ($130^{\circ}/0^{\circ}/0^{\circ}$) were present 2.5 years after injury. The radiograph showed a healed, but bulb-shaped head, angulated 20° with a progressive radio-ulnar synostosis (Fig. 4).

Discussion

The management of fractures of the neck of the radius in children is controversial.³ In 1996 we published the results of the treatment of grade-IV fractures by open reduction and internal, transarticular fixation (ORIF).¹⁹ In that series, 10 out of 96 children with fractures of the neck had a grade-IV fracture. Eight were treated operatively, with one excellent (12.5%) and six poor (75%) results, while one patient (12.5%) was lost to follow-up. Two were treated conservatively because of delayed referral, with a poor outcome in both. Our overall results compared very unfavourably with those published by other authors who reported excellent conclusions after ORIF in 50%,¹¹ 43%,¹⁶ 38%,²⁰ 33%,¹⁰ and 22%¹ of cases. Overall, however, the results from ORIF are not satisfactory. Only one in three patients has an excellent outcome, indicating that this may not be the most appropriate method to treat these difficult fractures.

We therefore changed to intramedullary pinning, originally described by Métaizeau et al.^{6,7} Our results using this method show that five of our six patients (83%) achieved an excellent outcome. Métaizeau et al.⁷ and González-Herranz et al.²¹ reported almost identical results with CIMP with an excellent outcome in grade-IV fractures in 82% and 83% of patients, respectively.

A number of other techniques have been advocated for the management of fractures of the neck of the radius. Percutaneous reduction using a K-wire or a Steinmann pin without subsequent fixation has been reported by several authors.^{2,9,14,15} None of these studies can be directly compared with our series or those of Métaizeau et al.⁷ and González-Herranz et al.,²¹ since the indications for reduction (angulation $>30^{\circ}$ ¹⁵ and $>35^{\circ}$ ^{9,14}) and the grading systems used to assess outcome are different. In general, however, the results appear to be similar to those achieved by CIMP, and better than with ORIF. Futami et al.⁵ and Biyani, Mehara and Bhan²² described percutaneous reduction with subsequent percutaneous pinning of the head. Futami et al.⁵

reported excellent functional results in all ten patients, but four developed premature fusion of the epiphysis of the head. In the series of Biyani et al.,²² percutaneous reduction and pinning of grade-III and grade-IV fractures yielded excellent results in 43% of cases. We agree with both groups that grade-IV fractures require fixation after reduction to avoid redisplacement and repeated manoeuvres to achieve reduction which may compromise the blood supply to the neck.^{7,16} We believe that CIMP is as easy and safe to perform as percutaneous pinning, but allows better positioning of the head of the radius.

An important prognostic feature is the presence of associated injuries. The only child in our study with a poor outcome had a concomitant dislocation of the elbow and was older than ten years. In most published studies, concomitant injuries were associated with unfavourable results.^{1,7,10,15,19,20,23} Some authors have suggested that outcomes in adolescent patients^{4,8,10,11,14,20} are associated with the limited capacity for remodelling due to the amount of growth remaining.

CIMP offers satisfactory stabilisation of the head of the radius while healing of the fracture occurs. The technique is safe, easy to perform and minimally invasive. It avoids additional surgical damage, and prevents redisplacement and repeated manipulations of the head. Early mobilisation of the joint with the wire in situ is possible and shortens the period of rehabilitation. Although our experience is based on a small number of patients, our results together with those of Métaizeau et al.⁷ and González-Herranz et al.²¹ suggest that CIMP is a good method of treatment of grade-IV fractures in children.

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.

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