ANGULATED RADIAL NECK FRACTURES IN CHILDREN

A PROSPECTIVE STUDY OF PERCUTANEOUS REDUCTION

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We made a prospective study of angulated radial neck fractures in children reduced by leverage with a percutaneous Kirschner wire. Of 36 consecutive cases with angulation of more than 30° reduction was successful in 33. We obtained an excellent or good final result in 31 (94%).

Fractures of the radial neck in children are usually seen after the appearance of the proximal radial epiphysis at about the age of five years. They are frequently caused by a fall on the outstretched hand with the forearm supinated and the elbow extended, which produces a valgus strain (Aufranc et al 1967).

There is some controversy about the management of these fractures, and they are more likely to have an unsatisfactory outcome than fractures of the distal radius. There is little agreement as to what may be accepted as a satisfactory reduction (Dougall 1969; Tibone and Stoltz 1981). Minor degrees of angulation can be accepted and treated conservatively, but advice on the maximum acceptable angulation varies widely, up to as much as 45° (Key 1931; Conn and Wade 1961; Judet, Judet and Lefranc 1962; Creasman, Zaleske and Ehrlich 1984).

The more severely angulated and displaced fractures have been variously treated by closed reduction, open reduction, or open reduction with internal fixation, but the precise indications for each are not clear (Blount, Schulz and Cassidy 1951; Blount 1955; Jones and Esah 1971; Vahvanen and Gripenberg 1978). In a previous retrospective study we found that open reduction of radial neck fractures generally had a poor result and that open reduction with internal fixation was even worse, as has been reported by others (Newman 1977; Wedge and Robertson 1982).

Percutaneous leverage as a means of reduction of these fractures in children has been described previously (Feray 1969; Angelov 1981; Pesudo, Aracil and Barcelo 1982) but the technique is not widely known or used. We now report a prospective study of this method.

PATIENTS AND METHODS

From August 1987 to July 1990 we considered for the prospective study all the children who presented at three Belfast hospitals with radial neck fractures. We included all those with a fracture angulated more than 30°, seen within 24 hours of injury, and we obtained informed written consent from their parents. We excluded patients with concomitant elbow fractures which required open operation. All the percutaneous reductions were performed by the senior author (HKG) or by senior registrars instructed in the technique.

A total of 36 children entered the trial; there were 21 boys and 15 girls, with a median age of eight years nine months (four to 16). The mean follow-up was two years nine months (18 months to four years).

Method of reduction. The injured elbow is screened, using a high-resolution image intensifier with magnification facilities and a thermographic printer (Siremobile 4; Siemens, Sunbury-on-Thames, England). Under general anaesthesia the extended elbow is screened in the anteroposterior plane through the range of forearm rotation.

The position of maximum angulation and displacement of the fracture is then recorded on a magnified thermographic print. The degree of angulation is the angle of intersection of a perpendicular line drawn through the epiphyseal plate with another line drawn along the midline of the radial diaphysis (O'Brien 1965). Because of the influence of rotation, this angle can rarely be measured on the original radiographs. The fracture is then assigned to one of four groups at 30° intervals of angulation (Table I, Fig. 1). Displacement of the fracture is measured from the same print using dividers to measure.
the width of the uncovered radial metaphysis and the total width of the metaphysis, then expressing the ratio as a percentage.

The elbow is then prepared and draped free, using the image intensifier as the operating surface. A 15 cm long smooth Kirschner wire in a T-handled chuck is used for the reduction. The diameter of the wire is 1.5 to 2 mm, selected according to the patient’s size. The entry for the wire, chosen on a lateral view, is through a lateral skin puncture in the mid-axial line, made as far forearm rotation are checked under the image intensifier. Passive rotation to 60° in each direction is acceptable (Wilkins 1991). The arm is held in a long-arm backslab cast at 90° flexion and neutral rotation for three weeks before starting active mobilisation.

Patients were reviewed at one month and three months, and then at six-monthly intervals. Of the four patients who failed to attend for review after cast removal, three were examined in their own homes, and one by his general practitioner. We used a goniometer to proximally as possible so as to avoid the posterior interosseous nerve. The point is advanced into the fracture under screening (Fig. 2) and far enough to reach the opposite cortex. The fracture is then reduced by a cephalad sweep of the operator’s hand, which levers the radial head proximally against the capitellum (Fig. 3). Over-reduction is prevented by the capitellum, but there may be some minor redisplacement when the wire is removed. This rarely exceeds 5° and is acceptable; there is some lateral angulation of the head on the shaft of the radius in normal elbows (Vahvanen and Gripenberg 1978). Another magnified thermographic print is taken and the postoperative angulation and displacement are recorded.

The stability of the reduction and the range of record forearm rotation, elbow flexion-extension and the carrying angles of both arms. In 32 patients anteroposterior and lateral radiographs were taken of both elbows to assess fracture remodelling, carrying angle (Bauman) and any growth disturbance. If the radial epiphysis showed premature closure, radiographs of the whole forearm were taken to determine radial shortening.

We recorded clinical results as excellent, good, fair or poor by a grading system (Table II), taking the normal range of forearm pronation as 90° and supination as 85°. Many children had a greater range than this in the uninjured extremity, achieved by joint laxity and trick movements. An otherwise excellent result could include loss of pronation or supination of up to 15°. The flexion-extension arc and change in carrying angle were assessed

<table>
<thead>
<tr>
<th>Grade</th>
<th>Displacement (per cent)</th>
<th>Angulation (degrees)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0 to 10</td>
<td>0 to 30</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>11 to 50</td>
<td>31 to 60</td>
<td>19</td>
</tr>
<tr>
<td>III</td>
<td>51 to 90</td>
<td>61 to 90</td>
<td>14</td>
</tr>
<tr>
<td>IV</td>
<td>&gt; 90</td>
<td>&gt; 90</td>
<td>3</td>
</tr>
</tbody>
</table>

Fig. 1
Diagram to show grading of radial neck fractures based on angulation and displacement (see text).

Fig. 2
Thermographic prints showing the Kirschner wire being introduced into the fracture (Fig. 2) and the reduction achieved by leverage (Fig. 3).

Fig. 3
Table II. Grading of the results of treatment of radial neck fractures

<table>
<thead>
<tr>
<th>Grade</th>
<th>Forearm rotation</th>
<th>Loss of flexion-extension</th>
<th>Increase in carrying angle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pronation</td>
<td>Supination</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>75° to 90°</td>
<td>70° to 85°</td>
<td>0° to 5°</td>
</tr>
<tr>
<td>Good</td>
<td>60° to 74°</td>
<td>55° to 69°</td>
<td>6° to 10°</td>
</tr>
<tr>
<td>Fair</td>
<td>45° to 59°</td>
<td>40° to 54°</td>
<td>11” to 15”</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 45°</td>
<td>&lt; 40°</td>
<td>&gt; 15°</td>
</tr>
</tbody>
</table>

Table III. Results related to treatment group in 36 grade II to IV radial neck fractures

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percutaneous reduction</th>
<th>Open reduction</th>
<th>Open reduction and internal fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>21</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Good</td>
<td>10</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fair</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Poor</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Unusual Monteggia-type fracture, involving the radial metaphysis (a) before and after open reduction and internal fixation (b).

Salter-Harris type I epiphyseal separation of the radial head, showing a grade III injury based on angulation and displacement. The radial head is seen en face with almost 90° of angulation and there is an associated olecranon fracture, before (a) and after percutaneous reduction by Kirschner wire leverage (b).

Salter–Harris type II epiphyseal injury with a 70° angulation and a 55% displacement (grade III), before (a) and after percutaneous leverage (b).
against the uninjured elbow. The lowest grade scored in any category was recorded as the outcome, and the presence of pain other than cold sensitivity, downgraded the result to poor.

RESULTS

In 20 elbows the fracture line was entirely metaphyseal (Fig. 4), and in 16 it was epiphyseal: three Salter–Harris type I (Fig. 5) and 13 type II separations (Fig. 6). Eighteen of the patients (50%) had associated injuries which implied a less favourable prognosis (Lindham and Hugosson 1979). Sixteen had ulnar fractures, and three had humeral fractures: one flexion supracondylar fracture, one lateral condylar separation, and one medial epicondylar separation. These injuries were managed conservatively by closed reduction or simple immobilisation. Four other patients required open management of associated elbow injuries and were therefore excluded from the study.

In 33 of the 36 patients a satisfactory position was achieved by percutaneous Kirschner wire reduction (Table III). One patient required a second Kirschner wire reduction, but his original thermographs had been lost and it was not known if this was for redisplacement or because of an inadequate primary procedure.

Percutaneous reduction was not attempted in the other three patients because the radial head had dislocated and was lying free from the metaphysis. Two of these patients had open reduction with repair of the annular ligament but no internal fixation. One of these developed avascular necrosis and had a poor result because of pain and stiffness; the other healed by fibrous union and had a good clinical result in the short term. Only one fracture required internal fixation, by a small AO lag screw, for an unusual Monteggia-type injury. A displaced diaphyseal fracture of the ulna and an open dislocation of the radial metaphysis left the radial head within the annular ligament (Fig. 4) and there was a traction injury of the posterior interosseous nerve. After wound debridement and fixation of both fractures the clinical result was excellent with recovery of the nerve palsy.

The mean angulation of the fractures was 52° (30 to 90) before reduction and 15° (5 to 35) after reduction. Mean fracture displacement was 46% (10 to 100) before reduction and 8% (0 to 15) after reduction. At final follow-up residual angulation and displacement had undergone extensive remodelling.

There were no iatrogenic nerve injuries or infections. The only patient in the percutaneous reduction group with a poor result had developed complete radio-ulnar synostosis between the radial neck fracture and a greenstick fracture of the olecranon (Fig. 7). One other patient had a fair result because of growth arrest in the proximal radial epiphysis which had produced a 12° increase in carrying angle.

In seven elbows some degree of growth arrest or premature closure of the epiphysis was noted. This resulted in increased carrying angles ranging from 2° to 12° and radial shortening of 1 to 5 mm.

DISCUSSION

Current opinion favours a conservative approach to fractures of the radial neck in children, with attempts at closed reduction for over 30° of angulation, although some surgeons accept up to 45° before advising an open procedure. Closed reduction is often incomplete and sometimes produces no improvement (Reidy and Van Gorder 1963).

![Fig. 7](image)

An oblique radiograph showing early heterotopic ossification between a radial neck fracture and a greenstick fracture of the olecranon.

We believe that percutaneous leverage by Kirschner wire is useful. The method is safe in that nerve injury and infection can be avoided, and it is effective in the majority of cases. We achieved an acceptable reduction in all fractures in which there was some remaining contact between the radial head and the metaphysis. There is no surgical scar and the technique has a high degree of patient satisfaction.

Significant redisplacement of the percutaneously reduced fractures did not occur. Our experience at three open reductions in which there were associated displaced olecranon fractures, however, was that unless there is complete dislocation of the radial head a significant portion of the annular ligament remains intact; this supports and retains the radial head after reduction. In these three patients, simple elevation of the radial neck fracture provided a satisfactory and stable reduction. A short period of immobilisation was adequate in our series; this is very important in preserving the range of elbow motion. Henrikson (1969) emphasised that pronation and supination are particularly likely to be limited after these fractures, and that this can be a disabling
limitation. There is no satisfactory answer for the rare completely displaced fracture. We believe, however, that open reduction with repair of the annular ligament, but without fixation, is probably the procedure of choice.

Our grading of fracture angulation is helpful in planning treatment. Grade I fractures (0° to 30°) require pain relief by simple immobilisation for seven to ten days, but older patients may benefit from aspiration of the haemarthrosis and injection of 0.25% bupivicaine. Grade II and grade III fractures (31° to 90°) require reduction by closed manipulation or by percutaneous leverage. Grade IV fractures require open reduction, preferably without the use of internal fixation.

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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