ABSTRACT

Purpose. To review records of 108 children with radial neck fractures and develop an algorithm for treatment.

Methods. Records of 50 girls and 58 boys aged 2 to 14 (mean, 8.7) years with radial neck fractures were reviewed. The most common injury mechanism was tripping and falling on an outstretched hand while running (n=44), followed by falling from monkey bars (n=11). Fractures were classified into grade 1 (n=25), grade 2 (n=60), grade 3 (n=16), grade 4a (n=6), and grade 4b (n=1). 21 patients had associated fractures involving the olecranon, proximal ulna, and/or the humeral supracondyle. The time from injury to treatment ranged from 0 to 7 days. Treatments included casting without manipulation (n=86), closed reduction and casting (n=8), percutaneous Kirschner wire–assisted reduction and casting (n=7), and open reduction and casting (n=7).

Results. Patients were followed up for a mean of 2.7 (range, 1–5) years. Outcome was excellent in 93 patients, good in 11, and fair in 4. Higher fracture grades correlated positively with poorer outcomes (p=0.001) and more invasive treatment (p=0.001). Nonetheless, the post-reduction angles of all the patients were not significantly different (p>0.05). Older children sustained more severe fractures (p=0.04) and had poorer outcomes, even after correction for fracture grade (p=0.007). Patients with associated fractures had significantly poorer outcomes (p<0.05). Two patients developed synostosis of the proximal radio-ulnar joint. One of whom had an associated olecranon fracture and underwent open reduction and casting. The other had an associated proximal ulnar fracture and underwent repeated percutaneous Kirschner wire–assisted reduction owing to loss of reduction. Five patients developed heterotopic ossification. Four of whom had associated fractures (3 involved the olecranon and one the proximal ulna). 14 patients developed cubitus valgus deformity of 3° to 10°.

Conclusion. Open reduction should only be performed after more conservative treatments fail to achieve reduction.

Key words: radius fractures; complications, treatment outcome
INTRODUCTION

Radial neck fractures account for 5 to 10% of all elbow fractures in children. The ossification centre of the proximal radial epiphysis usually appears at age 4 to 5 years. The physis closes at age 14 to 17 years. Fractures through the articular surface of the radial head are rare in children. The more common site is through the physis (with a metaphyseal fragment, Salter-Harris type II) or the neck. The epiphysis of the radial head is completely covered with cartilage and the blood supply enters through the metaphysis. Avascular necrosis of the radial head is rare, as the injury site is distal to the entry of the vessels.

Treatment for radial neck fractures in children varies according to the displacement, angulation, and skeletal maturity. Most fractures are undisplaced or minimally displaced and can be treated with closed reduction and casting with good outcome. Severely displaced or angulated fractures often have poorer outcomes, even after open reduction. Complications include pain, decreased range of motion, cubitus valgus, radio-ulnar synostosis, heterotopic ossification, radial head overgrowth, premature physeal closure, avascular necrosis, malunion, and non-union. Risk factors associated with poor outcome include age, radial neck angulation, associated injury, open reduction, and internal fixation. We reviewed records of 108 children with radial neck fractures and proposed a treatment algorithm.

MATERIALS AND METHODS

Records of 50 girls and 58 boys aged 2 to 14 (mean, 8.7) years with radial neck fractures who presented between 1997 and 2001 were reviewed. 56 of the patients injured the right arm. The most common injury mechanism was tripping and falling on an outstretched hand while running (n=44), followed by falling from monkey bars (n=11). Radial head angulation was defined as the angle between the perpendicular of the axis of the displaced radial epiphysis and the axis of the radial shaft (Fig. 1). According to the Judet classification, fractures were classified into grades 1 (n=25), 2 (n=60), 3 (n=16), 4a (n=6), and 4b (n=1). 21 patients had associated fractures involving the olecranon (n=12), the proximal ulna (n=5), the humeral supracondyle (n=2), the olecranon and the humeral supracondyle (n=1), and the olecranon and proximal humerus with elbow dislocation (n=1).

The time from injury to treatment ranged from 0 to 7 days. Treatments included casting without manipulation for a mean of 3.4 (range, 1–8) weeks for those with an angulation of 0º to 40º (mean, 8º) [n=86], closed reduction and casting for those with an angulation of 30º to 59º (mean, 51º) [n=8], percutaneous Kirschner wire-assisted reduction and casting for those with an angulation of 45º to 81º (mean, 62º) [n=7], and open reduction and casting for those with an angulation 52º to 80º (mean, 65º) [n=7].

Clinical outcome was evaluated in person for 79 patients and over the telephone for 29 patients. Radiographs were assessed for complications. Student’s t-test was used for comparisons between groups. Pearson’s correlation was used to determine correlation between outcome and patient age/fracture grade/treatment.

RESULTS

Patients were followed up for a mean of 2.7 (range, 1–15) years. The mean follow-up time was 2.7 (range, 1–15) years. The mean follow-up time was 2.7 (range, 1–15) years. The mean follow-up time was 2.7 (range, 1–15) years. The mean follow-up time was 2.7 (range, 1–15) years. The mean follow-up time was 2.7 (range, 1–15) years.
1–5) years. Clinical outcome was excellent in 94 patients, good in 10, and fair in 4. No patient had chronic pain. Higher fracture grades correlated positively with poorer outcomes (p=0.001, Pearson’s correlation) and more invasive treatment (p=0.001, Pearson’s correlation). Nonetheless, the post-reduction angle after different treatment modalities was not significantly different (p>0.05, t-test with Bonferroni correction). Older children sustained more severe fractures (grade 3 or higher) [p=0.04, t-test] and had poorer outcomes, even after correction for fracture grade (p=0.007, t-test, Table 3). Patients with associated fractures had significantly poorer outcomes (p<0.05, Pearson’s correlation). Among patients with grade 3 fractures (n=16), more invasive treatment correlated positively with poorer outcomes (p=0.006, Pearson’s correlation). Among patients with grade 4 fractures (n=7), there was a trend toward poorer outcome after open reduction rather than percutaneous Kirschner wire-assisted reduction (Table 4).

A 5-year-old girl with an angulation of 51º and displacement of 50% underwent intramedullary fixation using a Kirschner wire. The Kirschner wire was removed after 3 weeks and casting was applied for another 3 weeks. Two patients underwent a second surgery within 2 weeks: one had loss of reduction at day 2 after percutaneous Kirschner wire-assisted reduction and casting; the procedure was repeated. The other patient had loss of reduction at week 1 after closed reduction and casting and underwent open reduction. Casting was applied for 4 more weeks in both patients.

Two patients developed synostosis of the proximal radio-ulnar joint. One of whom had an associated olecranon fracture and underwent open reduction and casting. The other had an associated proximal ulnar fracture and underwent repeated percutaneous Kirschner wire-assisted reduction owing to loss of reduction. Five patients developed heterotopic ossification. Four of whom had associated fractures (3 involving the olecranon and one the proximal ulna). 14 patients developed cubitus valgus deformity of 3º to 10º. Four patients had transient radial nerve palsy secondary to the injury. No patient developed wound infection, dehiscence, or avascular necrosis of the radial head.

**DISCUSSION**

Mismanagement of radial neck fractures can lead to debilitating loss of elbow function. Higher fracture grades prognosticate poorer outcomes, regardless of the post-reduction angle ensuing after different treatment modalities. This suggests that factors other than just good post-operative reduction affected outcomes.

Older children tend to sustain more severe fractures and have poorer outcomes. Skeletal maturity confers a poor prognosis.1,8,13,15,16 This could be due to the higher energy involved in the injuries in older children. In addition, younger children’s bones are more cartilaginous and hence more cushioned. The energy from the trauma is more effectively absorbed,

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### Table 3

<table>
<thead>
<tr>
<th>Fracture grade</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
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<td>5–9</td>
<td>&gt;10</td>
<td>&lt;5</td>
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<td>Outcome (no. of patients)</td>
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<tr>
<td>Fair</td>
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### Table 4

<table>
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<th>3</th>
<th>4</th>
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<tbody>
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<td>Treatment</td>
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<td>Casting without manipulation</td>
<td>Casting without manipulation</td>
<td>Closed reduction and casting</td>
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<tr>
<td>Outcome (no. of patients)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Excellent</td>
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<td>53</td>
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<td>7</td>
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<tr>
<td>Good</td>
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<td>4</td>
<td>1</td>
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<td>Fair</td>
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resulting in less severe fractures. The bone also has greater remodelling potential and hence can achieve better outcomes.

Radial neck fractures associated with other fractures generally indicate higher energy trauma. This may be attributed to more soft-tissue injury and poorer outcomes. Poorer outcomes can be caused by complications (proximal radio-ulnar synostosis and heterotopic ossification), which often result in restriction of range of motion or cubitus deformity.

The associations between heterotopic ossification and patient age, fracture grade, and the number and types of surgeries performed remain unclear. Nonetheless, the association between heterotopic ossification and associated fractures was strong, as was the association between heterotopic ossification and elbow dislocation.

Synostosis of the proximal radio-ulnar joint is a debilitating complication. An association between radio-ulnar synostosis and open surgery has been reported, as open surgery and repeated percutaneous levering causes iatrogenic disruption of the periostium and surrounding soft tissues and results in disorganised callus forming synostosis. In our study, the 2 patients who developed synostosis of the proximal radio-ulnar joint were aged >7 years and had associated fractures and underwent open surgery for grades 3 and 4 fractures.

To avoid debilitating complications, we propose a step-wise ‘level of invasiveness’ protocol (Fig. 2).

Patients with undisplaced fractures or displaced fractures with <45° angulation should be treated with casting without manipulation. For those with angulation of >45°, closed reduction should be attempted. When closed reduction fails, percutaneous Kirschner wire–assisted reduction under general anaesthesia should be attempted, failing which open reduction and cross wiring should be performed.

REFERENCES