ORIGINAL ARTICLE

Compared outcomes after percutaneous pinning versus open reduction in paediatric supracondylar elbow fractures

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KEYWORDS
Child elbow fracture; Crossed pinning; Percutaneous pinning; Supracondylar fracture; Surgical treatment

Summary

Background: Supracondylar fractures of the elbow are common in children. Their treatment is controversial when displacement has occurred, although percutaneous pinning is usually advocated.

Hypothesis: In paediatric extension-type supracondylar fractures of the elbow, percutaneous pinning and crossed K-wire fixation after open reduction via the medial approach produce similar functional outcomes and complication rates.

Materials and methods: We retrospectively reviewed the medical charts of 58 children aged 2 to 15 years who underwent surgery for extension-type supracondylar elbow fractures between 2004 and 2008. Closed reduction and percutaneous pinning was used in 33 patients with a mean age of 7 years and 11 months; open reduction with cross-wiring in 25 patients with a mean age of 7 years. Functional outcomes were assessed using Flynn’s criteria. Baumann’s angle was determined and postoperative complications and sequelae were recorded.

Results: Outcomes were satisfactory in 30 (90.9%) patients treated with percutaneous pinning and in 23 (92%) patients treated with open reduction and cross-wiring. Mean Baumann’s angle at last follow-up was 73.9 ± 5.74° after percutaneous pinning and 74.76 ± 4.07° after open reduction and cross-wiring. Postoperative complications consisted of reoperation in six (10.3%) patients and iatrogenic nerve injury in two (3.4%) patients. Cubitus varus occurred in two (6.0%) patients after closed treatment and in one (4%) patient after open treatment. In each group, three (5.1%) patients had greater than 15° of motion range limitation.

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Introduction

Supracondylar fractures of the elbow account for 16.6% of all fractures in paediatric patients [1]. The broad range of non-operative and operative methods developed with the goal of restoring normal elbow anatomy include long-arm plaster cast immobilisation, axial traction applied using tape or a transolecranon pin, Blount’s technique, elastic and stable intramedullary nailing, external fixation, percutaneous pinning, and pinning after open reduction [2—5]. Percutaneous pinning is the most widely advocated technique [2—4,6,7]. Open surgery is indicated in patients with irreducible fractures, unstable fractures, vascular complications, or compound fractures [1]. In our department, Blount’s technique has been preferred since the study by Clavert et al. [8]. When Blount’s technique fails, percutaneous pinning as described by Judet and Judet is performed as the first-line treatment when reduction is satisfactory [9] and open reduction via the medial approach followed by crossed K-wire fixation otherwise. This treatment algorithm is based on the hypothesis that percutaneous pinning and open medial reduction with cross-wiring produce similar functional outcomes and complication rates. We give preference to the less aggressive of these two techniques whenever possible. The objective of this retrospective study of paediatric patients with extension-type supracondylar elbow fractures was to confirm our hypothesis by comparing patients managed with percutaneous pinning and those managed with open reduction and cross-wiring.

Materials and method

Study population

We retrospectively reviewed the medical charts of 82 patients younger than 15 years at the time of treatment for extension-type supracondylar elbow fractures. These patients were managed between 2004 and 2008 at the paediatric orthopaedics department of the Hautepiere Hospital, Strasbourg, France. We excluded patients with flexion-type fractures, associated bony injuries in the same limb, and incomplete data. Patients were included if they received regular postoperative follow-up for at least 3 months. Of the 82 patients, 58 met these criteria and were included in the study. There were 31 (53.4%) boys and 27 (46.6%) girls with a mean age of 7 years and 6 months and an age range of 2 to 15 years. The fractures were classified according to Lagrange and Rigault [10] (Table 1).

Operative treatment

Surgery was performed under general anaesthesia by a senior surgeon in all 58 patients. Time to treatment was defined as the time from emergency department admission to arrival in the operating room. When Blount’s technique failed and closed reduction of the fracture was satisfactory, percutaneous pinning was performed. When closed reduction was not satisfactory, open reduction was performed via the medial approach then stabilised using crossed K-wire fixation. Patients with recurrent displacement after percutaneous pinning were also managed using cross-wiring.

For percutaneous pinning, the surgeon gradually applied traction to the limb with the elbow extended while the assistant applied counter-traction at the axilla. Fluoroscopy was used to determine whether translation of the distal humerus occurred. While gradually flexing the elbow to about 120°, the surgeon applied direct pressure to the olecranon with the thumb to correct any residual posterior tilting. With the elbow flexed, anteroposterior and lateral radiographs were obtained to evaluate the quality of the reduction. An Esmarch’s bandage was placed to maintain the position. After sterile preparation of the elbow, two identical wires 1.6 to 2 mm in diameter were inserted from lateral to medial, using a slow-rotation power drill (Fig. 1).

For cross-wiring (Fig. 2), a medial incision, centred on the medial epicondyle, was performed and the ulnar nerve was isolated and placed in a noose. The fracture site was then approached via the intermuscular interstice. Reduction was achieved and a wire 1.6 to 2 mm in diameter was then inserted from medial to lateral using a slow-rotation power drill. A lateral wire of the same diameter was inserted percutaneously under fluoroscopic guidance starting at the lateral epicondyle. The wound was closed in two planes with a continuous intradermal suture.

In all patients, the wires were bent back and buried under the skin. A long arm plaster cast with the elbow flexed at 90° was used in all patients for 45 days, after which the wires were removed under general anaesthesia.

Comparison of the two operative techniques

To compare the two operative techniques, we retrospectively allocated the patients into two groups based on the surgical technique used. Although treatment allocation was not randomised, provided the two groups were homogeneous, this method allowed comparisons of treatment outcomes. The percutaneous pinning (PP) group included 33 patients (20 boys and 13 girls) with a mean age of 7 years and 11 months and the open reduction/crossed pinning (OR/CP) group included 25 patients (11 boys and 14 girls) with a mean age of 7 years.

Table 1 reports the main epidemiological, diagnostic, and therapeutic features in the study patients. Associated injuries were present in 24 (41.3%) patients and consisted of vascular abnormalities in nine (14.5%), nerve injuries in 10 (16.1%), and breaks in the skin in five (8%). Of the nine vascular abnormalities, seven were arterial spasms.
that resolved after reduction and pinning and two were vascular injuries that required patch reconstruction. A pressure sensor was placed in the anterior forearm compartment to allow postoperative monitoring. The nerve injuries consisted in neurapraxia secondary to contusion, stretching, or entrapment. Open surgery was performed when closed reduction failed, the fracture was unstable, vascular abnormalities persisted despite reduction and the application of Blount’s technique, or secondary displacement occurred after Blount’s technique (which was the first-line treatment).

**Evaluation of outcomes**

Mean time to fracture healing was 45 days in both groups. Postoperative functional outcomes were assessed using Flynn’s criteria (Table 2) [6]. We recorded hospital stay length (mean ± SD), Blaumann’s angle (mean ± SD) at the fractured elbow, postoperative complications (iatrogenic nerve injury, re-operation, infection, and compartment syndrome), and sequelae (elbow axis deviation, motion range limitation, and neurological deficits). Comparisons were with the Chi² and t tests, with P values smaller than 0.05 being considered significant.

**Results**

Satisfactory outcomes were noted in 30 (90.9%) patients in the PP group, 23 (92%) patients in the OR/CP group, and 53 (91%) patients overall (Table 3). The difference between the two groups was not significant (P = 0.8835, Chi² test). Mean hospital stay length was 3.03 ± 1.45 days (range, 2–7 days) in the PP group and 4.08 ± 1.82 days (range, 2–7) in the OR/CP group; again, the difference was not significant (P = 0.0127, Chi² test). Mean Baumann’s angle immediately after surgery was 78.12 ± 7.31° (range, 66–92°) in the PP group and 78.48 ± 5.96° (range, 69–90°) in the OR/CP group; the difference was not significant (P = 0.8377, t test). At last follow-up, mean Baumann’s angle was 73.9 ± 5.75° (range, 62–90°) in the PP group and 74.76 ± 4.08° (range, 70–88°) in the OR/CP group (non-significant: P = 0.5123, t test).

Postoperative complications occurred in eight (13.8%) patients. They consisted in re-operation in six (10.3%) patients and iatrogenic nerve injuries in two (3.4%) patients. The reasons for re-operation were inadequate reduction or secondary displacement detected on the postoperative radiograph. Re-operation was required in five patients in the PP group and one in the OR/CP group (non-significant difference, P = 0.2021, Chi² test). Both cases of iatrogenic nerve injury occurred in the PP group. The median nerve was involved in one patient and the radial nerve in the other. The outcome was favourable within 4 to 5 months in six (75%) of the eight patients with trauma-related nerve injuries and in both patients with iatrogenic nerve injuries. The two patients with persistent trauma-related nerve dysfunction required electrophysiological studies. No cases of infection or compartment syndrome were recorded.

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**Table 1** Main epidemiological, diagnostic, and therapeutic features in the groups managed with percutaneous pinning and open reduction followed by crossed K-wire fixation.

<table>
<thead>
<tr>
<th></th>
<th>Percutaneous pinning (n = 33)</th>
<th>Open reduction + cross-wires (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, years [range]</strong></td>
<td>7.95 [2–15]</td>
<td>7 [2–14]</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Female</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td><strong>Associated injuries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vascular</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Skin break</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Nerve injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>3</td>
<td>M</td>
</tr>
<tr>
<td>U</td>
<td>1</td>
<td>R</td>
</tr>
<tr>
<td>M + R</td>
<td>2</td>
<td>U + M</td>
</tr>
<tr>
<td>NR</td>
<td>1</td>
<td>NR</td>
</tr>
<tr>
<td><strong>Classification according to Lagrange et Rigault</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage III</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Stage IV</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td><strong>Time to treatment, hours [range]</strong></td>
<td>1.67 [0.45–4]</td>
<td>1.74 [0.5–3.63]</td>
</tr>
</tbody>
</table>

U: ulnar nerve; M: median nerve; R: radial nerve; NR: not reported.

**Table 2** Flynn’s criteria [6].

<table>
<thead>
<tr>
<th>Results</th>
<th>Cosmetic factor: loss of carrying angle (in degrees)</th>
<th>Functional factor: loss of motion (in degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfactory</td>
<td>0–5</td>
<td>0–5</td>
</tr>
<tr>
<td>Excellent</td>
<td>6–10</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>11–15</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>Poor: &gt; 15</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1 Stage IV supracondylar fracture managed with closed reduction and percutaneous pinning: a: preoperative appearance (anteroposterior view); b: preoperative appearance (lateral view); c: postoperative appearance (anteroposterior view); d: postoperative appearance (lateral view).

Table 3 Outcomes according to Flynn’s criteria [6] in the groups managed with percutaneous pinning and open reduction followed by crossed K-wire fixation.

<table>
<thead>
<tr>
<th></th>
<th>Percutaneous pinning (n = 33)</th>
<th>Open reduction + cross-wires (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfactory results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent (%)</td>
<td>17 (51.5)</td>
<td>14 (56)</td>
</tr>
<tr>
<td>Good (%)</td>
<td>8 (24.1)</td>
<td>5 (20)</td>
</tr>
<tr>
<td>Fair (%)</td>
<td>5 (15.2)</td>
<td>4 (16)</td>
</tr>
<tr>
<td>Poor results (%)</td>
<td>3 (9.1)</td>
<td>2 (8)</td>
</tr>
</tbody>
</table>
Cubitus varus was noted in three (5.1%) patients; the angles were 10°, 15°, and 25°, respectively. Of these three patients, two (6.06%) had had PP and one (4%) OR/CP. The patients with 15° and 25° of angulation were managed by lateral closed wedge osteotomy of the humerus. Another patient in the OR/CP group had 10° of cubitus valgus.

In each group, three patients had greater than 15° of motion range limitation. In two patients managed with PP, the cause was a bone spur arising from the anterior metaphysis (Fig. 3). Two patients in the OR/CP group reported pain at the site of the medial scar.

Discussion

Limitations of our study are the retrospective design, small sample size, and absence of randomisation, with the surgical strategy being dependent on the usual practice of a single centre. Thus, open reduction was performed when inadequate closed reduction precluded percutaneous pinning or secondary displacement occurred after percutaneous pinning.

The diverse range of treatment methods attests to the challenges raised by extension-type supracondylar fractures of the elbow. The management of severely displaced forms is controversial and has given rise to various schools of thought. Advantages of percutaneous pinning include rapidity and absence of periosteal separation and dissection, which result in a minimal risk of infection. Disadvantages are the higher risk of secondary displacement and the risk of iatrogenic nerve injury. The open technique allows fracture reduction under visual guidance, which limits the risk of ulnar nerve injury, but is associated with higher risks of infection and motion.

Figure 2 Stage IV supracondylar fracture managed with open reduction and crossed K-wire fixation: a: preoperative appearance (anteroposterior view); b: preoperative appearance (lateral view); c: postoperative appearance (anteroposterior and lateral views).
range limitation and may result in unsightly or painful scars.

Our assessment of outcomes using Flynn’s criteria showed no significant difference between percutaneous pinning and open reduction with crossed K-wire fixation (90.9% versus 92% of satisfactory outcomes; \( P = 0.8835 \)). Percutaneous pinning has produced satisfactory outcomes in 95% to 100% of cases in earlier studies [2,4,11] and is consequently the most widely advocated first-line treatment [2–7,12,13].

The postoperative complication rates were 8.6 and 22% in case-series of cross-wire fixation [2,13] and 13.8% in our study. Of eight postoperative complications, six (10.4%) consisted in secondary displacement, of which five cases occurred after percutaneous pinning and a single case after open reduction and cross-wiring (non-significant difference, \( P = 0.2021 \)). Secondary displacement was chiefly ascribable to technical shortcomings. Crossing of the pins in the fracture site is associated with secondary displacement, as occurred in 21% of cases in the case-series by Damsin et al. [14]. Therefore, keeping the pins parallel and at least 10 mm apart has been advocated [15]. To avoid secondary displacement, Judet and Judet [9] used either a lateral pin or a thoracobrachial plaster cast to prevent shoulder rotation or a second lateral pin inserted through the olecranon and condyle into the diaphysis. More recently, Skaggs et al. [16] recommended using three diverging lateral epicondylar pins when concern arose about the stability of the fixation. Using three pins provides the same degree of biomechanical stability as the cross-pinning technique described in 1948 by Swenson [17] and demonstrated in experimental studies by Zions et al. [18]. Although the multiple drill holes in the distal humeral physis might in theory impair epiphyseal growth, this complication did not occur in any of the patients studied by Skaggs et al. [16].

Iatrogenic nerve injuries are seen in about 6% of patients with supracondylar fractures [19] and consist chiefly in damage to the ulnar nerve during percutaneous pinning, which has been reported in 11% of patients [20]. Gurkan et al. [19] reported iatrogenic ulnar nerve injury in 4.5% of cases after reduction via the medial approach. The cause was probably stretching of the nerve during reduction manoeuvres. In contrast, we found no cases of iatrogenic ulnar nerve injury after open reduction. Electrostimulation to identify the ulnar nerve during pinning has been advocated [7,20]. The favourable outcome of nerve injuries in our study is consistent with earlier reports [20,21].

Cubitus varus is the most common residual abnormality after extension-type supracondylar elbow fractures in children [6,14,21]. Cubitus varus is a cosmetic rather than a functional disability and is due to persistent distal fragment rotation after reduction. Baumann’s angle should be measured to minimise the risk of cubitus varus, [14,22]. In our study, the cubitus varus rate was 6.06% after percutaneous pinning and 4% after open reduction with cross-wiring. El-Adl et al. [2] reported a rate of 8.6% after percutaneous pinning and Shakir et al. [13] a rate of 6% after reduction via the medial approach. Cubitus varus can occur after all types of treatment and remains stable over time [22]. Kohler et al. [22] suggested that correction might be best-performed 18 to 24 months after the initial injury. Correction of cubitus varus relies on hemi-epiphysiodesis or humeral osteotomy [20,22]. In our case-series, we performed lateral closed wedge osteotomy of the humerus. The limited growth potential of the distal humeral growth plate does not allow full correction of architectural deformities, and anatomic reduction must therefore be performed.

Motion range limitation of the elbow is common after supracondylar fractures, with a rate of 15% in the study by Damsin and Langlais [14]. The causes include soft tissue injuries, posttraumatic remodelling, fibrous surgical scars, and malunion. In our study, a bone spur on the anterior metaphysis caused motion range limitation in two patients, who were managed with surgical release of the elbow. The appropriateness of physical therapy in patients with restricted elbow motion remains controversial. Long-term follow-up is in order, as the physical activities to which children are naturally inclined result in some degree of self-rehabilitation.

Conclusion

Blount’s technique remains the preferred treatment of extension-type supracondylar elbow fractures at our surgical centre. When this technique fails or is contraindicated, percutaneous pinning is the first-line alternative, with open reduction via the medial approach as the second-line strategy. In our study, no significant differences were found between percutaneous pinning and open reduction with cross-wiring in terms of postoperative stability, functional outcomes, and complications. We believe these results support the fist-line use of percutaneous pinning, which is simpler and less aggressive than open reduction and cross-wiring.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


