Does the technique of lateral cross-wiring (Dorgan's technique) reduce iatrogenic ulnar nerve injury?

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Abstract In this study we compared the results of patients with displaced supracondylar humeral fractures who had been treated with all lateral cross-wire and medio-lateral cross-wire fixation techniques. Only the 139 patients who were able to attend the final examination were included in the assessment. The patients were allocated retrospectively into two groups according to the pin configuration used. Group 1 comprised 75 patients, 60 male and 15 female, with a mean age of 7.5 years (range, 1.5–14 years). After closed reduction, fixation was achieved with crossed K-wires placed from the lateral condyle and lateral humerus towards the medial epicondyle. Care was taken so that the end of the K-wire passing from the lateral humerus did not protrude excessively at the level of the medial epicondyle. Group 2 comprised 64 patients, 54 males and ten females, with a mean age of 7.8 years (range, 2–13 years). After closed reduction, two cross-wires passed—one from medial and one from lateral. In group 1 there was no postoperative iatrogenic nerve damage whereas in group 2 iatrogenic ulnar nerve damage developed in six (9%) patients. On statistical evaluation, a significant difference was seen between the two groups. According to Flynn's criteria, there was no statistically significant difference between the two groups. In conclusion, the lateral cross-wire fixation technique may be a good choice in the treatment of paediatric supracondylar humerus fractures as it reduces the possibility of ulnar nerve damage and achieves the same level of stabilisation as medio-lateral fixation.

Introduction

Paediatric supracondylar humeral fractures are the most common fracture, accounting for 50–60% of fractures in the elbow region and 30% of all extremity fractures. Displaced supracondylar fracture of the distal humerus in children is also a serious problem. The incidence of neurological and vascular injury ranges from 5% to 30% [2, 11]. In the treatment of non-displaced humeral fractures, conservative methods are used, while in non-reducible cases, closed reduction and percutaneous pinning or open reduction and Kirschner-wire (K-wire) fixation may be used [2, 10, 14]. The most commonly used configurations of K-wires for fixation are two parallel wires inserted through the lateral condyle across the fracture and continuing into the medial cortex, or two cross-wires, one inserted laterally and one through the medial condyle [5]. Previous studies have reported the most stable configuration to be medio-lateral cross pinning [6, 16]. However, there is a risk of iatrogenic ulnar nerve damage [12]. The lateral double wire technique introduced by Dorgan and used by the author since 1994 is known to achieve good stabilisation and reduce the rate of ulnar nerve damage [3, 13].

In this study we compared the results of patients with displaced supracondylar humeral fractures who had been treated with all lateral cross-wire and medio-lateral cross-wire fixation techniques.

Materials and methods

One hundred eighty-nine paediatric patients who had undergone treatment for supracondylar humeral fracture between 1994 and 2006 were evaluated. Only the 139 patients who were able to attend the final examination were

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included in the assessment. Patients treated by other methods or whose medical records were incomplete were excluded from the study.

Any neurological injuries were identified and recorded both before and after surgery, and the nerve injured and type of injury were determined by examination. Vascular evaluation was performed at the first visit during reduction and surgery, and recorded. Fractures were classified according to Gartland's system.

The causes of injury were as follows: a fall from height in 87 cases (62%), motor vehicle accidents in 31 (22%), and bicycle and game accidents in 21 (16%). Forty three (31%) of the fractures were on the right side, and 96 (69%) were on the left.

The patients were operated upon within 24 hours after the trauma. All cases were Gartland type 3 fractures; 79 (57%) of the fractures were displaced posterolaterally, 38 (27%) posteromedially, and 17 (12%) posteriorly, and five (4%) were flexion-type fractures. Ipsilateral forearm or radius distal end fractures were present in 11 cases and femoral fractures in seven. Accompanying injuries were treated surgically. There were three open fractures: one type 1 and two type 2 according to Gustilo-Anderson classification. There was radial nerve paralysis in two cases (postero-medial displacement), ulnar nerve paralysis in two cases (one flexion type, one postero-lateral displacement), and median nerve paralysis in one case (postero-lateral displacement). In two cases where no pulse was detected before reduction, pulses returned after reduction. Injury type was thought to be due to spasm and surgery was not necessary.

Closed reduction was performed on all patients, the adequacy of which was assessed by C-arm fluoroscopy.

There was immediate postoperative neurological assessment for ulnar, radial and median nerves. The patients were discharged on postoperative day one.

First-generation cephalosporin (2×500 mg/day) was administered to all patients for 24 hours only as a prophylactic.

The patients were allocated retrospectively into two groups according to the pin configuration used. The choice of the medio-lateral crossed or lateral cross pin fixation was made according to the treating resident's personal practice.

Group 1 This group comprised 75 patients, 60 male and 15 female, with a mean age of 7.5 years (range, 1.5–14 years). After closed reduction, fixation was achieved with crossed K-wires placed from the lateral condyle and lateral humerus towards the medial epicondyle. Care was taken so that the end of the K-wire passing from the lateral humerus did not protrude excessively at the level of the medial epicondyle. The end of the K-wire was left outside the skin (Fig. 1).

Group 2 This group comprised 64 patients, 54 males and ten females, with a mean age of 7.8 years (range, 2–13 years). Two cross-wires passed—one from medial and one from lateral (Fig. 2). K-wires were bent and left out of the skin for subsequent removal.

At the third week, elbow radiographs were taken and examined, K-wires were removed after which time the elbow was immobilised for a further two to four weeks. Healing was seen on radiographs after the removal of the cast and patients were allowed full use of the extremity without restriction.

Fig. 1 The all lateral cross-wire technique. **a** Preoperative view. **b** Postoperative anteroposterior (AP) X-ray with all lateral cross-pinning

Fig. 2 One medial and one lateral cross-wire technique. **a** Preoperative view. **b** Postoperative anteroposterior (AP) X-ray with medio-lateral cross-wiring technique

At the final examination, elbow movements were assessed and X-rays were taken. Outcomes were evaluated according to the criteria of Flynn et al. [4]. Humerus, forearm, and wrist angles were measured. The results obtained were statistically analysed and compared. Student's *t*-test and chi-square tests were used in statistical analysis.

Table 1 Patient outcomes according to carrying angle

Outcomes	Group 1	Group 2
Excellent	39 (53%)	33 (51%)
Good	23 (31%)	20 (32%)
Moderate	7 (9%)	5 (8%)
Poor	6 (7%)	6 (9%)

Table 2 Patient functional outcomes

Outcomes	Group 1	Group 2
Excellent	35 (47%)	31 (49%)
Good	25 (33%)	21 (32%)
Moderate	9 (12%)	8 (13%)
Poor	6 (8%)	4 (6%)

Results

All patients were followed-up until fracture union, resolution of all complications, and achievement of full range of motion. The mean follow-up period was three years (range, 2–6 years).

In group 1 there was no postoperative iatrogenic nerve damage whereas in group 2 iatrogenic ulnar nerve damage developed in six (9%) patients. On statistical evaluation, a significant difference was seen between the two groups ($p < 0.05$).

On images taken one week afterwards, reduction loss was seen in only two (2.6%) patients in group 1 and in one (1.5%) patient in group 2, and these patients underwent secondary surgery. There was no statistical significance between the two groups according to the secondary surgery ($p > 0.05$).

Pin site infection was seen in 14 (9.3%) of 150 pins in group 1 and in 11 (8%) of 128 pins in group 2. There was no development of deep infection or osteomyelitis. There was no statistically significant difference between the two groups ($p > 0.05$).

Functional results were evaluated according to Flynn's criteria. According to carrying angle, in group 1, results were 39 patients excellent (53%), 23 good (31%), seven fair (9%) and six poor (7%). In group 2, 33 were excellent (51%), 20 good (32%), five fair (8%) and six poor (9%). There was no statistically significant difference between the two groups ($p > 0.05$) (Table 1). According to functional results, in group 1, there were 35 (47%) excellent, 25 (33%) good, nine (12%) moderate and six (8%) poor. In group 2, there were 31 (49%) excellent, 21 (32%) good, eight (13%) moderate and four (6%) poor. There was no statistically significant difference between the two groups ($p > 0.05$) (Table 2).

Discussion

Some of the methods used in the treatment of paediatric humerus supracondylar fractures are traction, closed reduction and plaster fixation, closed reduction and

crossed K-wire osteosynthesis, and open reduction and fixation with K-wires. While excellent results may be obtained with conservative treatments in Gartland type 1 and 2 fractures, adequate treatment is not achievable by conservative methods in type 3 fractures. In these fractures, long-term immobilisation is required, and vascular and neural complications are encountered, and therefore surgery is recommended. Currently, the technique of choice is closed reduction and percutaneous K-wire osteosynthesis [1, 9, 10, 13].

Different configurations of pinning for fixation are proposed for the treatment of supracondylar humeral fractures in children. In recent biomechanical studies it has been shown that cross-wire pinning configuration is the most stable fixation technique [7]. Although loss of reduction is high in lateral divergent pinning at 28%, only 2% have been reported for cross-wire fixation, and no loss of reduction cases have been reported for all lateral cross-wire pinning in the literature [3, 13]. In our study loss of reduction was detected as 2.6% for cross-wire and 1.5% for all lateral cross-wire fixation groups. No statistical difference could be shown for the superiority of either fixation technique.

Wind et al. [15] reported that ulnar nerve location was not palpable in 32% of their cases and that pinning therefore ran the risk of serious nerve damage. Iatrogenic neural injury rates of 2–5% have been reported after closed reduction [8–10]. Royce et al. [12] and Wind et al. [15] reported even higher rates. Anterior subluxation of the ulnar nerve has been reported in 5–17% of cases of hyperflexion during closed reduction, and this increases the incidence of iatrogenic nerve injury [1, 9, 10, 16]. Pin configuration is important; a neural injury rate of 6% has been reported with crossed K-wires, while a rate of 0% has been reported with lateral pin configuration [14]. In our study a rate of 9% ulnar nerve damage was seen in medial and lateral cross-wire cases. However, there have been no reports of iatrogenic ulnar nerve damage from lateral cross-wire configuration [3, 13]. As our cases which were treated with lateral cross-wire configuration showed no iatrogenic ulnar nerve damage, it is thought that in the treatment of paediatric supracondylar fractures, the use of lateral cross K-wires may reduce the possibility of iatrogenic ulnar nerve damage.

Pin site infection may occur after treatment of displaced supracondylar fractures. Deep infection and osteomyelitis are rare. In recent publications, an infection incidence of 2.4–6.6% has been reported with percutaneous fixation [9, 10]. Wound infection occurred in two of our patients, suggesting that there is no difference between the two techniques in terms of infection.

In conclusion, the lateral cross-wire fixation technique may be a good choice in the treatment of paediatric supracondylar humerus fractures as it reduces the possibility of ulnar nerve

damage and achieves the same level of stabilisation as medio-lateral fixation.

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