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Treatment of displaced supracondylar humeral fractures among children: Crossed versus lateral pinning

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ABSTRACT

This retrospective study evaluated different pinning configurations used in the treatment of displaced supracondylar humeral fractures among children, mainly regarding maintenance of fracture reduction and avoidance of complications. The fractures (41 type II and 67 type III) of 108 children (mean age 6.48 years) were treated by closed reduction and percutaneous pinning: 37 with crossed pins, 37 with two lateral pins and 34 with two lateral and one medial pin. Mean follow-up period was 7.4 months. Type III fractures fixed by two lateral pins were found significantly prone to postoperative instability, late complications and need for medial pin fixation. There was a significant relation between either delay to surgery or postoperative instability and occurrence of complications. Final outcome was significantly poorer in type III than in type II fractures. Fixation by two lateral pins only is not recommended for treating type III supracondylar humeral fractures, but could be used initially to fix severely unstable fractures to allow extension of the elbow before inserting a medial pin. Every effort should be made to avoid iatrogenic ulnar nerve injury while inserting the medial pin.

1. Introduction

Closed reduction with percutaneous pin fixation has become the treatment of choice for displaced supracondylar fractures of the humerus among children. Successful management involves avoiding early ulnar nerve injury, redisplacement and late malunion complications.[2,5,12,13,21] Controversy about which pin configuration is best in treating these fractures is ongoing.[1,5,8,10] Two principal configurations have appeared in the literature: crossed pins (medial and lateral) and two lateral pins. Iatrogenic ulnar nerve injury is a known complication during placement of a medial pin,[3,4,9,14] and proponents of two lateral pins claim that the configuration is sufficiently stable and eliminates the risk of this injury. Some who support the crossed-pinning technique correctly argue that it is the more stable fixation,[1,5,13,18,20,21] but others have found that it offers no clinically significant advantages. They recommend that if two lateral pins are used, they should be parallel or divergent rather than crossing at the site of the fracture.[3,11,15,17]

At our institution, we have uniformly treated children with displaced supracondylar humeral fractures by closed reduction and pinning. The rare fractures that were irreducible were treated with open reduction and pinning. Pin placement has been left to the judgement of the treating surgeon. The aim of this retrospective study was to review over a period of 5 years all children with displaced supracondylar fractures of the humerus treated by closed reduction and percutaneous pinning, and to evaluate and compare the results of different pinning configurations in maintaining fracture reduction and avoiding possible early and late complications.

2. Materials and methods

We retrospectively reviewed all children with Gartland types II and III supracondylar distal humeral fractures treated at our institution by closed reduction and percutaneous pinning between January 2001 and December 2005. Exclusion criteria were open fractures, fractures that required open reduction, neurological or vascular injuries found on presentation, previous ipsilateral elbow fracture, presence of any concomitant fractures in the ipsilateral limb and loss from follow-up.

We reviewed the hospital records of the study cohort in detail, including personal data, preoperative clinical examinations, time from injury to surgery, operative notes, postoperative evaluations, duration of immobilisation, time of pin removal, presence of

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complications, need for further surgery and clinical assessment at final follow-up visit. Preoperative, intraoperative and early postoperative radiographs were examined to determine fracture type, accuracy of reduction, pin configuration, Baumann's angle, humerocapitellar angle and lateral rotational percentage (the percentage of displacement of the proximal humeral metaphysis at the fracture site in relation to the width of the distal humerus just distal to the fracture site as measured on the lateral radiograph).[3] Change in the lateral rotational percentage between intraoperative and postoperative radiographs or any loss in Baumann's angle or the humerocapitellar angle was considered a sign of instability at the fracture site and of incipient loss of reduction.

A total of 108 children fulfilled the inclusion criteria of the study, including 61 boys and 47 girls. Their mean age was 6.48 ± 2.79 (2–13) years; 50 children had fractures on the right side and 58 on the left side. There were 41 type II fractures and 67 type III fractures.

All the children underwent general anaesthesia, closed reduction and percutaneous pinning. The surgeon selected the pin size to be used according to the age of the child and the size of the arm (usually 1.6 mm for younger children and 1.8–2.0 mm for older children). The decision for pin configuration also was the choice of the operating physician, based on testing reduction and fracture stability intraoperatively both anteroposterior and lateral planes with the image intensifier, as well as the severity of the elbow swelling. The pin ends were bent outside the skin, and an above-elbow back slab was applied with approximately 90° of elbow flexion and neutral forearm rotation.

The children were discharged home when comfortable (usually after 1–2 days) and were seen in the clinic 1 week after surgery. Radiographs were obtained in both anteroposterior and lateral planes. If these were acceptable, the child was seen again after 3 weeks, when the cast was removed and more radiographs obtained. Whenever acceptable healing was confirmed, pins were removed in the clinic and motion was encouraged. The average immobilisation time in the present study was 5.1 ± 1.04 (4–8) weeks. Formal physiotherapy was indicated only if ~~there~~ elbow stiffness was developing.

Follow-up continued until full range of motion was regained. Some children had prolonged follow-up because of a postoperative complication or residual deformity. The average follow-up period was 7.4 (5–36) months. The clinical and radiological assessments were reviewed at the final visit. Clinical assessment included range of motion, carrying angle, neurological and vascular examination, return to full function and need for reoperation. Radiological assessment was made by comparing Baumann's angle in the initial postoperative and final follow-up radiographs. A change in Baumann's angle of more than12° was defined as a major loss of reduction; a change from 6° to 12°as mild displacement; and a change of less than 6° as no displacement.[5] The data collected were processed for statistical analysis with the SPSS statistical software package, version 12 (SPSS, Chicago, IL, USA). For crude analysis of independent groups of data, the chi-square test and Fisher's exact test were used; $p < 0.05$ was considered significant and $p < 0.001$ as highly significant.

3. Results

Closed reduction and pinning was performed within 8 h of injury for 48 fractures, ~~after~~ 8–24 h for 57 fractures and after 24 h for 3 fractures. The mean delay between injury and surgery was 8.95 ± 4.66 (3–2) h. Table 1 shows the distribution of pin configurations applied according to fracture type. When a lateral pin configuration was used, the pins were parallel or divergent and placed well apart from each other. In the group with fixation by one medial and two lateral pins (34 children), the medial pin was added to the two lateral pins whenever persistent intraoperative instability was noted (Fig. 1). In 56 of the 71 cases with medial pin fixation, the ulnar nerve was palpated before to insertion of the pin; in 9 cases a small incision was used to allow safe pin placement.

Table 1
Distribution of pin configuration according to fracture type (numbers).

Pin configuration	Fracture type		Total fractures
	II	III	
One medial and one lateral	18	19	37
Two lateral	20	17	37
Two lateral and one medial	3	31	34
Total fixations	41	67	108

Intraoperative radiographs showed that the fracture reduction was accepted in all cases. Significant instability due to inadequate fixation, and early loss of reduction of different degrees and in different planes, were observed in postoperative radiographs of nine children who underwent fixation by two lateral pins (eight had type III fractures and one had a type II fracture) as shown in Fig. 2. However, no measures were taken to restore the original reduction or to improve the stability of the fixation. Two boys, aged 3 and 8 years, developed postoperative ulnar nerve palsy; both had a type III fracture that was fixed with one medial and two lateral pins. In both cases the ulnar nerve was palpated intraoperatively before pinning. Under observation they recovered spontaneously and fully. One child developed a pin-track infection which resolved completely with local wound care, and six required an extended period of intensive physiotherapy because of persistent elbow stiffness.

Final clinical and radiological assessment confirmed complete healing of the fractures among all the children, without neurological or vascular compromise. All regained full range of motion, except for one boy who lost approximately 20° of elbow flexion and had an extension lag of <10°, and one girl who also had an extension lag of <10°. Among the nine children who showed loss of reduction in early postoperative radiographs, one had a minor residual deformity (obliteration of the carrying angle) and three had an evident cubitus varus deformity that justified corrective osteotomy (Fig. 3). Overall limb function was affected among four children (the three who had cubitus varus deformity and the boy who had limitation of elbow motion).

Statistical analysis of our results showed that girls are more likely than boys to sustain a supracondylar humeral fracture in the preschool period ($p = 0.015$). Gender, age and site of the fracture did not significantly influence fracture type, stability of the fracture, occurrence of complications or final outcome. Type III fractures that were fixed by two lateral pins were found to be more prone to postoperative instability ($p = 0.021$) and late complications ($p < 0.0001$). The need for medial pin fixation was significantly associated with type III fractures ($p < 0.0001$). There was a significant relation between delayed surgery and the occurrence of complications ($p = 0.03$), but there was no significant relation between delay to surgery and ulnar nerve injury ($p = 0.402$). Postoperative instability increased the risk of complications ($p = 0.019$). The final outcome was significantly worse in type III than in type II fractures ($p = 0.028$).

4. Discussion

The successful treatment of displaced supracondylar humeral fractures of children depends on achieving and maintaining an acceptable reduction until the fracture is healed, while avoiding

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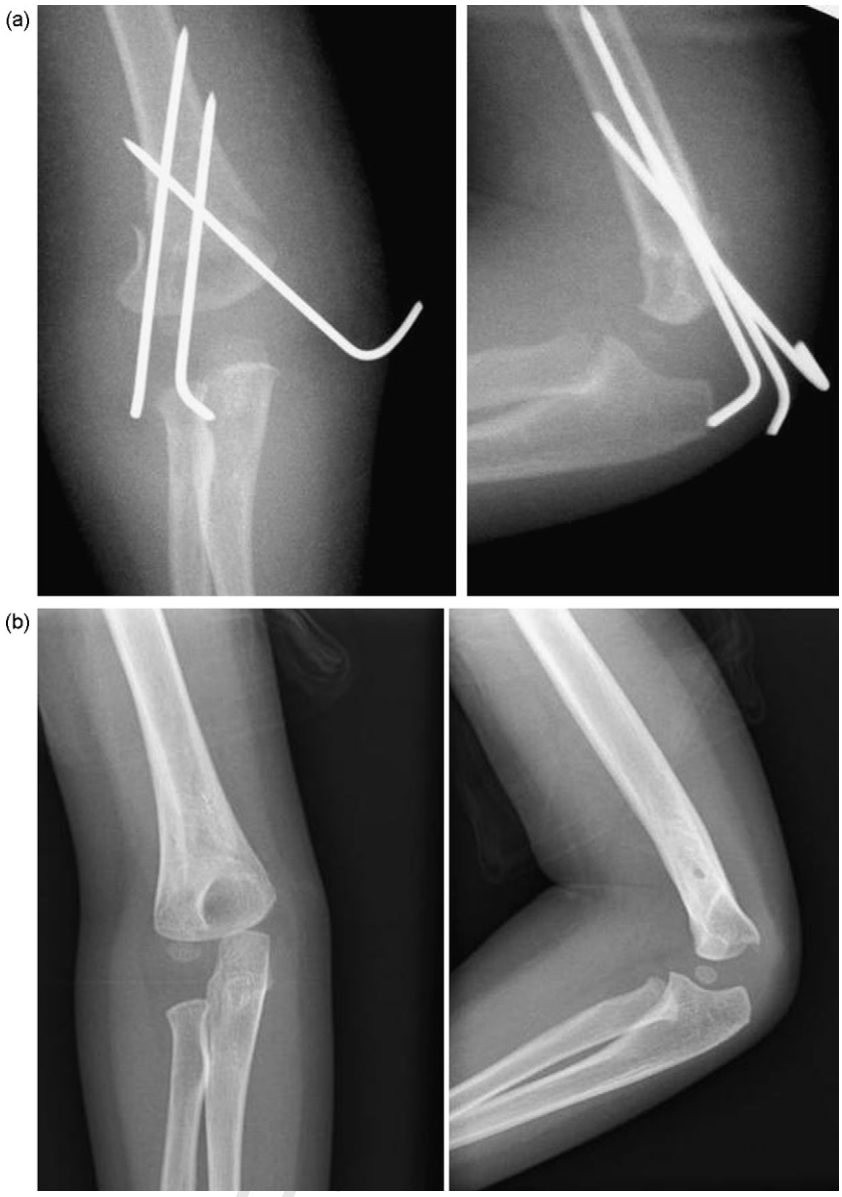

Fig. 1. (a) Anteroposterior and lateral views of the right elbow showing type III supracondylar humeral fracture, fixed primarily with two lateral pins. A medial pin was added to achieve stability. (b) Fracture united with normal alignment.

complications. Controversy persists regarding the optimal pin fixation technique.[1,2,5]

According to clinical data, the use of two lateral pins placed in either a parallel or a divergent pattern (the latter being more biomechanically stable) provides adequate biomechanical stability with minimal risk of ulnar nerve injury, and is therefore gaining in popularity.[6,10,12,15,16,17] However, biomechanical studies of adult cadavers and synthetic paediatric bone models have suggested that properly placed lateral pins still do not offer adequate stability against torsional forces,[1,7,18,21] and a third medial pin must be added whenever there is rotational instability.[3,8,10,20]

Type II fractures are distinguished by the presence of intact bone or periosteum posteriorly at the fracture site, preventing loss of rotational alignment. Type III fractures, however, lack this inherent stability and the comminution of the medial cortex, which is usually present in a type III fracture, adds more instability. Q1 Even a small degree of malrotation of the fragments ~~of~~ can cause marked tilting in anteroposterior alignment, allowing cubitus varus deformity to develop, and this usually requires corrective surgery at a later date to improve elbow function.[3,8,19]

Our clinical results supported this observation. Of 23 type II fractures fixed in our study primarily with two lateral pins, 3 (13%) showed intraoperative instability that required an additional medial pin and 1 (4.3%) showed postoperative instability with posterior tilting that remodelled without sequelae. However, of the 48 type III fractures fixed primarily with two lateral pins, 31 (65%) showed intraoperative instability that warranted an additional medial pin. Of the 17 fractures fixed by lateral pins alone, 8 (47%) demonstrated significant postoperative instability and 4 of these (23.5% of the 17 fractures) developed cubitus varus deformity.

Although the use of a medial pin is known for its association with ulnar nerve injury, it is interesting to note that, when examining the overall probability of iatrogenic nerve injury, there is still a 2% probability of radial or anterior interosseous nerve damage associated with lateral entry pin fixation.[1,5,21]

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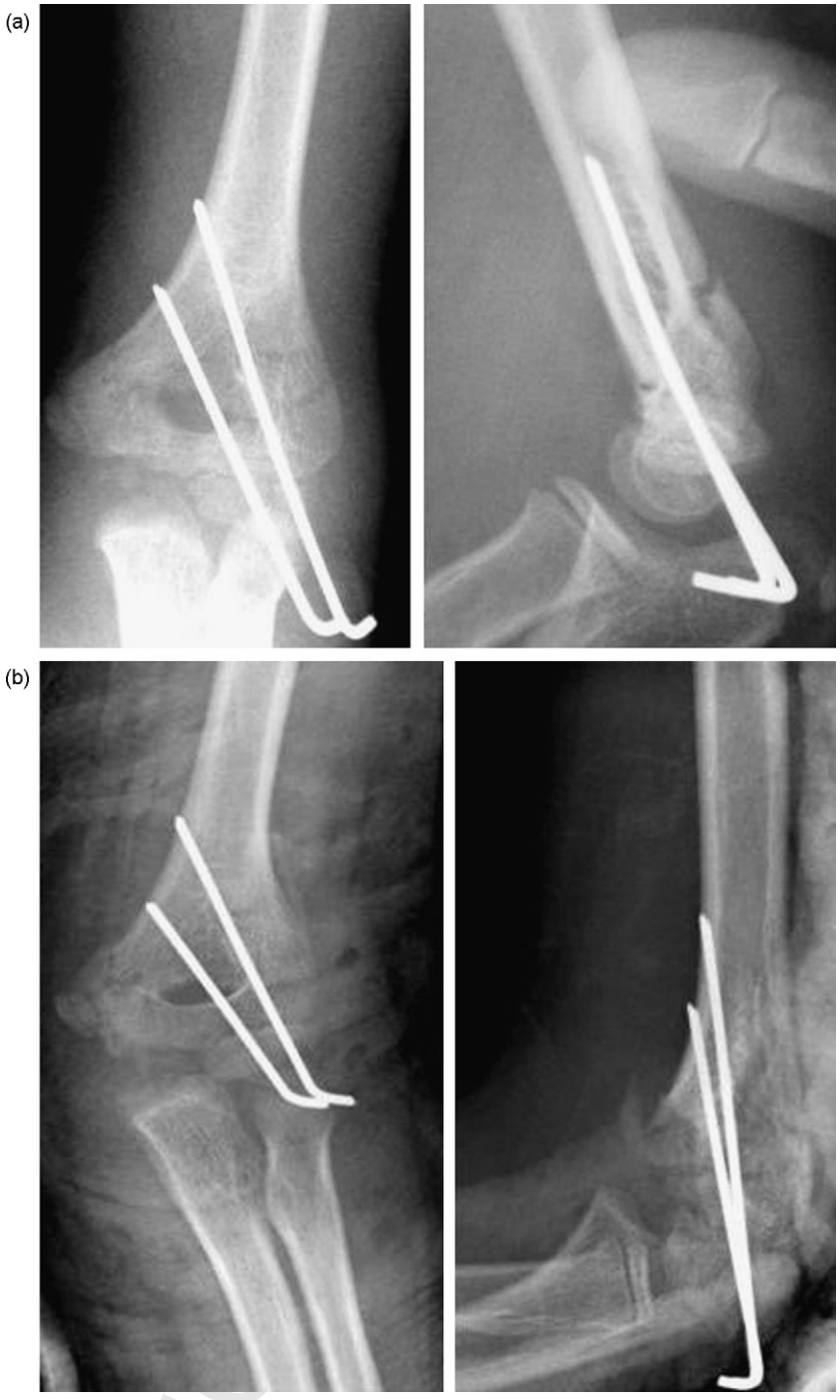

Fig. 2. (a) Anteroposterior and lateral views of the left elbow showing type III supracondylar humeral fracture reduced perfectly and fixed with two lateral pins. (b) Early postoperative redisplacement, more evident in lateral radiograph, due to persistent instability at the fracture site.

The incidence of reported iatrogenic ulnar nerve lesions caused by a medial pin ranges from 1.4% to 15.6%.[4,13,14] In our study, the incidence (1.9%) was comparatively low. Injury of the ulnar nerve results from penetration, contusion or kinking of the nerve by a misdirected medial pin. Iatrogenic constriction of the cubital tunnel by an apparently correctly placed medial pin, and damage to a hypermobile ulnar nerve that can subluxate anteriorly when the elbow is held in a hyperflexed position, are other mechanisms that have been recently reported.[3,11,12,19] Iatrogenic ulnar nerve injury has a natural history that is benign and, in most cases, observation is appropriate management. In a few cases, where the medial pin appears to have a position in the ulnar notch, it may be appropriate either to remove that pin and replace it with another in a more anterior position, or to perform early exploration.[4,9,12]

Measures taken to avoid iatrogenic ulnar nerve damage while inserting a medial pin include relative extension of the elbow with a maximum of 60° flexion, after inserting the lateral pin. This should reduce possible ulnar nerve subluxation before inserting the medial pin. In very unstable fractures, a second lateral pin may be needed to provide more stability before partially extending the elbow for safe medial pin placement. If the ulnar nerve and groove cannot be identified with confidence, a small incision should be

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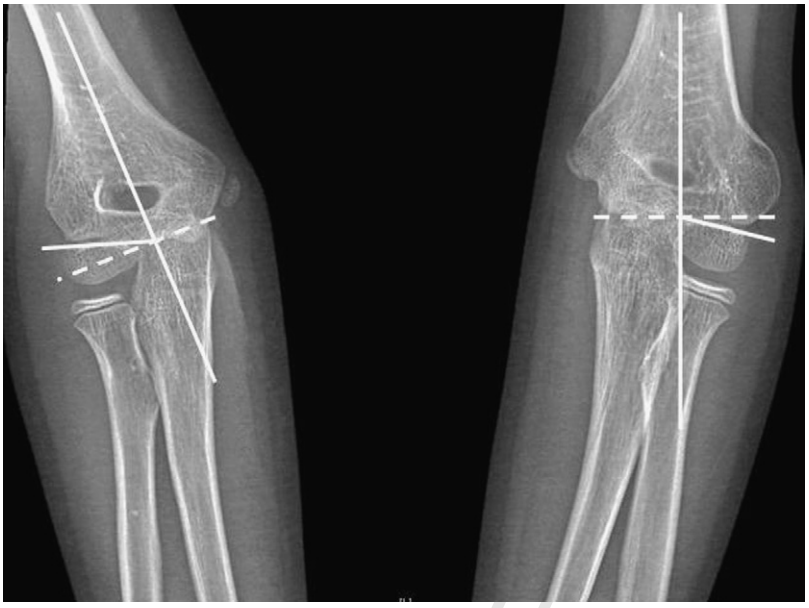

Fig. 3. Same case as Fig. 2, after union of the fracture with major loss of Baumann's angle (as compared with the sound right elbow) and evident cubitus varus.

made over the pin insertion site and blunt dissection should be performed down to the bone, to place the pin under direct vision.[1,2,3,14,19,20] Dorgan's technique of inserting crossed pins from the lateral side of the arm, as described by Shannon et al.,[13] offers the biomechanical advantages of cross-pinning while avoiding the risk of iatrogenic ulnar nerve injury.

Its retrospective nature is the main weak point of the current study. Another weak point is the lack of standard protocol, in that pin configuration was left to the choice of the surgeon. However, the investigation was strengthened by the large number of cases included with fully detailed preoperative, operative and post-operative data. Furthermore, there was no surgeon bias towards specific pin configuration; choice was based on testing intraoperative stability and severity of the elbow swelling.

The authors noted that precise lateral pin placement, which is stressed by advocators of the lateral pin configuration, is often difficult to achieve *in vivo*, and all measurements described to test stability after inserting the two lateral pins can be altered by small changes in elbow position. On the other hand, the stability of crossed pins is well documented and independent of any measurement. The authors believe that efforts spent on proper lateral pin placement and testing subsequent stability, which may prove unsatisfactory, could have been better directed towards avoiding ulnar nerve injury during medial pin placement.

In conclusion, our results suggest that fixation with two lateral pins is suitable for type II supracondylar humeral fractures, but does not provide enough stability in most type III fractures to avoid redisplacement. Therefore, the authors do not recommend lateral pinning in treating type III supracondylar humeral fractures in children. In severely unstable fractures, two lateral pins could be used initially to allow extension of the elbow before inserting the medial pin. In doubtful cases with a massively swollen elbow, a small incision can save the ulnar nerve from injury.

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