Closed Reduction and Internal Fixation of Completely Displaced and Rotated Lateral Condyle Fractures of the Humerus in Children

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Objective: To determine the usefulness of closed reduction and internal fixation as the initial treatment for completely displaced and rotated fractures of the lateral condyle of the humerus in children.

Design: Prospective.

Setting: Three Level I trauma centers.

Patients: We prospectively studied 24 consecutive completely displaced and rotated lateral condylar fractures of the humerus in children (Jakob Stage 3, 20 boys and four girls) that were treated by three different surgeons working at different hospitals during the same period.

Intervention: In 21 fractures, we initially attempted closed reduction and internal fixation; in three, we used open reduction and internal fixation and made no attempt at closed reduction.

Main Outcome Measurement: We assessed the preoperative degree of displacement and postoperative radiographic quality of closed reduction. Clinical results were graded using the criteria suggested by Hardacre et al.

Results: Eighteen of 24 (75%) completely displaced and rotated fractures were reduced within 2 mm of residual displacement using the closed method. Three fractures were treated with open reduction and internal fixation initially and internal fixation because of one surgeon's lack of confidence in closed reduction, because of lack of experience with it, early in the study period. Closed reduction to within 2 mm failed in three fractures, so open reduction and internal fixation was then performed. There were no significant complications such as limited range of motion, pain, osteonecrosis of the trochlea or capitellum, nonunion, malunion, or early physeal arrest.

Conclusion: Closed reduction and internal fixation is an effective treatment for completely displaced and rotated lateral condyle fractures of the humerus in many children.

Key Words: lateral condyle fracture, rotation, closed reduction and internal fixation, children

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INTRODUCTION

Several researchers have recommended open reduction and internal fixation (ORIF) as the best procedure for displaced and rotated lateral condylar fractures of the humerus in children to prevent further displacement, nonunion, and malunion.[1–10] Only a few reports have focused on closed reduction and internal fixation (CRIF) of lateral humeral condyle fractures.[11–13] Recently, we achieved satisfactory reduction and secure fixation of displaced and rotated lateral humeral condyle fractures in children using CRIF, finding no need to convert to ORIF. We prospectively studied the use of CRIF as the initial treatment for a group of such fractures.

PATIENTS AND METHODS

After obtaining informed consent from the patients' parents or guardians and the approval of our Institutional Review Board, we prospectively studied 24 consecutive completely displaced and rotated lateral condyle fractures of the humerus (Jakob Stage 3)[3] treated independently at three different hospitals between February 2006 and March 2008. All of the patients were treated by a single pediatric orthopaedic surgeon in each hospital, and three experienced orthopaedic surgeons measured the amount of fracture displacement and classified the fracture pattern three times for each patient over an interval of more than 2 weeks using a picture-archiving and communications system network (Marosis, DICOM Version 3.0; INFINITT, Seoul, Korea). Fracture fragment displacement was measured from the lateral metaphyseal cortex of the distal humerus to the lateral cortex of the fracture fragment on the anteroposterior, internal oblique, and external oblique radiographic views.[14] The posterior cortex was used to measure displacement on the lateral view. The greatest displacement on any single view was recorded as the amount of displacement of the fragment.

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Observer agreement was measured to determine inter- and intraobserver reliability. We calculated the kappa value to assess such reliability regarding fracture pattern with a value of 1 indicating complete agreement. Interobserver reliability regarding measurement of fracture displacement on preoperative and postoperative anteroposterior and internal oblique radiographs was very high (range, 0.899–0.915 for preoperative anteroposterior radiographs, 0.925–0.940 for preoperative internal oblique radiographs, 0.910 for postoperative anteroposterior radiographs, and 0.811–0.914 for postoperative internal oblique radiographs).

As a first step, we attempted CRIF for 21 of the 24 completely displaced and rotated fractures. The other three patients were treated with open reduction without any attempt at closed reduction owing to one surgeon's lack of confidence in closed reduction. CRIF failed in three of 21 patients.

To reduce unstable fractures, we applied traction with a gentle varus force to the elbow while the patient was under general anesthesia, and we attempted to reposition the rotated fragment by using Kirschner wires as joysticks or by directly pushing on the fragment (Figs. 1 and 2). After repositioning, we applied gradual direct compression to the distal fracture fragment anteromedially. We then applied slight valgus force to the elbow with the forearm supinated and the elbow slightly extended to maintain the reduction. After the fracture reduction was confirmed to be within 2 mm, especially as seen on the internal oblique, anteroposterior, and lateral radiographs,[14] we used smooth Kirschner wires to perform percutaneous pinning (Fig. 3). One group used two parallel 1.2-mm diameter Kirschner wires for patients younger than 3 years, two parallel 1.4-mm diameter wires for those between 3 and 5 years, and two parallel 1.8-mm diameter wires for those older than 5 years. The other group used three divergent 1.6-mm diameter wires in eight patients and four 1.2-mm diameter wires in one patient. If we could not reduce the fragment within 2 mm as shown on any of the four radiographic views, ORIF was performed. We applied a long arm cast in all patients and left it in place for 4 weeks. We removed the pins 4 to 5 weeks after surgery. At the latest follow-up examination, we evaluated elbow range of motion, radiographic changes (including osteophyte formation and hypertrophy of the capitellum), and clinical symptoms. Results were graded using the criteria suggested by Hardacre et al (Table 1).[7]

RESULTS

A total of 24 fractures were evaluated in 20 boys and four girls whose ages ranged from 1 year 7 months to 9 years 6 months (average age, 5 years 6 months). Fourteen fractures involved the left elbow and 10 involved the right elbow. Treatment was performed within 1 day of trauma in 19 patients and within 2 days in five patients. The average length of follow-up monitoring was 2 years 6 months (range, 1 year to 3 years 7 months). The average amount of initial displacement was 13.3 mm (range, 5–33 mm) on the anteroposterior radiograph and 13.5 mm (range, 5–27 mm) on the internal oblique radiograph. For the entire group, the average amount of postoperative displacement was less than 2 mm on both the anteroposterior and internal oblique radiographs. Eighteen of the 21 fractures could be reduced to less than 2 mm of residual displacement with CRIF and were stabilized with percutaneous Kirschner wires. Six of the 24 fractures were treated by ORIF. There were minor complications: 15 instances of osteophyte formation without any subjective symptoms and four instances of mild hypertrophy of the capitellum with no change in the carrying angle. There were no serious complications—no osteonecrosis of the trochlea or capitellum, nonunion, malunion, or early physeal arrest. Clinical results, using the criteria of Hardacre et al, were excellent in 17 of 18 (94.4%) patients, good in one patient, and poor in no patients. Thus, in 18 of the 24 patients (75%), the displaced and rotated lateral humeral condyle was treatable with CRIF, resulting good clinical outcomes and no serious complications.

DISCUSSION

A fracture of the lateral humeral condyle is more likely to result in a significant functional loss of elbow motion when

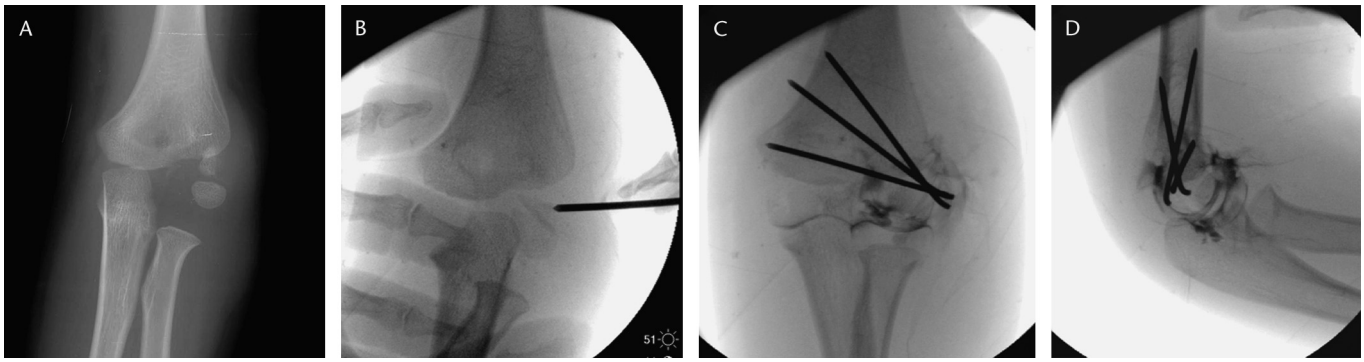

FIGURE 1. Anteroposterior radiograph (A) showing a completely displaced fracture with rotation of the fracture fragment. Intraoperative anteroposterior (B) radiograph from the same patient showing reposition the rotated fragment by using a Kirschner wire (K-wire) as a joystick. Postreduction anteroposterior (C) and lateral (D) arthrograms showing fixation with three Kirschner wires and a congruent articular surface.

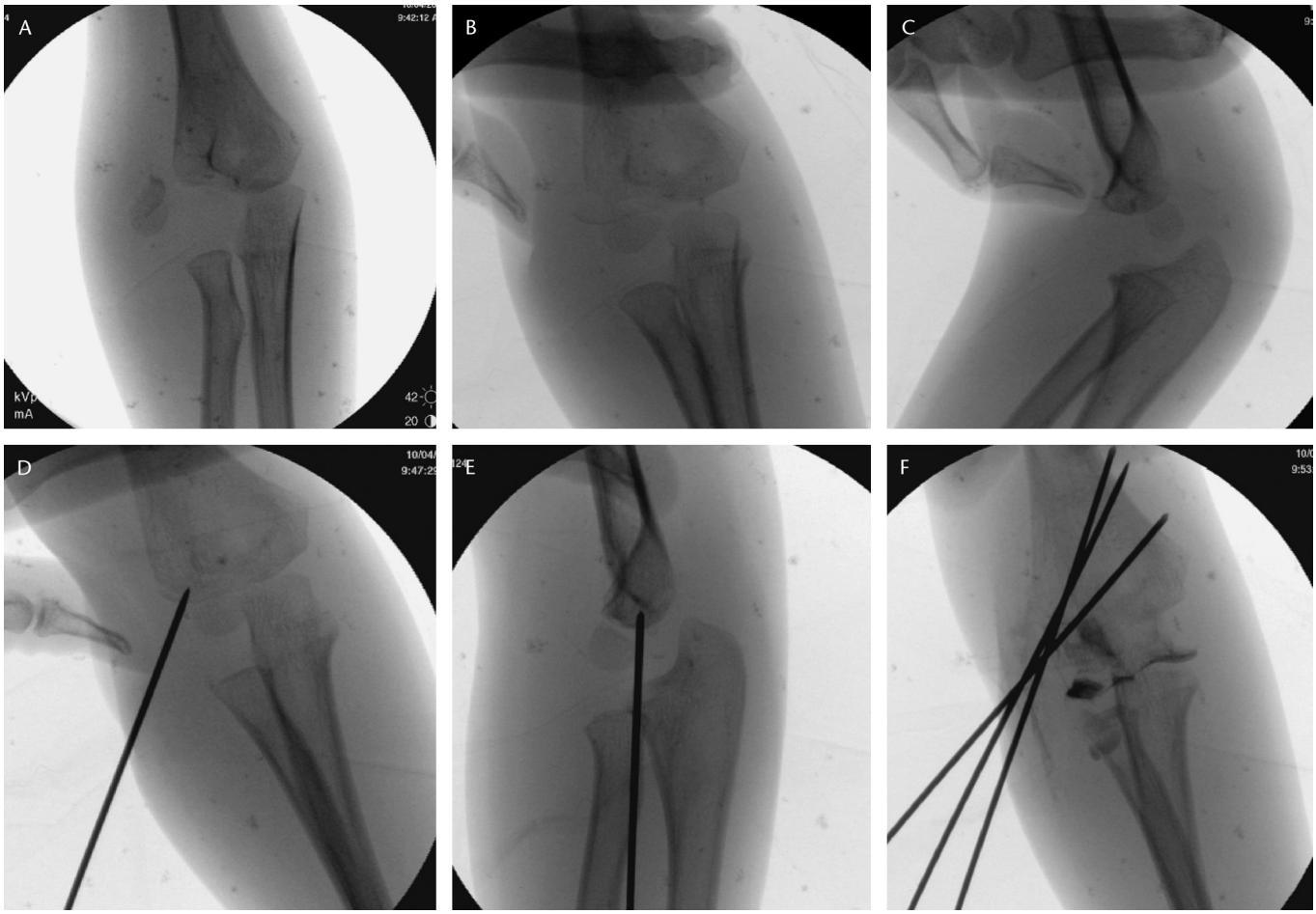

FIGURE 2. Anteroposterior radiograph (A) showing a completely displaced fracture with rotation of the fracture fragment. Intraoperative anteroposterior (B) and lateral (C) radiographs from same patient showing reduction by pushing the fragment backward and medially with the operator's thumb. Intraoperative anteroposterior (D) and lateral (E) radiographs showing final reduction of the fragment less than 2 mm of displacement with a Kirschner wire. Postreduction anteroposterior (F) arthrogram showing fixation with three Kirschner wires resulting in congruent reduction of the articular surface.

it is inadequately treated.[1] Generally, there has been uniform agreement regarding the need for ORIF of displaced and rotated fractures of the lateral condylar physis. Because it is difficult to maintain the reduction of a displaced lateral condylar fracture and because of the high prevalence of poor functional and cosmetic results associated with CRIF and casting, ORIF has become the most widely advocated method for the treatment of unstable fractures with Jakob Stage 3 displacement.[1–10] However, even with ORIF, malunion may occur because of a lack of intraoperative confirmation of the reduction status or osteonecrosis caused by excessive soft tissue dissection.

Only a few reports have focused on percutaneous pin fixation of these fragments.[11–13] Mintzer et al[11] tried CRIF only for selected fractures with 2 to 4 mm of displacement and an arthrographically demonstrated congruent joint space, and Foster et al[12] did so for nondisplaced or minimally displaced fractures as an acceptable alternative in any situation in which close clinical and radiographic follow-up monitoring cannot be ensured. Although others do not recommend CRIF for the treatment of Jakob Stage 3 displaced and rotated lateral condyle fractures,[1–10] we preliminarily reported a 50% success rate with that very treatment for just such fractures.[13] After accumulating experience, we achieved more than good results in 18 of the 24 (75%) such fractures using CRIF and percutaneous pin fixation (Fig. 1). In three of 21 cases, CRIF failed at an early point in our study, which means that a learning period is necessary for proper interpretation of fracture patterns and proper application of the reduction technique. It is our impression that the reasons for our high success rate with CRIF were accurate interpretation of the direction and patterns of fracture,[14] routine intraoperative confirmation of the reduction on both anteroposterior and internal oblique radiographs, and secure maintenance of the reduction with percutaneous Kirschner wires.[1]

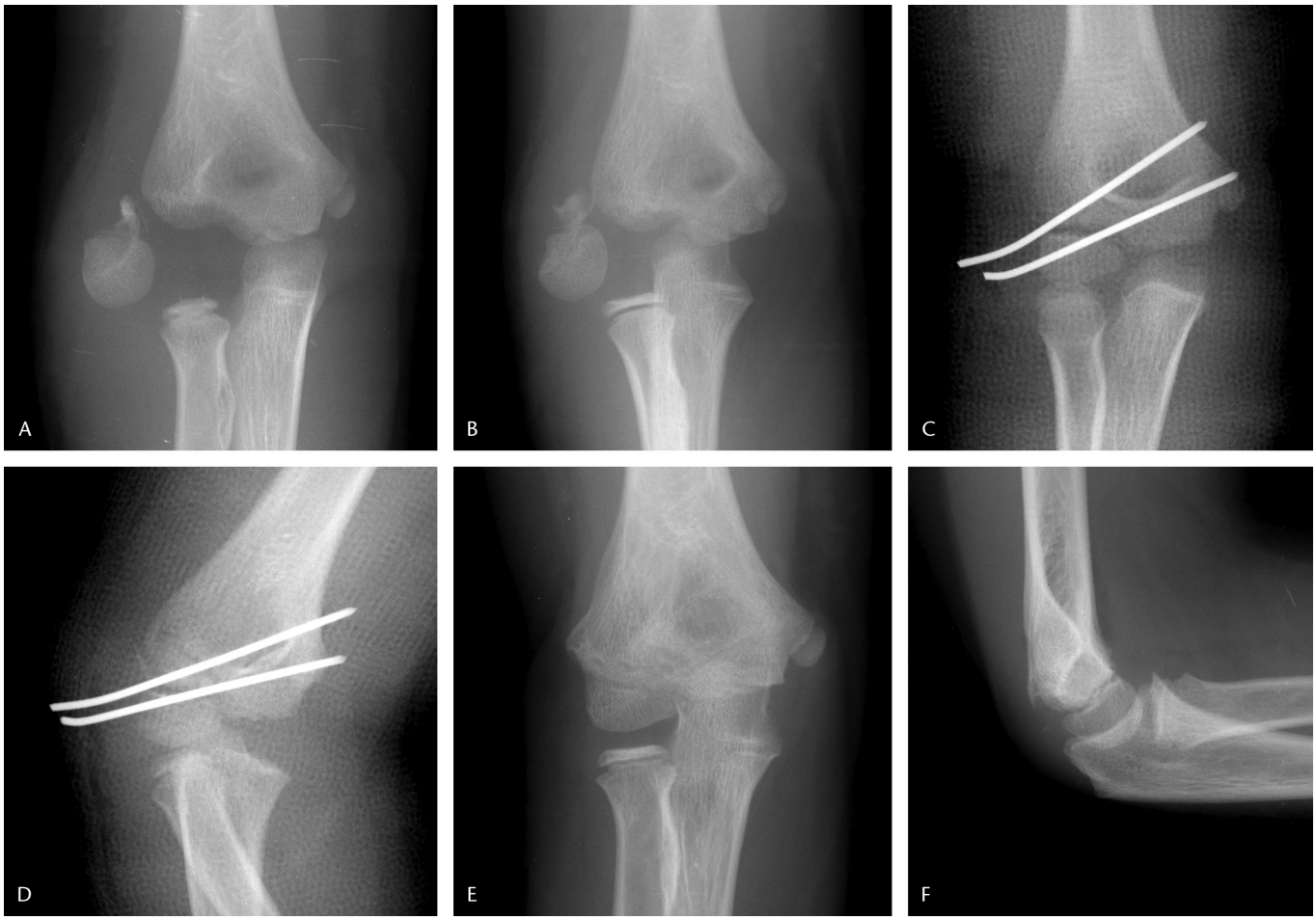

FIGURE 3. Anteroposterior (A) and internal oblique (B) radiographs showing a completely displaced Stage 5 fracture with rotation of the fracture fragment. Postoperative anteroposterior (C) and internal oblique (D) radiographs from the same patient showing reduction of the lateral cortex with a minimal lateral gap and less than 2 mm of displacement and fixation with two smooth Kirschner wires. Anteroposterior (E) and lateral (F) radiographs, obtained 12 months after surgery, showing fracture union.

TABLE 1. Evaluation of Results by Hardacre Et al

	Range of Motion	Carrying Angle	Symptom
Excellent	No limitation	No alteration	No symptoms
Good	Functional range of motion (lacking no more 15° of complete extension)	Inconspicuous	No arthritic, neurologic symptoms
Poor	Disabling loss of function	Conspicuous alteration	Arthritic symptom, ulnar neuritis, roentgen findings of nonunion, avascular necrosis

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Invited Commentary

Fractures of the lateral humeral condyle are the second most frequent elbow fracture in children, and their treatment has been a subject of much discussion for many years. Historically, displaced lateral humeral condylar fractures have been considered a "fracture of necessity" for which open reduction and internal fixation is mandatory,[1] a recommendation that has stood the test of time. Closed reduction and internal fixation (CRIF) of Type III fractures certainly runs counter to standard orthopaedic principles; closed treatment of even Type II fractures remains controversial. Pediatric orthopaedists debate whether even 2 to 4 mm of displacement is acceptable for pinning. However, because the distal humeral physis provides only 20% of growth and the elbow is not a weightbearing structure, anatomic reduction and rigid fixation are not as essential as in, for example, fractures with physeal and articular displacement in the knee and ankle in children.

Just as advances in technology and techniques have altered standards of treatment in other areas, advances in fluoroscopy and closed reduction techniques (ie, "joystick" manipulation of fracture fragments) may alter how we view the treatment of displaced lateral humeral condylar fractures. After all, pediatric orthopaedists have been using CRPP for supracondylar humeral fractures for several decades. In recent years, we have used percutaneous manipulation for radial head and neck fractures. All orthopaedic surgeons are interested in "percutaneous" techniques (slipped capital femoral epiphysis) and "minimally invasive techniques" that, in theory, should result in less morbidity for the patients.

It is difficult to argue with success, and these authors have reported 96% and 94% excellent results with the technique applicable to approximately 75% of displaced, rotated fractures, albeit in relatively small numbers of patients.[2] However, the authors note that there is a substantial "learning curve," and one surgeon in their study did not use the CRIF method because of a "lack of experience" with it. Familiarity with and skill in percutaneous joystick manipulation of fracture fragments under fluoroscopic guidance appear to be prerequisites for the success of this technique. Another concern is the limit of displacement that can be reduced with percutaneous manipulation. Can substantial fracture displacement (ie, in which the fragment is "flipped" 180° and the articular surface is dislocated laterally) be satisfactorily reduced with percutaneous methods?

The good clinical outcomes and lack of serious complications in these 18 patients are impressive arguments for the use of CRIF, but the technique does require experience and, especially, astute judgment as to which fractures are appropriate for CRIF. Those of us with a great deal of experience in elbow fractures in children do see complications such as osteonecrosis of the lateral humeral condyle and malunion after surgery. With that being said, open reduction and internal fixation has been proven to be a reliable method for obtaining and maintaining reduction with low morbidity and good clinical results, and more data are necessary to make CRIF a standard treatment method for these fractures. Like with every new technique, this one will require use by a number of other investigators to confirm reproducibility of these good outcomes, which might make this technique the standard of care in the future.

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Invited Commentary

This article represents an interesting and novel approach to the treatment of displaced fractures of the lateral humeral condyle in children. Open reduction is most often used without attempts at closed reduction. Closed reduction and percutaneous pinning has been proposed for less severe injuries. However, the authors of this study were able to reduce fractures that can be difficult to reduce even under direct vision through an open surgical exposure. The use of a pin to help guide reduction under fluoroscopic control has sometimes been successful for radial neck fractures. It is logical to attempt this before considering open reduction for lateral humeral condyle fractures. The posterior blood supply needs to be protected when open reduction is performed, so this method may relieve that concern when successful. Also, minor displacements can be accepted without resorting to open reduction if this closed method can be learned and performed by others. It makes sense to attempt closed reduction before open reduction because there is little harm in the attempts and reduction may be achieved without resorting to open reduction.

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