Fracture of the Medial Humeral Epicondyle in Children: A Comparison of Operative and Nonoperative Management

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To compare clinical and radiographic outcomes of medial epicondylar fractures treated operatively to those treated nonoperatively, 30 patients with 31 fractures were divided into three groups: (a) nondisplaced, six treated nonoperatively; (b) incarcerated fragment, four with operative treatment; and (c) displaced but not incarcerated, 21 fractures, 14 treated operatively and seven nonoperatively. Clinical outcomes were assessed with follow-up examination and the Japanese Orthopaedic Association elbow assessment score. Average elbow scores were 98 in nondisplaced fractures, 94 with an incarcerated fragment, 95 in displaced fractures treated operatively, and 94 in displaced fractures treated nonoperatively. The only nonunion was in a fracture with an incarcerated fragment. Both operative and nonoperative treatment produced good outcome scores in displaced but not incarcerated fractures, but radiographic deformity and instability were more frequent in those treated nonoperatively. (Journal of Surgical Orthopaedic Advances 24(3):188–192, 2015)

Key words: children, medial epicondyle fracture, nonoperative treatment, operative treatment, outcomes

Fractures of the medial humeral epicondyle represent approximately 12% to 20% of all pediatric elbow fractures (1). Despite their frequency, their treatment continues to be a matter of debate. It is commonly accepted that nondisplaced fractures are best treated nonoperatively with immobilization in a long arm cast or splint, while open fractures and fractures with an irreducible incarcerated fragment within the joint are absolute surgical indications (1). The surgical indications for fractures with displacement but no incarcerated fragment are less established, and good results have been reported with both operative and nonoperative treatment (2–8). A retrospective review was done to determine clinical and radiographic outcomes of a group of pediatric patients with fractures of the medial humeral epicondyle and to compare the operative and nonoperative treatment of displaced but not incarcerated fractures for which optimal treatment is yet to be determined.

Materials and Methods

Following institutional review board approval, a retrospective search identified 62 skeletally immature patients (age 4 to 16 years) with 63 acute, isolated medial epicondylar fractures. Attempts were made to contact all 62 patients. Thirty patients with 31 fractures were available for follow-up examinations at a minimum of 2 years.

Patients were divided into three groups for further evaluation: nondisplaced fractures, displaced fractures with incarcerated fragments, and displaced fractures without an incarcerated fragment. All patients returned for a clinical examination and radiographs. The clinical outcome was assessed using the Japanese Orthopaedic Association (JOA) elbow assessment score (Table 1). The JOA elbow assessment score was chosen because it evaluates both subjective (e.g., pain, activities of daily living) and objective (e.g., range of motion, instability) outcomes, is simple for both patients and examiners to understand and complete, and provides a single score for each patient that allows comparison among groups (8, 9).

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Injury radiographs were examined to determine the amount of displacement of the medial epicondylar fracture. The point of maximal displacement measured on an anteroposterior radiograph was used as the determinant of initial displacement (Fig. 1). Radiographic examination at the follow-up visit consisted of plain anteroposterior and lateral radiographs and stress anteroposterior radiographs of the injured elbow and contralateral elbow. A standard protocol was used to obtain the stress radiographs. The injured and uninjured elbows were imaged simultaneously. Each elbow was held in 15° of flexion while two researchers applied a manual valgus stress. The uninjured stressed elbow was used as a control to assess valgus instability. Opening to valgus stress was considered significant if the medial joint space widened 1 mm or more compared with the normal stressed elbow. Follow-up plain radiographs were assessed for epicondylar nonunion, width of the distal humerus, and vertical position of the medial epicondyle. Specific measurements were taken as outlined by Skak et al. (10) to identify any residual deformity of the distal humerus (Fig. 2). As in the study by Skak et al. (10), only differences of 3 mm or more of the width of the distal humerus and height of the epicondyle were considered relevant. The presence or absence of an ulnar sulcus sign also was noted (9) (Fig. 3). Statistical analysis included paired t tests for continuous variables and Fisher's exact test for categorical variables; significance was set at a p value $\leq .05$.

TABLE 1 Japanese Orthopaedic Association elbow assessment score

Category	Maximal Points
Pain	30
Range of motion	30
Instability	10
Deformity	10
Activities of daily living	12
Muscle power	8
Total Score	100

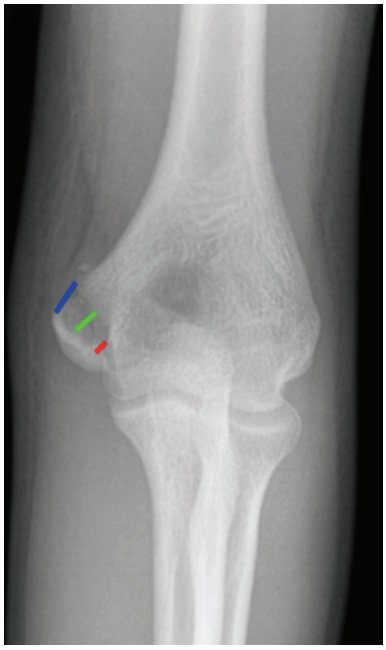

FIGURE 1 Anteroposterior radiograph of a left elbow with a fracture of the medial epicondyle. There are three different places where displacement could be measured. The red line represents 2 mm of displacement; the green line, 3 mm; and the blue line, 5 mm. Measurements were made on the basis of the area of maximal displacement. (Reprinted from Pappas, N., Lawrence, J. T., Donegan, D., et al. Intraobserver and interobserver agreement in the measurement of displaced humeral medial epicondyle fractures in children. J. Bone Joint Surg. Am. 92(2):322-327, 2010.).

Results

The 31 fractures (30 patients) were categorized as nondisplaced (six fractures), displaced with incarcerated fragments (four fractures), or displaced with no incarcerated fragment (21 fractures). Of the 30 patients, 25 (83%) were male and five (17%) were female. The dominant extremity was involved in 23 (74%) fractures. The average patient age at the time of injury was 12 years (range, 6–15 years), and the average follow-up was 4 years (range, 2–16 years). The average displacement was 8 mm (range, 0–32 mm). Nine fractures had associated

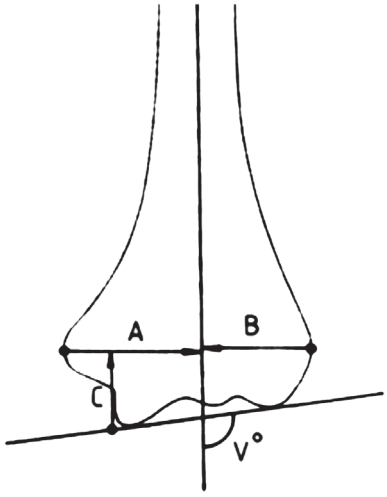

FIGURE 2 On equivalent anteroposterior films of both elbows, the width of the distal humerus (A + B) and the vertical position of the medial epicondyle (C) were compared. Differences of less than 3 mm were ignored. (Reprinted from Skak, S. V., Grossmann, E., Wagn, P. Deformity after internal fixation of fracture separation of the medial epicondyle of the humerus. J. Bone Joint Surg. Br. 76(2):297–302, 1994.).

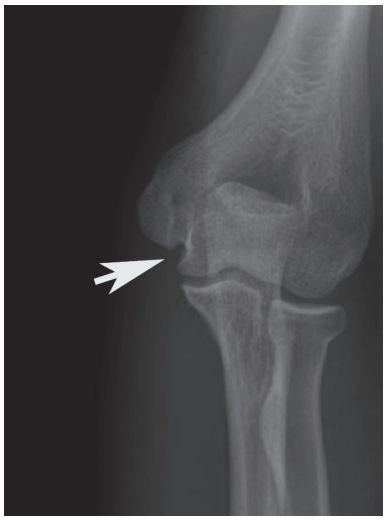

FIGURE 3 Ulnar sulcus sign.

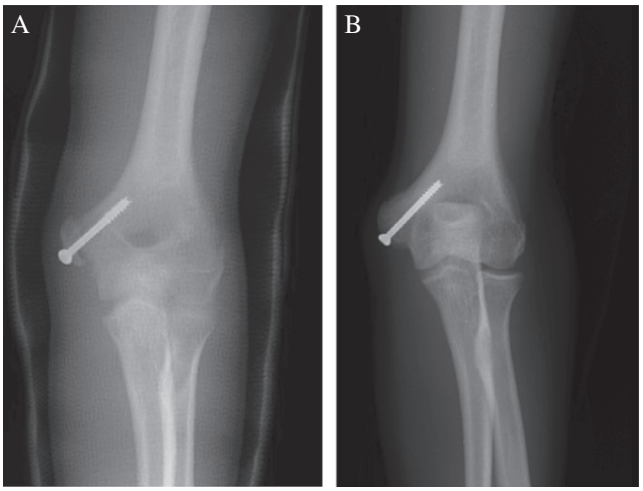

FIGURE 4 (**A**) Two weeks after fixation with a single 4-mm cannulated screw. (**B**) Four weeks after surgery.

elbow dislocations. Five of the displaced but not incarcerated fractures were associated with documented elbow dislocations.

Treatment

The six nondisplaced fractures were all treated with approximately 3 weeks of cast immobilization, followed by range-of-motion exercise. Three of the four fractures with incarcerated fragments were treated with operative fixation with a single 4-mm cannulated screw (three fractures); one comminuted fracture required a 4-mm cannulated screw with a washer, a 0.062-inch Kirschner wire, and suture augmentation. A long arm splint was worn for approximately 3 weeks, followed by a supervised physical therapy program. Of the remaining 21 fractures that were not incarcerated in the joint but had some degree of displacement on initial radiographs, 14 were treated with open reduction and internal fixation and seven were treated nonoperatively. All of the fractures with an associated elbow dislocation were in the operatively treated group. Internal fixation consisted of a single 4-mm cannulated screw (Fig. 4) in nine, a 4-mm cannulated screw and washer in four, and two 0.062-inch Kirschner wires in one. The length of immobilization and the decision to implement a formal physical therapy program varied at the discretion of the treating surgeon, but typically range of motion began at 3 to 4 weeks after the initial injury or surgical stabilization.

Outcomes

The overall average JOA score was 95, with the highest average score in the nondisplaced group (Table 2). The only nonunion occurred in a fracture with an incarcerated fragment; this was a comminuted fracture that was fixed with a cannulated screw and washer, a Kirschner wire, and suture augmentation. Of the six fractures that developed distal humeral deformities, four were in displaced fractures without an incarcerated fragment, which were treated nonoperatively (Table 2). Two patients developed a hyperplastic distal humerus, one patient developed a hypoplastic distal humerus, and one patient's medial epicondyle healed in an inferior position. Two of these patients also had an ulnar sulcus deformity visible on radiographs (Fig. 3), and both had instability on valgus stress radiographs (+3.5 mm and +2.5 mm) (Fig. 5). Valgus instability was demonstrated in four patients: two with incarcerated fragments and two with displaced but not incarcerated fractures treated nonoperatively. There was no correlation between radiographic instability and painful symptoms at follow-up in our study group.

Discussion

While guidelines of treatment for nondisplaced medial epicondylar fractures and those with an incarcerated fragment are well established, much debate has centered on how much displacement is acceptable for nonoperative treatment. Josefsson and Danielsson found that nonoperative treatment of fractures with up to 15 mm of displacement resulted in good long-term function and range of motion (4). Other authors recommend operative treatment of displaced medial epicondylar fractures, but have varying cutoffs for the maximal acceptable displacement: 2 mm, 5 mm, and 10 mm (2, 6, 7). Hines et al. treated 31 medial epicondylar fractures displaced 2 mm or more with open reduction and internal fixation and reported

TABLE 2 Patient demographics and outcomes of treatment

Demographic	Nondisplaced (6 Fractures)	Incarcerated (4 Fractures)	Displaced/Operative (14 Fractures)	Displaced/Nonoperative (7 Fractures)	*p* Value[a]
Age at injury	12 years (8-15)	9 years (6-12)	13 years (7-15)	11 years (9-14)	.13
Follow-up	3 years (2-6)	7 years (2-16)	4 years (2-8)	4 years (2-5)	.35
Initial displacement	0	28 mm (25-32)	7 mm (1-15 mm)	4 mm (2-8 mm)	.04
Nonunion	0	1	0	0	
Distal humeral deformity	0	1	1	4	.03
Valgus instability	0	2	0	2	.10
Elbow score	98 (91-100)	94 (86-100)	95 (83-100)	94 (85-100)	.63

96% good to excellent results (2). Some authors place more emphasis on elbow instability than on the extent of displacement in identifying fractures that require surgical treatment and recommend gravity stress testing if valgus instability is suspected (3, 6). Dias et al. recommended nonoperative management even for medial epicondylar fractures associated with elbow dislocations (11). They stated that the inability to manipulate a fractured medial epicondyle entrapped in the joint is probably the only indication for surgical exploration.

Because of the retrospective nature of the study, the treating surgeons' criteria for operative treatment in fractures that were displaced but not trapped in the joint could not be determined. There was a statistically significant difference in the average initial displacement between fractures treated operatively (7 mm) and nonoperatively (4 mm), but the ranges of initial displacement in these two groups were quite broad (Table 2). Other selection biases included a tendency to more operative treatment for patients involved in overhead athletics and operative treatment of all fractures with documented associated elbow dislocations.

Nonunion rates as high as 60% to 90% have been reported after nonoperative treatment of displaced medial epicondylar fractures (4, 5). Farsetti et al. (5) stated that fibrous unions were asymptomatic and did not compromise elbow function, while others have advocated operative treatment to obtain a solid bony union and prevent valgus instability (3, 7). Smith et al. described symptomatic nonunions in eight patients after nonoperative treatment of medial epicondylar fractures (12). All eight patients had medial elbow pain, particularly with provocative activities such as throwing or lifting weights. After surgical fixation of the nonunion, all had decreased pain and improved elbow function and all returned to athletics. In our series, the only fibrous union was in a comminuted fracture with an incarcerated fragment; the patient demonstrated valgus instability on stress radiographs. All other patients obtained solid bony union, but three demonstrated radiographic valgus instability. Two of these patients had displaced fractures treated nonoperatively and both healed with deformity of the distal humerus, as well as an ulnar sulcus. The third patient had a fracture with an incarcerated fragment that healed with a solid union but demonstrated a distal humeral deformity and valgus instability.

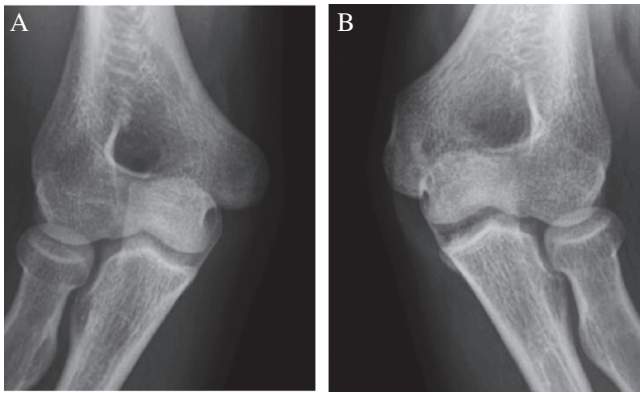

FIGURE 5 Valgus stress radiographs showed instability in both patients with an ulnar sulcus sign.

Using the specific measurements outlined by Skak et al. (10) to assess radiographic deformity of the distal humerus associated with medial epicondylar fractures, the vertical position of the medial epicondyle and the width of the distal humerus was evaluated in all fractures; multiple deformities were identified, including pseudarthrosis (one), hyperplasia (two), hypoplasia (one), lower epidondylar position (three), and ulnar sulcus deformity (two). The ulnar sulcus sign has been described as a consequence of malunion of a medial epicondylar fracture (10); its relation to instability is unknown, but because it changes the insertion site of the ulnar collateral ligament (13), the deformity may result in attenuation of the ligament, which could contribute to instability. When comparing operatively treated to nonoperatively treated displaced fractures, distal humeral deformity was much more frequent in the nonoperative group (four of seven fractures) than in the operative group (one of 14 fractures, $p = .03$).

Despite the radiographic deformity and instability that occurred in the displaced fractures treated nonoperatively, they had excellent JOA outcome scores with an average of

94 (maximum 100). This compared favorably to displaced fractures treated operatively, with an average score of 95 ($p = .63$). Two patients with operative treatment required hardware removal because of pain from a prominent screw. During one of the removals, the screw head broke and the shaft was left in place.

Determining the degree of displacement of medial epicondylar fractures can be difficult, and the method by which displacement is measured has been questioned. Pappas et al. noted that intraobserver agreement overall was low and suggested that agreement might be improved to acceptable levels by adopting a standard set of measurement guidelines by which the point of maximal displacement is measured on the anteroposterior radiograph (14); this is the technique that was used in this study. Although various methods to measure displacement of medial epicondylar fractures have been described since the publication by Pappas et al., many rely on atypical radiographic projections or advanced imaging techniques, which were not routinely used at the time these patients were treated; therefore, it was decided to group the patients in this study on the basis of the measurement of maximal displacement.

Limitations of this study include its retrospective nature, which brings with it inherent weaknesses and selection bias, and the fact that fewer than half (48%) of the eligible patients returned for follow-up evaluation. Farsetti et al. also had a return rate of less than half (40%) of eligible patients in their study, but did not consider this a limitation (5). A recent study meta-analysis identified an average rate of return of 68% in pediatric orthopaedic retrospective call-back studies (15). A strength of this study is the availability of valgus stress radiographs for all patients; these radiographic views identified more frequent instability in displaced fractures treated nonoperatively than in those treated operatively. O'Driscoll pointed out the difficulty of diagnosing valgus instability by clinical examination alone and the importance of stress radiographs in accurately identifying valgus instability (16). Deformities of the distal humerus also were more frequent after fractures treated nonoperatively. In this large series of medial humeral epicondylar fractures, both operative and nonoperative treatment of displaced but not incarcerated fractures had good to excellent functional outcomes at midterm follow-up (minimum of 2 years). Because several had open humeral physes at the time of final follow-up, these patients will need to be followed to skeletal maturity to definitely determine if a fibrous union occurs and if excellent function is maintained.

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