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Original Research

Long-Term Outcomes of Operatively Treated Medial Epicondyle Fractures in Pediatric and Adolescent Patients

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Purpose: Medial epicondyle fractures are among the most common pediatric elbow injuries. The management of these fractures continues to be debated. To better understand patient results with operative fixation, we reviewed the outcomes of operatively treated medial epicondyle fractures.
Methods: A retrospective review was performed to identify all patients less than 18 years of age at the time of injury who were treated surgically for medial epicondyle fractures. Outcomes were assessed based on the Patient-Reported Outcomes Measurement Information System (PROMIS) Upper Extremity and Pain Interference domains, Visual Analog Scale for pain, subjective range of motion, ulnar nerve function, and requirement for secondary surgery.
Results: We identified a cohort of 95 patients treated for a medial epicondyle fracture with open reduction and screw fixation. Of these, 39 patients with a mean age of 12.2 years (SD, 2.2 years; range, 7.6−16.0 years) at surgery were assessed for an average follow-up of 6.3 years (SD, 3.2 years; range, 2.2−13.9 years). Outcome measures and pain scores were excellent. The mean PROMIS Upper Extremity score was 56.9, the mean Pain Interference score was 38.5, and the mean Visual Analog Scale score was 0.4.Sixteen patients (41%) required secondary surgery for symptomatic hardware removal. Seven patients (18%) developed sensory complaints and 2 (5%) developed motor complaints consistent with ulnar nerve irritability. Three patients (8%) reported dissatisfaction with elbow range of motion. Patients who required secondary surgeries had higher (worse) PROMIS Pain Interference scores.
Conclusions: At an average of 6.3 years after surgery, the clinical outcomes for medial epicondyle fracture were excellent. While operative treatment for medial epicondyle fractures in children leads to excellent clinical outcomes, patients and surgeons should be aware of high rates of hardware removal.
Type of study/level of evidence: Therapeutic IV

Medial humeral epicondyle fractures comprise 11% to 20% of all pediatric elbow fractures, most commonly in boys aged 9 to 14.[1] Mechanisms of injury include falls, direct blows to the elbow, avulsions, and, less commonly, high-energy trauma such as motor vehicle collisions. Associated injuries include elbow dislocation and neurapraxia. These injuries often occur during gymnastics, football, and baseball. The medial epicondyle ossifies at 5 to 7 years of age and fuses to the distal humerus at 15 to 20 years of age.[2] It serves as the attachment point of the flexor-pronator mass and ulnar collateral ligament of the elbow.

The treatment of pediatric medial epicondyle fractures is controversial, with good results from both nonoperative and operative management.[3−16] In a classic study, nonoperative treatment of 56 medical epicondyle fractures with 35 years of follow-up showed good results despite 31 cases of pseudarthrosis.[16] The understanding of the medial elbow structures such as the flexor-pronator mass and ulnar collateral ligament with its complex role in valgus stability of the elbow has since evolved.[17−19] The indications for fixation of medial epicondyle fractures have changed and a variety of factors have been considered absolute or relative indications for surgery, including an incarcerated epicondyle

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fracture, open fracture, elbow dislocation, ulnar nerve symptoms, valgus instability, marked displacement, and athletes who throw overhead or load the elbow in sports (ie, baseball, gymnastics).[20] These considerations have led to more aggressive treatment by some surgeons, including open reduction and internal fixation to restore elbow mechanics and allow early range of motion (ROM).[2,3]

In our experience, both operative and nonoperative treatment of medial epicondyle fractures will result in a subset of patients with less than ideal outcomes, including a need for secondary surgery, limited elbow motion, and medial epicondyle nonunion. While many studies have shown mixed results of nonoperative treatment, we focused on the results and complications after operatively treated fractures.[3,6,16,21,22] The purpose of this investigation was to review the long-term outcomes of patients with operatively treated medial epicondyle fractures. We hypothesized that the majority of operatively treated medial epicondyle fractures would have excellent outcomes, with a return to all activities without pain, but that some patients would have problematic nonunion and elbow stiffness.

Materials and Methods

Institutional review board approval was obtained, and a retrospective chart review identified 108 patients under the age of 18 years who were treated surgically for an isolated medial epicondyle fracture at a single institution by 1 of 12 surgeons between 2005 and 2016. Of these patients, 95 were treated with open reduction and screw fixation. We excluded patients who underwent surgery for medial epicondyle nonunions, open fractures, or patients who were treated with any fixation aside from a screw. The patients were contacted via telephone using a specific phone script; a hand surgery resident or medical student collected all data. We were able to identify and complete all data points with a total of 39 patients who met all inclusion criteria and were available for final analysis. The remaining patients were excluded from the final analysis as they were unable to be contacted despite attempting several searches to locate current contact information. Figure 1 shows a flowchart of the patient selection criteria. Consent was obtained from the patient or a legal guardian (if the patient was less than 18 years of age) for completion of the questionnaires.

The mean time from injury to surgery was 4.7 days (SD, 6.3 days; range, 0–27 days). Elbow dislocation was the most common associated injury, occurring in 26 patients (67%), and 8 patients (21%) had an incarcerated fragment in the elbow joint. The mean initial displacement of the fracture was 11.5 mm (SD, 5.1 mm; range, 5–22 mm) among 37 patients whose images were accessible for measurement. Gymnastics (13 patients; 33%), football (5 patients; 13%), and wrestling (4 patients; 10%) were the most common sports-related injuries. The mean age at surgery was 12.2 years (SD, 2.2 years; range, 7.6–16.0 years). At the time of fixation, 5 patients (13%) had concurrent ulnar nerve exploration and/or decompression secondary to complaints of numbness or tingling in the ulnar nerve distribution. Of these, one patient's treatment included an exploration to free an entrapped ulnar nerve from the elbow joint. None of the patients had nerve complaints at the final follow-up.

Clinical outcomes were assessed with the Patient-Reported Outcomes Measurement Information System (PROMIS) Upper Extremity (UE) and Pain Interference (PI) domains, which have been validated in upper extremity fractures.[23,24] Patients older than or equal to 18 years of age filled out adult PROMIS forms and patients younger than 18 years of age completed pediatric PROMIS forms. If the parent completed the PROMIS form for a patient less than 18 years of age, a parent-proxy PROMIS form was used. Patient-Reported Outcomes Measurement Information System scores are standardized to a population-normalized mean of 50 points and an SD of 10 points.[25]

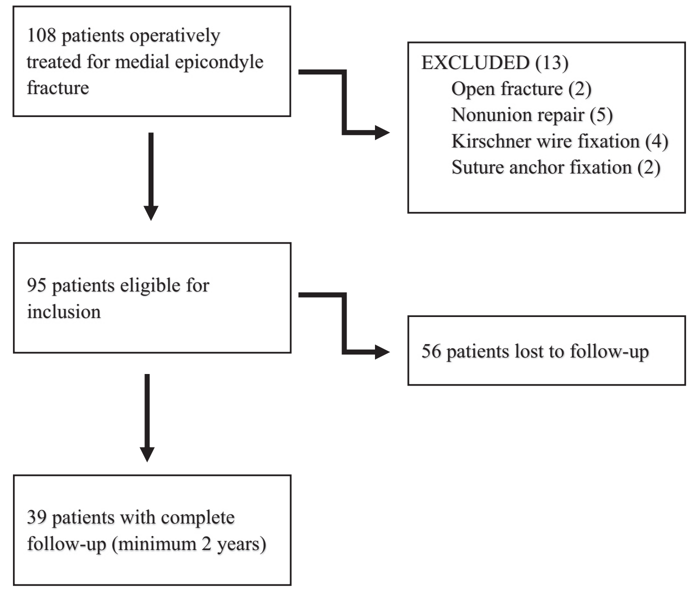

Figure 1. Flowchart for patient selection. A total of 95 patients met the inclusion criteria and 39 were reached for final follow-up.

In addition to the assessment using the PROMIS questionnaire, pain was assessed on the Visual Analog Scale (VAS) with a score of 0 (no pain) to 10 (severe pain). Range of motion deficits were assessed by asking the patient or legal guardian whether they were dissatisfied with the ROM or whether there were motion differences from the contralateral elbow. This method has been employed in similar long-term follow-up studies in pediatric and young adult elbow conditions.[26–28]

Ulnar nerve function was assessed by asking a series of 5 "yes or no" questions related to sensation and motor function.[29,30] We asked: "Are you able to make a fist with your hand?," "Can you easily move your ring finger and pinky finger?," "Do you have any numbness or tingling in your hand?," "Does your hand fall asleep more than you'd expect it to?," and "Can you easily spread all of your fingers apart?" Any positive answers to these questions led to a more comprehensive discussion with the patient/guardian.

Surgery

The initial surgical indications and fixation method were decided by the treating surgeon. There were 12 pediatric-trained surgeons who treated patients in this cohort. Each surgeon had his/her own indications, with displacement more than 5 mm on the anterior-posterior radiographic view considered heavily, but with other factors also included, such as an incarcerated fragment, a dislocation event, and the treatment of patients involved in overhead throwing sports and gymnastics. All fractures were fixed using open reduction and internal fixation (ORIF) with a screw. Ulnar nerve exploration with or without decompression or transposition was performed if the patient had preoperative nerve symptoms, including numbness or tingling in the ulnar nerve distribution. The ulnar nerve was identified and protected in all cases. Other associated injuries and procedures were recorded. Postoperatively, elbows were immobilized in a long-arm splint or cast for a mean duration of 12.9 days (SD, 6.6 days; range, 4–34 days). Hand therapy was used if there were motion limitations at follow-up and at

Table 1
Outcome Measures and Pain Scores at Final Follow-Up

	Mean (SD)	Range
PROMIS UE	56.9 (3.8)	41.9–61.0
PROMIS PI	38.5 (4.1)	32.0–52.2
VAS pain score	0.4 (0.9)	0–3

PI, pain interference; PROMIS, Patient-Reported Outcomes Measurement Information System; UE, upper extremity; VAS, Visual Analog Scale.

Table 2
Secondary Surgeries

	n (%)
Secondary surgery	18 (46%)
Hardware removal	16 (41%)
Open elbow release/HO excision	1 (3%)
Ulnar nerve transposition	1 (3%)

HO, heterotopic ossification.

Table 3
Rate of Hardware Removal*

	Hardware Removed (%)	*P* Value
Screw + washer	10/25 (40%)	.74
Screw only	6/13 (46%)	

* Data are missing from 1 patient and we were unable to determine whether a washer was utilized. This left 38 patients for comparison.

the discretion of the treating surgeon. Secondary surgery for implant removal or nonunion was performed as indicated by patient complaints. We recorded information around surgery and recovery from a comprehensive chart and radiographic review.

Statistical analysis

Descriptive statistics were computed for all variables collected. The mean values of continuous variables were compared using an unpaired, parametric Student *t* test using a 2-tailed *P* value. Categorical variables were compared with the Fisher exact test. The definition of statistical significance was set at a P value $< .05$.

Results

The mean age at surgery was 12.2 years (SD, 2.2 years; range, 7.6–16.0 years) for 39 patients, with an average follow-up of 6.3 years (SD, 3.2 years; range, 2.2–13.9 years). At the final follow-up, PROMIS outcome measures were above mean scores and VAS pain scores were quite low (Table 1). Eighteen patients (46%) required secondary surgeries, with the majority (16 patients) requiring symptomatic screw removal (Table 2). One patient required an open elbow release with heterotopic ossification excision, and another required an ulnar nerve transposition. A screw and washer were used in 25/38 (66%) patients and were not associated with a higher rate of hardware removal compared to using a screw alone (40.0% vs 46.2%, respectively; $P = .74$; Table 3). Formal hand therapy was prescribed for 29/39 (74%) patients.

Patients who required secondary surgeries had higher PROMIS PI scores than those who did not (mean difference, 2.7; 95% confidence interval, 0.18–5.28; $P = .036$); however, there was no difference in the PROMIS UE scores between these groups (Table 4). The presence of an elbow dislocation during injury, an incarcerated fragment in the elbow joint, the use of a washer, or elbow immobilization greater than 14 days had no difference in final PROMIS PI or UE scores.

One patient who had an initial fracture-dislocation with incarcerated medial epicondyle fragment developed stiffness and underwent removal of hardware, open elbow capsular release, and heterotopic ossification excision 8 months after the index procedure. Seven months later, the same patient underwent a subcutaneous ulnar nerve transposition for cubital tunnel syndrome. Secondary surgery improved the ROM in this patient and the patient scored better than our cohort means for PROMIS PI, PROMIS UE, and VAS scores at the final follow-up. None of the reoperations were for symptomatic nonunion, implant failure, or infection.

There were 7 patients (18%) who reported sensory complaints and 2 (5%) who reported motor complaints attributable to the ulnar nerve. Only one of these patients reported considerable dysfunction, but none sought further assessment or treatment. Three patients (8%) reported dissatisfaction with their elbow ROM, but none felt this was impeding function enough to schedule a clinic appointment.

Discussion

Given the recent trend toward operative management for medial epicondyle fractures, we investigated the clinical outcomes and complications in a large group of these patients.[3,6,31,32] We found that the long-term pain and upper extremity outcomes after operatively treated medial epicondyle fractures were excellent. None of the patients in our cohort required secondary surgery for symptomatic nonunion. There was a high rate of secondary surgery for hardware removal and a notable number of patients had ulnar nerve complaints, including 18% with sensory complaints and 5% with hand motor complaints; these did not seem to negatively impact function or pain. Although the patients were not examined clinically, all of these patients and/or guardians declined further evaluation when asked during the phone interview as these symptoms were considered mild. Five patients had ulnar nerve exploration or decompression at the index surgery, but none of these patients had nerve complaints at the final follow-up. Given our findings and the literature limited to case reports on nerve management for these fractures, we will continue our practice of identifying and protecting the nerve for all cases and will perform nerve exploration and decompression only for those patients with preoperative symptoms.

K-wires were historically used for fixation, but more recently screw fixation has gained support because of fixation rigidity, a decreased risk of pin site infection, and avoidance of pin site irritation. All patients in our cohort had screw fixation, with a 41% rate of hardware removal because of a symptomatic screw. Lee et al[33] reported the 2-year outcomes of 25 patients who were fixed with either a screw, tension band, or K-wires. Outcomes were equivalent across the fixation methods, but 23/25 patients underwent hardware removal.

We immobilized most elbows (25/39, 64%) for less than 2 weeks and found a low rate of patients with subjective dissatisfaction with ROM (8%) or a need for surgical release/manipulation (1 patient). Prior studies have reported differing rates of stiffness after operative fixation. In 1994, Duun et al[5] reported on 33 patients at a mean of 8 years after surgery with a mean age at surgery of 12 years who underwent ORIF. In contrast to our cohort, most patients in their study had K-wire or Palmer pin fixation (29 patients), and only one had a screw. Patients were immobilized in a plaster cast for 3 to 5 weeks, and 10 patients reported mild pain. Three patients had restricted extension of 20° to 25°, and there was a correlation between the duration of immobilization and restriction of ROM. Murphy et al[34] found immobilization longer than 2 weeks to be associated with a loss of extension. Other factors associated with

Table 4
Outcome Measures Stratified by Elbow Dislocation, Incarcerated Fragment, Immobilization Length, and Secondary Surgery

	n	PROMIS UE, Mean	*P* Value	PROMIS PI, Mean	*P* Value
Elbow dislocation					
Yes	26	57.2	.45	38.1	.35
No	13	56.2		39.4	
Incarcerated fragment					
Yes	8	57.9	.41	38.3	.85
No	31	56.6		38.6	
Washer*					
Screw + washer	25	56.5	.51	38.0	.25
Screw only	13	57.4		39.6	
Postoperative immobilization					
<14 days	25	57.1	.63	38.5	.89
≥14 days	14	56.5		38.7	
Secondary surgery					
Yes	16	56.5	.56	40.2	.04†
No	23	57.2		37.4	

PI, pain interference; PROMIS, Patient-Reported Outcomes Measurement Information System; UE, upper extremity.
* Data are missing from 1 patient, and we were unable to determine whether a washer was used based on a record review.
† Denotes a statistically significant difference at a *P* value < .05.

less than excellent functional outcomes included multiple fractures and operative (vs nonoperative) treatment. However, the median follow-up was only 112 days (range, 42 to 2728 days) in this study. Another study of 139 patients immobilized elbows for 4 weeks after ORIF with K-wires or a screw and found excellent results and ROM in most patients at 4 years of follow-up.[35] It is well known that the loss of elbow extension is better tolerated than the loss of flexion, even when considering modern-day tasks such as using a keyboard or mobile phone.[36]

It is widely agreed that patients with incarcerated medial epicondyle fragments should undergo ORIF to prevent long-term stiffness, instability, and degeneration of the elbow joint. However, elbow dislocation without an incarcerated fragment is a relative indication for operative management. Furthermore, it is not always clear whether a frank dislocation-relocation event occurred during the injury. Fowles et al[15] evaluated 28 children with medial epicondyle fractures associated with elbow dislocation. Of the 9 patients who were treated with ORIF, only 3 had normal elbows and 6 had lost 37° of flexion. Four children also required ulnar nerve transposition. In our cohort, the majority of elbows (67%) were dislocated during the injury, but we did not find differences in final PROMIS UE or PI scores.

Dodds et al[37] reported on 14-month follow-ups after ORIF in 11 patients with an incarcerated fragment. They had excellent ROM results, but a high complication rate related to ulnar neuropathy. Another study of 13 children with incarcerated fragments who underwent ORIF reported similar excellent ROM and Mayo Elbow Performance scores at 29 months of follow-up but a 31% complication rate, including issues with screw prominence, triceps irritation, and median nerve entrapment.[11]

We did not have any reoperations for symptomatic nonunion. While we did not investigate differences in nonoperative versus operative care, many studies have reported a high rate of radiographic nonunion with nonoperative treatment. In 42 patients with medial epicondyle fractures, Farsetti et al[6] found similar outcomes between the nonsurgical treatment and ORIF with K-wires or a T-nail. They noted a high percentage of radiographic nonunions in the nonsurgical group, but there was no detriment to ROM, strength, or stability of the elbow. They did find poor outcomes when the medial epicondyle was excised, as patients required suture fixation of the tendons and ulnar collateral ligament. Stepanovich et al[12] reported on 6 patients who underwent operative management and 6 who were managed nonoperatively. They reported higher rates of radiographic nonunion and malunion in the nonoperative group. However, both groups had high satisfaction scores and low pain scores at 3 years of follow-up, with no statistical difference. This study is limited by the small cohort size and low follow-up rate (12/140; 8.6%). The previously mentioned study and others have also reported a 100% rate of union after operative fixation.[10–12]

There are limitations to note in this study. First, our follow-up rate was 41%, as we lost patients to follow-up. Our patients were treated as children and many are now adults living in different geographic areas who have had changes in phone numbers, making it difficult to establish contact despite extensive efforts, including detailed Internet searches.[38,39] Second, we did not report radiographic outcomes. As discussed earlier, multiple studies have shown that nonoperative treatment can lead to asymptomatic radiographic nonunion.[6,12] Therefore, in the absence of pain or dysfunction, we did not feel the additional clinic visit (challenging because of the length of travel) and radiation dose could be justified in this high-functioning population. Third, our study included surgeries performed by multiple surgeons. While this introduces variability in indications and surgical technique, we feel our results are more generalizable to all surgeons treating pediatric upper extremity fractures. Finally, we did not include a nonoperative group for comparison in our study. We specifically aimed to examine the clinical results, complications, and reoperations for operative cases. Additionally, a retrospective review would lead to notable selection bias among the nonoperatively and operatively indicated patients. A prospective cohort study would be a preferable future approach to provide a comparison.

The long-term clinical outcomes after surgery for medial epicondyle fracture demonstrate excellent upper extremity function and minimal pain, but patients had a high rate of reoperation. Patients with reoperations were associated with marginally higher final PROMIS PI scores, but these did not meet the minimal clinically important difference (−4.1 to −9.7).[40,41] There were no symptomatic nonunions, and only a small percentage of patients (8%) were dissatisfied with their ROM. While medial epicondyle fractures in children can be successfully treated with surgery, patients and surgeons should be aware of high reoperation rates and their implications.

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