Success Rates for Reduction of Pediatric Distal Radius and Ulna Fractures by ED Physicians

A thesis submitted to the University of Arizona College of Medicine – Phoenix in partial fulfillment of the requirements for the Degree of Doctor of Medicine

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Abstract

**Objective:** To determine the success rates for reduction of pediatric distal radius and/or ulna fractures by emergency department (ED) physicians.

**Methods:** We conducted a retrospective study of children <18 years of age who presented to a large, urban free standing children’s hospital between January 1, 2009 and December 31, 2010 with a fracture of the radius and/or ulna. Patients were excluded if they had an open fracture, were taken directly to the operating room without attempted ED manipulation, or had additional fractures besides isolated radius/ulna fractures. The primary endpoint was the proportion of successful reductions of closed forearm fractures in the ED, as defined by first orthopedic follow up visit.

**Results:** All reductions were performed by Board certified/eligible Pediatric Emergency Medicine (PEM) physician or PEM fellow. There were a total of 15 different PEM faculty and 10 PEM fellows that were involved in the fracture reductions during the study period. There were 295 forearm fractures reduced in the ED during the study period. The mean age was 8.27 years (median 8 years; range 1 to 16) and males comprised 69.2% (n=204) of the study group. A total of 225 (76.3%) fractures were of the distal forearm and 70 involved the midshaft (23.7%). All but 67 (22.7%) patients returned for their orthopedic follow up exam. A total of 33 (14.5%) of all patients required re-manipulation at follow up; 24 in the distal forearm fracture group (22 were closed reductions and 2 open reduction with internal fixation [ORIF]), versus 9 in the midshaft group (7 closed reductions and 2 ORIF).

**Conclusion:** The literature reveals that between 7% and 39% of children who have fracture reductions in the ED by orthopedics will require re-manipulation. Our rate of 14.5% is consistent within that range. With training, pediatric ED physicians have similar success rates as orthopedists in the reduction of forearm fractures.
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Objective

The primary objective was to quantify the success rates for reduction of pediatric distal radius and/or ulna fractures by pediatric emergency department (ED) physicians. The secondary objectives were to assess complications after ED reduction and assess time to fracture union.

Introduction

Forearm fractures of the distal radius and/or ulna are common childhood injuries, typically resulting from fall on an outstretched hand with dorsiflexion of the wrist. They are generally classified into three types: buckle or torus, incomplete or Greenstick, and complete fractures. Radiographic imaging confirms fracture type and determines the degree of deformity and angulation, which then guides necessity for reduction prior to immobilization. Children, in particular, have impressive capacity for rapid healing and bone remodeling despite angulation at the time of injury. Specifically, the acceptable level of angulation varies by fracture location, type and age of the patient. Significantly displaced or angulated fractures require reduction and immobilization, which is often performed in the Emergency Department. Close follow up with Orthopedic Surgery assesses proper alignment and appropriate healing, along with determination of need for additional surgical repair. Re-fracture and/or loss of reduction can occur after ED reduction. The literature reveals that between 7% and 39% of children who had fracture reductions in the ED by Orthopedics required re-manipulation. (6)

Many pediatric forearm fractures are minimally or non-displaced and require no reduction. Emergency physicians are, however, trained in urgent reduction techniques in the ED, particularly for closed fractures associated with neurovascular compromise that require timely manipulation.

A small, retrospective cohort study in closed pediatric distal radius and ulna injuries evaluated short term outcomes for fractures reduced by Emergency physicians without orthopedic consultation at the time of the injury. (5) The study revealed equal success in fractures reduced by EM physicians versus orthopedic residents. In fact, all subjects had acceptable fracture alignment when followed up 3-5 days later. The subjects whose fractures were reduced by an EM physician had significantly shorter length of stay in the ED than in the
control group (3.1 hours versus 5.1 hours), which implies a possible additional benefit to EM reduction. However, the study had a limited number of cases and controls 22 and 42, respectively. (5) To date, a large, study using multiple providers has not been performed to evaluate pediatric distal radius and/or ulna fractures reductions by non-orthopedists. This was a large retrospective study that assessed pediatric closed forearm fracture reductions and immobilization in the ED.
Methods

This was a retrospective study of children <18 years of age who presented to Phoenix Children’s Hospital between January 1, 2009 and December 31, 2010 with diagnosis of a fracture of the wrist, radius, or ulna. Subject inclusion required a clinical deformity in addition to evidence in the radiology report of angulated/displaced fracture(s) of the wrist, specifically radius and/or ulna requiring manipulation. Patients excluded were those with an open fracture, those who were taken directly to the operating room (OR) without attempted ED manipulation, fractures involving a joint, and those who had additional fractures besides isolated radius/ulna fractures. All reductions were performed by a Board certified/eligible PEM physicians or PEM fellows and subjects were placed in either a sugar-tong or volar splint at the discretion of the PEM faculty.

The primary outcome was successful reduction of a forearm fracture at the first orthopedic follow-up visit, which most often occurred one week after the ED visit. Secondary outcomes included pain, range of motion, strength following forearm reduction, fracture displacement, and re-fracture rate.

Data was abstracted from the medical record and included: age, gender, ethnicity, date of visit, date of injury, bone fractured, initial treatment (ED physician manipulation or Orthopedic Surgeon manipulation), return visits, subsequent treatments and investigations (x-ray studies and requirement for further interventions), and clinical outcomes (such as pain, range of motion, strength, fracture displacement, and re-fracture). Two study personnel and one research assistant, who were not blinded to the study objectives, extracted data from the medical records. Fracture angulation and displacement were obtained directly from initial radiographs. Subsequent radiographs were also reviewed to confirm chart report. Key variables were assessed including the treatment initiated in the ED, need for further manipulation, repeat x-rays, re-fracture and displacement rates.

The primary endpoint was the proportion of successful reductions of closed forearm fractures in the ED. The secondary objectives were to assess complications after ED reduction and assess time to fracture union which is a radiographic definition that varies for each patient.
and can be determined by the follow up visit at which Orthopedics declares the fracture healed. (1, 2, 3)

Study data were summarized using descriptive statistics with parametric and nonparametric methods as necessary. Statistical comparisons between groups relied on Students t-tests for continuous data and Chi-square test for categorical data; nonparametric analogs were used when appropriate. Data were analyzed using Stata (College Station, TX).
Results

All reductions were performed by a Board certified/eligible PEM physicians or PEM fellows. There were a total of 15 different PEM faculty and 10 PEM fellows that were involved in the fracture reductions during the study period. There were 295 forearm fractures reduced in the ED during the study period. The mean age was 8.27 years (median 8 years; range 1 to 16) and males comprised 69.2% (n=204) of the study group (table 1).

Distal forearm fractures are often more stable than midshaft fractures; therefore the results were further broken down into these two types. A total of 225 (76.3%) fractures were of the distal forearm and 70 involved the midshaft (23.7%). There were 37 (12.5%) fractures that involved the growth plate. Table 2 illustrates the mean degree of angulation and percent displacement of the fractures included in the study. All but 67 (22.7%) patients returned for their orthopedic follow up exam. These patients were not tracked down as they did not return to the children’s hospital or affiliates for their follow up care for unknown reasons. A follow up rate of greater than 70% was considered adequate for purposes of the retrospective study.

A total of 33 (14.5%) of all patients required re-manipulation at follow up; 24 (10.7%) in the distal forearm fracture group (22 were closed reductions and 2 ORIF), versus 9 (12.9%) in the midshaft group (7 closed reductions and 2 ORIF). There was no significant difference in the number of patients requiring re-manipulation based on location of the fracture (P>0.05). Of those in need of re-manipulation, the need for re-manipulation was recognized and relayed to the Orthopedic service prior to patient discharge from the ED on initial visit in 5 of the distal forearm group and in 6 of the midshaft group. The remainder involved a loss of reduction that was determined at the orthopedic follow up visit.
### Table 1: Patient Characteristics

<table>
<thead>
<tr>
<th>Study sample</th>
<th>295 subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age (years)</td>
<td>8.2 +/- 3.5 years</td>
</tr>
<tr>
<td>Male</td>
<td>69.2%</td>
</tr>
<tr>
<td>Fractured radius only</td>
<td>20%</td>
</tr>
<tr>
<td>Fractured ulna only</td>
<td>3.1%</td>
</tr>
<tr>
<td>Fractured both radius and ulna</td>
<td>76.9%</td>
</tr>
<tr>
<td>Fractured distal radius +/- ulna</td>
<td>n=225</td>
</tr>
<tr>
<td>Fracture displaced</td>
<td>75.6%</td>
</tr>
<tr>
<td>Fracture angulated</td>
<td>92.4%</td>
</tr>
<tr>
<td>Fractured midshaft radius +/- ulna</td>
<td>n=70</td>
</tr>
<tr>
<td>Fracture displaced</td>
<td>44.3%</td>
</tr>
<tr>
<td>Fracture angulated</td>
<td>91.4%</td>
</tr>
<tr>
<td>Fracture involving growth plate</td>
<td>12.5%</td>
</tr>
<tr>
<td>Remanipulation required</td>
<td>33</td>
</tr>
<tr>
<td>Closed reduction</td>
<td>87.9%</td>
</tr>
<tr>
<td>Open reduction internal fixation</td>
<td>12.1%</td>
</tr>
<tr>
<td>Unscheduled ED visits</td>
<td>6.1%</td>
</tr>
<tr>
<td>Complications</td>
<td>36.8%</td>
</tr>
<tr>
<td>Pain</td>
<td>5.5%</td>
</tr>
<tr>
<td>Limited range of motion</td>
<td>16.9%</td>
</tr>
<tr>
<td>Decreased strength</td>
<td>0.9%</td>
</tr>
<tr>
<td>Fracture displacement</td>
<td>18.7%</td>
</tr>
<tr>
<td>Re-fracture</td>
<td>0.5%</td>
</tr>
<tr>
<td>Sensory deficit</td>
<td>0%</td>
</tr>
<tr>
<td>Compartment syndrome</td>
<td>0%</td>
</tr>
</tbody>
</table>
Table 2: Amount of angulation/displacement at initial ED visit

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean anteroposterior angulation</th>
<th>Mean anteroposterior displacement</th>
<th>Mean lateral angulation</th>
<th>Mean lateral displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal radius +/- ulna</td>
<td>24.5 degrees</td>
<td>72.0%</td>
<td>34.1 degrees</td>
<td>80.2%</td>
</tr>
<tr>
<td>Midshaft radius +/- ulna</td>
<td>15.7 degrees</td>
<td>48.4%</td>
<td>26.3 degrees</td>
<td>49.5%</td>
</tr>
</tbody>
</table>
Unscheduled return ED visits occurred in 18 (6.1%) patients. These involved pain (12), returning to the ED for follow up rather than to the orthopedic clinic (5), and a broken splint (1). None of these return visits were for compartment syndrome.

The average total time in cast was 37.0 days (+/- 12.1 days) for the distal forearm group and 38.5 days (+/-13.2 days) in the midshaft group. These end points were considered to be the time to fracture union determined by the follow up visit at which Orthopedics declared the fracture healed.
Discussion

A retrospective cohort study published in 2007 CJEM evaluated 124 pediatric patients with bi-cortical minimally angulated (≤15 degrees) distal metaphyseal radius fractures with or without associated distal ulnar fracture that were not reduced in the ED. The fractures were managed simply by plaster splinting, then referred for orthopedic follow up. They concluded that over 88% of the fractures were angulated ≤20 degrees at the time of follow up, while less than 2% progressed to more severe angulation (30-35 degrees) during the follow up period. They concluded that minimally angulated fractures can successfully be immobilized in the ED without reduction, most of which will need no future surgical repair. (2) As such, many forearm fractures in the ED may be managed conservatively with immobilization and do not require immediate Orthopedic intervention. However, if there is displacement of the fracture fragments or angulation > 15-20 degrees then the fractures often need to be reduced. In many cases this is performed by the Orthopedic service at a hospital but in some ED’s this procedure is performed by ED physicians or physician extenders.

A previous small pediatric retrospective cohort study showed that fractures reduced by EM physicians had acceptable fracture alignment on short-term follow up with shorter stays in the ED. (5) This study was limited by the fact only two ED providers performed all the reductions and they had a small sample size.

Our study focused on pediatric emergency physicians at a large, urban free-standing children’s hospital, which is classified as a Level I trauma center. The literature reveals that between 7% and 39% of children who had fracture reductions in the ED by Orthopedics required re-manipulation. (6) The rate of re-manipulation in this study was 14.5%. The pediatric emergency physicians in our study had success rates that were within the accepted values for reductions performed by Orthopedic surgeons in 295 pediatric patients with forearm fractures.

In several patients, it was known prior to ED discharge that the fracture would require re-manipulation and orthopedics was notified. In this unique subset of individuals, the PEM physicians successfully identified the need for re-manipulation by Orthopedics and determined that further intervention could be performed on an outpatient basis in consultation.
There were several significant limitations to our study. This was a retrospective study and there was no control group. As no study of this kind had previously been performed at a Level I trauma center, we thought our design was best suited for an initial study. In addition, this study was based on data collected at a large Level I trauma center where PEM physicians and fellows were exposed to a high number of fractures requiring reductions, so our results may not be generalizable to other smaller hospitals or clinics where physicians may have less exposure to fracture reductions. Another limitation was that 22.2% of patients did not attend their Orthopedics follow-up appointments. All discharged patients were provided with an Orthopedics appointment, but some did not attend for unknown reasons. It is possible that these patients were seen at other Orthopedic clinics, by their primary care provider, or elected to remove the splint by themselves.

Some studies have reviewed the potential for treatment by physician extenders rather than orthopedic specialists. In one study comparing 139 pediatric subjects that evaluated closed forearm fracture treatment by trained physician extenders versus orthopedic residents. The study found no statistically significant difference in outcomes, including the use of conscious sedation, cast characteristics, fracture characteristics, length of follow up, or necessity for major interventions at follow up (p>0.05). (4) Our institution limits reductions to be performed by faculty level physicians and fellows so we were not able to assess this but suggests that simple reductions may be managed by ED personnel.

Separately, our study revealed that a higher percentage of midshaft fractures of the radius/ulna required re-manipulation. It is well known that fractures of the midshaft are more unstable than distal fractures of the radius/ulna, which is why the data was separated for analysis.

Based on our results, one can conclude that reductions performed by PEM physicians have similar success rates as compared to those performed initially by Orthopedists. This may lead to shorter time spent in the emergency department as well as decreased costs while maintaining good outcomes. However, this would need to be examined in a prospective manner.
**Future Directions**

While our study demonstrated good results, it was retrospective in nature. A large prospective trial should be performed to further assess if emergency medicine physicians are as successful at reductions as Orthopedic surgeons. Prospective studies should also be done to evaluate the quality of splint/cast immobilization and also distinguish which types of splints/casts minimize the risk of loss of reduction.

**Conclusions**

The literature reveals that between 7% and 39% of children who have fracture reductions in the ED by orthopedics will require re-manipulation. Our rate of 14.5% is consistent within that range. With training, pediatric ED physicians have similar success rates as Orthopedists in the reduction of forearm fractures.
References:


DATA COLLECTION FORM

Success Rates for Reduction of Pediatric Distal Radius and Ulna Fractures by ED Physicians

MRN# ____________

Age (years): _______

Gender:  M  F

Ethnicity: Hispanic  Caucasian  African-American  Asian  Other

Date of visit (mm/dd/year): ___/___/____

Date of injury (mm/dd/year): ___/___/____

Bone(s) fractured:  Radius  ulna  both

Location of fracture: distal  midshaft

Need for reduction:  Y  N

Degree of radial angulation prior to reduction: _____degrees

Degree of ulnar angulation prior to reduction: _____degrees

Amount of radial displacement prior to reduction: _____cm

Amount of ulnar displacement prior to reduction: _____cm

Degree of radial angulation post-reduction: _____degrees

Degree of ulnar angulation post-reduction: _____degrees

Amount of radial displacement post reduction: _____cm

Amount of ulnar displacement post reduction: _____cm

__________________________________________

Degree of radial angulation first follow up visit: _____degrees

Degree of ulnar angulation first follow up visit: _____degrees
Amount of radial displacement first follow up visit: _____cm
Amount of ulnar displacement first follow up visit: _____cm
Degree of radial angulation first follow up visit: _____degrees
Degree of ulnar angulation first follow up visit: _____degrees

Amount of radial displacement first follow up visit: _____cm
Amount of ulnar displacement first follow up visit: _____cm

Degree of radial angulation at time of fracture union: _____degrees
Degree of ulnar angulation at time of fracture union: _____degrees
Amount of radial displacement at time of fracture union: _____cm
Amount of ulnar displacement at time of fracture union: _____cm

Degree of radial angulation at time of fracture union: _____degrees
Degree of ulnar angulation at time of fracture union: _____degrees
Amount of radial displacement at time of fracture union: _____cm
Amount of ulnar displacement at time of fracture union: _____cm

Initial treatment:   ED physician manipulation   Orthopedic Surgeon manipulation   ORIF
Return visit(s): To ED ___/___/___   To Orthopedics ___/___/___

Did orthopedics need further intervention besides casting?  Y  N
If Yes: Closed reduction   Open reduction   Other: ______________
Were further radiographs obtained:  Y  N
If Yes what was reading: _______________________________________________

Was there loss of reduction after the first follow up visit? If so, when? _____ days
Was there re-fracture after the first follow up visit? If so, when? _____ days
Total time in cast: ______ days

Time to fracture union (as determined by Orthopedics): _____ days

Complications:

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<thead>
<tr>
<th></th>
<th>Y</th>
<th>N</th>
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<tbody>
<tr>
<td>Pain</td>
<td></td>
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<tr>
<td>Range of motion</td>
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<td></td>
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<tr>
<td>Strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracture displacement</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Re-fracture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensory deficit</td>
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