Re-displacement of Extraphyseal Distal Radius Fractures Following Initial Reduction in Skeletally Immature Patients

Can It Be Prevented?

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Abstract

Purpose: *The purpose of this study was to evaluate the efficacy of sugar tongs splints to maintain reduction of pediatric distal radius and distal both bones forearm fractures compared to acute casting.*

Materials and Methods: *The trauma database of an urban level-one trauma center was queried for skeletally immature patients who had sustained a displaced extraphyseal distal radius fracture. Inclusion criteria included: complete radiographs, skeletal immaturity, and presence of a displaced fracture of the radius within the metaphyseal segment, proximal to the distal radial physis, with or without an associated ulna fracture. All patients were seen in the emergency department and treated with a standardized protocol of closed reduction and immobilization.*

All radiographs were reviewed for initial and residual displacement. Baseline demographic data was also collected, including age at time of injury, handedness, and mechanism of injury. Need for operative intervention and associated complications were noted. All fractures were followed until union.

Results: *Thirty-three patients were treated with closed reduction and immobilization in a sugar tongs splint, 10 patients were acutely casted, and 2 patients were placed into a short arm volar splint.*

Twenty-five patients who were initially splinted were treated to completion without the need for operative intervention. Eight of the patients treated with sugar tongs splints (24%) required surgery. Eight patients who were initially casted were treated to completion closed. Two of the patients who were initially casted (22%) required operative intervention for loss of reduction. Both of the patients who were initially immobilized using a volar splint were treated to completion without operative intervention. There was no statistically significant difference in the need for operative intervention amongst these groups.

Conclusions: *This study demonstrates that use of closed reduction and placement of a sugar tongs splint can effectively maintain reduction of extraphyseal distal radius fractures with rates of displacement similar to that seen with acute casting.*

Distal metaphyseal radius fractures are among the most common pediatric orthopaedic injuries. The incidence of these fractures in skeletally immature patients has been found to be anywhere from 400 per 100,000[1] to 1,000 per 10,000.[2] These fractures account for 20% of all fractures in childhood[3-5] and for 62% of upper limb fractures.[6,7] More than 80% of these fractures occur in children over 5 years old,[2,4,7] with a peak incidence of these fractures at 12 to 14 years of age in boys and 10 to 12 years of age in girls.[2,5,7,8]

Recent articles have reported significant rates of re-displacement after closed reduction and immobilization of distal metaphyseal radius fractures in skeletally immature patients. Studies have shown rates of re-displacement after closed reduction and casting anywhere from 21% to 47%.[9-11]

Several recent studies have attempted to elucidate the risk factors in re-displacement of distal radial fractures in children.[12-15] Factors that have been previously identified include the amount of initial displacement of the fracture,[9,14] failure to achieve an anatomic reduction,[9,16] both an associated fracture of the distal ulna[14] as well as an intact ulna,[10,11] loss of three-point reduction,[15] poor cast molding,[17] and acutely bivalving the immediately applied cast.[15] As shown

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by Younger and coworkers loss of reduction in the cast has been shown to be the most important factor in the final distal radial alignment at union.[15]

Moreover, controversy exists regarding the most appropriate type of initial immobilization. Some investigators argue for the use of long arm plaster casts in order to achieve better stability and lessen the risk of re-displacement.[10,17,18] Others have reported that below the elbow plaster casts are sufficient to pain the reduction of metaphyseal distal radius fractures.[17,19-21] These investigators argue that short arm casts are easier to apply, are comfortable, and give more function for activities of daily living.[20,21] Distal radius fractures in adult patients are often initially immobilized in sugar tongs splints following closed manipulations. However, only one retrospective cohort study exists which addresses the use of sugar tongs splints in the treatment of pediatric distal radius fractures.[22]

The purpose of our study was to evaluate the efficacy of sugar tongs splints for the acute treatment of extraphyseal distal radius and distal radius and ulna fractures compared with other methods of initial immobilization in an urban trauma center.

Materials and Methods

Data was collected from a single level one urban trauma center. Institutional review board approval was obtained prior to the collection of data.

We identified potential patients by querying the hospital's orthopaedic trauma database for pediatric patients who sustained a displaced extraphyseal distal radius fracture. Inclusion criteria included: availability of radiographs for review, skeletal immaturity at the time of injury, and the presence of a displaced fracture of the radius within the metaphyseal segment, proximal to the distal radial physis. All patients meeting these criteria were included regardless of the presence or absence of an associated ulna fracture. Patients were excluded if they sustained an open fracture or if they presented following initial fracture manipulation and immobilization at an outside institution.

All patients were treated in the emergency room with a standardized protocol. Reductions were performed by orthopaedic housestaff under the supervision of an attending orthopaedic surgeon. The pediatric emergency room physician on duty sedated patients with intravenous ketamine. Closed reduction was performed and confirmed utilizing fluoroscopic imaging. After acceptable reduction was obtained, all patients were immobilized based on the preference of the orthopaedic attending on call. Patients were placed into one of three initial types of immobilization: a sugar tong splint, a long arm cast, or a short arm volar splint.

Sugar tongs splints consisted of 10 to 12 layers of 3 to 4 inch plaster casting material applied over a layer of cast padding. The splint was then held in place with an additional layer of cast padding and an elastic bandage. All sugar tongs splints extended from just proximal to the distal palmar crease, around the elbow, to just proximal to the metacarpal heads, and were molded with a three-point mold. Post reduction anteroposterior (AP) and lateral radiographs were taken in all cases. Patients were discharged from the emergency room and were asked to follow up within one week for a cast and x-ray evaluation. At 2 weeks, patients who were initially placed into a sugar tong splint and had maintained their reduction were converted to a short arm fiberglass cast. Patients initially placed in a long arm cast were converted to a short arm fiberglass cast at 2 to 4 weeks at the discretion of the attending physician. Patients initially placed into a volar splint were changed to a short arm fiberglass cast at first follow-up visit. Short arm casts remained in place until healing in all three groups. Thus the ultimate immobilization was a short arm fiberglass cast in all cases.

Data was collected retrospectively on all patients who met the inclusion criteria. Radiographs were reviewed for initial angulation, displacement, and shortening by a single observer (RG). Post reduction radiographs were also evaluated for residual angulation, displacement, and shortening. Baseline demographic data was also collected, including age at time of injury, handedness, and mechanism of injury.

At subsequent follow-up visit, radiographs were assessed for loss of reduction. The need for re-manipulation or operative intervention was also documented. For patients who underwent operative intervention, time to surgery, type of fixation, and postoperative complications were noted. All fractures were followed until union.

Institutional Review Board approval was obtained and informed consent was waived. Statistical analyses were conducted using *Statistical Package for the Social Sciences*, version 18.0 (IBM, Somers, NY). Descriptive statistics are reported as means with associated standard deviations. Categorical data are reported as summaries. Data was analyzed using t-tests and ANOVAs to compare means for continuous variables. Categorical data was analyzed using Chi-squared analyses.

Results

Over a 4-year period (8/03/2004 to 2/26/2009), there were 145 closed extraphyseal distal radius fractures in 145 skeletally immature patients that presented to our emergency department. Eighty-six patients had sustained fractures that were non- or minimally displaced and were splinted without manipulation and were excluded from analysis. Fifty-nine patients sustained a displaced extraphyseal distal radius fracture requiring closed reduction in the emergency department. Fourteen patients had incomplete follow up and were excluded from the final analysis. Forty-five patients (76%) were followed to fracture union. Thirty-three (73%) of these patients were treated with closed reduction and immobilization in a sugar tong splint, 10 patients (22%) were acutely placed into long arm casts, and 2 (5%) were placed into a short arm volar wrist splint (Fig. 1). There were 30 male and 14 female patients treated. The average age at injury was

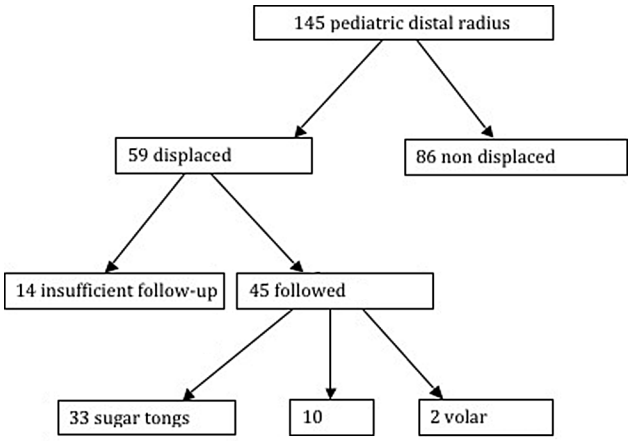

Figure 1 Breakdown of study population.

Table 1 Ulnar Fractures

Type of fracture	Number of pts
No ulnar fracture	21
Buckle fracture	7
Plastic deformation	2
Complete, nondisplaced fracture	5
Complete, displaced fracture	7
Total	43

10.03 ± 3.40 years. Twenty-nine patients (66.5%) sustained their injury as a result of a low energy fall. Sixty-nine percent of fractures occurred in the non-dominant hand. Twenty-two patients (52%) of the patients had an associated ulna fracture. Thirty-two percent of these ulnar fractures were displaced (Table 1). No patients in the study had an associated neurologic or vascular injury. Demographics and injury patterns of those lost to follow-up were similar to the study group.

Patients who were treated with initial sugar tongs splint did not differ from those who received a cast or a volar wrist splint with regards to age at time of injury, sex, side of injury, mechanism of injury, or the presence of an associated ulna fracture. There was no association between date of injury and the type of immobilization utilized (Table 2). Cast indices were calculated for all patients initially treated in a cast.[17] Average cast index was 0.85 ± 0.11 (range: 0.56 to 0.95).

At presentation, radiographs demonstrated an average 9.3 (± 3.8) mm of shortening in the operative group and 7.88 ± 7.33 mm of shortening in the nonoperative group (p = 0.65). There was an average of 4.13 ± 4.8 mm of radial translation in the operative group and 3.3 (± 3.8) mm in the nonoperative group (p = 0.71). The operative group demonstrated an average of 8.3 ± 2.2 mm of dorsal displacement while the nonoperative group demonstrated 1.4 ± 8.9 mm (p = 0.06). Post reduction, these numbers were improved. The operative group demonstrated shortening of 2.5 mm compared to 6.4 mm (p = 0.31) in the nonoperative group. There was 4.03 ± 1.16 mm of residual radial displacement in the operative group and 2.27 ± 1.30 mm in the nonoperative group (p = 0.06). The operative group had 0.85 ± 2.5 mm of residual dorsal displacement while the nonoperative group demonstrated 1.3 ± 3.0 mm (p = 0.79).

At initial follow-up, both groups demonstrated no measurable shortening. There was 0.36 ± 0.84 mm of radial displacement in the nonoperative group and 0.88 ± 0.81 mm of radial displacement in the operative group (p = 0.39). There was 0.14 ± 1.1 mm of dorsal displacement in the nonoperative group and 0.22 ± 1.68 mm of dorsal displacement in the operative group (p = 0.91). This indicated that initial follow-up reduction was maintained for all parameters.

Of those patients with an associated ulna fracture, eight (36%) required surgical intervention for loss of reduction. Only one patient (6%) without an associated ulna fracture required surgical intervention for loss of reduction. This

Table 2 Demographic Data by Immobilization Type

Factor		Sugar tongs	Cast	Volar splint	p
Age (years)		10.09 (± 3.2)	9.71 (± 4.3)	n/a	0.79
Gender	Male	23	6	1	0.84
	Female	10	3	1	
Side	Right	8	3	n/a	0.32
	Left	23	4	n/a	
Mechanism of injury	Fall	22	5	2	0.22
	Skating	2	1	0	
	Sports	1	2	0	
	Bicycle	4	1	0	
	Other	3	1	0	
Ulna fx	Yes	14	7	1	0.20
	No	18	2	1	

Table 3 Patients Requiring Operative Intervention by Immobilization Type

	Operative	Nonoperative	Total
Sugar tongs splint	8	25	33
Cast	2	8	10
Volar splint	0	2	2
Total	10	35	45

difference was statistically significant (p = 0.013). No other patient specific or injury specific factor was significantly different between those groups requiring operative intervention and those groups who could successfully be treated to completion without surgery.

Twenty-five patients (76%) who were initially splinted were treated to completion without the need for operative intervention. Eight of the patients (24%) treated with sugar tongs splints required surgery. Of those who required surgical intervention, six underwent closed reduction and percutaneous pinning with two K-wires while the other two patients underwent open reduction and internal fixation with a volar plate. Eight patients who were initially casted were treated to completion closed. Two patients (22%) required operative intervention for loss of reduction. Both of these patients were treated with closed reduction and percutaneous pinning. Both of the patients who were immobilized using a volar splint were treated to completion without operative intervention. There was no statistically significant difference amongst these groups (Table 3). In addition, there was no significant difference between the cast indices of patients who required operative intervention (CI = 0.88) and those that did not (CI = 0.82) (p = 0.49).

Discussion

Distal radius fractures are the most common pediatric fracture, accounting for almost one-quarter of all pediatric fractures.[3-5] Of those that are displaced, most undergo acute closed reduction and immobilization; however, unacceptably high rates of re-displacement have been reported, ranging anywhere from 21% to 47%.[9-11,16] Numerous studies have attempted to predict which fractures will displace post-reduction, and many have addressed the method of immobilization post-reduction. Overall, we had a 25% re-displacement rate following initial closed reduction of a displaced extraphyseal distal radius (ulna) fracture.

While method of initial immobilization was not associated with a loss of reduction requiring operative intervention, the presence of an associated ulna fracture was. Some controversy exist over whether the association of an ulna fracture improves stability,[10,11] worsens stability,[14] or has no effect.[19] However, in our study, patients with an associated ulnar fracture were clearly more likely to require surgery than those that did not. This is likely secondary to the fact an intact ulna provides some level of rotational stability to the fractures. Moreover, displaced fractures of both bones tend to be higher energy with greater initial displacement, making them more at risk for redisplacement.[9,14]

This study sought to compare the need for operative intervention in a population of skeletally immature patients with displaced distal radius fractures immobilized with sugar tongs splints versus casts. The patients in this study experienced similar rates of re-displacement to those reported in the literature,[9-11,16] regardless of the type of immobilization utilized, with a rate of re-displacement of approximately 25%. Our patients, similar to what is reported in the literature, trended toward surgical intervention with greater pre-reduction displacement.[9,14] In addition, those who failed to achieve an anatomic reduction trended towards an increased rate of surgical intervention.[9,16] While these trends failed to reach statistical significance, it is likely that this is secondary to the size of the study population.

The goal of a closed reduction is to achieve and maintain an acceptable reduction with minimal residual deformity. However, controversy exists regarding the most appropriate way to maintain these reductions. Some investigators argue for the use of long arm plaster casts in order to achieve better stability and lessen the risk of re-displacement.[10,18] Others have reported that below the elbow plaster casts are sufficient to pain the reduction of metaphyseal distal radius fractures.[17,19-21] These investigators argue that short arm casts are easier to apply, are comfortable, and give more function for activities of daily living.[20,21]

However, all of the studies that explore casting as the method of immobilization after manipulation for pediatric distal radius fractures identify the technical difficulties of cast application. These investigators state that the casts must be "well molded" in order to maintain the reduction.[17,20,21] A "cast index" was created which describes how well a cast is molded to the normal contours of the forearm.[17] This cast index is defined as the sagittal cast width measurement divided by the coronal cast width measurement at the fracture site.[17] A cast index of 0.70 has been identified as the ideal molding for pediatric distal forearm fractures,[17] and many investigators argue the importance of a favorable cast index for maintenance of the reduction.[17,19-21] These investigators identify a learning curve to proper cast application and note that those casts with poor cast indices were most often placed by inexperienced junior housestaff or non-orthopaedic physicians.[17] The average cast index in our study was 0.87, and our range was 0.82 to 0.95, indicating the casts in this study were largely poorly molded. There was no significant differ-

ence in the cast indices of the group that required operative intervention and those that did not, though this was likely due to the small sample size.

Distal radius fractures in adult patients are often initially immobilized in sugar tongs splints following closed manipulations. However, these splints have been criticized in the pediatric population. Only one study to date has addressed the use of sugar tongs splints in the treatment of pediatric distal radius fractures.[22] In a retrospective review of 53 fractures immobilized post reduction with a sugar tongs splint, the investigators found that only 4% of patients lost reduction. The investigators argued that the technique of applying a well-molded sugar tongs splint is quickly learned and consistently reproducible. Sugar tongs splints are commonly utilized for adult distal radius fractures; and therefore, physicians are more often experienced with this method of immobilization.

Denes[22] further argues that the elastic ace bandage more readily adjust to swelling. Bivalving a circumferential cast is associated with loss of reduction in pediatric distal radius fractures.[15] However, placement of a circumferential cast acutely after manipulation risks the development of compartment syndrome with increased swelling. As a result, these patients often require admission to the hospital for overnight observation. Sugar tongs splints allow for swelling, as they are not circumferential. In addition, as swelling decreases, the effectiveness of a well-placed mold can be lost with casting. The elastic bandage of a sugar tongs splint allows continued contact as swelling improves and minimizes the risk for loss of reduction.

While the current study demonstrates similar rates of re-displacement between groups regardless of initial immobilization type, the study is limited by several factors. We have a small sample size. Pediatric distal radius fractures are extremely common; however, distal radius fractures requiring reduction represent only a small percentage of these fractures (40.8% in this study). Nondisplaced fractures occur much more commonly. We further reduced our sample size by looking at only patients with extraphyseal fractures.

In addition, this is a retrospective study. As a result, the study is limited in its ability to explore functional outcomes and the lack of randomization risks selection bias. There was no set protocol for treatment of these injuries at the time of presentation. The choice of post-reduction immobilization was left to the discretion of the consulting resident and the orthopaedic attending. This allowed residents who were not comfortable placing casts to choose to use a splint instead. Thus, the casting group may have had a higher rate of late displacement if casts had to be applied by all residents. Indications for operative intervention were also not standardized and were left to the discretion of the attending physician.

Despite the small sample size and retrospective nature, this study is in concordance with the existing literature and clearly demonstrates that the use sugar tongs splints as a method of initial immobilization following closed reduction is an acceptable alternative to casting for extraphyseal pediatric distal radius and ulna fractures requiring reduction. Patients who received closed reduction and placement of a sugar tongs splint had radiographic outcomes similar to those who received a cast.

Disclosure Statement

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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