Displaced Distal Radius Fractures in Children: To Reduce or Not to Reduce? To Pin or Not to Pin?

Walter H. Truong, MD, FRCS(C), FAOA[1,2]; Andrew W. Howard, MD, FRCS(C)[3]; Andrew G. Georgiadis, MD[1,2]

[1]Gillette Children's Specialty Healthcare, Division of Orthopedics, St. Paul, MN, USA; [2]University of Minnesota, Department of Orthopedic Surgery, Minneapolis, MN, USA; [3]Division of Orthopaedic Surgery, The Hospital for Sick Children, Toronto, Canada

Abstract: Displaced distal radius fractures in children are routinely treated with closed reduction under sedation, which adds risk and cost. Yet some metaphyseal fractures, especially in young children (under age 10), have the capacity to remodel some degrees of displacement without reduction. At any given age, it is not clear which patients and which fractures need reduction, and further which fractures need to be pinned. This review summarizes the available literature and hopes to guide clinicians in the treatment of children with distal radius fractures presenting to their practice.

Key Concepts:

- Remodeling potential of the metaphyseal distal radius is significant in both the sagittal and coronal planes.
- Complete remodeling without sequelae of 100% displaced and shortened distal radius fractures has been reported in children under age 10.
- Despite the above, displaced distal radius fractures in children often undergo sedated reduction, and when performed, pinning eliminates loss of reduction but may lead to unnecessary surgery.
- Prospective randomized trials that compare in situ stabilization and reduction are needed.

Introduction

Distal radius fractures (DRF) comprise 20-25% of all pediatric fractures[1, 2] and are the most common children's fracture seen in emergency departments (ED) (approximately 32 per 1000 patients seen).[3] The majority of these fractures are extra-articular and extra-physeal, and the necessity of near-anatomic reduction for completely displaced fractures is increasingly questioned for children under the age of 10 years.[4]

Displacement or angulation may create anxiety in families, and many factors are generally considered when determining the necessity of formal reduction. How much angulation and shortening are acceptable and at what age? Will the deformity be acceptable to the family and child while it remodels? Will there be any functional deficits for the child in the near or long term? These concerns lead to procedural sedation for many of the estimated 280,000 distal radius fractures seen each year in children less than 10 years of age in the U.S.[5]

One study of consecutive patients under age 10 who were seen in an ED for a distal radius fracture showed that 55% (142/258) underwent sedated reduction and immobilization.[5]

Conscious sedation, often employed for the reduction of displaced DRFs, is not benign, and adverse events have been reported at a rate of 2.3-17% in children with the most severe, including respiratory depression, vomiting, cardiovascular instability, or even death.[6-8]. Even after successful reduction, the risk of re-displacement is reportedly high (29-91%).[9, 10] Children have undergone a second reduction or surgery in 9-14% of cases following emergency provider reduction,[11, 12] and 7-39% of cases reduced by an orthopedic team.[13, 14] The cost of reduction is also far greater, ranging from 50% to 700% more than non-reduction treatment.[5, 15]

Figure 1 shows the radiographs of a 6-year-old male who sustained a distal radius and ulna fracture after a fall at a playground. Radiographs at one-week post-injury were significant for 30° of apex volar angulation and 25° of radial angulation (Figure 1a). The fracture was reduced under nitrous sedation, was thereafter deemed unacceptable (Figure 1b), and subsequently the cast was wedged (Figures 1c). Sagittal angulation was minimal, but radial angulation was of sufficient concern that the treating surgeon performed closed reduction and percutaneous pinning under general anesthesia. Pins were removed in clinic without complication, and the injury went on to uncomplicated healing without further sequelae. Were these procedures necessary or would equivalent results have been achieved without any reduction treatment (i.e. would remodeling have allowed for equivalent cosmesis and function)?

If we had Level 1 guidelines on which distal radius fractures would remodel and therefore don't need reduction, children would be spared morbidity and money would be saved. This review summarizes the available literature and serves as a reference for providers faced with this injury in children.

Natural History/Remodeling Potential

In 1979, Friberg determined that the dorsal-volar remodeling of distal radius fractures averaged about 0.9° per month, with greater initial remodeling velocity accompanying greater fracture angulation and decreasing

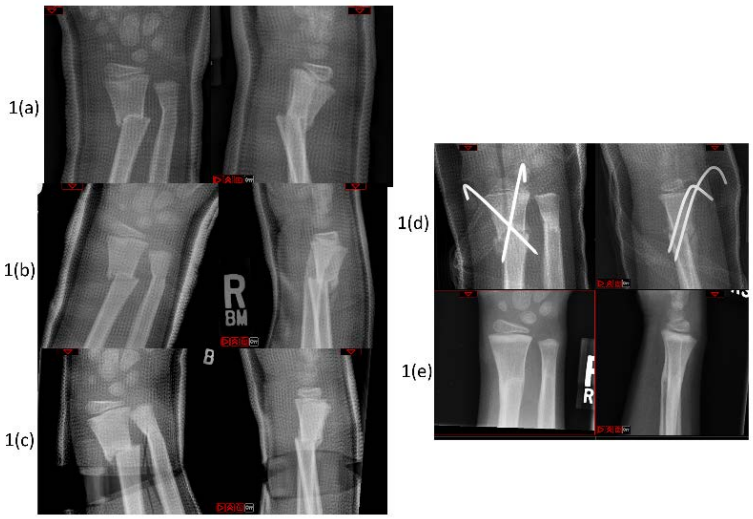

Figure 1. *A 6-year-old boy with distal radius fracture. Radiographs at one week (a), reduced again with nitrous sedation (b), wedged after coronal plane deemed unacceptable (c), then went to OR for pinning (d). Final X-rays, healed (e)*

velocity thereafter.[16-18] Jeroense et al. found a much higher remodeling speed in 40 patients (ages 3-14) with a mean sagittal angulation of 23° (range 15-49°) and mean coronal angulation of 21° (range 15-33°). At an average of 2° per month (range 0.4-7.6°), this rate decreased exponentially with time leaving very little residual angulation.[19] By multivariate analysis, they found that the larger the initial angulation, the greater the remodeling speed regardless of the age and sex of the patient.[19] In 2016, Van der Sluijs et al. created a predictive equation successfully anticipating the remodeling of 76% of distal radial malunions in children. Average remodeling was ~ 1°/month with 1.5 °/month occurring in the first six months. Consistent with the study by Jeroense et al., these remodeling rates were present for all fractures in children up until 14 years of age, regardless of sex.[20]

Published Recommendations on Acceptable Limits of Angulation and Shortening

In 2003, Do et al. reported on isolated distal both bone forearm fractures in children less than 14 years of age. They found that 15° of angulation and 1cm of shortening

underwent complete remodeling at seven and a half months, and equivalent outcomes were obtained with and without near-anatomic reduction as an index treatment.[15] The only differences were markedly longer emergency room visit times and double the cost of care if the fracture was reduced. Similarly, in 2007 Al-Ansari et al. published on 124 patients (girls < 11 years, boys <13 years) with <15° of angulation and <5mm of shortening and found no difference in outcomes between the reduction and no reduction groups.[21] The 2010 edition of *Rockwood and Wilkins' Fractures in Children*, a classic orthopaedic text, recommends <25° of sagittal angulation and <10° of coronal angulation in children 5-10 years of age, while those >10 years should have <20°of sagittal angulation and no coronal angulation.[22]

Table 1. *Summary of Literature for Acceptable Alignment of Distal Radius Fractures*

< 10 years of age					
Acceptable	**Do 2003[15]**	**Al-Ansari 2007[21]**	**Waters 2010[22]**	**Crawford 2012[4]**	**Chia 2015[23]**
Dorsal-Volar Angulation (deg)	<15	<15	<25	min	<25
Radial-Ulnar Angulation (deg)			<10	min	<15
Axial Rotation (deg)					
Shortening/ Bayonet Apposition (cm)	<1	<0.5	<0.5	any	any

10 years of age or older		
Acceptable	**Waters 2010[22]**	**Chia 2015[23]**
Dorsal-Volar Angulation (deg)	<20	<20
Radial-Ulnar Angulation (deg)	0	<15
Axial Rotation (deg)	0	
Shortening/ Bayonet Apposition (cm)	0	0

More recently, Crawford et al. reported on a series of 51 children aged 3-10 years with 100% displaced DRF with significant shortening. Gentle cast molding was performed without sedation until there was no significant angulation, and all DRF remodeled by one-year post-injury. Based on a short survey, families and children were also satisfied with the care and recovery.[4]

In 2015, Chia et al. published treatment recommendation based on their interpretation of the literature and clinical experience. Acceptable alignment in children ≤ 8 years of age included < 25° of sagittal angulation, <15° of radial tilt, and bayonet apposition. Those older than 8 years are allowed <20° of sagittal angulation, <15° of radial tilt, and <50% displacement. The authors stipulated these parameters to be maintained as long as the physes are open and at least two years of growth remain[23]. The studies discussed above are summarized in Table 1 for ease of reference.

Consensus Among Providers?

One indicator of the strength of available scientific evidence is whether consensus exists among caregivers. In 2015, Bernthal performed a survey of 781 surgeons from North America caring for children with distal radius fractures. They asked the surgeons to state their acceptable criteria for children above and below nine years of age. For those younger than 9, about half of the respondents would allow up to 20° of sagittal angulation, while another third would allow up to 30°. Respondents tended to allow 10° or less of coronal angulation. Half of respondents would accept up to 1cm of shortening while a third would not allow any shortening. As expected, surgeons would accept much less in children over age 9 and 71% would not allow any shortening. Interestingly, when asked to state their treatment plan for 10 hypothetical cases, 20% of surgeons treated the cases differently than stated in their acceptable criteria, tending to be more aggressive with reduction. They also found that hand surgeons and general orthopedic surgeons were 2.9 and 1.6 times more likely to perform an open reduction and fixation in about half of the cases compared to pediatric orthopedic surgeons.[24]

Subsequently, nine pediatric orthopedic surgeons were presented with 100 wrist radiographs and asked to classify the fracture by type, state their treatment

preference, immobilization type, duration of immobilization, follow-up and radiography schedule, and subjective sense of stability. There was only slight interobserver agreement (k = 0.059-0.163) on most responses and only fair agreement (k = 0.320-0.379) on fracture type and stability.[25]

To Pin or Not to Pin?

Two previous studies have looked specifically at this question and found similar results. The risk of loss of reduction was 0% in both studies when pinning was performed and ranged from 21-39% in cast only groups, while pin-related complications ranged from 6% to 38%.[26, 27] The complications were minor: pin site infection, pin migration under skin, tendon irritation, and transient hypoesthesia. Clinical outcomes were similar at three months,[26] and costs were similar between pinning and cast treatment groups.[27] Anecdotally, there are significant regional differences in the rates of pinning procedures performed around the world. With up to 40% of patients having re-displacement, reliable follow-up is paramount to ensure timely re-reduction, if necessary, and may be the reason some centers prefer pinning over casting alone. However, this also means that 60% of patients had anesthetic or sedation and pinning that may not have been necessary to maintain the desired alignment and exposed them to possible pin-related complications.

Cost

Patients undergoing ED reduction spend two hours longer in the ED than those undergoing nonreduction treatment.[5, 15] Crawford et al. found that ED reduction and casting cost $3,819 more than an office visit application of a cast ($4,846 vs. $1,027).[4] Orland et al. performed a cross-sectional study at a single tertiary pediatric emergency room in the USA and found that the cost difference between those reduced and not reduced was estimated at approximately $7,000 ($8,077 vs. $1,027). They estimated that 15% of the 258 patients <10 years of age seen in that two-year span had unnecessary reductions based on measures of acceptability of <20° of angulation and <1cm of shortening. Based on 280,000 ER visits per year for children <10 years of age with distal radius fractures, with a 15% unnecessary reduction rate, they estimated an annual savings of $270 million.[5]

Future Directions

A recent survey suggests that most Pediatric Orthopedic Society of North America members would perform sedated reduction of 100% displaced distal radius fractures in children under age 10 years. However, a majority of respondents would also be willing to randomize the treatment of these injuries.[28] Large RCTs of distal radius and ulna fractures are being conducted in Germany[29] and are being planned in the United Kingdom[30] and the United States.[31]

Table 2. *Authors' Guidelines for Acceptable, Maximal Angulation*

	<10 yoa	≥ 10 yoa
Dorsal-Volar Angulation (deg)	<25 deg[22,23]	<20 deg[22,23]
Radial-Ulnar Angulation (deg)	<15 deg[23]	<15 deg[23]
Axial Rotation (deg)	Unknown	Unknown
Shortening/Bayonet Apposition (cm)	<1 cm[4,15,23]	0[22,23]

Summary

While among the most common injuries of childhood, treatment of displaced distal radius fractures can vary widely. Variations in treatment are based on country, community, surgeon preference, surgeon experience, or dogma. Some question why so many sedated reductions, re-reductions, and pinnings are performed when there is such enormous remodeling potential of approximately 1.5° per month in the first six months and up to 1° per month in all distal radius fractures in growing children until 14 years of age. Table 2 summarizes our current practice based upon the available literature and we are part of a multicenter research group in North America that, in the near future, will be asking centers like yours to participate in a randomized controlled trial on the controversial, bayonetted, distal radius fracture.[31]

Additional Links

http://www.posnacademy.org/media/t/0_ljc1jg4n/19139582

https://posna.org/Physician-Education/Study-Guide/Pediatric-Distal-Radius-and-Galeazzi-Fractures

http://orthokids.org/I-Broke-My/Pediatric-Forearm-Fractures

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