Tips & Tricks: Closed Reduction of Pediatric Distal Radius Fractures in the Emergency Department

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Introduction

Distal radius fractures are the most common type of fracture encountered in patients below the age of sixteen.[1] As such, they are frequently encountered in the emergency room setting by the orthopaedic physician on call.

Although no universally accepted standardized treatment protocol for the treatment of pediatric distal radius fractures exists, the principal of restoring functional alignment dictates management. The distal radius has immense remodeling potential, as the distal radial physis contributes 75% to the longitudinal growth of the radius. However, remodeling potential is inversely correlated with age; therefore, there is a lower tolerance for incompletely reduced distal radii in older children.[2] Malalignment can lead to a loss of range of motion and in turn a loss of function. For example, while angulation of greater than 10 degrees in the distal third of the forearm results in loss of 20 degrees of pronation-supination range of motion, angulation less than 10 degrees cause minimal limitation on range of motion.[3] (Figure 1)

Guided by acceptable restoration of function, general radiographic parameters have been described that constitute an acceptable reduction. In younger patients (e.g., less than 10 years), 20-25 degrees of sagittal plane angulation and 10 degrees of coronal plane angulation can be expected to remodel. In patients greater than 10 years, less than 15 degrees of residual angulation can be accepted. Deformity is typically better tolerated in the plane of motion of the wrist joint (i.e., sagittal). By this same principle, rotational deformities are poorly tolerated and cannot be expected to significantly remodel.[4] However, while rotational malalignment can ultimately limit range of motion, this may not lead to functional limitations.

Minimal bayonet apposition, or overriding of the major fracture fragments, can be accepted in patients under 10 as this is not likely to limit range of motion or function and may remodel.[5] Ultimately, as children approach skeletal maturity, treating fractures with bayonet apposition using closed reduction can pose a significant challenge given the deforming forces and narrow margin of acceptable radiographic parameters. In practice, there remains high variation between surgeons in terms of tolerance of residual deformity, especially in older children.[3,6]

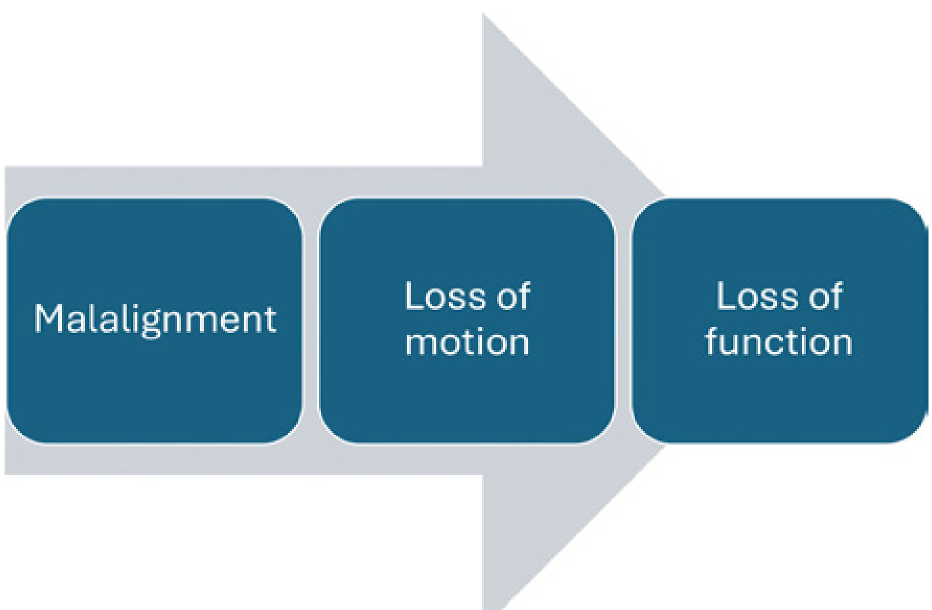

Figure 1. Downstream effects of malaligned distal radius fractures on patient outcomes.

Treating distal radius fractures successfully via closed reduction saves healthcare costs, risks of anesthesia, and risks of operative management, and is frequently definitive treatment of the injury.[7] Given their frequency, there is significant interest in guidance on closed management of these injuries.[8] Successful nonoperative management relies on precise closed reduction, a well-molded cast, and frequent observation in clinic. Ideal closed reduction maneuvers are simple, easily reproducible, and effective for both new and more experienced practitioners. In this paper, we aimed to describe a series of tips and tricks to aid in closed reduction and management of pediatric distal radius fractures.

Tips and Tricks

#1 Let It Hang!

The most significant deforming force on the distal radius is the brachioradialis, a muscle originating from the lateral distal humerus and inserting on the radial styloid. It aids in elbow flexion but, following a distal radius fracture, retracts the distal fragment proximally, which can result in a bayonet deformity.[9]

Prior to attempting closed reduction for shortened fractures, encircle the index and middle finger with a role of gauze or finger traps and securely attach to a ceiling fixture. Place a counterweight around the elbow, typically created using bags of saline and stockinette. This setup counteracts the shortening and radial deviation caused by the brachioradialis before fracture manipulation and fatigues the muscle. Leave the patient in this position for five to fifteen minutes to maximize the effect. Patients should be counseled that their fingers may discolor due to tourniquet constriction, which will quickly resolve once this reduction aid is removed.

#2 Help Yourself!

Two maneuvers can accomplish self-provided counter-force for reduction when an assistant is unavailable:

- A bedsheet can be folded lengthwise and draped over the upper arm with the elbow flexed at 90 degrees. Counter traction is applied by anchoring on the sheet by standing on it while applying axial traction distal to the fracture side.
- The physician's leg is placed over the patients arm so that the physician can flex their knee and capture the patients' upper arm. When axial traction is applied distal to the fracture site, the physician has precise control of the proximal arm to provide counter traction. This method has been shown to provide a significant force of countertraction and allows for close positioning for more precise direction of the distal fracture fragment in the axial, coronal, and sagittal planes,[10] (Figure 2)

Figure 2. Demonstration of the lower extremity assisted counter-traction method for distal radius reduction. The lower extremity provides axial counterforce as the distal fragment is manipulated. This position allows for precise control of the distal fragment and strong counter-traction, ideal for fractures with bayonet deformity.

#3 Its More Than You Think!

Due to periosteal entrapment within the fracture site, the reduction requires recreation of deformity at the fracture site to free the soft tissues. In addition, bayonetted forearm fractures require significant deformity recreation to angle the opposed cortex of the distal fracture and allow for axial traction to bring the distal segment "up and over" the proximal segment. A short course of live fluoroscopy can reveal the degree of recreation required to free the cortex of the fracture fragment. This technique should be used with caution to not expose the patient to excess radiation. The distal fracture may need to be "walked" over the proximal fragment with several small reduction maneuvers to achieve an adequate final position.

If an incomplete ulna fracture prevents deformity recreation, completion of the fracture may be required to achieve acceptable reduction of the distal radius. This should be discussed as a potential outcome with the parents prior to beginning the reduction attempt. Although the idea of completing a fracture seems oppositional to orthopaedic principles, restoring length to the radius is required for the principle of restoring functional outcomes.

#4 Know When to Hold'Em

After adequate closed reduction has been obtained, a fiberglass cast is then applied. Significant care must be taken while the undercast padding and then the cast is applied to not lose the reduction. For dorsally displaced fractures, wrist flexion can help hold the reduction during the cast application process. The reduction can also be held by an assistant holding the child's index and middle fingers to apply ulnar deviation with the child's elbow flexed to 90 degrees. Holding and molding in a position of stability may prevent re-displacement of the fracture in the cast.[11]

#5 Proper Molding, Take a Seat!

After the cast is applied, the critical step of molding is performed. A well-placed mold is critical for preventing fracture re-displacement.

Studies have validated radiographic parameters to evaluate cast applications, the most frequently used being the cast index, or the measurement of the cast in the sagittal plane divided by the measurement in the coronal plane at the fracture site. A ratio $<.80$ is predictive of maintaining reduction in the cast.[12] A three-point mold prevents re-displacement by buttressing the fracture in the plane of original displacement.

One method is for the physician to sit on a stool adjacent to the patient. The knee should be placed at the apex side of the deformity, just proximal to the fracture site. The palms are placed on either side of the knee on the opposite side of the cast to create the three-point mold. Alternate this position with oppositional force in the sagittal plane at the fracture site to optimize the cast index. (Figure 3)

Another method is to first establish the cast index by performing an interosseous mold along the entire cast. Then, the physician places their thenar eminence just proximal to the fracture site on the apex side of the deformity and the other thenar eminence on the opposite side over the distal fragment. This counteracts the deforming force. The hand on the non-apex side of the cast alternates between the distal fragment and a point proximal to the apex-sided hand to create the three-point mold.

#6 Beat the Heat, Circle Back

An exam should always be performed after closed reduction and after the patient has recovered from sedation. The degree of swelling should be assessed, as well as any signs of nerve compression (e.g., median neuropathy) that may occur.

Figure 3. Demonstration of a three-point mold for a dorsally displaced fracture. The knee is placed on the apex side of the deformity in the sagittal plane, just proximal to the fracture site. The distal palm is used to buttress the fracture from re-displacing. The proximal palm completes the three-point mold. This position should be alternated with direct compression at the fracture site to optimize the cast index.

In patients with significant swelling before or after reduction, bivalving the cast can allow more room for soft tissue expansion. The risk of bivalving includes a loss of reduction as the patient's swelling decreases. A compressive wrap or another layer of cast material can be applied after the cast is loosened.

Preventing cast burns when bivalving or removing casts is paramount. Risk factors for cast saw burns include inexperienced physicians, conscious sedation, and casts over the wrist.[13] The utmost caution must be taken when using a cast saw in a patient who is still under sedation and cannot report feeling the heat of the blade. If the cast needs to be bivalaved, wait until the patient has recovered from sedation to allow for their feedback during removal. Commercially available safety strips can be slid between layers of the cast padding provide an additional layer of protection.

#7 See You Again

Because re-displacement can occur in over 20% of pediatric distal forearm fractures,[14] children who undergo

Figure 4. Posteroanterior (A) and lateral (B) radiographs of a 13-year-old male who sustained a left dorsally displaced distal radius metadiaphyseal fracture with bayonet apposition and distal ulnar diaphysis and ulnar styloid fractures after a basketball injury. The fracture was reduced under conscious sedation in the emergency department and placed in a short arm fiberglass cast using many of the tips and tricks described. PA (C) and lateral (D) demonstrate maintenance of the reduction at 1 week follow up. Cast index is 0.70.

closed reduction of these fractures should follow up in fracture clinic in a week for a fracture alignment check.

#8 Bailout - Wedge It

Fractures in even the most well-molded casts can re-displace. When fractures re-displace along one plane, the cast can be wedged to correct this malalignment.

The opening wedge is most used, in which the cast is cut in the concavity of the deformity and cast is then wedged open on that side to correct the angular deformity.[15]

While several methods have been described to calculate the amount of wedging required to correct a given angular deformity, a simple method without the need for mathematical calculations exists. A piece of paper is overlaid on a radiograph of the fracture and the long axes of the proximal and distal fracture segments are traced with a pen. The paper is then cut along the traced line, creating a template of the fracture deformity. The paper is then placed on the cast and the angular deformity is traced with a marker. The cast is then cut at the concavity of the fracture deformity, leaving a hinge at the point of maximal convexity. The cast can then be wedged open until the fracture lines that were traced on the cast beforehand are made straight.

Conclusion

Displaced pediatric distal radius fractures can provide a significant challenge to treat using closed reduction. Reduction of these fractures is critical to restore functional outcomes of the upper extremity. Application of these tips and tricks during each step of the reduction process can aid in closed management of pediatric distal radius fractures in the emergency department by the physician on call.

References

1. Randsborg P-H, Gulbrandsen P, Šaltyte Benth J. *et al.* Fractures in Children: Epidemiology and Activity-Specific Fracture Rates. JBJS. 2013;95(7):e42.

2. Jeroense KTV, America T, Witbreuk MMEH, *et al.* Malunion of distal radius fractures in children: Remodeling speed in 33 children with angular malunions of ≥ 15 degrees. Acta Orthopaedica. 2015;86(2):233–237.

3. Greig D, Silva M. Management of Distal Radius Fractures in Adolescent Patients. Journal of Pediatric Orthopaedics. 2021;41:S1.

4. Ray S, Manske MC. Pediatric Forearm Malunions. *Hand Clinics*. 2024;40(1):35–48.

5. Crawford SN, Lee LSK, Izuka BH. Closed treatment of overriding distal radial fractures without reduction in children. The Journal of Bone and Joint Surgery. *American Volume*. 2012;94(3):246–252.

6. Bernthal NM, Mitchell S, Bales JG, *et al.* Variation in practice habits in the treatment of pediatric distal radius fractures. *Journal of Pediatric Orthopaedics B*. 2015;24(5):400.

7. Godfrey JM, Little KJ, Cornwall R, *et al.* A Bundled Payment Model for Pediatric Distal Radius Fractures: Defining an Episode of Care. *Journal of Pediatric Orthopedics*. 2019;39(3):e216–e221.

8. Hennrikus WL, Mehlman CT. The Community Orthopedic Surgeon Taking Trauma Call: Pediatric Distal Radius and Ulna Fracture Pearls and Pitfalls. *Journal of Orthopaedic Trauma*. 2019;33 Suppl 8:S6–S11.

9. Koh S, Andersen CR, Buford WL, *et al.* Anatomy of the distal brachioradialis and its potential relationship to distal radius fracture. *The Journal of Hand Surgery*. 2006;31(1):2–8.

10. Eichinger JK, Agochukwu U, Franklin J, *et al.* A New Reduction Technique for Completely Displaced Forearm and Wrist Fractures in Children: A Biomechanical Assessment and 4-year Clinical Evaluation. *Journal of Pediatric Orthopaedics*. 2011;31(7):e73.

11. Kralj R, Pešorda D, Keretić D, *et al.* Secondary displacement in distal forearm fractures in children: adequate positioning of the wrist in the cast is more important than cast index. *Journal of Pediatric Orthopedics. Part B*. 2023;32(2):145–151.

12. Kamat AS, Pierse N, Devane P, *et al.* Redefining the Cast Index: The Optimum Technique to Reduce Redisplacement in Pediatric Distal Forearm Fractures. *Journal of Pediatric Orthopaedics*. 2012;32(8):787.

13. Larson JE, Nicolay RW. Cast Saw Burn Prevention: An Evidence-Based Review. *JAAOS–Journal of the American Academy of Orthopaedic Surgeons*. 2021;29(9):380.

14. McQuinn AG, Jaarsma RL. Risk Factors for Redisplacement of Pediatric Distal Forearm and Distal Radius Fractures. *Journal of Pediatric Orthopaedics*. 2012;32(7):687.

15. Samora JB, Klingele KE, Beebe AC, *et al.* Is there still a place for cast wedging in pediatric forearm fractures? *Journal of Pediatric Orthopedics*. 2014;34(3):246–252.