FRACTURES OF THE DISTAL RADIUS & ULNA IN CHILDREN

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I. GENERAL CONSIDERATIONS
A. Introduction: A Benign Injury?
   1. Usually good results
      a. In a series of 1,767 fractures, only 2.5% showed significant angulation (1).
      b. A more recent series of 1,346 fractures reported a 7% remanipulation rate (2).
   2. Analysis of factors leading to poor results may facilitate avoiding the pitfalls that can occur.
B. Incidence of All Forearm Fractures
   1. Various series (3, 4) have all confirmed that with age, the geographic location of fractures of the radius migrates distally due to the increased discrepancy between wider weaker distal metaphysis and the more proximal and stronger diaphysis.
   2. Regional Distribution (1, 4, 5, 6, 7, 8)
      - Shaft: 20%
      - Distal Metaphysis: 66%
      - Distal Physis: 14%
      - Proximal 1/3 fractures: 1-2%.
C. Mechanism of Injury
   1. Most common mechanism is a fall on the outstretched arm.
   2. Modern children are exposed to even newer mechanisms.
      a. Acute: small wheels mobility devices such as roller skates, in-line skates, skateboards and small wheel scooters all increase the forward kinetic energy of the child increasing the likelihood of a fracture.
      b. Chronic: Gymnastics, (9,10) breakdancing, (11) and bicycle “Wheelies” (12) all put chronic compressive forces across the distal radial physis specifically increasing the incidence of chronic stress fractures.

II. PHYSEAL FRACTURES OF THE DISTAL RADIUS
A. Incidence
   1. 2% of all children's fractures
   2. 39% of all physeal injuries
   3. Peak ages:
      a. Males 13 - 14 years
      b. Females 9 - 10 years
   4. Male: Female ratio 77:33
   5. Incidence of growth arrest 4%
   6. 75% S-H II patterns (13)
   7. Rarely an isolated injury, usually associated with:
      a. Distal ulnar metaphysis
      b. Avulsion ulnar styloid
      c. Distal ulnar physeal injury (extremely rare)
      d. Common ipsilateral injuries include: scaphoid, supracondylar humerus.
B. Mechanisms
   1. Acute
      a. Dorsiflexion injuries with wrist dorsiflexed 95%
      b. Palmar flexion injuries with wrist acutely palmar flexed 5%
   2. Chronic
      a. Chronic weight bearing in hyperextension most commonly associated with gymnastics (14,15)
      b. Produces ulnar variance with chronic wrist pain
C. Diagnosis
   1. Displaced fractures usually obvious
   2. Peterson I Fracture Patterns
      a. Fracture pattern involves comminution of the adjacent metaphysis of the distal radius.
      b. The fracture lines extend up to, but not across the physis (Fig. 1).
While benign appearing, a significant number of these develop a silent arrest.

3. Pronator Sign:
Swelling or displacement of the fat pad anterior to pronator quadratus indicates bleeding into this muscle from an undisplaced fracture of the distal radial physis (Fig. 2).

D. Classification (two basis)
1. Direction of Displacement (Fig. 3)
   a. Type A - Distal Fragment Dorsal (95%)
   b. Type B - Distal Fragment Volar (5%)
2. Type of physeal fracture pattern, i.e., Salter-Harris or Peterson

E. Treatment
1. Non-Operative
1) Traction - Distraction method:
   a) Using finger trap traction (Fig. 4)
   b) Theoretically decreases the shear forces across the physis

![FIGURE 4. Author's method of closed reduction of distal physeal fractures of the radius. (A) Position of the fracture fragments as finger-trap traction with traction is applied (arrows). (B) Often with traction alone the fracture will reduce without external pressure (arrows). (C) If the reduction is incomplete, simplying direct pressure over the fracture site in a distal volar direction with the thumb often completes the reduction while maintaining traction. This technique theoretically decreases the shear forces across the physis during the reduction process.]

2) Immobilization:
   a) Good three-point molding more important than wrist flexion.
   b) Four weeks usually adequate.
   c) Don't remanipulate if late displacement occurs.
   d) Don't manipulate primarily if fracture more than 3 days old unless severely displaced.
   e) Aitken has shown remarkable remodeling capacity (16,17)

2. Operative Indications
   a. Percutaneous Pin Fixation
      1) Most common indication is with ipsilateral fractures
      2) Obese patients or severe swelling
      3) Single pin is placed obliquely dorsally avoiding physis to serve as a dorsal buttress preventing dorsal displacement (Fig. 5)

![Figure 5 Percutaneous pin
The pin is placed obliquely dorsally to avoid physis but still serves as a buttress to prevent dorsal displacement.]

b. Failure to achieve adequate reduction due to interposed structures, i.e., and or tendons.
   c. Open fractures.
   d. Comminuted intra-epiphyseal and intra-articular fractures.
   e. Carpal tunnel or compartment syndromes.
3. **Beware the Type B Fractures. They are unstable!**
   a. A reverse 3-point molding of the cast at the fracture site is required if the fracture is stable with closed reduction alone.
   b. Almost all should undergo pin fixation because of the high incidence of late displacement and unacceptable cosmetic appearance when they displace.

III. **FRACTURES OF THE DISTAL ULNAR PHYSEIS.**

A. Incidence.
   1. Thirty percent of distal radial fractures (physeal and metaphyseal fractures) have an associated fracture of the ulnar styloid.
   2. Transphyseal fractures through the distal ulna constitute only 5% of all children's physeal fractures.

B. Growth Arrest.
   1. While incidence of ulnar physeal fractures are rare, the incidence of growth arrest is very high, i.e., 60%. (18)
   2. Thus don't ignore the transphyseal fractures of the ulna. They can arrest (Fig. 6)

C. Treatment.
   1. Styloid fractures usually can be ignored even if nonunion. It is extremely rare that operative management is indicated.
   2. Transphyseal fractures:
      a. Usually respond to closed reductions.
      b. **If associated with an unstable distal radius (Galeazzi equivalent) pin fixation of the distal ulna may be required to maintain radial length.** (19)
      c. Occasionally there are interposed structures (tendons, ulnar nerve) which need to be extracted surgically.

IV. **FRACTURES OF THE DISTAL RADIAL METAPHYSIS.**

A. Anatomical Factors.
   1. The metaphysis is an area of remodeling, thus the cortex is thin predisposing it to incomplete failure patterns such as torus compression and greenstick tension fractures.
   2. Extensive remodeling due to adjacent physis.

   **Pitfall**
   3. Bulk of soft tissues volar which help hide apex-volar deformities. However, dorsal-apex deformities are more prominent clinically (Fig. 7).
      a. Thus one needs to be more aggressive in reducing apex dorsally angulated fractures.
B. Incidence.
1. Peak incidence related to growth velocity, i.e., females 10 - 12 years, males 13 - 14 years.
2. 57% Non-dominant extremity.
3. 70% Males.
4. Ipsilateral.
   a. Five percent have ipsilateral humeral supracondylar fractures.
   b. The incidence of associated scaphoid fractures is high enough so that with all distal radial metaphyseal fractures, the navicular and its fat stripe should always be evaluated.

C. Classification - important because it dictates the treatment.
1. Directional displacement (distal fragment).
   a. Dorsal 98 - 99%.
   b. Volar.
2. Fracture combinations.
   a. Isolated distal radius.
   b. Distal radius with distal ulna.
      1) Ulnar styloid.
      2) Ulnar physis.
      3) Ulnar metaphysis incomplete.
      4) Ulnar metaphysis complete.
   a. Torus.
   b. Greenstick.
      1) One cortex.
         a) Usually termed Compression Greenstick
         b) Usually stable i.e. rarely angulate late.
      2) Both cortices
         a) If volar cortex disrupted termed Tension Greenstick
         b) Beware!!! These fracture patterns tend to angulate late (Fig.8).
   c. Complete.
      1) Length maintained.
      2) Bayonet apposition

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**Figure 7. Dorsal angulation**
This 7 y.o. developed 20° which was more apparent clinically because there is only minimal soft tissue to cover the angulation on the dorsum of the distal forearm.
D. Pathology.
1. Periosteum usually intact on surface in which distal fragment is displaced (Fig. 9A).
2. With volar bayonet fractures the distal aspect of the proximal fragment may be button-holed through the extensor tendons (Fig. 9B).

E. Treatment - Non Operative.
1. Dependent upon the biomechanical pattern.
2. Torus fractures.
   a. Usually stable and requires only simple immobilization, i.e., short arm cast or volar splint.
3. Greenstick fractures - The issues in the treatment of these fractures:
   a. Acceptable angulation
      1) Age dependent.
      2) Rules of remodeling.
         a) Remodeling occurs in both dorsal (apex anterior) and radially angulated fractures.
      3) Rules of remodeling.
         a) Dorsal angulation = 0.9° per month
         b) Radial angulation = 0.8° degrees per month
         c) Need at least five years of growth to allow for complete remodeling, i.e., females 8 years – males 10 years.
         d) Thus, in the 8 year old female one can expect full remodeling of 30° of angulation.
   b. Complete the fracture.
      1) Usually occurs when fracture is reduced.
      2) Most authors recommend to complete the fracture to reduce the incidence of late angulation.
   c. Position of immobilization.
      1) Three point molding in a direction opposite the original deformity is more important than pronation or supination of the forearm (Fig. 10).
Figure 10. Three Point Molding
Once the cast is applied a three point mold is applied with proximal and distal (down arrows) dorsal pressure points and a middle volar (up arrow) pressure point.

3. Complete fracture
   a. Length maintained - simply correct the angulation.
   b. Bayonet apposition (dorsal).
      1) Obtain reduction in two steps:
         a) Regain length and then reduce by hyperextending the distal fragment (Fig. 11)

Figure 11. Use of the thumb to push the distal fragment hyperdorsiflexed 90° (solid arrow) until length is reestablished. Countertraction is applied in the opposite direction.

   b) Once length regained replace fragment by volar flexion (Fig. 12).

Figure 12. Once length has been reestablished, the distal fragment is flexed into the correct position. Alignment is checked by determining the position of the fragments with the thumb and forefingers of each hand.

2) Immobilization
   a) Short arm cast is adequate but it must be oval with cast index of 0.7 or less (Fig. 13).
Figure 13. The cast index is obtained by dividing the sagittal diameter (A) by its coronal diameter (B) at the fracture site. To be adequate, the ratio or index should be 0.7 or less.

b) Apply the cast with patient in finger traps traction (negates need for an assistant). (Fig. 14) Include thumb in cast to eliminate thenar eminence pressure on edge of cast. (Fig. 15)

Figure 14. Suspended in finger-traps, a very snug cast is applied incorporating the thumb.

Figure 15. Thumb incorporated in cast.

c) Apply a very tight cast then split the cast along the ulnar border and spread to allow for delayed swelling. (Fig. 16)

Figure 16. While still suspended and before release of the tourniquet for the Bier block, the cast is split and spread in its distal three fourths. The separation should include the padding down to the skin.
3) Postoperative care.
   a) See in one week. Check position with x-rays
   b) close cast and cut-out around the thumb
   c) Six weeks adequate for cast immobilization
   c) Use volar splint for light protection during activity hours another
      7-10 days until strength and mobility regained.

   c. Volar (Reverse) Bayonet (Fig. 17)

   Figure 17. Volar
   Bayonet. The distal
   fragment lies volar to the
   proximal fragment.

   Pitfall

1) Beware!!
2) Less stable.
3) Reduction and immobilization techniques are reversed from dorsal bayonet.
4) Proximal fragment may be button-holed through the extensor tendons (See Fig. 8B).

F. Treatment Operative Indications.
   1. Percutaneous pin fixation - same as for distal physeal injuries.
   2. Open fractures.
   3. Primary open reductions.
   4. Remember dorsal bayonet apposition will remodel up to 12.5 years of age.

G. Complications.
   1. Loss of position.
      a. Voto's series reported up to 7% required remanipulation. (2)
      b. Loosening of the cast after swelling subsides appears to be the greatest cause for
         loss of reduction.
      c. In those fractures which are massively swollen due to the primary injury or frequent
         remanipulation, redisplacement may be prevented by securing the reduction
         with a simple cross pin.
      d. The decision to remanipulate depends upon the amount of remodeling expected.
      e. If fracture remanipulated, often pin fixation may be needed to prevent recurrence
         of the deformity.

   2. Neurological dysfunction.
      a. As with distal radial physeal injuries, the nerve dysfunction which resolves with
         reduction.
      b. Rare cases have been reported in which there has been incorporation of the
         median and ulnar nerves in the fracture site. (20,21).
3. **Compartment syndrome** (22,23).
   a. The recent literature reports that compartment syndrome can occur more commonly than originally suspected after the fractures of the distal radius.
   b. The classic findings of marked swelling, pain out of proportion to the injury, and pain on passive extension of the fingers are all usually present.
   c. However, these findings are inherent with the fracture itself.
   d. Compartment pressure measurements may be the only accurate method of determining the presence of a compartment syndrome.
   e. In some cases, i.e. difficult reductions with massive injury post reduction compartment measurements have been recommended. (15)
   f. Before releasing compartment surgically one needs to be sure the entire compartment has an elevated pressure. Don’t measure only at the fracture site. Measure proximally as well.

4. **Cross union - extremely rare.**

5. **Refracture.**
   a. Occurs within six months and through the old fracture site.
   b. Prevented by protecting the forearm with a splint during rehabilitation phase.

V. **GALEAZZI FRACTURES - DISRUPTION OF THE DISTAL RADIOULNAR JOINT**

A. **Incidence.** (24)
   1. Occurs in 3% of distal radial injuries.
   2. But initially recognized in only 40% of the cases.
   3. Of all age groups of Galeazzi Fractures only 11.2% involve children. (25,26,27)

B. **Mechanism.**
   1. Probably axial loading plus rotation.

C. **Classification (Walsh).** (24)

   1. Two major types (Figs. 18,19).
      a. Dorsal – distal fragment supinated.
      b. Volar - distal fragment pronated.
**FIGURE 18.** (line drawing) Walsh's classification. (A) The most common pattern, in which there is dorsal displacement with supination of the distal radius (open arrow). The distal ulna (black arrow) lies volar to the dorsally displaced distal radius. (B) The least common pronation pattern. There is volar or anterior displacement of the distal radius (open arrow) and the distal ulna lies dorsal (black arrow). (Walsh, H.P.J., and McLaren, CANA: Galeazzi Fractures in Children. J. Bone Joint Surg., 69B:730-733, 1987.)

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2. Biomechanical fracture patterns.
   a. Radius can be either complete or greenstick.
   b. Ulna - intact or equivalent, i.e., disrupted distal physis.

3. Treatment.
   a. Reverse the deformity, i.e., pronate dorsal and supinate pronated volar fracture patterns. Hold in long arm cast.
   b. If radius shortened, plates are the treatment of choice.
   c. If distal ulnar physis unstable - may need pin fixation (Fig. 19).

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**Fig. 19.** Radiographs of Galeazzi Fractures

Type-A

Type-B

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**Fig. 19** Stabilization of ulnar styloid

*Figure 19 Stabilization of ulnar styloid.* (Left) Injury film of Type A Galeazzi fracture showing S-H III fracture of the distal ulnar physis (arrow). (Right) Because the ulnar fracture was unstable, it was stabilized with a percutaneous pin.
REFERENCES


