Pediatric Fractures of the Forearm, Wrist and Hand
Pediatric Forearm Fractures-
Radial and Ulnar Shafts

• Approximately 4% of children’s fractures
• Middle and proximal radius more protected by musculature than distal
• Ulna subcutaneous and susceptible to trauma when raised for self protection
• Most fractures are from fall on an outstretched arm
Forearm Developmental Anatomy

- Primary ossification centers at 8 weeks gestation in both radius and ulna
- Distal physes provide most of longitudinal growth
- Distal epiphyses of radius appears radiographically at age 1, of distal ulna at age 5
- Proximal and middle radius connected to ulna by intraosseous membrane
Pediatric Forearm Fractures

- Complete
- Greenstick fractures
- Buckle or torus fractures
- Plastic deformation
- Proximal, middle or distal
- Fxs at same level
- Fxs at different level
- Almost always a rotational component
Goals of Treatment

• Regain full forearm rotation
• Restore alignment and clinical appearance
• For ADL’s need 50 degrees supination, 50 degrees pronation
Closed Reduction Methods

- Adequate analgesia / anesthesia
- Traction – countertraction
- Increase deformity
- Reduce / lock on fragments
- Correct rotational deformity
Excellent Reduction with Well Molded Cast
Cast Burns- can occur during cast removal if blade dull or improper technique used
Remodeling Potential – Variables to Consider

- Age
- Distance from fracture to physis
- Proximal forearm fractures less forgiving
- Amount of deformity
- Direction of angulation
- Rotational deformities will not remodel
How Much Angulation is too Much?

• Case by case decisions
• Closed reduction should be attempted for angulation greater than 20 degrees
• How much to accept before proceeding with open reduction dependent on many factors
• Angulation encroaching on interosseous space may be more likely to limit rotation
Forearm Rotation Position in Cast – Supinate, Pronate or Midposition?

- Depends on location of fracture and position of distal fragment in relation to proximal.
- Match distal fragment to proximal – can use bicipital tuberosity as a guide, and compare diameter of bones at fx.
After Closed Reduction and Casting

- Weekly radiographs for 3 weeks to confirm acceptable alignment and rotation
- overriding (bayonette) position OK
- Can remanipulate up to 3 weeks after injury for shaft fractures
- Angular deformity exceeding 10 degrees in child older than 8 years - consider remanipulation
Maintaining Reduction

- Appropriately molded cast very important
- Easier to maintain an initial excellent reduction than a marginal one
- Above elbow or below elbow immobilization – surgeon preference for distal 1/3 fractures
Indications for Open Reduction

- Open fractures
- Inability to maintain acceptable reduction
- Multiple trauma
- Floating elbow
- Neurologic/vascular compromise
- Refracture

IM fixation- little soft tissue disruption required to insert
Open Metadiaphyseal Fractures- I&D, Pinning
Implant Choice for Pediatric Forearm Fractures

- IM nails (2 mm typically) allow for stabilization with minimal soft tissue dissection and easy removal of implants
- IM fixation usually augmented with short term above elbow cast immobilization
- Older children (10 years and above) may be better treated as adults with plates and screws
Metal Removal

• In younger children IM fixation usually removed
• At 3-6 months when solid healing noted on radiographs
• When plates and screws used then often implants not removed unless symptomatic
Open Both Bone Forearm Fracture
16 Year old with Rotational Malunion-in older patients operative treatment preferred to maintain functional forearm rotation
12 Year Old- Accept Less Angulation in Older Kids
Forearm Fractures - Complications

- Malunion - most common
- Refracture – 5% within 6 months
- Compartment syndrome – observe closely, diagnosis and treatment similar to adults
- Synostosis rare
- Neurologic injury uncommon
Plastic Deformation of the Forearm

- Fixed bending remains when bone deformed past elastic limit
- Most commonly in forearm, may be ulna or radius
- Periosteum intact and thus usually no periosteal callus
- Can limit rotation
Plastic Deformation

- Remodeling not as reliable
- Significant curvature that produces clinical deformity should be corrected
- Greater than 20 degrees, older than 8 years – reduce deformity
- General anesthesia
- Considerable force, slowly applied over a padded fulcrum
Galeazzi Fracture - Radial Shaft Fracture with DRUJ Injury

- Usually at junction of middle and distal thirds
- Distal fragment typically angulated towards ulna
- Closed treatment for most
- Carefully assess DRUJ post reduction, clinically and radiographically
Galeazzi Equivalent

Radial shaft fracture with distal ulnar physeal injury instead of DRUJ injury

Distal ulnar physeal injuries have a high incidence for growth arrest
Galeazzi Fracture
12 Year Old Male FOOSH-Galeazzi Equivalent
S/P Closed Reduction

Distal ulnar epiphysis
ORIF Distal Ulna

Exposed end of metaphysis

Ulnar epiphysis
Pin fixation ulnar epiphysis and ulna to radius pin with above elbow cast
Distal Radius Fractures

- Most commonly fractured bone in children
- Metaphyseal most frequent, distal radial physeal second
- Simple falls most common mechanism
- Rapid growth may predispose, with weaker area at metaphysis
Distal Radius Fractures

- Metaphyseal
- Physeal – Salter II most common
- Torus
- Greenstick
- Complete - Volar angulation with dorsal displacement of the distal fragment most common
Distal Radius Fractures – Associated Injuries

- Frequently distal ulnar metaphyseal fracture or ulnar styloid avulsion
- Occasionally distal ulnar physeal injury – high incidence of growth disturbance
- Median or ulnar nerve injury – rare
- Acute carpal tunnel syndrome can occur, also rare
Nondisplaced Distal Radius Fractures - Treatment

- Below elbow immobilization
- 3 weeks
- Torus fractures are stable injuries and can be treated with a removable forearm splint
Displaced Distal Radius Fractures - Treatment

- Closed reduction usually not difficult
- Traction (reduce shear), recreate deformity and reduce using intact periosteal hinge
- Immobilize – many different positions of wrist and forearm rotation recommended
- Well molded cast / splint, above or below elbow, surgeon preference
- 3-4 weeks immobilization
“Repeated efforts at reduction do nothing more than grate the plate away.”

“These injuries unite quickly, so that attempts to correct malposition after a week are liable to do more damage to the plate than good.”

Rang, *Children’s Fractures* 1983.
Treatment Recommendations - # Reductions / Acceptable Alignment?

- No correlation between # reduction attempts and growth retardation.

- No correlation between post-reduction position and growth retardation.

- Noted a relationship between fracture type (Aitken III/S-H IV) and growth arrest.

Aitken, JBJS 1935.
Treatment Recommendations

“An attempt should be made to reduce all displacements... however, repeated manipulations or osteotomy are not warranted.”

“Displacement of the epiphysis does not persist. All displacements are reduced well within a year.”

“The one case of deformity in the series is attributed to crushing of the physis.”

Aitken, *JBJS* 1935.
Treatment Recommendations

“For Salter-Harris type I and II injuries in children younger than 10 years of age, angulation of up to 30° can be accepted. In children older than 10 years, up to 15° of angulation is generally acceptable.”

Displaced Distal Radius Fractures – Care after Closed Reduction

- Radiograph within one week to check reduction
- Do not remanipulate physeal fractures after 5-7 days for fear of further injuring physis
- Metaphyseal fractures may be remanipulated for 2-3 weeks if alignment lost
- Expect significant remodeling of any residual deformity
Remodeling Potential- 12 yo Male

Presented 10 days after fracture – no reduction, splinted in ED and now with early healing

At 6 months – extensive remodeling of deformity noted
Distal Radius Fractures - Complications

- Growth arrest unusual after distal radius physeal injury
- Malunion will typically remodel – follow for one year prior to any corrective osteotomy
- Shortening usually not a problem – resolves with growth

Remodeling in 8 months
Distal Radius Fracture – Indications for Operative Treatment

- Inability to obtain acceptable reduction
- Open fractures
- Displaced intraarticular fxs
- Associated soft tissue injuries
- Associated fractures (SC humerus)
- Associated acute carpal tunnel syndrome or compartment syndrome
Distal Radius – Fixation Options

- Smooth K wire fixation usually adequate
- Ex fix for severe soft tissue injury
- Some fxs amenable to plate fixation
Complications

• Premature Physeal Closure / Growth Arrest
  – 1.25% (Aitken, 1935)
  – 3% (Bragdon, 1965)
  – 7% (Lee, 1984)

• Nerve Injury
  – 8%

• Ulnar Styloid Nonunions
  – 27% (Aitken, 1935)
Growth Arrest following Distal Radius Fracture

Injury films  Injured and uninjured wrists after premature physeal closure
Distal Radius Growth Arrest

- Relatively rare ($< 1 - 7\%$)
- Severity of trauma
- Amount of displacement
- Repeated attempts at reduction?
- Remanipulation or late manipulation?
Conclusions

- Most common physeal plate injury (46%)
- Increased incidence of growth plate abnormalities with 2 or more reductions
- Acceptable alignment: 50% apposition
  - $30^\circ$ angulation
- Accept malreduced fractures upon late presentation (over 7 days).
- Growth arrest rate up to 7%
Carpal Injuries in Children

- Unusual / Uncommon in children
- Scaphoid most commonly fractured carpal bone
- Capitate / Lunate / Hamate fractures also can occur
- Make a habit of carefully checking carpal bones on every wrist film
Acute Distal Radius Metaphyseal Fracture in a 13 year Skateboarder

• Did you note the scaphoid nonunion?—patient gave history of a fall sustained one year ago with a “bad wrist sprain”
Distal Radius and Scaphoid Fractures
Scaphoid Fractures - Treatment

- Tender snuff box – immobilize until tenderness resolves
- If still tender at 1-2 weeks – repeat xray
- Confirmed fracture – if nondisplaced immobilize in above elbow cast for 6 – 8 weeks
- Displaced fracture - ORIF
Hand Fractures

- Metacarpal and phalangeal fractures – if displaced closed reduction
- Correct angulation and rotation
- Immobilize in intrinsic plus position
- 3-4 weeks
- Indications for ORIF – open fractures, displaced intraarticular fractures, inability to obtain / maintain reduction
Open Crush Injury to Hand
Distal Phalangeal Fractures

- Crush injuries – address any associated nail bed injuries
- If open give appropriate antibiotics, I&D
- Mallet finger injuries – often physeal injury
- Closed management
Middle and Proximal Phalangeal Fractures

- Closed management for majority
- ORIF for displaced intraarticular fractures
- Restore rotational alignment
Can use pencil in webspace trick or flex MP to 90 and push radially to reduce “extra-octave” fractures
Reduce and Fix Displaced Intraarticular Fractures
Metacarpal Fractures

- Closed management for most
- Accept less angulation in index than small finger