Elbow and Wrist Injury
Different to many other pediatric injuries,

**Pediatric elbow fractures**

- High rate of complications
- Non-op tx are not always good
- Very quick healing due to a good vascularization

require the precise, often surgical, reduction
✓ distal humerus fractures
  ; over 86% in pediatric elbow fractures
✓ supracondylar fx > lat. condylar fx
  > med. epicondylar fx
✓ 5 to 10 years, boys, summer season
✓ increased incidence with advanced age
  ; due to weakening of perichondral ring
Difficulties in diagnosis of elbow trauma:

1. severely swollen elbow in uncooperative children → not easy to have physical exam
2. unossified cartilage portion of elbow region → difficult to have accurate diagnosis on the x-ray
Capitellum       1 yr
Radial Head      5-6yrs
Med. epicondyle  5-7yrs
Olecranon        8-10yrs
Trochlea         9-10yrs
Lat. Epicondyle  10-12yrs
Radiographic Landmarks

- Tear drop
- Lateral humero-condyle angle (shaft-condylar angle)
- Anterior Humeral line
- Coronoid line
Radiocapitellar line

A line drawn down the long axis of the radius should bisect the capitellum regardless of degree of flexion of the elbow.
Fat Pad Signs

if present, there is almost always an associated fractures

⇒ treatment in a sling or a splint
Supracondylar Fractures

- the most common pediatric elbow fracture
- peak age: 3-8 years
- extension type: 98%
- flexion type: 2%
**Gartland classification**

**type I** (nondisplaced); immobilization

**type II** (displaced with posterior cortical contact):
  - cast
  - CR / perQ pinning: **preferred**
    (especially, a medially impacted, varus-type injury)

**type III** (completely displaced)
  - CR/ perQ Pinning
  - OR/ IF ← *for irreducible fx*
Supracondylar Fractures

**Type II**

Posteromedial displacement → “pronation”

- Reduction & Cast
  
  Risks: NV compromise, loss of reduction

- Percutaneous Pinning: better choice
Supracondylar Fractures

Type II

Initial

Reduction
Supracondylar Fractures

Humerus at supracondylar level

Stable reduction is difficult to maintain.

Varus & ant angulation
Supracondylar Fractures

**Type III**

- most difficult to treat
- possibility of complications
  - Neuro-vascular
  - Volkmann’s contracture
  - Stiffness
  - Deformity
Supracondylar Fractures

**Pucker Sign**

Spike of proximal fragment into subQ tissue
Supracondylar Fractures

Oblique fractures

- more common in older children
- tend to be less stable than transverse fx
Supracondylar Fractures

Percutaneous pinning

✓ degree of urgency
  (swelling, vascular status, skin integrity)
✓ acceptable delay of definitive treatment
  ; hand perfusion, N neurologic exam
✓ reduction technique
  i. longitudinal traction,
  ii. correction of medial or lateral displacement,
  iii. elbow flexion,
  iv. pronation or supination
Supracondylar Fractures

\textit{pin configuration}:

- crossed pins
- or 2 lateral pins
  \hspace{1cm} ; similar stability

- greatest possible distance
  \hspace{1cm} ; \textit{1/3 rule}
Supracondylar Fractures

trend: 2 bicortical lateral pins

- test stability
- add a medial pin

if there is persistent rotational instability
Supracondylar Fractures

✓ interposition of soft tissue
⇒ “milk” brachialis
from the spike of the fracture
Supracondylar Fractures

- If irreducible → open, selectively; anterior
Supracondylar Fractures

Kapandji technique
Supracondylar Fractures

Assess **Baumann angle**: $73 \pm 6^\circ$

- Lateral condylar physis & long axis of distal humerus

Compare contra-lateral elbow

*Loser’s View*
Supracondylar Fractures

Vascular complications

- most common with type-III injuries
- 0.5%, brachial a
- Arteriography: not mandatory
- **Pulseless extremity** ➔ Algorithm
  . reduce the fracture
  . capillary refill (−)/ pulse (−)/ Doppler (−)
  ➔ perQ pinning & exploration of brachial a.
Supracondylar Fractures

Compartment syndrome

. Observation for at least 24 hours after treatment of an acute fracture
. if suspected, the splint should be removed.
  → If the symptoms resolve, observation
  → If the symptoms persist
    : measure compartment pressures
    > 30 mm Hg or symptom (+)
    → fasciotomies are indicated
Neurologic injury

- 7 - 11%
- neuropraxia
- on the direction of the initial displacement
  - radial N: 35-45%, PM
  - median or anterior interosseous N: 32-40%, PL
- observation for recovery
  - 3-6 months ➔ spontaneous recovery in most
Supracondylar Fractures

posteromedial

posterolateral

radial N

median N

ant interosseous N
Supracondylar Fractures

*indication of exploration*

- neurologic deficit from reduction or pinning
- no recovery until 5-6 months on P-Ex or EMG
medial pin strategy

- elbow flexed <90°
- making a 1-cm incision medially when swollen
Supracondylar Fractures

Cubitus Varus

Mal-union

- From improper reduction in the coronal plane
- rare functional impairment
- Late open reduction after 21 days
  ➔ not recommended ➔ “osteotomy”
  * increase the risk of myositis ossificans
Supracondylar Fractures

Distal humeral osteotomy

Song (JBJS, 1997)

Chung (JSES, 2003)

Dome osteotomy
Lateral Condylar Fractures

Lateral condyle Fx

varus stress

to the extended elbow & supinated forearm

Oblique view is important ← oblique cleavage plane
Milch classification

**Type I**
- Stable
- Angulation
- less common

**Type II**
- Unstable
- Angulation +
- more common
Lateral Condylar Fractures

Jakob stage

I ; controversial
Splinting/ close F-U
→ 5 & 10 D FU
; if any displacement
Fixation

II & III ;
CRPP or ORIF

II (2-4mm)
III (> 4mm)
Lateral Condylar Fractures

Type II-initial

Per Q pinning

postop

final
Lateral Condylar Fractures

Type III
-initital

postop

final
Nonunion

✓ not recognized or late displacement
✓ options

. **repair** ; within 1 cm of the joint
  a large metaphyseal fragment

. **observation** ; late nonunion(>12 weeks)
  with a good position / pain free
  to prevent stiffness after bone graft
Lateral Condylar Fractures

Treatment of established nonunion of the lateral humeral condyle is controversial. (Pain, Stiffness)
Progressive Cubitus valgus
with Tardy ulnar nerve palsy

- cause: nonunion or malunion
- fx tx→ in situ bone graft (not the reduction)
  due to possible osteonecrosis or stiffness
- ant transposition of the ulnar N
Osteonecrosis

injury itself,

or extensive surgical soft-tissue dissection posteriorly at the time of fx fixation

⇒ “fishtail-deformity”,

but not symptomatic

Growth arrest
Medial Epicondylar Fractures

Medial epicondyle Fx

- 10% of all children’s elbow fx
- between 9 and 14 years
- valgus stresses
- with elbow DL; upto 50%
Medial Epicondylar Fractures

Immobilization alone

⇒ adequate function & range of motion

All but two patients of casting group were seen to have nonunion of the fragment, but all had a normal result on valgus stress-test.

Medial Epicondylar Fractures

operative treatment

✓ absolute indications
  . irreducible incarceration of the fragment within the elbow joint
  . open fracture

✓ relative indication
  ; gymnasts, pitchers, tennis players
  a great deal of valgus stress on the elbow
Medial Epicondylar Fractures

Severely displaced

entrapped

dislocated

Open reduction
Monteggia fractures

a fracture of the ulna with an associated radiocapitellar dislocation
Monteggia fractures

A line drawn along the axis of the radius through the radial head should bisect the capitellum on every radiographic view.
Monteggia fractures

Most can be treated by **CR** (strong perisoteum)

- **Incomplete** fx or plastic deformation of the ulna
  → **closed reduction**

- **Complete** ulna fracture → **op**
  - transverse or short oblique → IM fixation
  - long oblique, seg, or comm fx → plate fixation
Monteggia fractures

- open reduction of radial head
  with internal fixation of ulna

  - imperfect reduction of ulna,
  - infolded annular ligament,
  - buttonholing of radial head through joint capsule
Monteggia fractures

✅ open reduction with recon. of annular lig. and/or ulnar corrective osteotomy; more than 3-4 weeks after the injury
Monteggia fractures

**DDX:** congenital DL of radial head

- Symmetrical involvement,
- Dysplastic, dome-shaped, & small radial head
- Long and slender neck

- *Kim HT, JPO, 2002*
Olecranon Fractures

Olecranon Fx

older age (9 years)

than supracondylar fx

predominant cartilage

⇒ less chance of a fracture

thick periosteum & thin metaphyseal cortex

⇒ minimally displaced greenstick fx
Olecranon Fractures

associated with other fractures

Radial neck

Lateral condyle
Olecranon Fractures

Operative Treatment

✓ >3 mm of intra-articular displacement
✓ “sleeve fracture” -- apophyseal avulsion fx that occurs with the elbow flexed;
  small metaphyseal fleck of bone

➤ OR/IF; tension band suture?
  (avoid the need for later wire removal)
Radial Neck Fractures

Radial Neck Fx

3 patterns

✓ isolated fx

  (valgus force with extended forearm)

  -- impacted

✓ with elbow dislocation – flipped upto 180 degree

✓ with fracture- dislocation (Monteggia variants)
Radial Neck Fractures

- normal articular surface of the radial head:
  - $80^\circ$ with long axis of radius shaft on AP x-ray
- remodeling potential of radial neck fx
  - surprisingly good,
  - But, very sensitive to surgery
    - growth disturbance
Radial Neck Fractures

Treatment options

*depends on*
  .initial displacement
  .angulation
  .patient's age

- **observation**: less than 30°
- **closed reduction**: always attempt first, 30-60°
- **closed reduction & perQ K-wire**: failed manipulation
Radial Neck Fractures
Radial Neck Fractures

✓ **open reduction** ; only failed case
  . oblique K-wire placement / cast
  . transcapitellar fixation - risk of pin breakage
✓ **excision** ; never indicated
  even in a necrotic radial head
  some potential for healing / ideal biologic spacer
Fractures of Distal Humeral Physis

- Most often in very young children
- Cause: difficult birth, child abuse
- Usually a Salter-Harris type-II injury
Fractures of Distal Humeral Physis

difficult to diagnose

because the only ossified structure is the capitellum

Normal  Lat condyle fx  Supracondyle fx  DL  Fx-sep. epiphysis
Fractures of Distal Humeral Physis

- closed reduction & immobilization for 3-4 weeks
- closed reduction with pinning
  -- the early risk of loss of reduction
Fractures of Distal Humeral Physis
Fractures of Distal Humeral Physis

Complication

- cubitus varus
- osteonecrosis of the medial humeral condyle
  due to incomplete reduction
T-condylar or Intercondylar Fractures

✓ supracondylar fractures in adolescents
  ➡️ metaphyseal bone is **less plastic**
✓ same mechanism to cause supracondylar fractures
  / with higher energy
  ➡️ olecranon acts as a wedge,
      splitting the trochlea
T-condylar or Intercondylar Fractures

Displaced intra-articular fx >2-3 mm, 
→ open reduction; postero medial approach or olecranon osteotomy

- very young age → K-wire
- adolescent → similar to adult
Forearm Fractures

**Heterotropic ossification** – Worst complication
Forearm & Wrist Fx

Forearm fractures;
the most common orthopaedic injuries in children,
30-50% of all pediatric fractures
. distal 1/3; 75-84%,
> middle 1/3; 15-18% > proximal 1/3; <5%
Distal Radius Fractures

tremendous remodeling potential

. because of proximity to the distal radial physis
. <12 years; upto 20-25° of sagittal angulation
  >12 years; upto 10-15° of sagittal angulation
  / 10° of radial deviation
Distal Radius Fractures

unacceptable angulation or displacement

. Closed reduction / above-the-elbow cast for 3-4 weeks

. then, below-the-elbow cast for 1-2 weeks more

. reduction loss within the first 3 weeks

→ remanipulation with or without surgical fixation
**percutaneous pin fixation**

- provides stable, anatomic reductions
  - without the need for additional treatment

- indication;
  - neurovascular compromise,
  - significant soft tissue swelling,
  - initial angulation > 30, displacement > 50%,
  - concomitant fracture of elbow

*Distal Radius Fractures*
Distal Radius Fractures
Complication

- pin-track infection
- irritation of the radial sensory nerve
- irritation of an extensor tendon
Distal Radius Fractures

Nonunion as a Complication of an Open Reduction of a Distal Radial Fracture – Song KS, JOT 2003
Fractures of the distal radial physis

mostly type S-H type II
occur in adolescent
dorsal displacement with apex volar angulation

Tx
- CR & immobilization
- CR & PerQ pinning
  unstable injuries, severe swelling
  N-V compromise (acute carpal tunnel syndrome)
  ipsilateral displaced supracondylar fracture
Distal Radius Fractures

initial

Reduction-incomplete?
Distal Radius Fractures

2 months

5 months-satisfactory remodel
Fractures of the distal radial physis

complications

✓ **growth arrest**  
  2 factors; . amount of initial trauma  
  . iatrogenic injury (repeated reduction)  
  ➔ distal R-U incongruity, ulnocarpal impaction  

✓ **mal-union**  
  . rare ⇐ tremendous potential of remodeling  
  . if no remodeling ➔ osteotomy  

“Long-term prognosis of distal physeal injuries to forearm bones is generally good.” (JOT 2003, Cannato)
Fractures of the distal radial physis
Forearm both bone fractures

3 categories

on the basis of the pattern of injury

✓ plastic deformation
✓ greenstick
✓ complete diaphyseal fractures
Closed reduction / immobilization
in an above-the-elbow cast

obvious deformity and 15-20° of angulation

- apex-dorsal fx; the wrist is supinated
  volarly directed pressure to the fx site
- apex-volar fx; the wrist is pronated
dorsally directed pressure
Forearm both bone fractures

To maintain fx reduction

- Interosseous mold
- 3-point mold
- Flat ulnar border
- AP > lateral diameter
Forearm both bone fractures

supination  Neutral  pronation

Same direction
residual deformity

→ result in loss of forearm rotation / poor function
  ▪ ulna alignment; cosmetic appearance of the forearm
  ▪ radial alignment; forearm rotation

Reduction under general anesthesia should be considered in patients older than 6 years who have a cosmetically unacceptable bowing deformity that is greater than 10°.

-- CORR 2003, Vorlat
Forearm both bone fractures

M, 11 Yrs

Initial

F-U

5 mo
Forearm both bone fractures

Mal-rotation limits movement.
Forearm both bone fractures

Pre-op

osteoartomy

Post-op

final
Forearm both bone fractures

**considering factors for treatment**

✓ less than 1 yr of skeletal growth remaining
  ; limited remodeling potential
  → should be treated as adults (= OR/IF)

✓ age factor
  . under 8 yr; 15-20° / bayonet - acceptable
  . over 8 yr; < 10° - acceptable

✓ maximal rotational correction should be obtained.
  (up to 30° of rotational malalignment
   - minimal functional loss : ?)
Intramedullary K-wire fixation is a good alternative for children with unstable forearm fractures for whom nonoperative management failed.

-- Shoemaker, JPO 1999
Forearm both bone fractures

IM fixation for forearm both bone fx

**ideal for unstable transverse fractures**

- internal splint: maintaining both length & alignment
- longitudinal & angular stability
  - + some compression & distraction
  - stimulates abundant fracture callus formation
- rotation -- not completely controlled
- postop cast immobilization is required
**Forearm both bone fractures**

✓ Ø  -- 1/3 of medullary canal
   K-wires - younger patients
   flexible titanium nail - older children
✓ ulna first – from olecranon
✓ radius ; dorsal radial incision
   btw the 2\textsuperscript{nd} & 3\textsuperscript{rd} dorsal extensor comp

**Reangulation of the non-fixed bone is common**
*in diaphyseal both-bone forearm fractures*
*after single-bone intramedullary wire fixation.*

-- Lee, CORR, 2002
Galeazzi fractures

radius fx with dislocation of distal R-U joint

“Classic Galeazzi “ -- rare

“Galeazzi equivalent” with distal ulnar physeal injury

-- more common
Galeazzi fractures

Tx

Anatomic reduction of both radius & ulna
⇒ restore normal function

✓ Greenstick or incomplete fx
  ; Closed reduction
✓ Complete fx
  Inability to reduce the ulnar physeal fx
    (extensor or periosteum interposition)
  ; OR/ IF