Fractures and Dislocations about the Elbow in the Pediatric Patient

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Elbow Fractures in Children

• Very common injuries (approximately 65% of pediatric trauma)
• Radiographic assessment - difficult for non-orthopaedists, because of the complexity and variability of the physeal anatomy and development
• A thorough physical examination is essential, because neurovascular injuries can occur before and after reduction
• Compartment syndromes are rare with elbow trauma, but can occur
Elbow Fractures in Children: Physical Examination

- Children will usually not move the elbow if a fracture is present, although this may not be the case for non-displaced fractures.
- Swelling about the elbow is a constant feature, except for non-displaced fracture. Swelling may not develop in the first 12 to 24 hours.
- Complete vascular exam is necessary, especially in supracondylar fractures. The doppler device may be helpful to document vascular status.
- Neurologic exam is essential, as nerve injuries are common. In most cases, full recovery can be expected.
Elbow Fractures in Children: Physical Examination

- Neuro-motor exam may be limited by the child’s ability to cooperate because of age, pain, or fear.
- Thumb extension – EPL (radial – PIN branch)
- Thumb flexion – FPL (median – AIN branch)
- Cross fingers - Adductors (ulnar)
Elbow Fractures in Children: Physical Examination

- Always palpate the arm and forearm for signs of compartment syndrome.

- Thorough documentation of all findings is important. A simple record of “neurovascular status is intact” is unacceptable.

- Individual assessment and recording of motor, sensory, and vascular function is essential.
Elbow Fractures in Children: Radiographs

• AP and Lateral views are important initial views. In fracture situations, these views may be less than ideal, because it can be difficult to position the injured extremity.

• Oblique views may be necessary for evaluation, especially for the evaluation of suspected lateral condyle fractures.

• Comparison views frequently obtained by primary care or ER physicians, although these are rarely used by orthopaedists.
Elbow Fractures in Children: Radiograph Anatomy/Landmarks

- Bauman’s angle is formed by a line perpendicular to the axis of the humerus, and a line that goes through the physis of the capitellum.
- There is a wide range of normal for this value, and it can vary with rotation of the radiograph.
- In this case, the medial impaction and varus position reduces Bauman’s angle.
Elbow Fractures in Children: Radiograph Anatomy/Landmarks

- Anterior Humeral Line: This is drawn along the anterior humeral cortex. It should pass through the middle of the capitellum.
Elbow Fractures in Children: Radiograph Anatomy/Landmarks

• The capitellum is angulated anteriorly about 30 degrees.
• The appearance of the distal humerus is similar to a hockey stick.
Elbow Fractures in Children: Radiograph Anatomy/Landmarks

• The physis of the capitellum is usually wider posteriorly, compared to the anterior portion of the physis.
Elbow Fractures in Children: Radiograph Anatomy/Landmarks

- Radiocapitellar line – should intersect the capitellum
- Make it a habit to evaluate this line on every pediatric elbow film
Supracondylar Humerus Fractures

- Most common fracture around the elbow in children (60 percent of elbow fractures)
- 95 percent are extension type injuries, which produces posterior displacement of the distal fragment
- Occurs from a fall on an outstretched hand
- Ligamentous laxity and hyperextension of the elbow are important mechanical factors
- May be associated with a distal radius or forearm fracture
Supracondylar Humerus Fractures: Classification

- Gartland (1959)
  - Type 1  non-displaced
  - Type 2  Angulated/displaced fracture with intact posterior cortex
  - Type 3  Complete displacement, with no contact between fragments
Type 1: Non-displaced

• Note the non-displaced fracture (Red Arrow)

• Note the posterior fat pad (Yellow Arrows)
Type 2: Angulated/displaced fracture with intact posterior cortex
Type 2: Angulated/displaced fracture with intact posterior cortex

• In many cases, the type 2 fractures will be impacted medially, leading to varus angulation.

• The varus malposition must be considered when reducing these fractures, applying a valgus force for realignment.
Type 3: Complete displacement, with no contact between fragments
Supracondylar Humerus Fractures: Associated Injuries

- Nerve injury incidence is high, between 7 and 16% (radial, median, and ulnar nerve)

- Anterior interosseous nerve injury is most commonly injured nerve

- In many cases, assessment of nerve integrity is limited, because children can not always cooperate with the exam

- Carefully document pre-manipulation exam, as post-manipulation neurologic deficits can alter decision making
Supracondylar Humerus Fractures: Associated Injuries

- 5% have associated distal radius fracture
- Physical exam of distal forearm
- Radiographs if needed
- If displaced pin radius also
Supracondylar Humerus Fractures: Associated Injuries

• Vascular injuries are rare, but pulses should always be assessed before and after reduction.

• In the absence of a radial and/or ulnar pulse, the fingers may still be well-perfused, because of the excellent collateral circulation about the elbow.

• Doppler device can be used for assessment.
Supracondylar Humerus Fractures: Associated Injuries

- Type 3 supracondylar fracture, with absent ulnar and radial pulses, but fingers had capillary refill less than 2 seconds.
- The pink, pulseless extremity
Supracondylar Humerus Fractures - Anatomy

• The medial and lateral columns are connected by a thin wafer of bone, that is approximately 2-3 mm wide in the central portion.

• If the fracture is malreduced, it is inherently unstable. The medial or lateral columns displace easily into varus or valgus.
Supracondylar Humerus Fractures: Treatment

• Type 1 Fractures:
  • In most cases, these can be treated with immobilization for approximately 3 weeks, at 90 degrees of flexion. If there is significant swelling, do not flex to 90 degrees until the swelling subsides.
Supracondylar Humerus Fractures: Treatment

- Type 2 Fractures: Posterior Angulation
- If minimal (anterior humeral line hits part of capitellum) - immobilization for 3 weeks. Close follow-up is necessary to monitor for loss of reduction
- Anterior humeral line misses capitellum - reduction may be necessary. The degree of posterior angulation that requires reduction is controversial - check opposite extremity for hyperextension
- If varus/valgus malalignment exists, most authors recommend reduction.
Type 2 SCH Fractures: Treatment

- Reduction of these fractures is usually not difficult, although maintaining the reduction usually requires flexion beyond 90 degrees.
- Excessive flexion may not be tolerated because of swelling, and these fractures may require percutaneous pinning to maintain the reduction.
- Most authors suggest that percutaneous pinning is the safest form of treatment for many of these fractures, as the pins maintain the reduction and allow the elbow to be immobilized in a more extended position.
Supracondylar Humerus Fractures: Treatment

• Type 3 Fractures:
• These fractures have a high risk of neurologic and/or vascular compromise, and can be associated with a significant amount of swelling.

• Current treatment protocols use percutaneous pin fixation in almost all cases.

• In rare cases, open reduction may be necessary, especially in cases of vascular disruption.
Supracondylar Humerus Fractures: OR Setup

- The monitor should be positioned across from the OR table, to allow easy visualization of the monitor during the reduction and pinning.
Supracondylar Humerus Fractures: OR Setup

- The C-Arm fluoroscopy unit can be inverted, using the base as a table for the elbow joint.
- Also can use radiolucent board.
- The child should be positioned close to the edge of the table, to allow the elbow to be visualized by the c-arm.
Supracondylar Elbow Fractures: Type 2 with Varus Malalignment

- During reduction of medially impacted fractures, valgus force should be applied to address this deformity.
Type 3 Supracondylar Fracture
Type 3 Supracondylar Fracture, Operative Reduction

- Closed reduction with flexion
- AP view with elbow held in flexed position to maintain reduction.
Supracondylar Elbow Fractures: Type 2 with Medial Impaction

• The elbow may need to be held in a hyperflexed position to maintain the reduction during pinning.

• The lateral entry pins are placed with the elbow held in this position.
Brachialis Sign - Proximal Fragment Buttonholed through Brachialis
Milking Maneuver- Milk Soft Tissues over Proximal Spike

From Archibeck et al. JPO 1997
Adequate Reduction?

- No varus/valgus
- anterior hum line
- minimal rotation
- translation OK

From M. Rang, Children’s Fractures
Medial Impaction Fracture

Type II fracture with medial impaction – not recognized and varus / extension not reduced
Medial Impaction Fracture

Cubitus varus 2 years later
Lateral Pin Placement

- AP and Lateral views with 2 pins
Lee et al. – JPO 2002
C-arm Views

• Oblique views with the C-arm can be useful to help verify the reduction
Supracondylar Fracture: Pin Fixation

- Different authors have recommended different pin fixation methods.
- The medial pin can injury the ulnar nerve. Some advocate 2 or 3 lateral pins to avoid injuring the median nerve.
- If the lateral pins are placed close together at the fracture site, the pins may not provide much resistance to rotation and further displacement. If 2 lateral pins are used, they should be widely spaced at the fracture site.
- Some recommend one lateral, and one medial pin
Pitfalls of Pin Placement

- Pins Too Close together
- Instability
- Fracture displacement
- Get one pin in lateral and one in medial column
Supracondylar Humerus Fractures - Pin Fixation

- Many children have anterior subluxation of the ulnar nerve with hyperflexion of the elbow
- Some recommend placing two lateral pins, assess fracture stability
- If unstable then extend elbow to take tension off ulnar nerve and place medial pin
Supracondylar Humerus Fractures

- After the pins have been placed, and a stable reduction obtained, the elbow can be extended to review the AP radiograph. Baumann’s angle can be assessed on these radiographs, although there can be a wide range of normal values for this measurement.

- With the elbow extended, the carrying angle of the elbow should be reviewed, and clinical comparison as well as radiograph comparison can be performed to assure an adequate reduction.
Supracondylar Humerus Fractures

• If pin fixation is used, the pins are usually bent and cut outside the skin.
• The skin is protected from the pins by placing felt pad around the pins.
• The arm is immobilized.
• The pins are removed in the clinic 3 weeks later, after radiographs show periosteal healing.
• In most cases, full recovery of motion can be expected.
Supracondylar Humerus Fractures: Indications for Open Reduction

- Inadequate reduction with closed methods
- Vascular injury
- Open fractures
Supracondylar Humerus Fractures: Complications

- Compartment syndrome
- Vascular injury / compromise
- Loss of reduction / Malunion – cubitus varus
- Loss of motion
- Pin track infection
- Neurovascular injury with pin placement
Supracondylar Humerus Fractures - Flexion type

- Rare, only 2%
- Distal fracture fragment anterior, flexed
- Ulnar nerve injury - higher incidence
- Reduce with extension
- Often requires 2 sets of hands in Or, hold elbow at 90 degrees after reduction to facilitate pinning
Flexion Type
Flexion Type - Pinning
Distal Humeral Complete Physeal Separation

- Often in very young children
- May be sign of NAT
- Swollen elbow, “muffled crepitance” on exam
- Through area of wider cross sectional area than SC humerus fx
- Restore alignment, may need pinning
Lateral Condyle Fractures

- Common fracture, representing approximately 15 percent of elbow trauma in children
- Usually occurs from a fall on an outstretched arm
Lateral Condyle Fractures: Jakob Classification

- Type 1: Non-displaced fracture. Fracture line does not cross through the articular surface
- Type 2: Minimally displaced. Fracture extends to the articular surface, but the capitellum is not rotated or significantly displaced
- Type 3: Completely displaced. Fracture extends to the articular surface, and the capitellum is rotated and significantly displaced
Lateral Condyle Elbow Fractures: Treatment

- Type 1:
- Oblique radiographs may be necessary to confirm that this is not displaced. Frequent radiographs in the cast are necessary to ensure that the fracture does not displace in the cast.
Lateral Condyle Fractures: Jakob Type 2

If displaced more than 2 mm on any radiograph (AP / Lateral / Oblique views) - reduction and pinning. Closed reduction and percutaneous pinning can be attempted, but articular reduction must be anatomic.

• If displaced, and the articular surface is not congruous, ORIF is necessary

Fracture line exiting posterior metaphysis (arrow) typical for lateral condyle fractures
Type 3 Lateral Condyle Fractures: Jakob Classification

- ORIF is necessary
- A lateral Kocher approach is used for reduction, and pins or a screw are placed to maintain the reduction.
- Careful dissection needed to preserve soft tissue attachments (and thus blood supply) to the lateral condyle fragment, especially avoiding posterior dissection.
Lateral Condyle ORIF
Lateral Condyle Fractures: Complications

- Non-union: This usually occurs if the patient is not treated, or the fracture displaced despite casting.
- Well-described in fractures which were displaced more than 2 mm, and not treated with pin fixation.
- Late complication of progressive valgus and ulnar neuropathy reported.
Lateral Condyle Fractures - Complications

- AVN can occur after excessive surgical dissection
- Cubitus varus can occur, may be because of malreduction or a result of lateral column overgrowth
Medial Epicondyle Fracture

• Represents 5-10 percent of pediatric elbow fractures
• Occurs with valgus stress to the elbow, which avulses the medial epicondyle
• Frequently associated with an elbow dislocation
Medial Epicondyle Fracture: Classification and Treatment

- Nondisplaced and minimally displaced (less than 5 mm of displacement) - May be treated without fixation, and early motion to avoid stiffness.
- Displaced more than 5 mm - Treatment is controversial, with some recommending operative, and others recommending non-operative treatment. Some have suggested that surgery is indicated in the presence of valgus instability, or in patients who are throwing athletes.
- Only absolute indication is entrapped fragment after dislocation with incongruent elbow joint
- Long term studies – favor nonoperative treatment
Medial Epicondyle Fracture: Elbow dislocation with Medial Epicondyle Avulsion

After attempted elbow reduction, medial epicondyle avulsion fragment is obvious.
Medial Epicondyle Fracture:

- Elbow dislocation with medial epicondyle avulsion, treated with ORIF.
Displaced Medial Epicondyle Fracture

- 12 year old female UE weight bearing athlete
- Treated nonoperatively
- Full motion, no valgus instability at 6 weeks
- Returned to competition at 8 weeks
Olecranon Fractures

- Relatively rare fracture in children (increased incidence in children with OI)
- May be associated with elbow subluxation/dislocation, or radial head fracture.
- The diagnosis may be difficult in a younger child, as the olecranon does not ossify until 8-9 years.
- In older children, the fracture may occur through the olecranon physis.
- Anatomic reduction is necessary in displaced fractures, restore active elbow extension.
Olecranon Fractures

• Olecranon fracture treated with ORIF in 14 year old, with tension band fixation.
Rare Distal Humeral Fractures

- Lateral Epicondyle: rare, usually represent a small avulsion fracture. Treated with early mobilization.

- T-Condylar fractures: occur in patients that are almost skeletally mature. Treatment similar to adult intra-articular elbow fractures.

- Medial Condyle: rare, treated with ORIF if displaced.
Proximal Radial Fractures

• 1% of children’s fractures
• 90% involve physis or neck
• Normally some angulation of head to radial shaft (0-15 degrees)
• No ligaments attach to head or neck
• Much of radial neck extraarticular (no effusion with fracture)
Proximal Radial Fractures - Types

- Valgus fractures – Salter I or II (intraarticular fractures rare)
- Metaphyseal fractures
- Associated with elbow dislocations or proximal ulna fractures
- Can be completely displaced, rotated
Proximal Radius Fractures - Treatment

- Greater than 30 degrees angulation - manipulate
- Usually can obtain acceptable reduction in fractures with less than 60 degrees initial angulation
- Traction, varus force in supination & extension, flex and pronate
- Ace wrap or Esmarch reduction
Proximal Radius Fractures - Treatment

• Unable to reduce closed
• Percutaneous pin reduction
• Intramedullary pin reduction
• Open reduction via lateral approach
Completely Displaced, Malrotated Radial Neck Fracture

After closed reduction the articular surface (arrow) is facing distally, 180 degrees malrotated.
Proximal Radial Fractures - Complications

• Loss of forearm rotation
• Radial head overgrowth
• Premature physeal closure – valgus
• Nonunion of radial neck rare
• AVN
• Proximal synostosis
100% Displaced, Failed Closed Reduction
Open “closed” reduction- blunt pin to push radial head back onto neck
Pin Fixation Augmented by LAC for 3 Weeks
Monteggia lesions: Ulnar Fracture-Radial Head Dislocation
Bado Classification

- **Type I** – anterior radial head dislocation
- **Type II** – posterior radial head dislocation
- **Type III** – lateral radial head dislocation
- **Type IV** – associated fracture of radius
Monteggia Lesions

- Most important is to make the diagnosis initially
- Radiocapitellar line critical
- A commonly missed diagnosis
- Every ulna fracture should have good elbow joint radiographs to avoid missing Monteggia lesion
Monteggia Lesions

- Be wary of plastic deformation of ulna or minimally displaced ulna fracture with radial head dislocation
- On lateral radiograph the ulna should be straight

Note anterior bow of ulnar shaft, and anterior radial head dislocation
Monteggia Lesions – Initial Treatment

• Closed reduction of ulnar angulation
• Direct pressure over radial head
• Usually will reduce with palpable clunk
• Immobilize in reduced position
• Supinate forearm for anterior dislocations
• Frequent radiographic follow-up to document maintenance of reduction
Monteggia Lesions

• If unable to obtain or maintain reduction of radial head

• Operative stabilization of ulnar fracture to correct angulation (oblique fractures may need plate fixation)

• Assess radial head stability- flexion may help for anterior dislocation
Missed Monteggia Lesion

Anterior radial head dislocation and heterotopic ossification

Healed prox ulna fx with anterior bow
Missed Monteggia Lesions - Possible Long Term Sequelae

- Progressive valgus
- Proximal radial migration with disruption of normal forearm and distal radioulnar joint mechanics
- Posterior interosseous nerve traction palsy
- Collateral ligament instability
Missed Monteggia Lesions – Treatment Options

- Annular ligament reconstructions – Bell-Tawse, fascia lata, Peterson
- Ulnar osteotomy
- Combination
- Transcapitellar pinning – be wary of possible pin breakage
Missed Monteggia – Ulnar Osteotomy and Radiocapitellar Pin

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