Fractures and Dislocations about the Elbow in the Pediatric Patient

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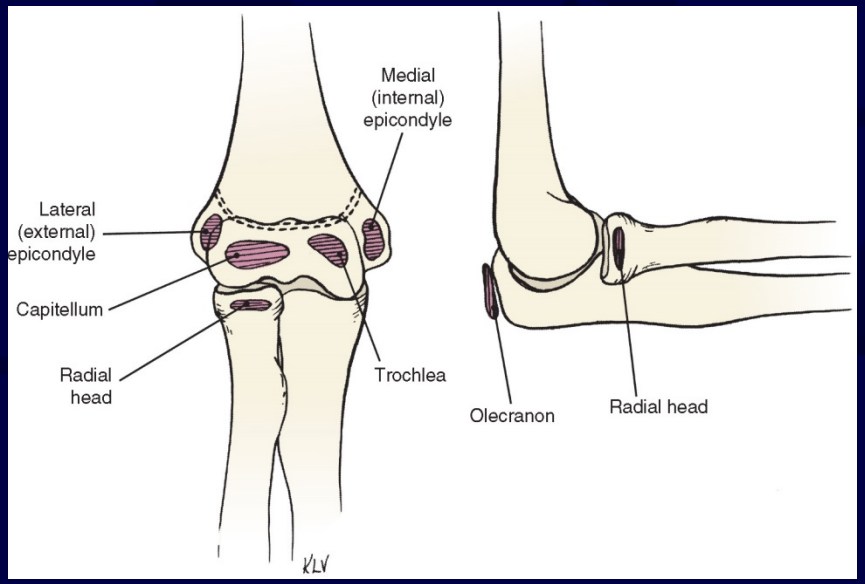
Elbow Fractures in Children

- Very common injuries (approximately 65% of pediatric trauma)
- Radiographic assessment
  - difficult for non-orthopaedists
  - Complex physeal anatomy and development



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Elbow Fractures
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
- Neurologic exam is essential, as nerve injuries are common
  - neurovascular injuries can occur before and after reduction
  - In most cases, full recovery can be expected

Elbow Fractures
Physical Examination

- Neurological 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/scissors - Ad/Abductors
  - Ulnar

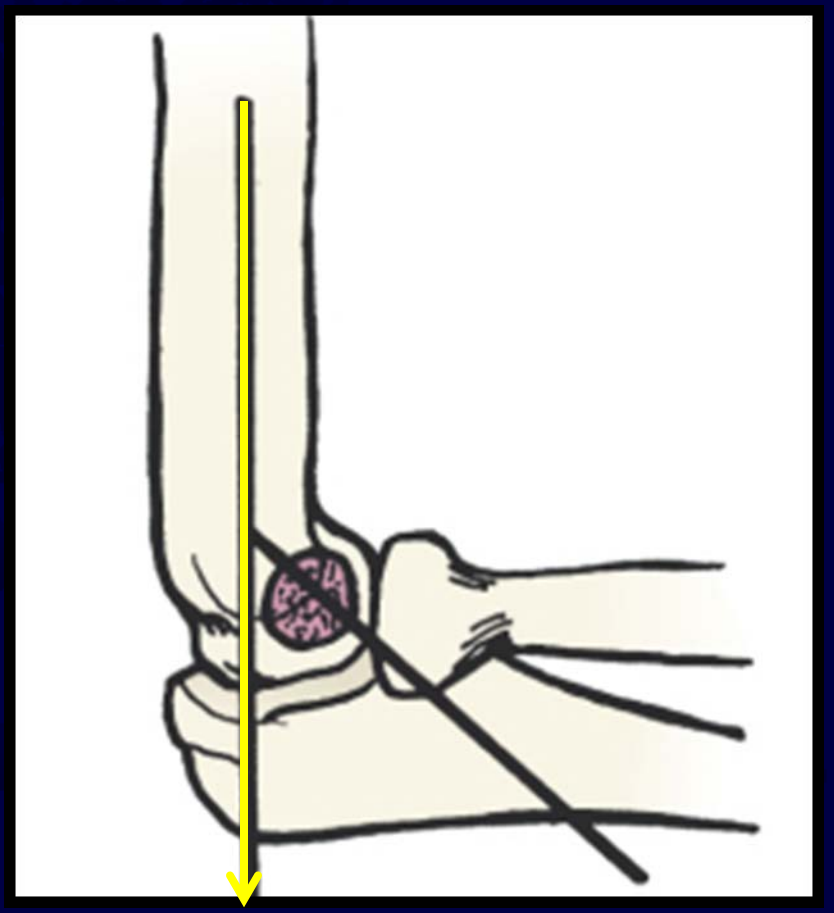
Elbow Fractures
Radiographs

- AP and Lateral views are important initial views
  - In trauma these views may be less than ideal, because it can be difficult to position the injured extremity
- Oblique views may be necessary
  - 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
Radiograph Anatomy/Landmarks

- Anterior Humeral Line
  - Drawn along the anterior humeral cortex
  - Should pass through the middle of the capitellum
  - Variable in very young children

-Herman. Relationship of the anterior humeral line to the capitellar ossific nucleus: variability with age. J Bone Joint Surg. 2009;91:2188.



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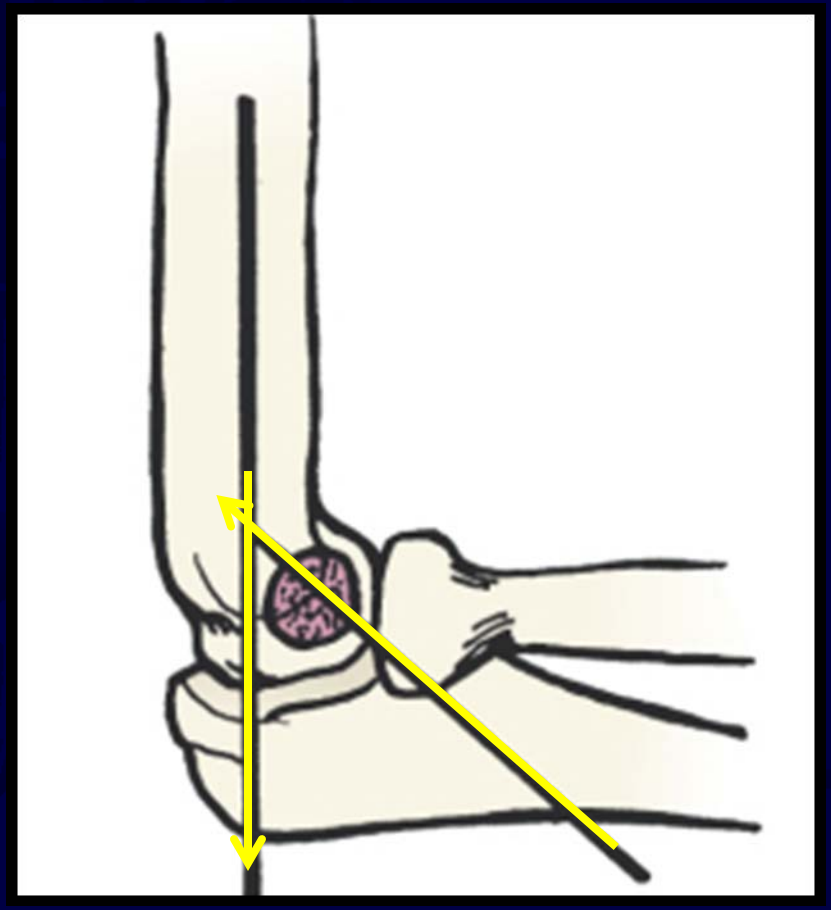
Elbow Fractures
Radiograph Anatomy/Landmarks

- The capitellum is angulated anteriorly about 30 degrees.
- The appearance of the distal humerus is similar to a hockey stick.



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Elbow Fractures
Radiograph Anatomy/Landmarks

- The physis of the capitellum is usually wider posteriorly, compared to the anterior portion of the physis

Elbow Fractures
Radiograph Anatomy/Landmarks

- Radiocapitellar line should intersect the capitellum *in all views*
- Make it a habit to evaluate this line on every pediatric elbow film

Supracondylar Fractures

- Most common elbow fx in children & adolescents
- 50 – 70% of all elbow fx.
- Frequently seen btw 3-10 yrs.
- 2 Types
  - Extension Type
  - Flexion Type

Courtesy of AL McIntosh

Appropriate Use Criteria

- 2014: AAOS adopted appropriate use criteria (AUC) for the management of pediatric supracondylar humerus fractures.
- 2015 : AUC for pediatric supracondylar humerus fractures with vascular injury
- These AAOS references should be reviewed prior to engaging in the treatment of a pediatric supracondylar humerus fracture.

Appropriate Use Criteria: Management of Pediatric Supracondylar Humerus Fractures. Journal of the American Academy of Orthopaedic Surgeons, 2015. 23(10): p. e52-e55.

Extension Type

- **95-98%** of all SCH fx
- Mechanism →FOOSH
- Forces the elbow into hyperextension.
- Olecranon acts as a fulcrum.
- Force propagates across medial & lateral columns
- **Distal fragment : posterior**

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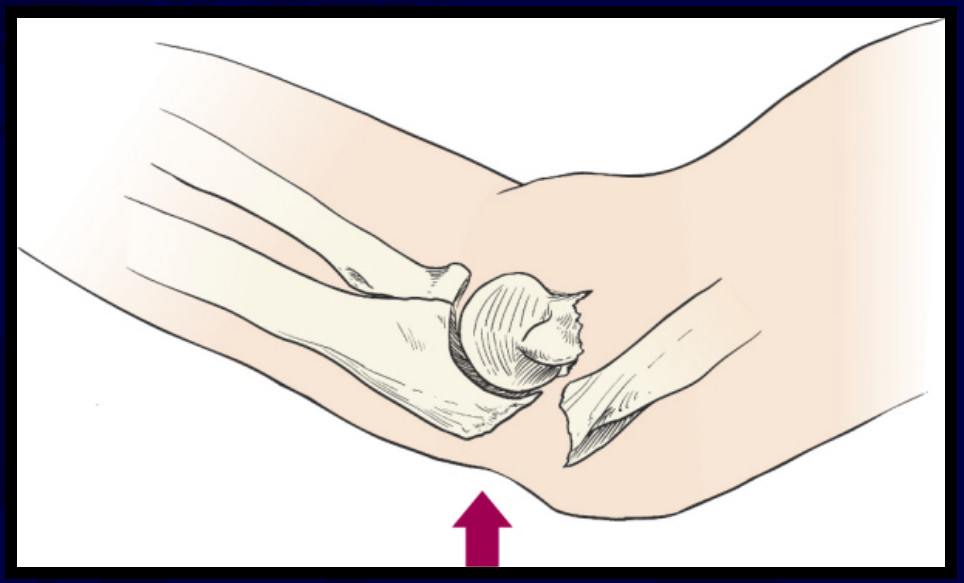
Flexion Type

- 2- 5% of SCH fx.
- Mechanism → Direct blow to a flexed elbow.
- Distal Fragment : Anterior



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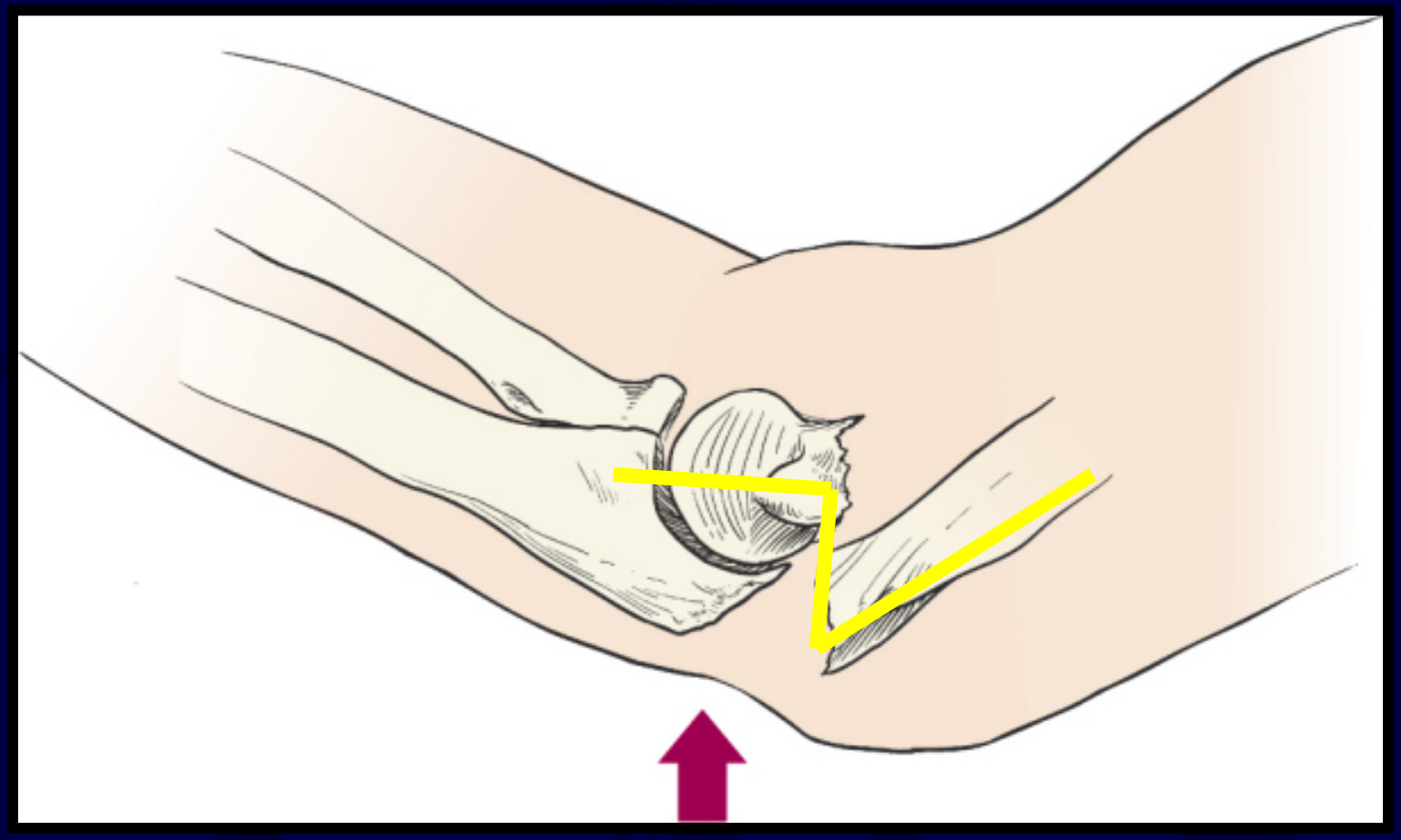


Ulnar n. tented over posterior Margin of prox. Fx.

Flexion Type

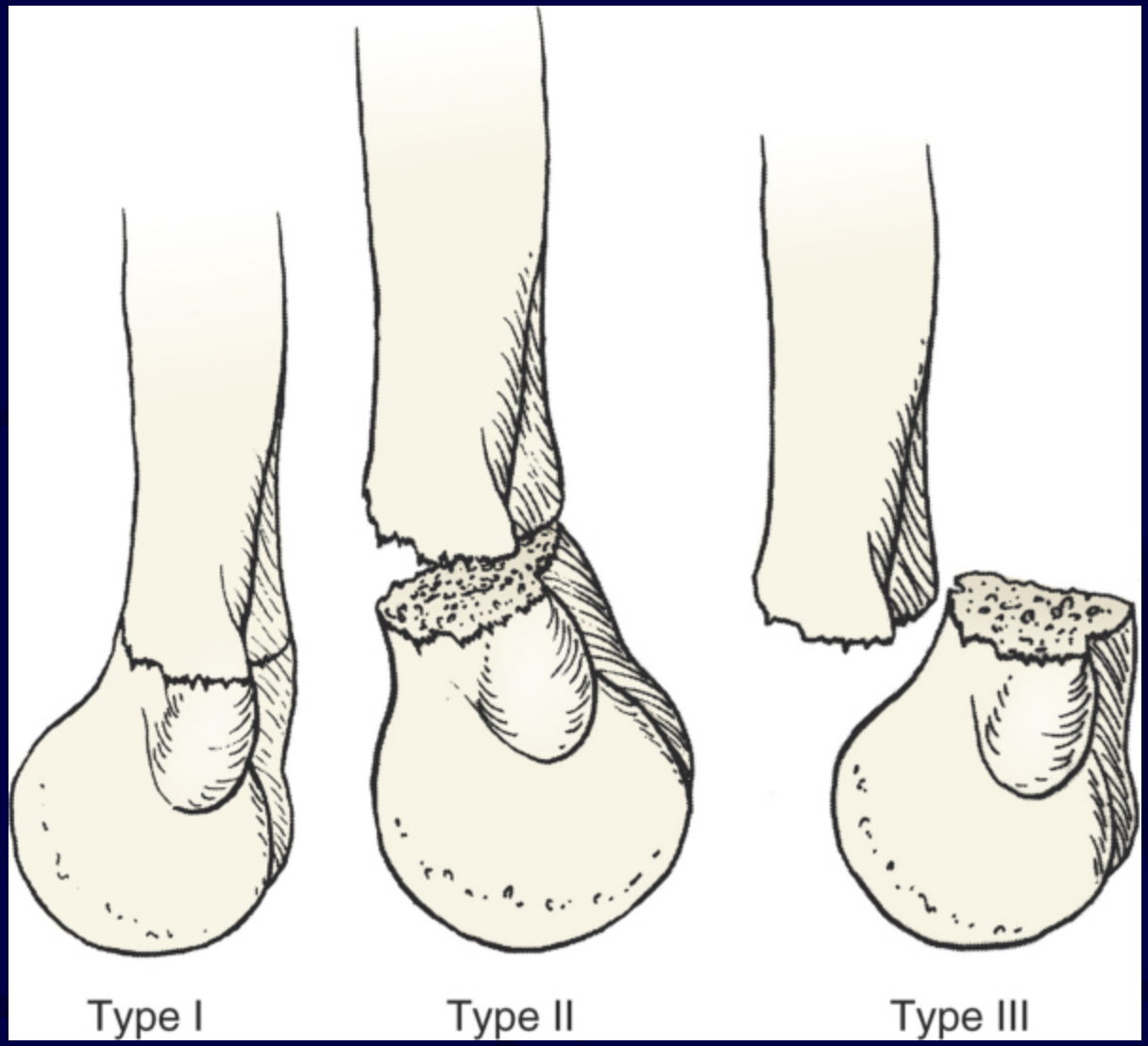
- Mahan et al: JPO 27(5) 2007
- n= 58 (1994- 2004)
- 3%: SCH II & III = flexion
- Older (7.5 yrs vs. 5.8 yrs)
- Increased need for open reduction (31% vs. 10%)
- Ulnar nerve injury (19% vs. 3%)
- Need for ulnar nerve decompression (19% vs. 0.5%)

Courtesy AL McIntosh

Gartland Classification (1959)

- **Type I-** no displacement
- **Type II-** moderate displacement
  - **Posterior cortex intact**
  - Plastic Deformation Possible
- **Type III-** severe displacement
  - **Ant & post cortex disruption**
- **Type IV**: multi-directionally unstable
  - Skaggs: JBJS 88A, 2006

Surg Gyn Obstet 1959 109(2) 145-154.



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extension

Type IV

flexion

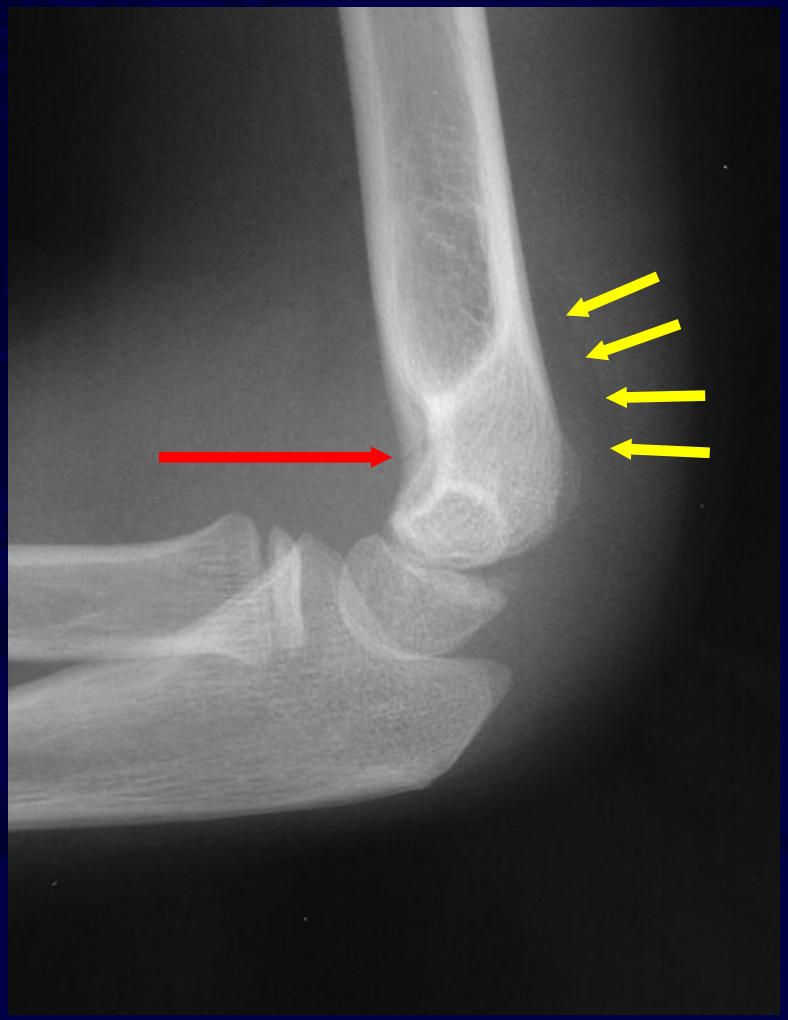
Courtesy of AL McIntosh

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

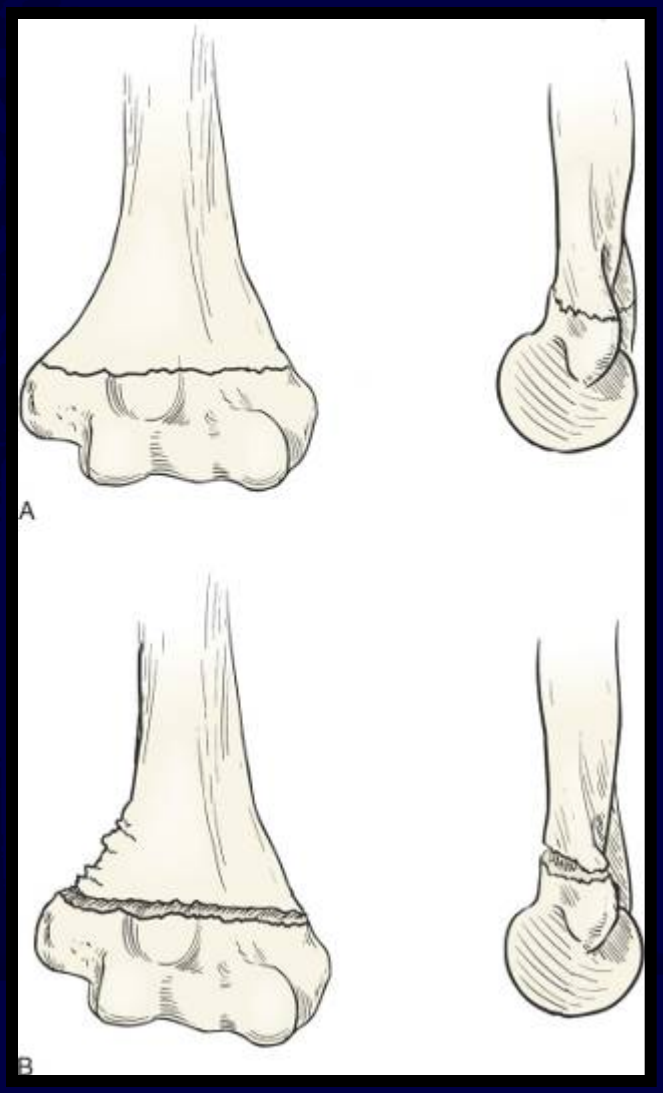
Type 1
Non-displaced

- Note the non-displaced fracture (Red Arrow)
- Note the posterior fat pad (Yellow Arrows)



Type I Subdivision

- (1994) Mubarak & Davids: Master Tech-Elbow.
- **Type IA:** nondisplaced → cast
- **Type IB:** medial comminution → **CRPP**
  - More unstable
  - Varus/hyperextension malunion



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Type 2 Fractures
Treatment

- Reduction of these fractures is usually not difficult
  - Maintaining reduction usually requires flexion beyond 90˚
- Excessive flexion may not be tolerated because of swelling
  - May require percutaneous pinning to maintain reduction
- Most authors suggest that percutaneous pinning is the safest form of treatment for many of these fractures
  - Pins maintain the reduction and allow the elbow to be immobilized in a more extended position

Fitzgibbons. Predictors of failure of nonoperative treatment for type-2 supracondylar humerus fractures. J Pediatr Orthop. 2011;31:372.

Supracondylar Humerus Fractures Treatment

- Type 3 Fractures
  - These fractures have a high risk of neurologic and/or vascular compromise
  - 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

Type III → CRPP

Courtesy of AL McIntosh

Ipsilateral Fx of distal radius (5%)

Courtesy of TSRH/CMC

Supracondylar Humerus Fractures Associated Injuries

- 5% have associated distal radius fracture
- Physical exam of distal forearm
- Radiographs if needed
- If displaced pin radius also
  - Difficult to hold appropriately in splint

Courtesy of TSRH/CMC

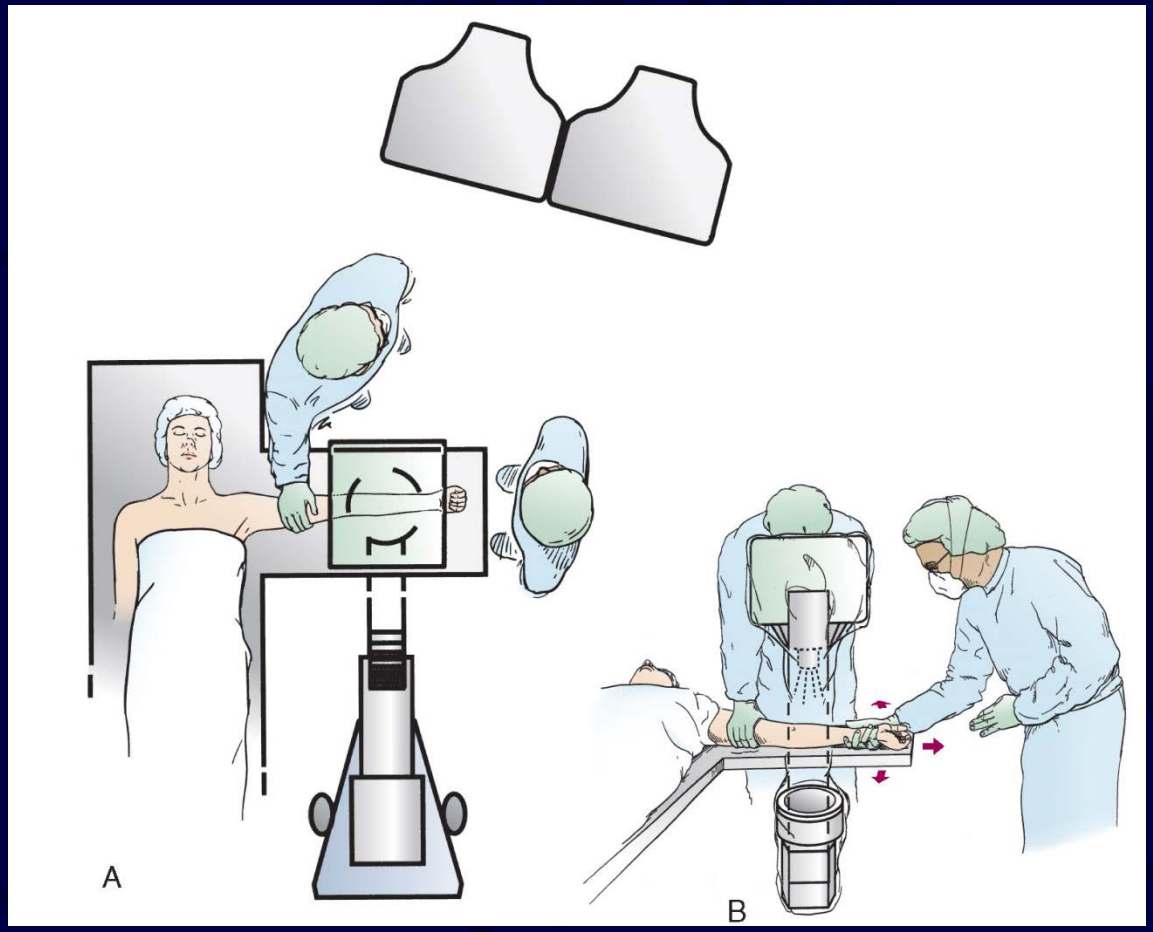
How to perform a CRPP

Brachialis Sign

Proximal Fragment Buttonholed through Brachialis

Courtesty of TSRH/ CMC

1. Correct coronal plane alignment & re-establish Length



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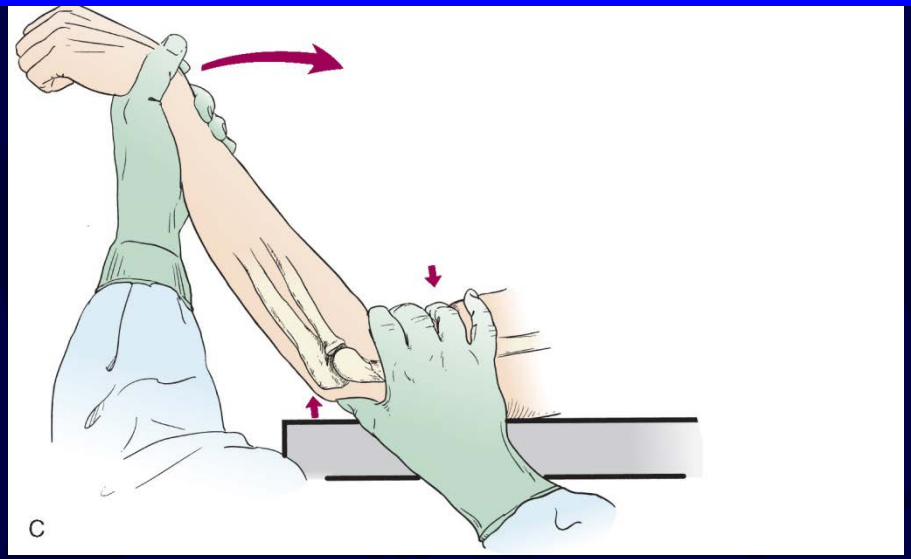
With the elbow in extension, align the distal fragment to the proximal fragment in the coronal plane.

3.Correct Angulation and Posterior Displacement



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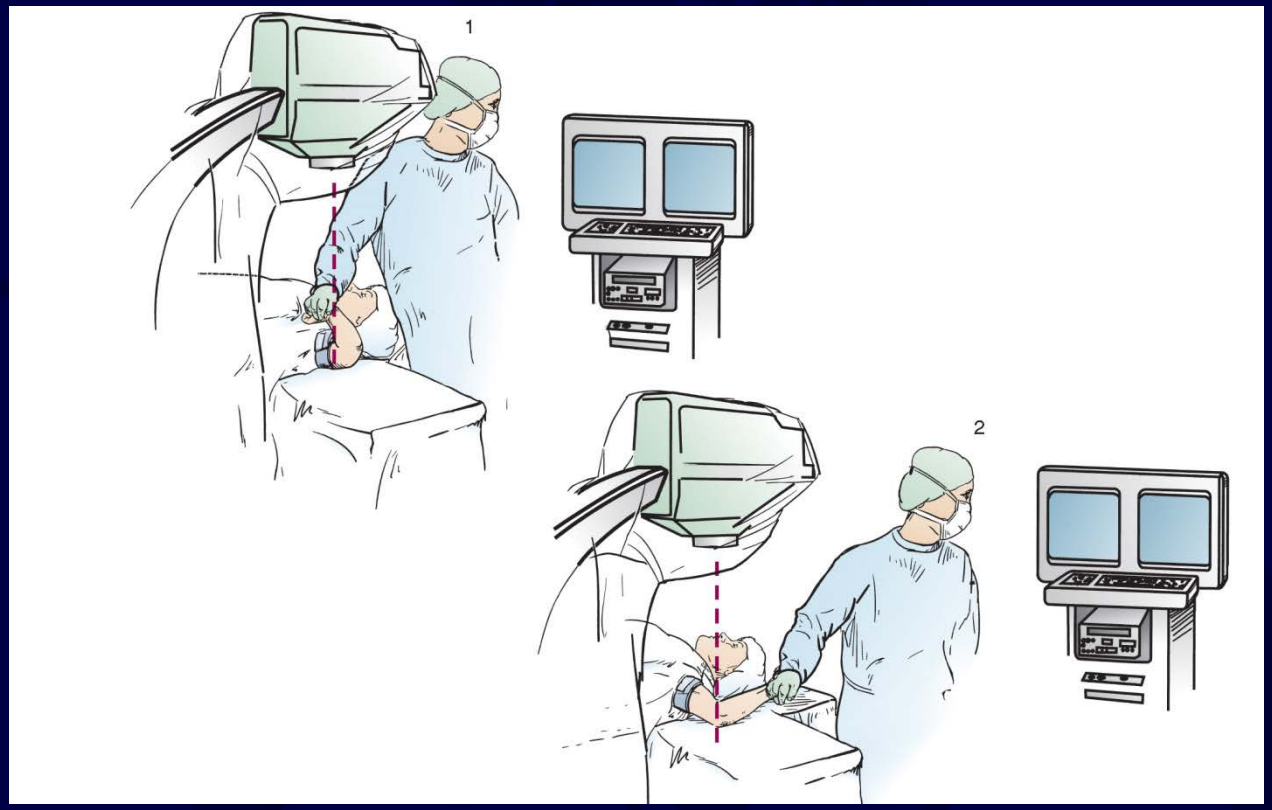
Apply longitudinal traction with the elbow semi-flexed,

Then, slowly flex the elbow to bring the distal fragment into alignment.

while applying posterior pressure on the proximal fragment.

Once the fragments are reduced,



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hyper-flex the elbow

with hyper-pronation

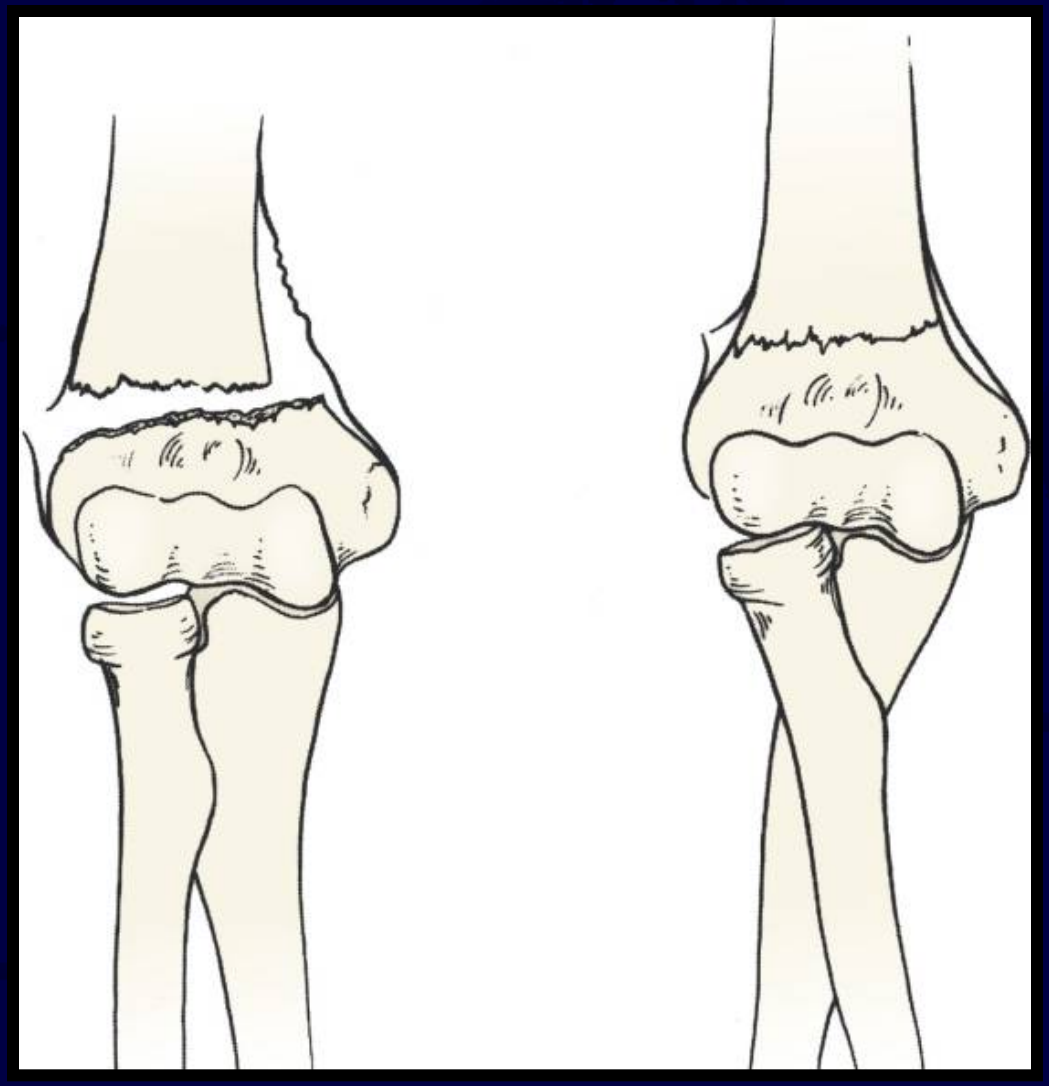
Then, confirm the reduction in full external rotation on the monitor.

Rule of Thumb

- **Thumb should point in the direction of initial displacement.**

- **Posterolateral (25%): Supinate → tightens the intact lateral soft tissue sleeve.**
- **Posteromedial (75%) : Pronate → tightens the intact medial soft tissue sleeve.**

Posteromedial displacement → pronate forearm to tension the intact medial tissues



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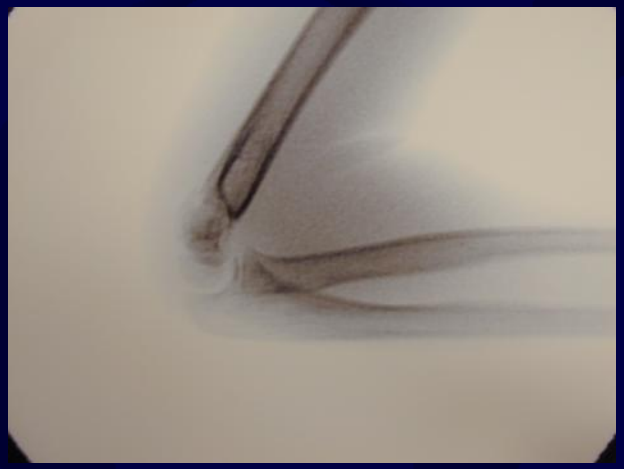
Type 3
Operative Reduction

- Closed reduction with flexion



- AP view with elbow held in flexed position to maintain reduction.

Courtesy of AL McIntosh

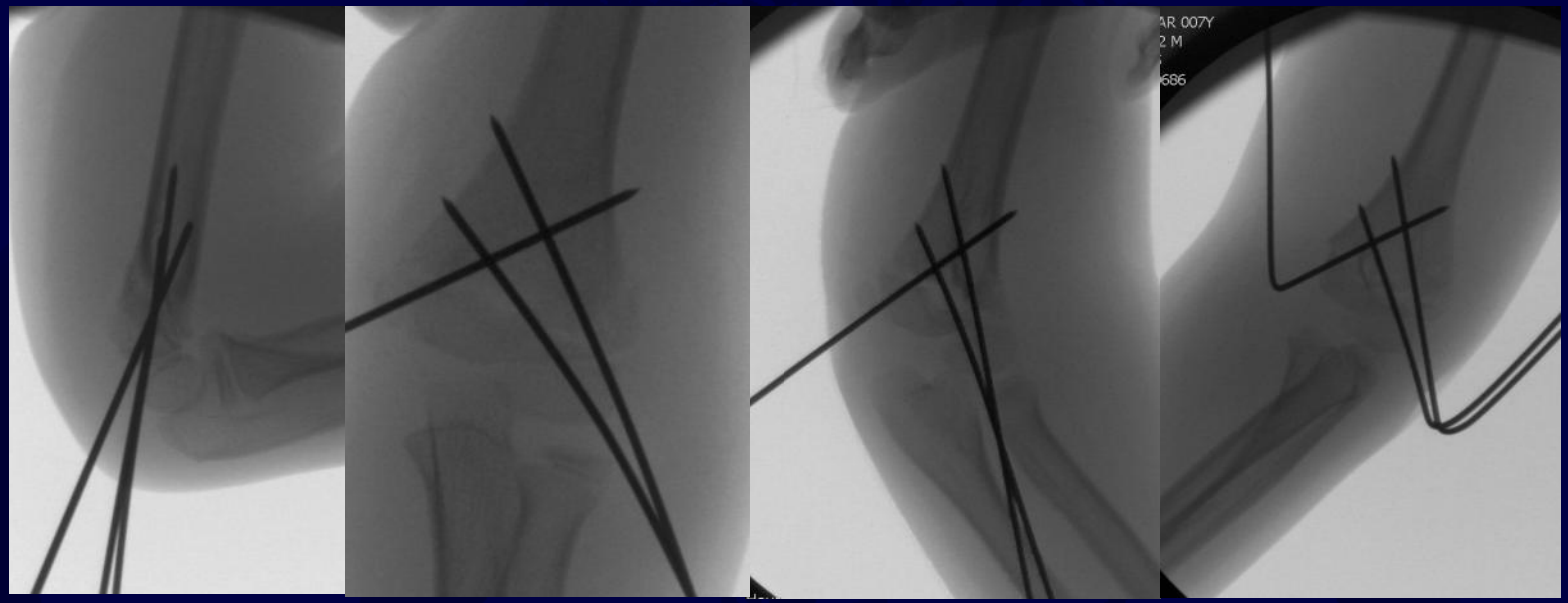
Which pin pattern is better??

Courtesy of AL McIntosh

Brauer et al: JBJS 89A, 2007

- Systematic Review
- N = 2054
- 35 studies
- Standard crossed pins: **5.04X** higher probability of **iatrogenic ulnar n. injury**
- Crossed pins: more stabile (0.58x) less likely to lose reduction

C-arm Views



Oblique views with the C-arm can be useful to help verify the reduction.

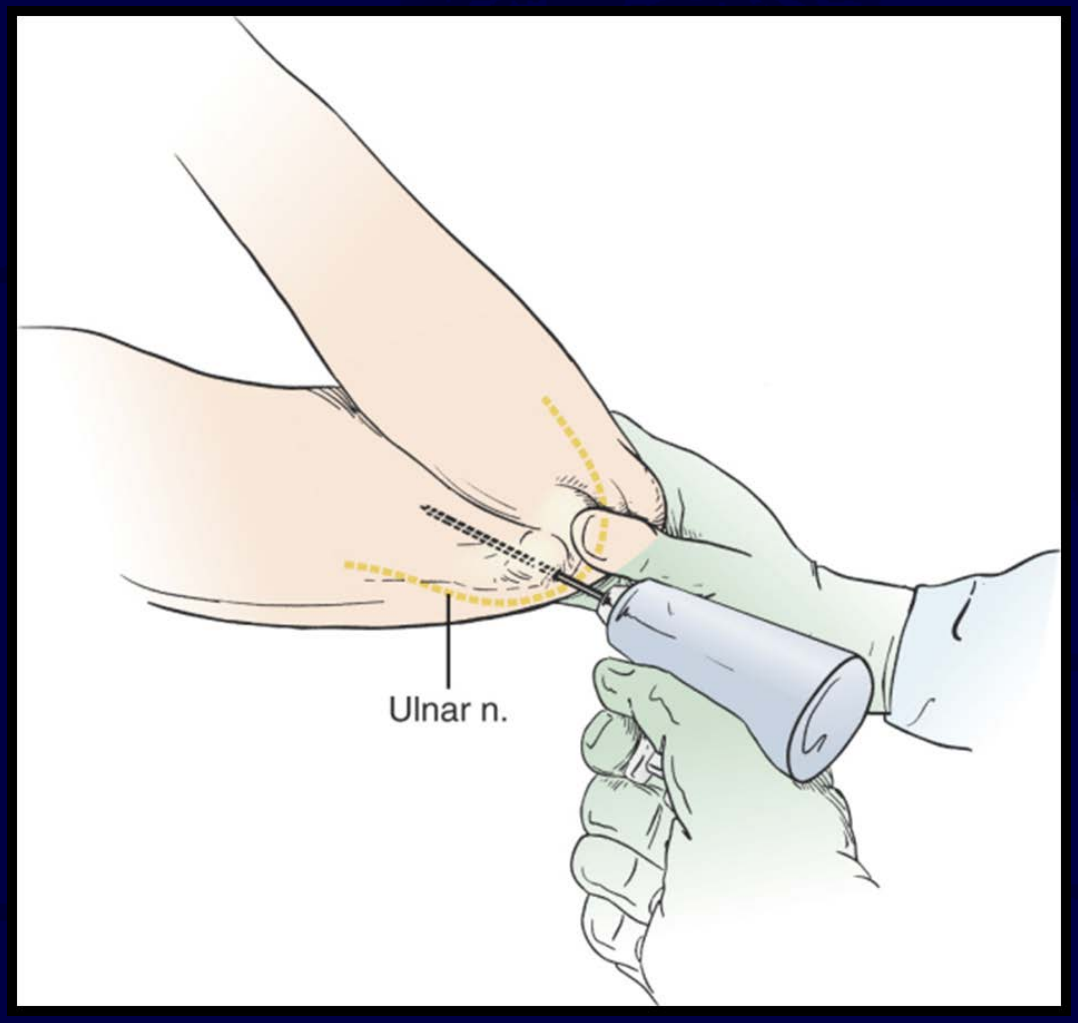
Note slight rotation and extension on medial column (right image).

Supracondylar Humerus Fractures Pin Fixation

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

Eberl. Iatrogenic ulnar nerve injury after pin fixation and after antegrade nailing of supracondylar humeral fractures in children. Acta Orthop. 2011;82:606.

Placement of medial pin w/ulnar nerve protected



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Supracondylar Humerus Fractures

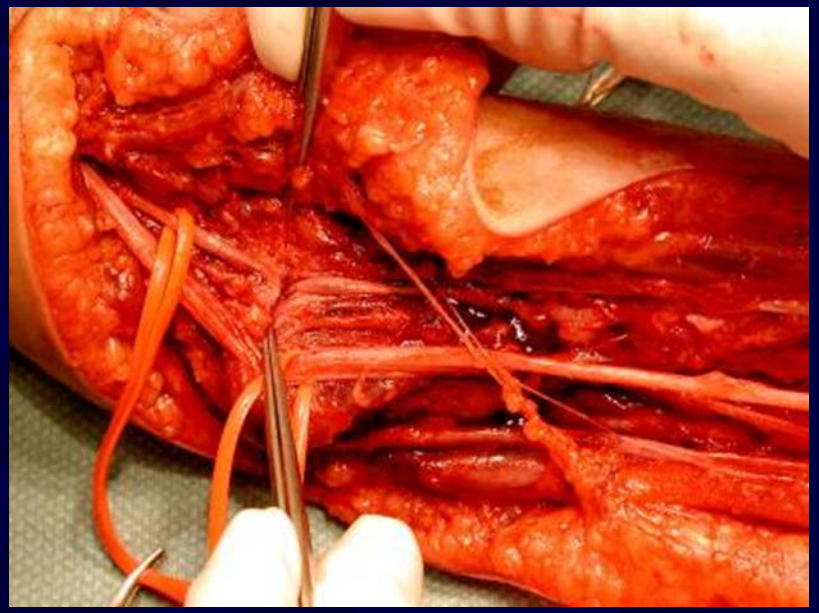
- After stable reduction and pinning
  - Elbow can be extended to review the AP radiograph
  - Baumann's angle can be assessed on these radiographs
    - Remember there can be a wide range of normal values for this measurement
- With the elbow extended, the carrying angle of the elbow should be reviewed, 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 a felt pad around the pins
- The arm is immobilized
- The pins are removed in the clinic 3 to 4 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



Couretsy of TSRH/CMC

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

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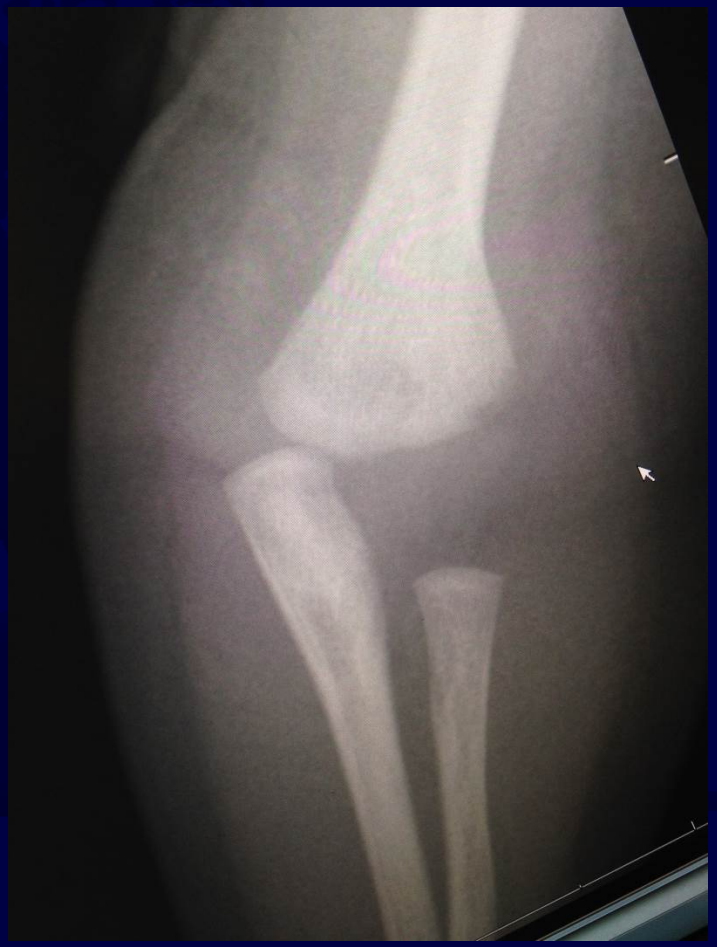
Distal Humeral Complete Physeal Separation

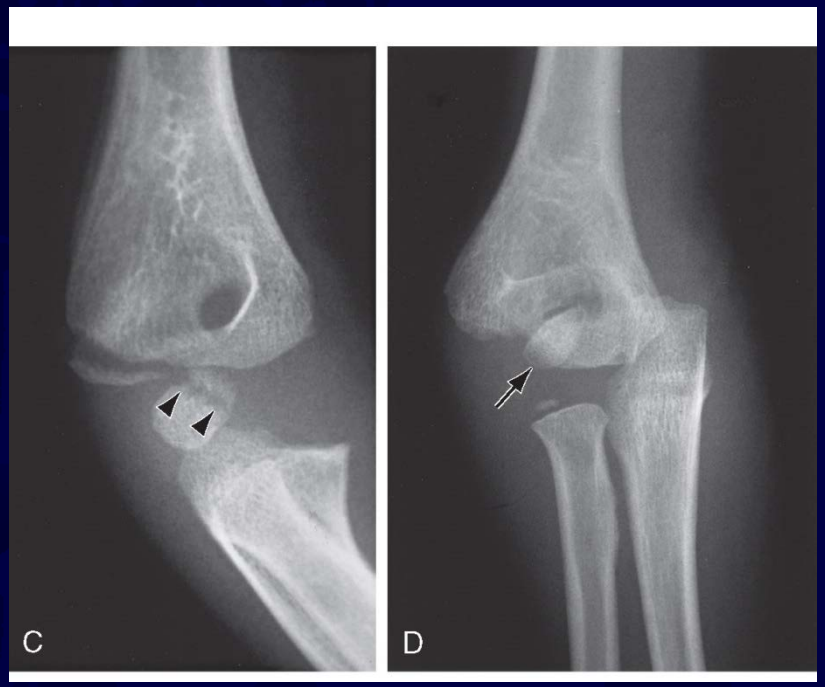
- Often in very young children
- May be sign of NAT
- Swollen elbow,“muffled crepitance” on exam
- Through area of wider cross sectional area than SC humerus fx
- Restore alignment, may need pinning



Courtesy of TSRH/CMC

Lateral Condyle Fractures

- Common fracture, representing approximately 15% of elbow trauma in children
- Usually occurs from a fall on an outstretched arm



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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

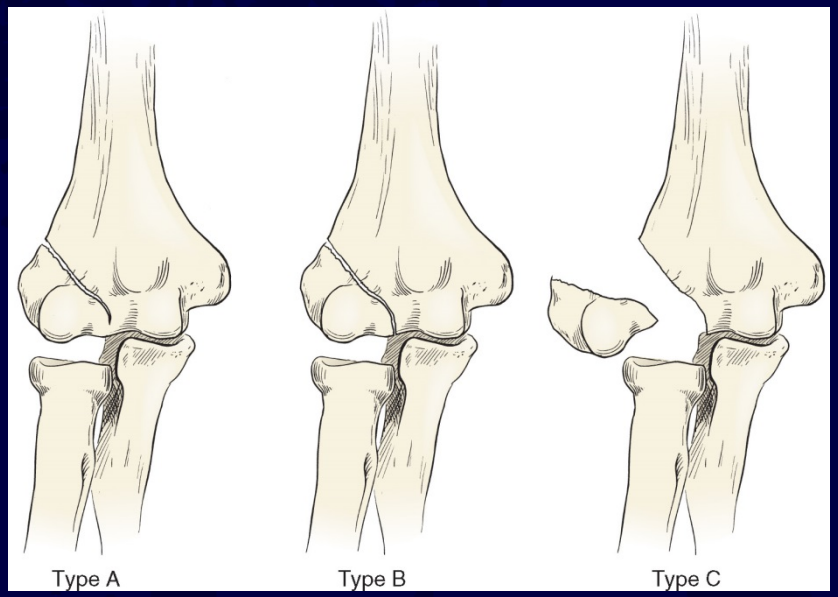

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Figure 33-72

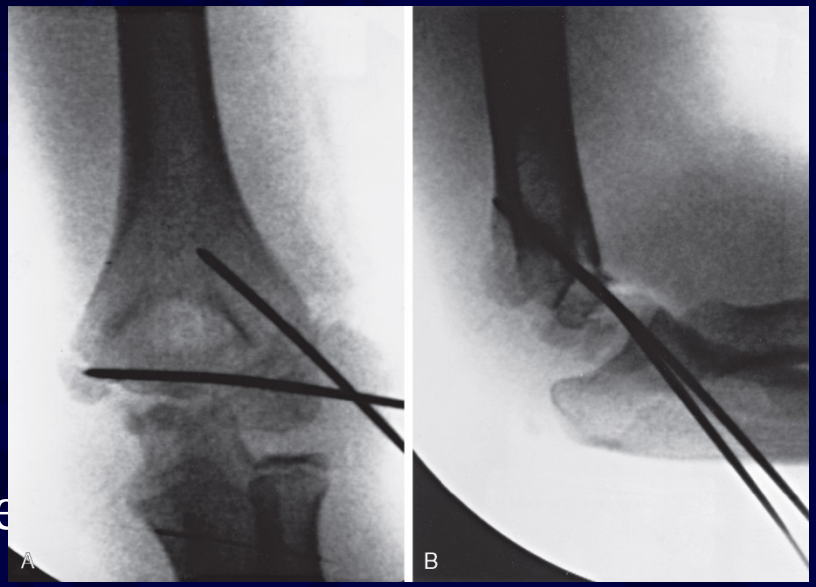
Jakob. Observations concerning fractures of the lateral humeral condyle in children. J Bone Joint Surg Br. 1975;57:430.

Lateral Condyle Fractures

- 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

- Displaced more than 2 mm
  - On any radiograph (AP/Lateral/Oblique views)
  - Reduction and pinning
  - Closed reduction can be attempted, but articular reduction must be anatomic
- If residual displacement and the articular surface is not congruous
  - Open reduction is necessary



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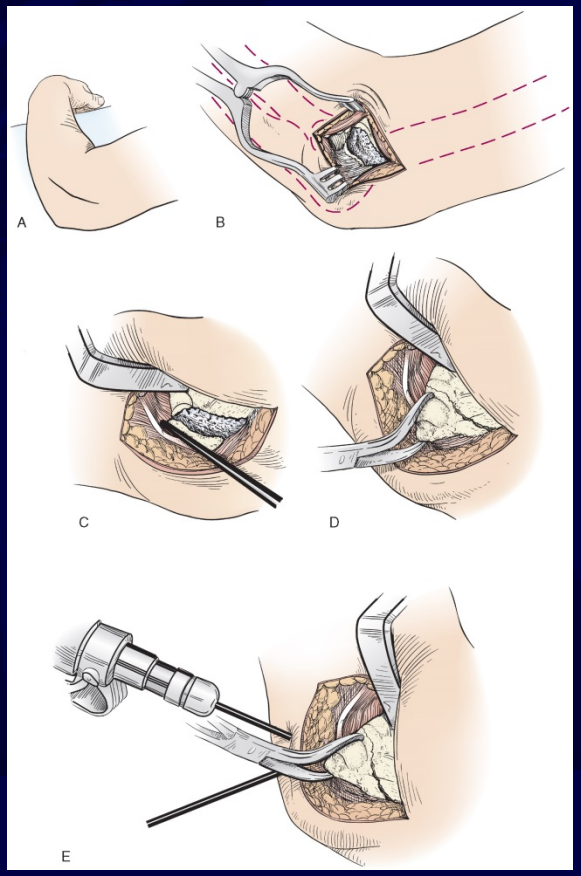
A new classification system predictive of complications in surgically treated pediatric humeral lateral condyle fractures. J Pediatr Orthop. 2009 Sep;29(6):602-5

Lateral Condyle Fractures
Jakob Type 3

- ORIF is *almost always* 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 condylar fragment, especially avoiding posterior dissection



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Lateral Condyle Fractures Complications

- Non-union
  - This usually occurs if the patient is not treated, or the fracture displaces 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

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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

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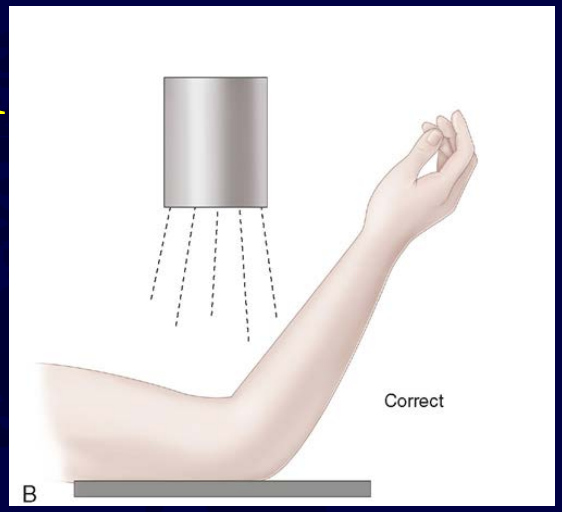
Medial Epicondyle Fractures

- Represent 5% to 10% of pediatric elbow fractures
- Occurs with valgus stress to the elbow, which avulses the medial epicondyle
- Frequently associated with an elbow dislocation

Landin. Elbow fractures in children. An epidemiological analysis of 589 cases. Acta Orthop Scand. 1986;57:309.

Medial Epicondyle Fractures Classification



- No good systematic method of classification
- Studies vary on how to measure displacement
- The best x-ray is obatined by positioning the central ray above the shoulder at 15 to 20 degrees from the long axis of the humerus, centered on the distal humerus.

J Pediatr Orthop. 2015 Jul-Aug;35(5):449-54.

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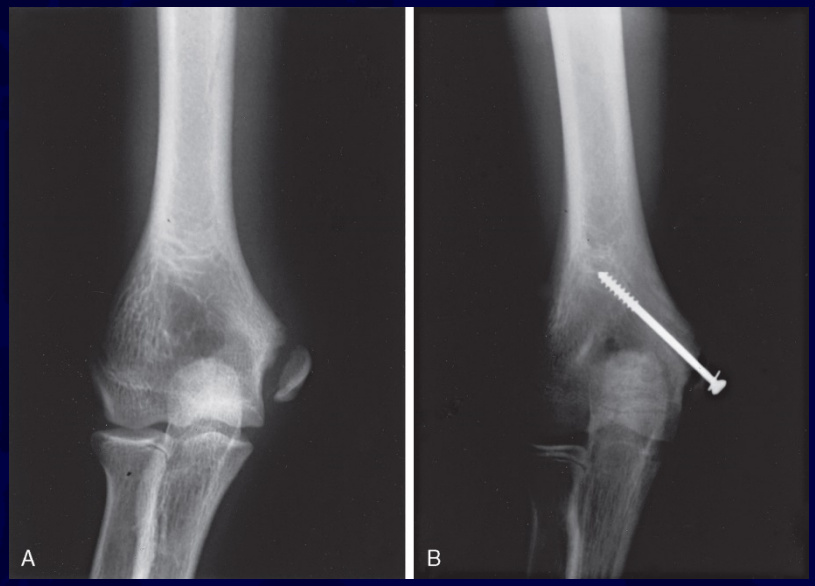
Medial Epicondyle Fractures Treatment

- Nondisplaced and minimally displaced
  - Less than 5 mm of displacement
  - May be treated without fixation
  - Early motion to avoid stiffness (3 to 4 weeks)



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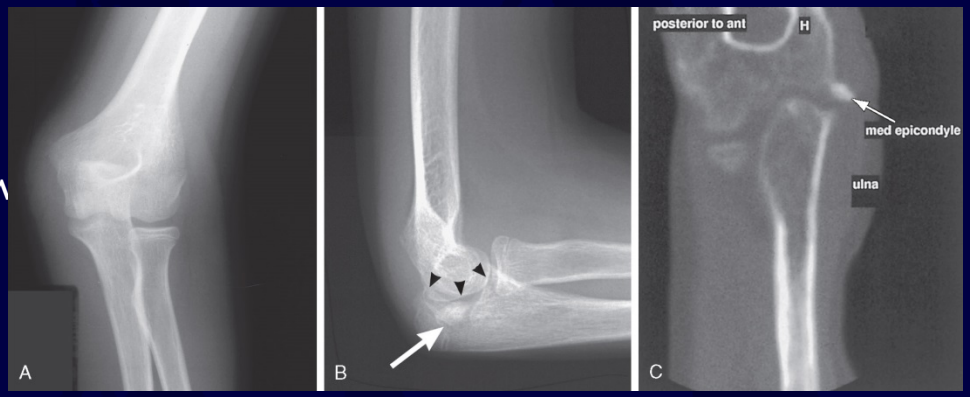
Medial Epicondyle Fractures Treatment

- Displaced more than 5 mm
  - Treatment is controversial
  - Some recommending operative, others 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
  - First attempt closed reduction
- Long term studies favor nonoperative treatment



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Medial Epicondyle Fracture
Elbow dislocation with Medial Epicondyle Avulsion

Medial Epicondyle Avulsion

After attempted elbow reduction, medial epicondyle avulsion fragment is obvious

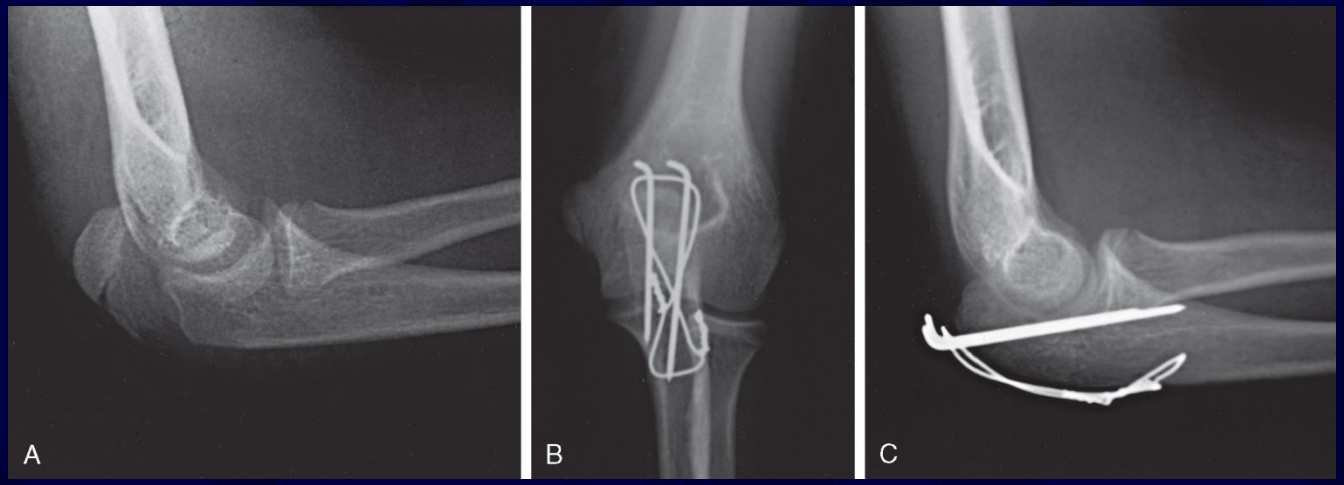
Olecranon Fractures

- 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
  - 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 to restore normal elbow extension.

Caterini. Fractures of the olecranon in children. Long-term follow-up of 39 cases. J Pediatr Orthop B. 2002;11:320.

Olecranon Fractures

- Olecranon fracture treated with ORIF in 14 year old, with tension band fixation.



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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

Medial Condyle Fracture

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Proximal Radius 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)

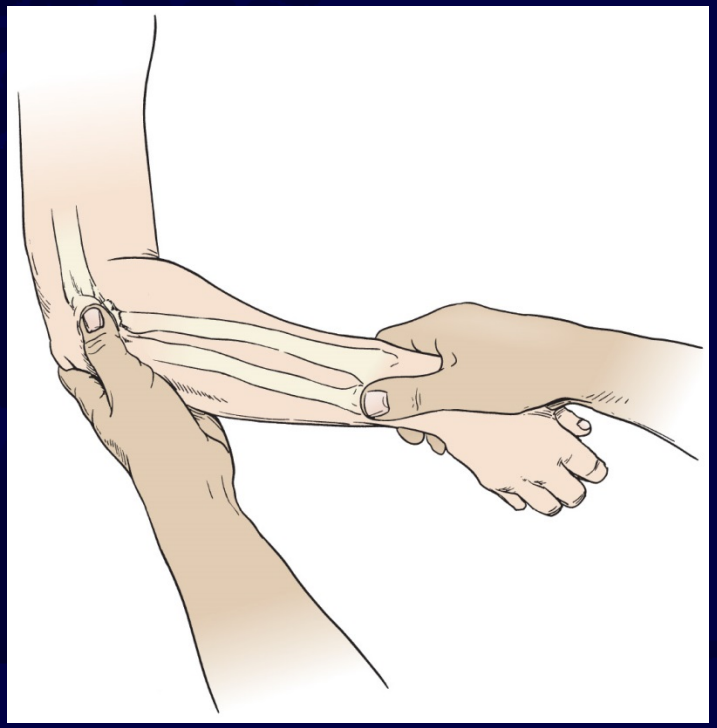
Vocke. Displaced fractures of the radial neck in children: long-term results and prognosis of conservative treatment. J Pediatr Orthop B. 1998;7:217.

Proximal Radius Fractures Types

- Valgus fractures
  - Salter I or II
  - Intra-articular fractures rare
- Metaphyseal fractures
- Associated with elbow dislocations or proximal ulna fractures
- Can be completely displaced, rotated

Proximal Radius Fractures Treatment

- Greater than 30˚ angulation
  - Attempt manipulation
  - Usually can obtain acceptable reduction in fractures with less than 60˚ angulation
  - Traction, varus force in supination & extension, flex and pronate
  - Ace wrap or Esmarch reduction



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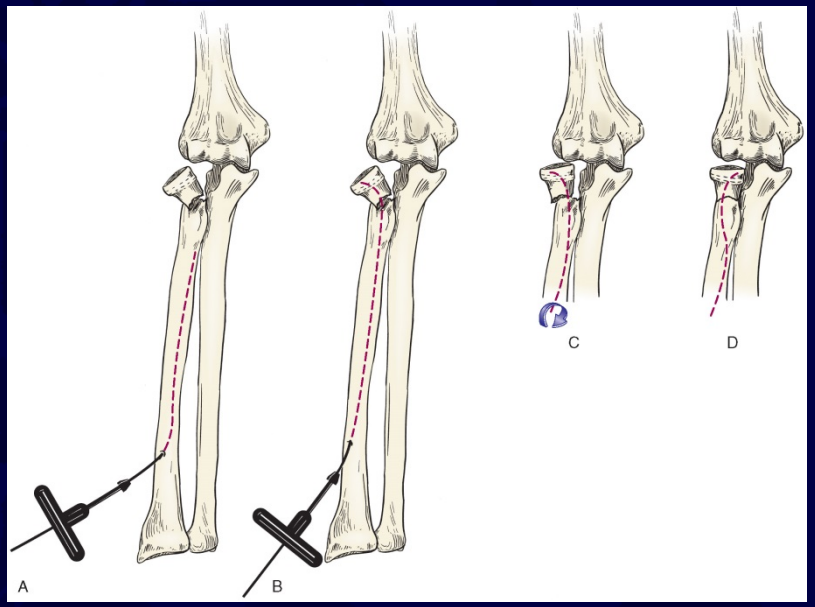
Proximal Radius Fractures Treatment

- Unable to reduce closed
  - Percutaneous pin reduction
  - Intramedullary nail reduction
  - Open reduction via lateral approach

IM nail reduction



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Proximal Radial Fractures Complications

- Loss of forearm rotation
- Radial head overgrowth
- Premature physeal closure – valgus
- Nonunion of radial neck rare
- AVN
- Proximal synostosis

Vocke. Displaced fractures of the radial neck in children: long-term results and prognosis of conservative treatment. J Pediatr Orthop B. 1998;7:217.

100% Displaced
Failed Closed Reduction

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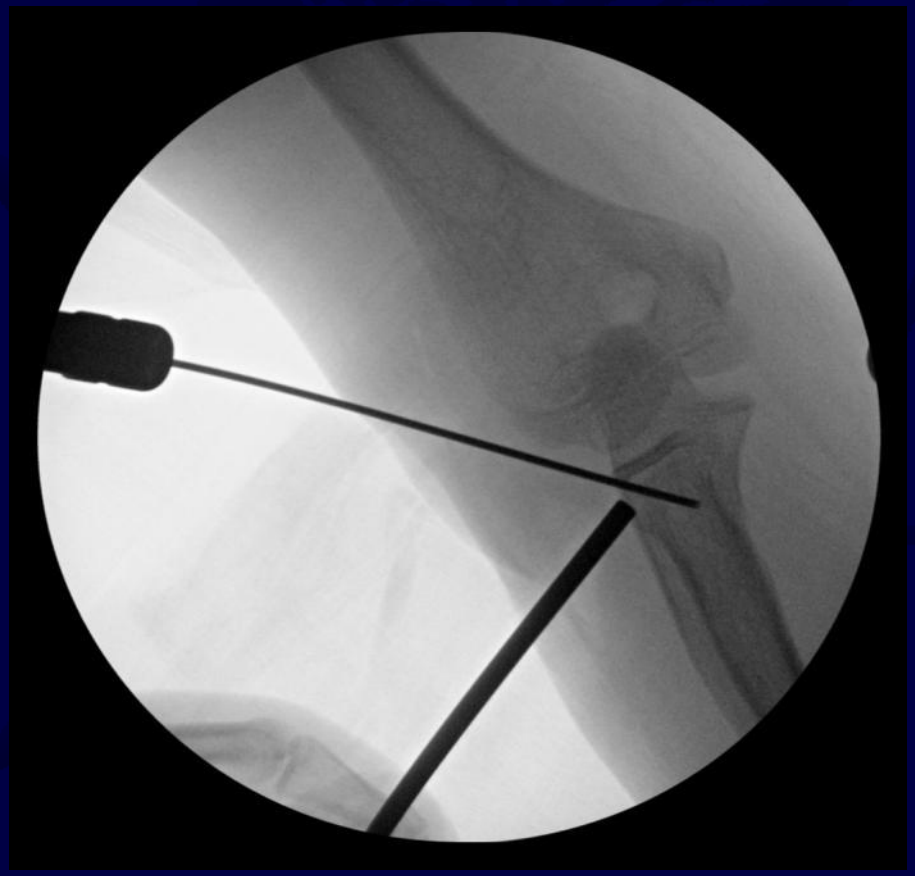
Open “closed” reduction

Blunt pin to push radial head back onto neck



Courtesy of TSRH/CMC

Pin fixation augmented by cast for 3 weeks

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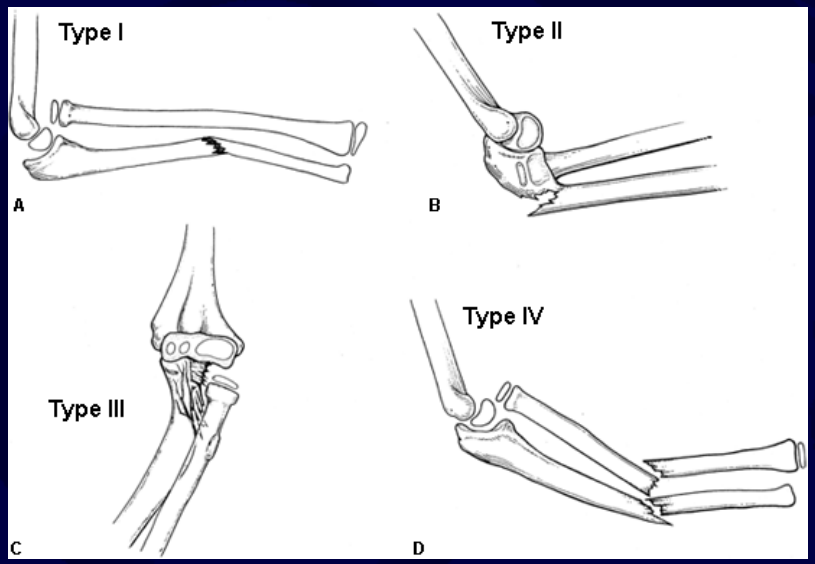
Monteggia Lesions
Ulnar Fracture-Radial Head Dislocation
Bado Classification



- 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

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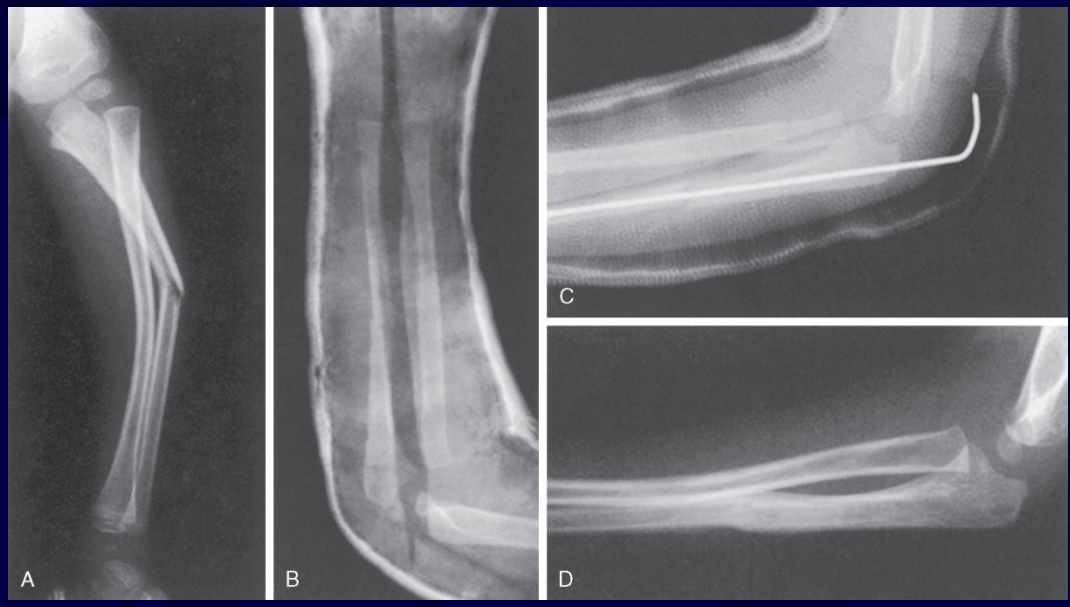
Monteggia Lesions
Initial Treatment

- 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

Wilkins. Changes in the management of monteggia fractures. J Pediatr Orthop. 2002;22:548.

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



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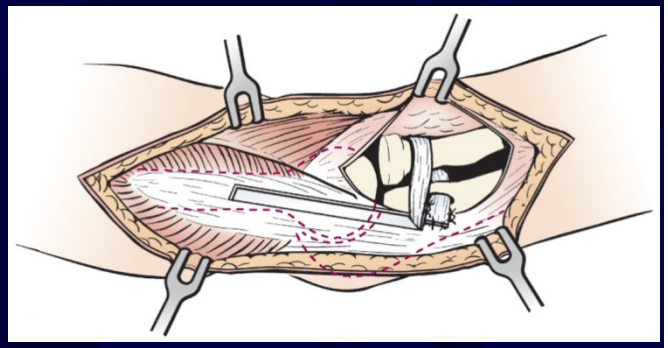
Missed Monteggia Lesions
Possible Long Term Sequelae

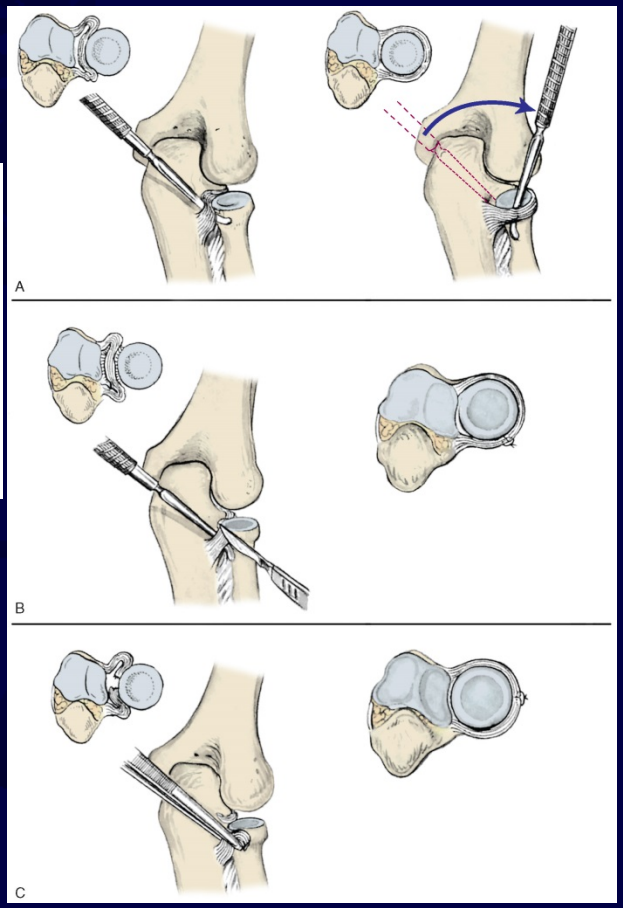
- Progressive valgus
- Proximal radial migration with disruption of normal forearm and distal radioulnar joint mechanics
- Posterior interosseous nerve traction palsy
- Collateral ligament instability

Nakamura. Long-term clinical and radiographic outcomes after open reduction for missed Monteggia fracture-dislocations in children. J Bone Joint Surg. 2009;91:1394.

Missed Monteggia Lesions Treatment Options

- Annular ligament reconstructions
  - Bell-Tawse
  - Fascia lata
  - Peterson
- Ulnar osteotomy
- Combination
- Transcapitellar pinning
- Be wary of possible pin breakage





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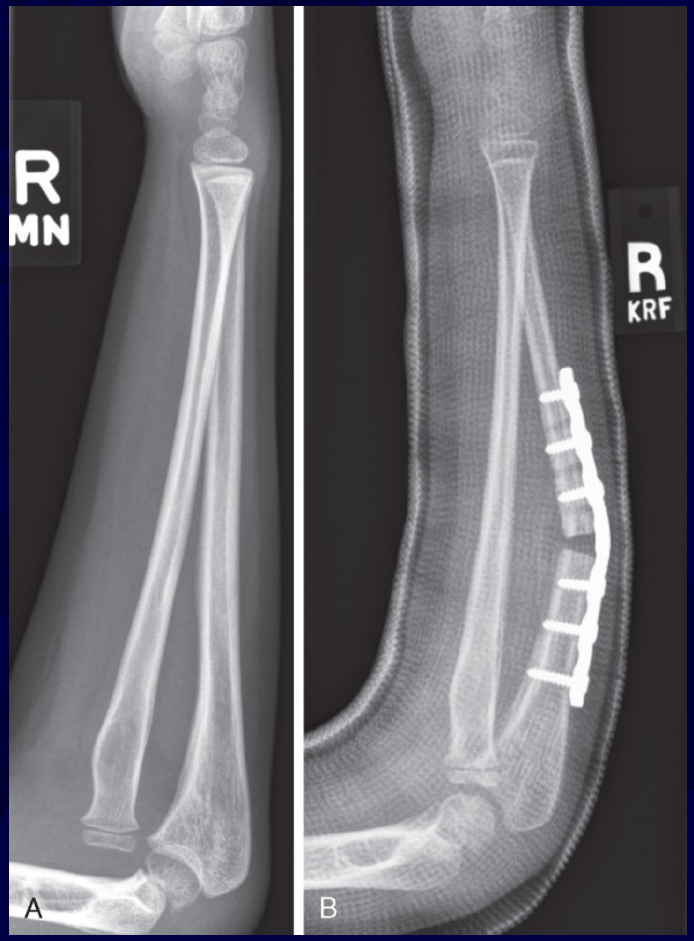
- Ulnar Osteotomy
- Arthrogram
- Open reduction radial head
- Repair annular ligament



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