

TUESDAY AUGUST 16, 2022

High Stakes Cases in Pediatric Orthopedic Trauma

Aaron Boyles, DO

Pediatric Orthopedic Surgeon



Children's Hospital Colorado
Here, it's different.™

Disclosures: None



Our Colorado Springs Orthopedic Team

Aaron Boyles, DO

Orthopaedic Surgery



PROVIDER'S LOCATION(S)

Children's Hospital
Colorado, Colorado
Springs

Travis Murray, MD

Orthopaedic Surgery



PROVIDER'S LOCATION(S)

Children's Hospital
Colorado, Colorado
Springs

Brian Shaw, MD

Orthopaedic Surgery



PROVIDER'S LOCATION(S)

Children's Hospital
Colorado, Colorado
Springs

Robert Hamblin, PA-C

Physician Assistant



PROVIDER'S LOCATION(S)

Children's Hospital
Colorado, Colorado
Springs

[View all \(2\) →](#)

Rachael Mahan, PA-C

Physician Assistant



PROVIDER'S LOCATION(S)

Outpatient Care at
Briargate

719-305-9060

Caitlin Dierkes, PA-C

Physician Assistant



PROVIDER'S LOCATION(S)

Children's Hospital
Colorado, Colorado
Springs

Jennifer Nance, PPCNP-BC

Certified Pediatric Nurse Practitioner



PROVIDER'S LOCATION(S)

Anschutz Medical
Campus, Aurora



Objectives

- Learn to identify subtle fracture patterns in the elbow, hand, hip and ankle
- Learn to identify compartment syndrome in the child
- Learn examination and x-ray reading tips to improve diagnostic ability
- Learn basic treatment plans for the fractures discussed
- Understand the importance of making these diagnoses in a timely manner



Elbow Cases



Case 1 – 3 year-old boy

Chief Complaint: Right elbow pain

History of Illness: 3 year-old boy fell approximately 3 ft from playground, fall was witnessed by mother, immediate crying with pain localized to right arm

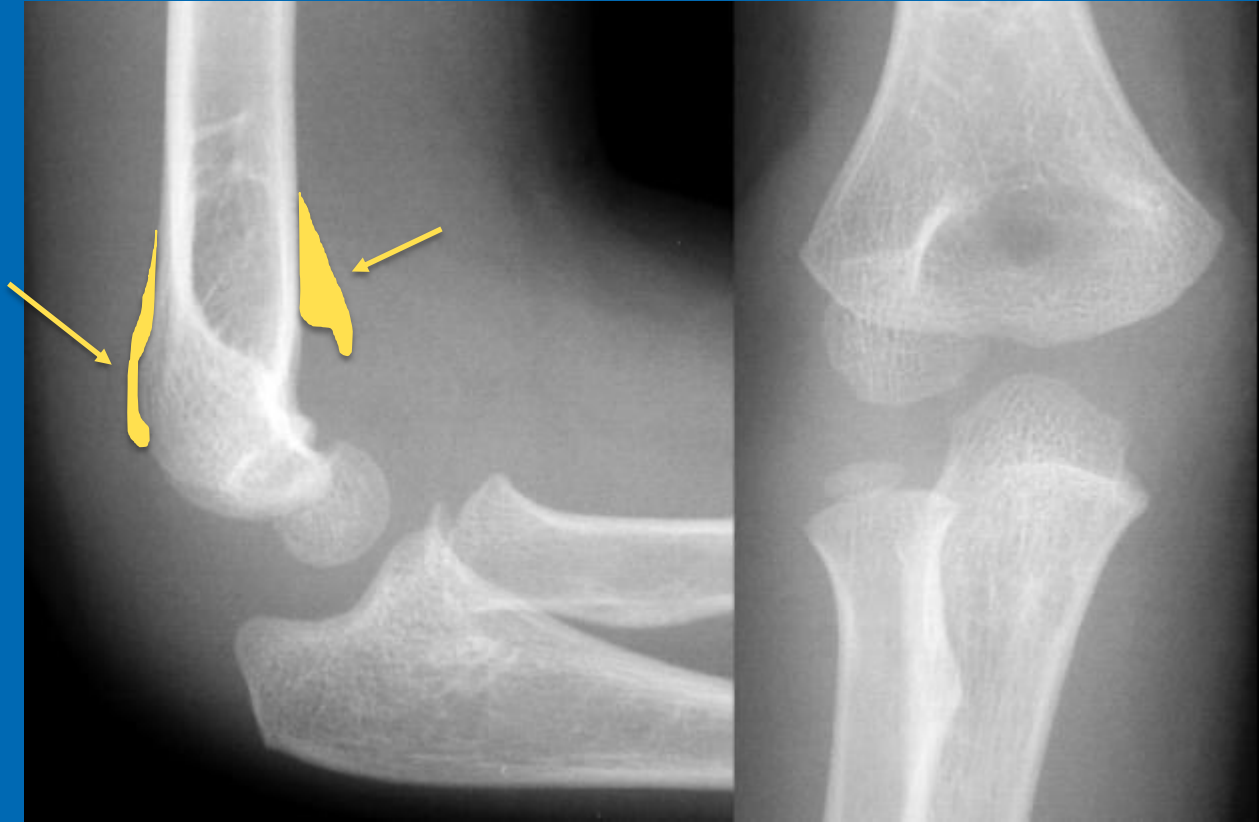
Past Medical/Surgical/Family/Social History: Negative, no Tob use in the home

Medications/Allergies: none

Physical Exam: Tearful, age-appropriate male, guarding right arm, decreased elbow ROM with tenderness of the distal humerus, moderate elbow swelling, no ecchymosis or breaks in the skin. Grossly moving all fingers, radial pulse 2/4.



Imaging



Diagnosis?

Occult fracture of the elbow



How to Make the Diagnosis: Examination Tips

Look for full extension on exam

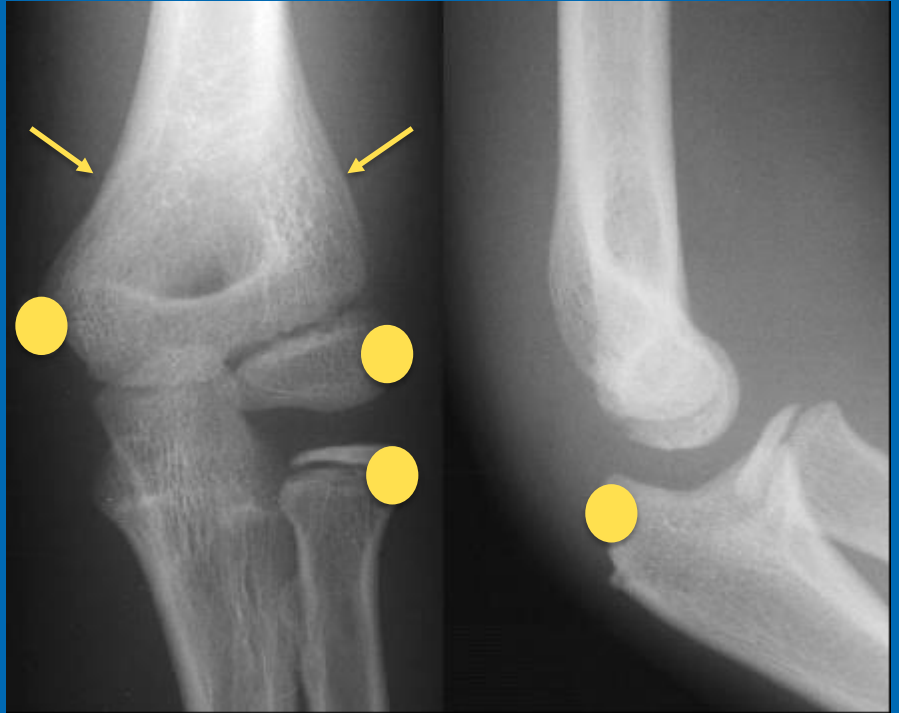
- Appelboam et al (1) found that of 780 adults and children evaluated for elbow trauma, 289 could fully extend the elbow. Of those, only 4% had a fracture.



How to Make the Diagnosis: Examination Tips

Palpate locations of common fractures

- Supracondylar: 55-75% of elbow fractures
- Medial Epicondyle
- Lateral Condyle
- Radial Head/neck
- Olecranon



How to Make the Diagnosis:

X-ray Tip

Look for the “fat-pad sign”

- Anterior is more sensitive but common in the normal elbow
- Posterior is more specific
- Skaggs et al (2) looked at 45 consecutive children with posterior fat-pad elevation:
 - 76% had evidence of a fracture on subsequent x-rays



Treatment: Occult Elbow Fracture

Long arm splint

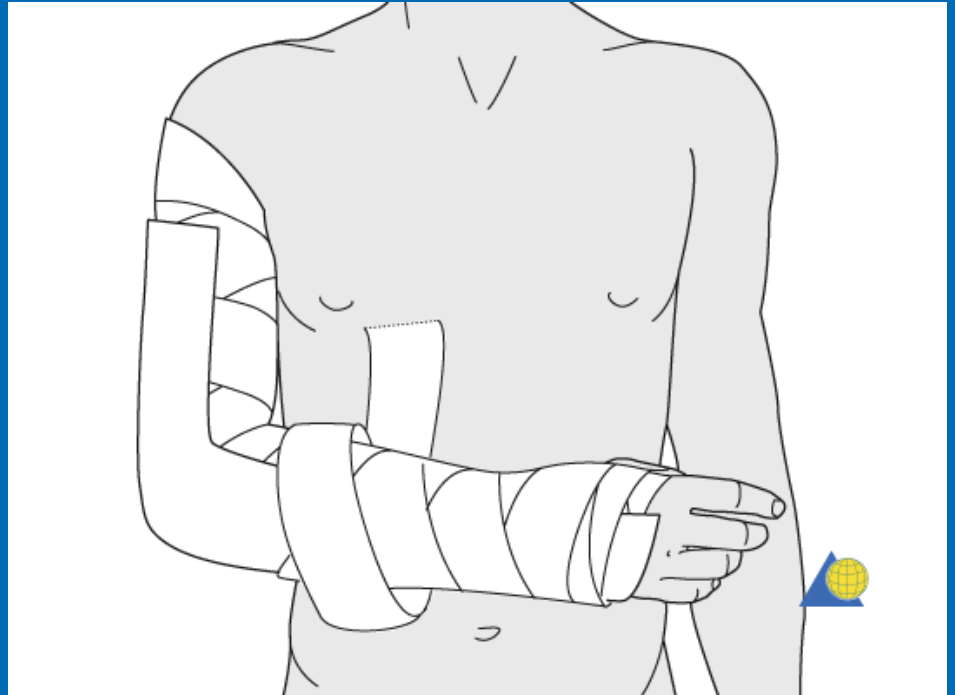
- Elbow at 70-90 degrees
- Include elbow and wrist
- Leave fingers free

Sling

- May be removed at night

Refer

- Should be seen in 7-10 days by specialist



Source: aofoundation.org



What if it gets missed?

- The fracture may go on to heal on it's own, without complication, but...
- A minor trauma could turn a non-operative fracture into one that requires surgery and all the risks that come with it
- Some elbow fractures are known to have late displacement that can be prevented with proper immobilization



Case 2: 7 year-old girl

Chief Complaint: Right elbow pain

History of Illness: 7 year-old girl fell onto outstretched hand while roller skating. Immediate pain in the right elbow with subsequent swelling. Fall was witnessed by parents.

Past Medical/Surgical/Family/Social History: Non-contributory

Medications/Allergies: none

Physical Exam: Non-acute, age-appropriate girl holding right arm. Moderate swelling, no ecchymosis, no lacerations. Tenderness over the lateral distal humerus. Decreased flexion, extension, pronation and supination. Motor function intact to hand, sensation intact to light touch throughout the hand, radial pulse 2/4.



Imaging



Source: www.hawaii.edu/medicine/pediatrics/pemxray/v2c18.html





External Oblique View



Internal Oblique View

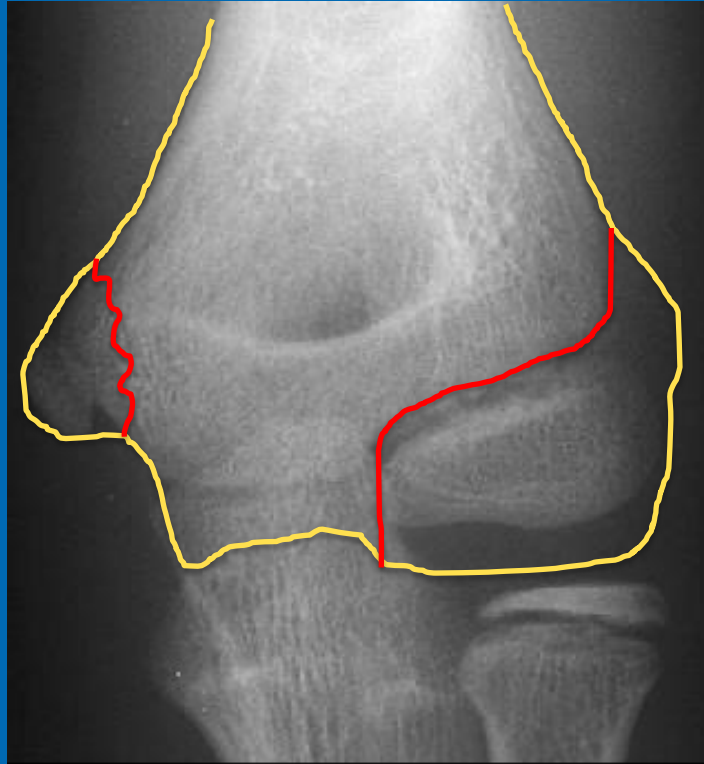


Diagnosis?

Lateral Condyle Fracture



Quick Anatomy Reminder: Condyle vs. Epicondyle



How to Make the Diagnosis

Exam Tips

Again...

- Check for full extension
- Palpate for areas of tenderness

Also...

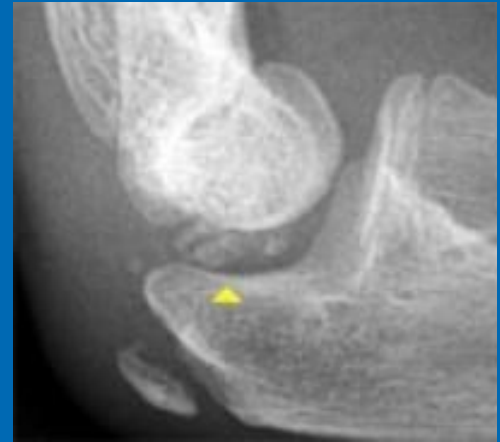
- Don't forget to check pronation and supination



How to Make the Diagnosis

X-ray Tips

- When in doubt, **get oblique views!**
- Also, one of the most under-rated and under-used diagnostic tools in pediatric orthopedics is the **contralateral x-ray**
- Contralateral films are especially useful in differentiating fractures from abnormal appearing ossification centers, especially the trochlea



Treatment: Lateral Condyle Fracture

Long arm splint

- Elbow at 70-90 degrees
- Include elbow and wrist
- Leave fingers free

Refer

- These fractures **frequently require surgery**, even with only small amounts of displacement
- **Urgent referral/consultation**



What if it gets missed?

- Lateral condyle fractures are prone to late displacement and nonunion when not treated properly
- Repair of a nonunion is a more difficult surgery, often requiring bone grafting and with somewhat less predictable outcomes
- Long standing nonunions are associated with nerve palsies and arthritic changes



Case 3: 8 year-old girl

Chief Complaint: Left elbow pain

History of Illness: 8 year-old girl complains of left elbow pain after a fall from the monkey bars.

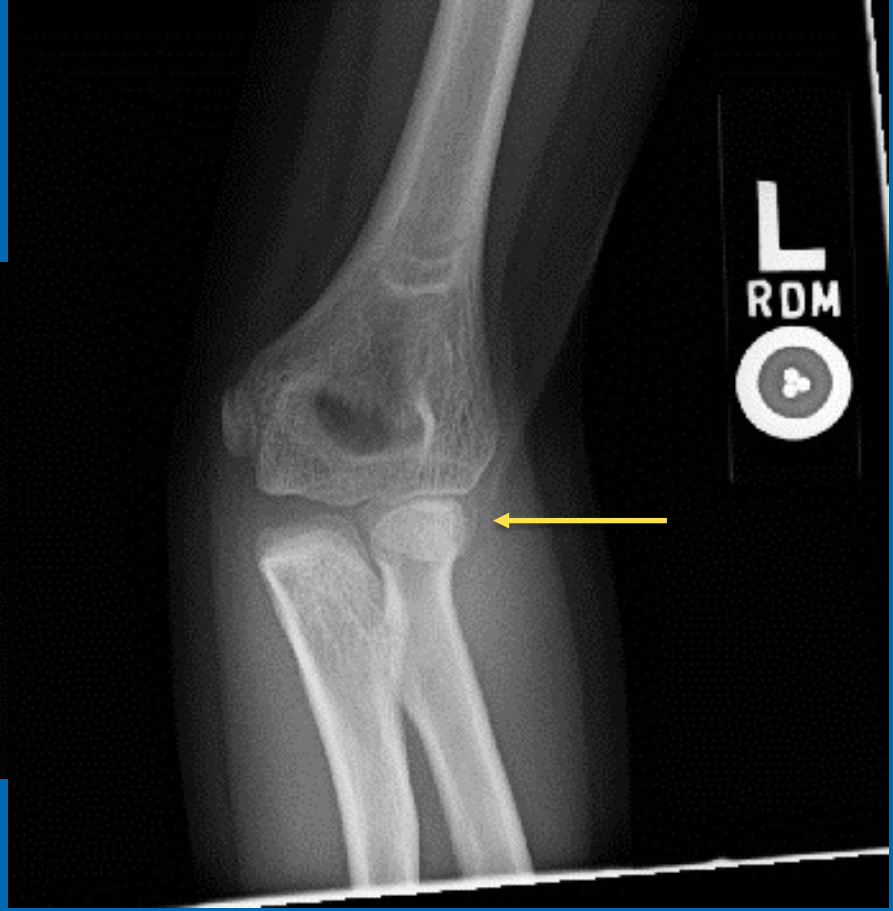
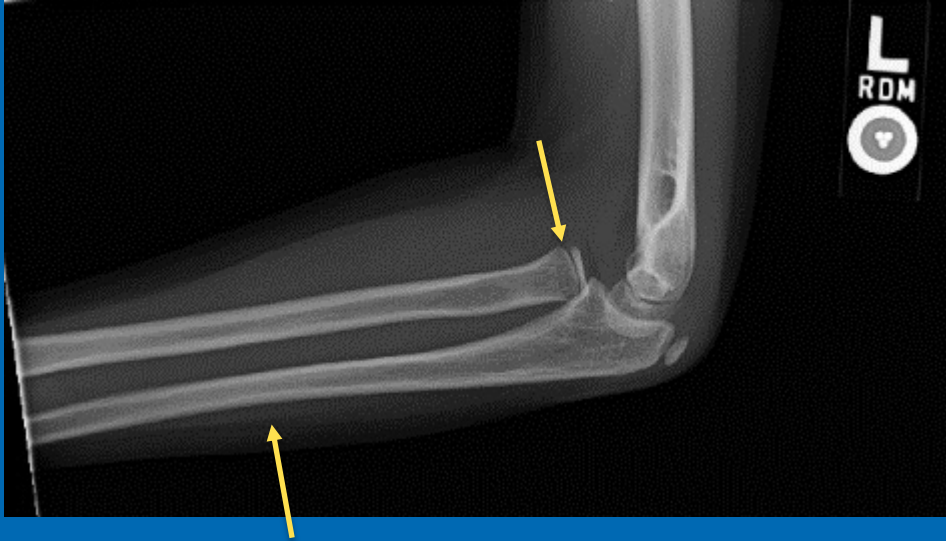
Past Medical/Surgical/Family/Social History: Non-contributory

Medications/Allergies: none

Physical Exam: Non-acute, age-appropriate girl. Exam of left arm shows tenderness over the ulna and lateral elbow. Limited extension, moderate to severe pain with pronation and supination. Motor, sensation and perfusion normal.



Imaging



Diagnosis?

Radial head dislocation with a proximal ulna fracture, AKA Monteggia Injury



How to Make the Diagnosis

Examination Tips

Again...

- Look for loss of motion, flexion-extension AND pronation-supination
- Palpation for common injury locations
 - In this case: radial head and ulnar shaft



How to Make the Diagnosis

X-ray Tips

- The axis of the radial head and neck should point to the capitellum of EVERY view, without exception
- Look for plastic deformity
- Always get x-rays that include the entire forearm and wrist
 - You will fail to diagnose 100% of the fractures you don't x-ray
- Most commonly missed fracture on x-rays?
 - Don't fall prey to “satisfaction of the search”
 - Minimal displacement of the ulna can still result in radial head dislocation

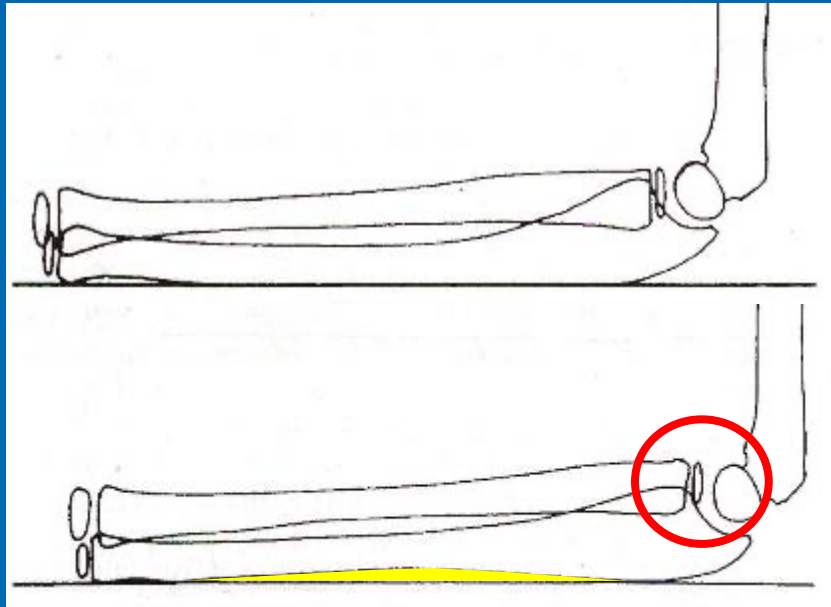


Radio-capitellar relationship

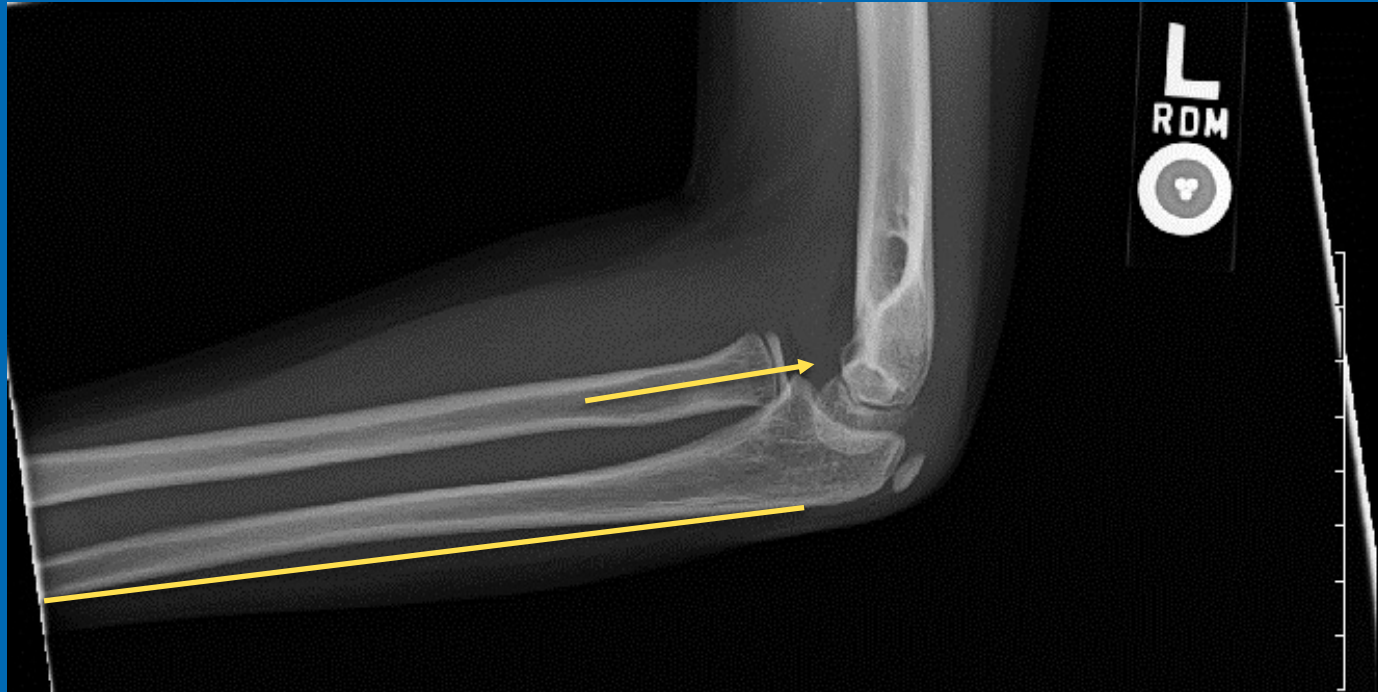


“Ulnar bow sign”

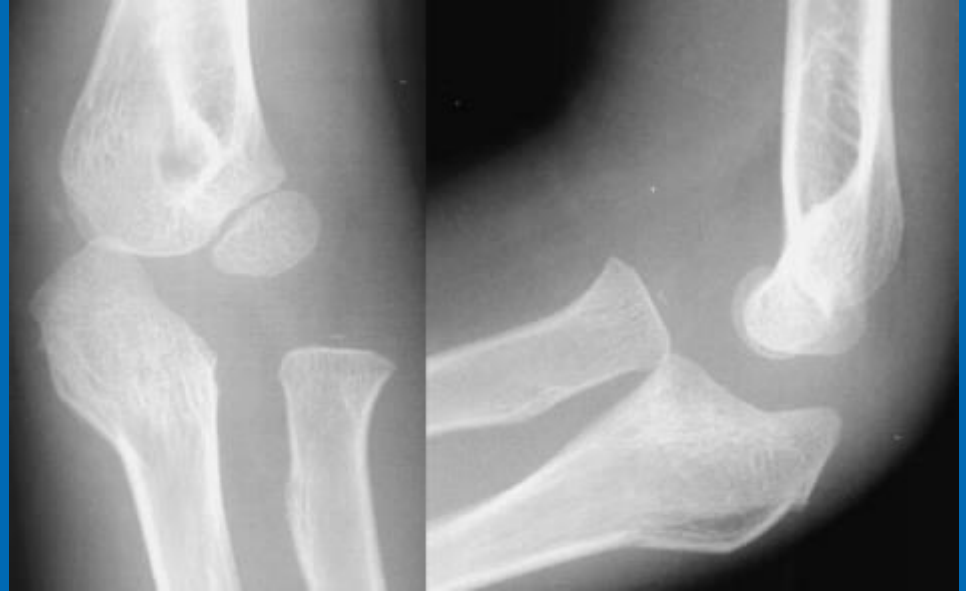
Lincoln and Mubarak (3) described this finding on a lateral of the forearm and elbow



Imaging

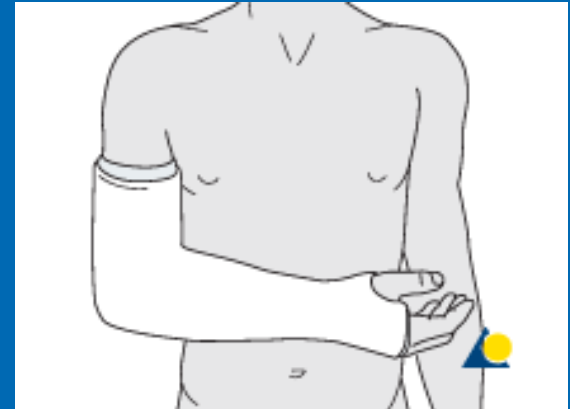


Imaging



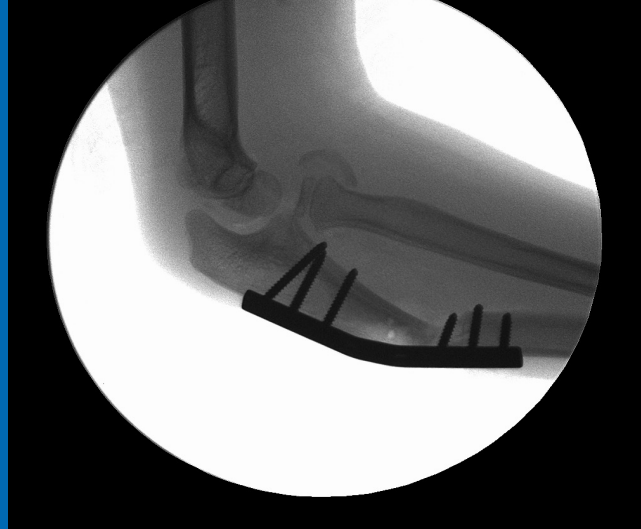
Treatment

- In outpatient setting: refer to ER
- In ER: perform reduction or consult specialist
- Reduction:
 - Key: Reduce the ulna and the radius will follow... most of the time
 - For 90% of these injuries reduction is achieved by traction, flexion and supination
 - **Must** confirm reduction of radial head on x-rays
- Immobilization:
 - Long arm splint or cast with elbow at 90 degrees and forearm in full supination



What if it gets missed?

- The radial head remains dislocated and the ulna heals in a deformed position
- Correction requires an osteotomy of the ulna and occasionally reconstruction of the annular ligament
- Outcomes are good in most cases, but often **surgery can be avoided altogether**



Case 4: 5 month-old female

Chief Complaint: Stopped using right arm

History of Illness: 5 month-old female presents with mother who is concerned that her daughter has not been using her right arm since she picked the child up from her boyfriend's house yesterday. No injuries were reported by the boyfriend.

Past Medical/Surgical History: none

Family/Social History: Child lives with mother and grandmother, occasionally is watched by mother's significant other

Medications/Allergies: none

Physical Exam: Well nourished, healthy appearing child in no distress. Does not use or bear weight on the right arm. Ecchymosis present around forearm. Pain with attempted ROM of the elbow. No pain or ecchymosis elsewhere in the head, neck, trunk, abdomen or other extremities.



Imaging



Source: www.orthobullets.com



Diagnosis?

Distal Humeral Physeal Separation



How to Make the Diagnosis

Examination Tips

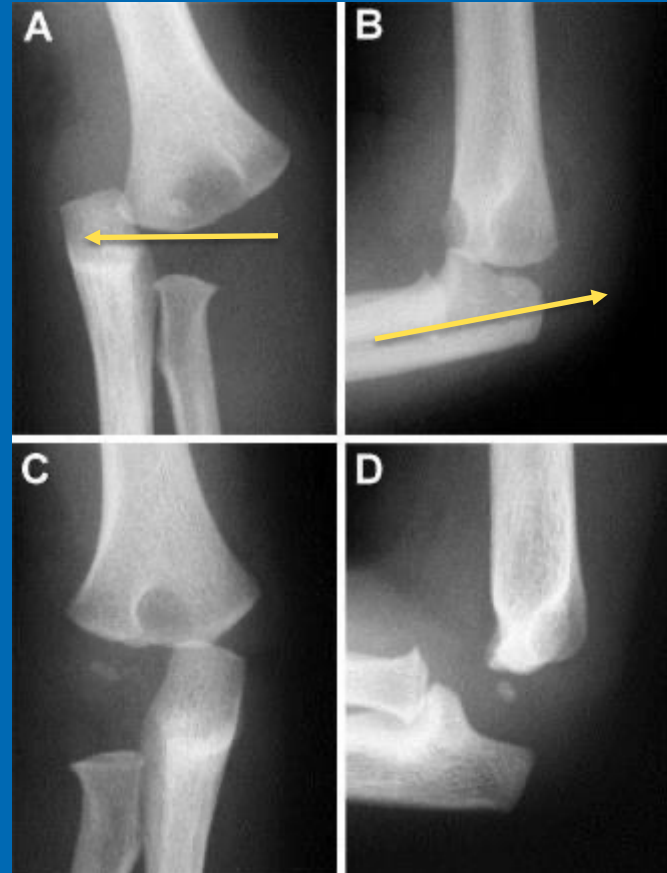
- Physeal separation of the elbow has a 13 times higher incidence of confirmed **child abuse** compared to SCH fractures. (Mehlman et al JBJB 2022;104:1204-11)
- Head-to-toe examination is mandatory and a skeletal survey (head-to-toe x-rays) is most often indicated
- Favorite toys are useful during the examination of an infants arms



How to Make the Diagnosis:

X-ray Tip

- Get x-rays of the entire arm
- Look for **medial and posterior displacement** of the radius and ulna relative to the distal humerus



Treatment

- Immobilize
 - Temporary long arm splint
- Non-accidental trauma evaluation
 - Should be done in all cases
- Consult specialist
 - Depending on age and severity, many require surgery



What if it gets missed?

- Infants have incredible powers of remodeling and in some cases will come to have normal anatomy, however...
- Missed physal separations often result in cubitus varus (“gunstock” deformity) that requires osteotomy for correction



Source: <https://radiopaedia.org/articles/cubitus-varus>



Case 5: 9 year-old boy

Chief Complaint: Left elbow pain

History of Illness: 9 year-old boy presents with pain after falling from a swing. He reports feeling the elbow “give out” when he landed. Pain is isolated to the elbow and he has noticed increasing swelling.

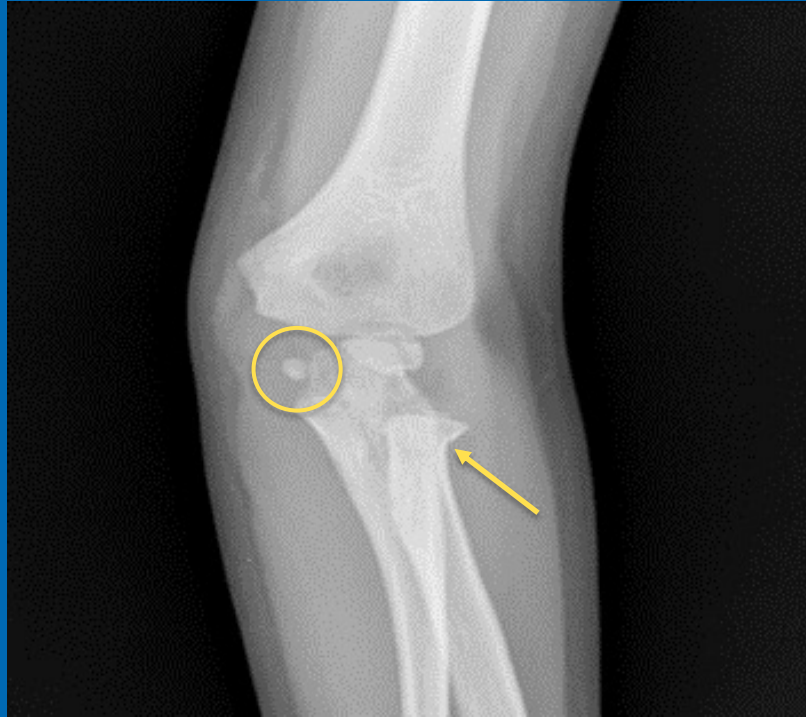
Past Medical/Surgical/Family/Social History: non-contributory

Medications/Allergies: none

Physical Exam: Age-appropriate male in no distress. Marked swelling of the left elbow, extremely limited ROM due to pain, motor, sensation and perfusion normal.



Imaging



Diagnosis?

**Medial epicondyle fracture
entrapped in joint**

Radial neck fracture

Presumed dislocation/subluxation



How to Make the Diagnosis: X-ray Tips

- Can present entrapped or become entrapped after reduction
- Medial epicondyle **appears at around age 5**
- Scrutinize films until you find it
- Must be certain of location on post-reduction films
- 50% of medial epicondyle fractures are associated with a dislocation resulting in gross instability of the elbow



Treatment

- Immobilize
 - Long arm splint in position of comfort
- Minimize unnecessary elbow ROM
- Refer to ER for urgent specialist consultation
- Urgent ORIF



What if it gets missed?

- Thankfully, this pattern rarely gets missed, however...
- Early diagnosis and extraction of the entrapped fragment can limit intraarticular damage
- Failure to recognize that medial epicondyle fracture can be associated with instability can result in delayed treatment and long term instability



Questions so far?



Compartment Syndrome in the Child

One of the most difficult diagnoses to make in orthopedics...even more difficult in kids



Compartment Syndrome in the Child

Classic Teaching: 5 P's

1. Palor
2. Paresthasias
3. Pain
4. Pulselessness
5. Paralysis

Only pain is a reliable early sign

Revised 5 P's

1. Pain
2. Pain
3. Pain
4. Pain
5. Pain

Three A's of pediatric Compartment Syndrome

1. Anxiety
2. Agitation
3. increasing Analgesia requirement



What if it gets missed?

- Missed compartment syndrome has permanent and devastating outcomes
 - Foot drop
 - Volkman's contracture
 - Infection
 - Amputation



Hand Case



Case 7: 11 year-old male

Chief Complaint: Right ring finger pain

History of Illness: 11 year-old male complains of pain and bleeding of his right ring finger after is was accidentally closed in a car door.

Past Medical/Surgical/Family/Social History: non-contributory
Medications/Allergies: none

Physical Exam: Well-appearing, age-appropriate male. Right ring finger with distal swelling and dried blood at the proximal nail fold. Unable to full extend DIP joint



Imaging



Diagnosis?

Open distal phalanx Salter-Harris 1 fracture, AKA Seymour fracture



How to Make the Diagnosis

Physical Exam Tips

- Blood in the nail fold should raise suspicion for this injury pattern
- A “mallet finger” deformity is typical



Treatment

Somewhat controversial

- Ranges from closed reduction and splint only to open reduction, pinning, nailbed repair and antibiotics
- Splinting should maintain full extension or slight hyperextension

What can go wrong?

- There is always damage to the **germinal matrix** and nail deformity can result
- The germinal matrix can become entrapped preventing complete reduction



Source: Reyes and Ho (5)



What if it gets missed?

At a minimum, all Seymour fracture should be thoroughly irrigated, reduced and receive a course of **antibiotics**.

- When this treatment was implemented within 24 hours, Reyes and Ho (5) reported no infections among 11 children.
- Compared to a **45% infection rate** in those treated after 24 hours



Hip Case



Case 8: 12 year-old male

Chief Complaint: Right knee pain

History of Illness: 12 yo male with intermittent knee pain for 3 months. No history of injury. Mother reports he has been limping for the past 2 weeks. He is typically active in football and basketball and has not been able to participate because of the pain. No swelling. Pain radiates up the thigh. Had x-rays and MRI of knee that were reportedly normal.

Past Medical/Surgical/Family/Social History: non-contributory

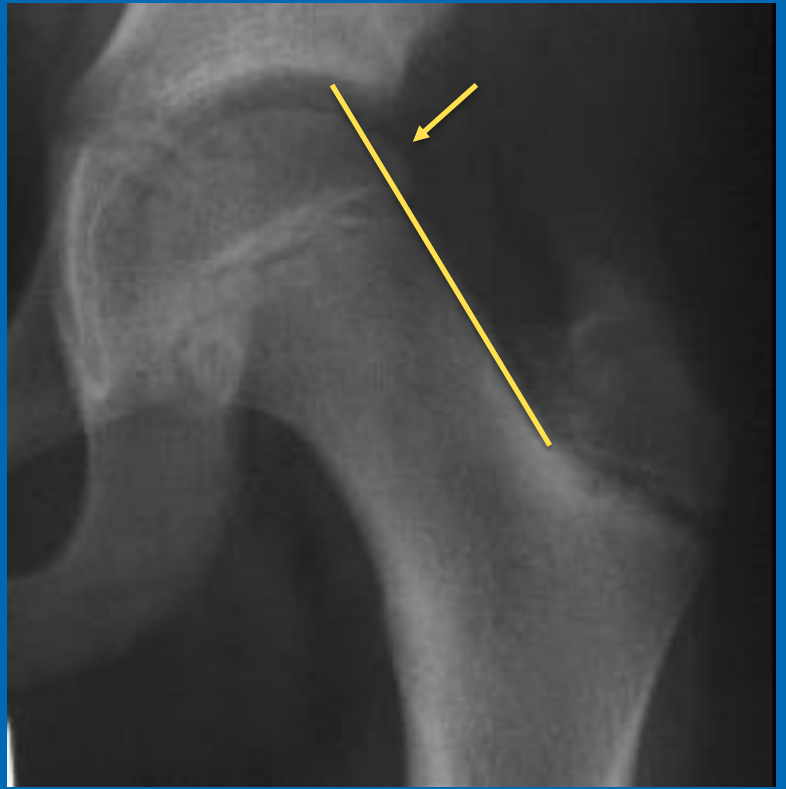
Medications/Allergies: none

Physical Exam: Age appropriate male in no distress. Moderately obese. Walks with a waddling gait, left foot is turned out, leaning over the left leg during weight bearing. Full knee range of motion, no effusion, normal patellar tracking, no tenderness, ligamentous exam stable. Hip exam shows limited hip internal rotation, especially with the hip in flexion



Imaging





Diagnosis?

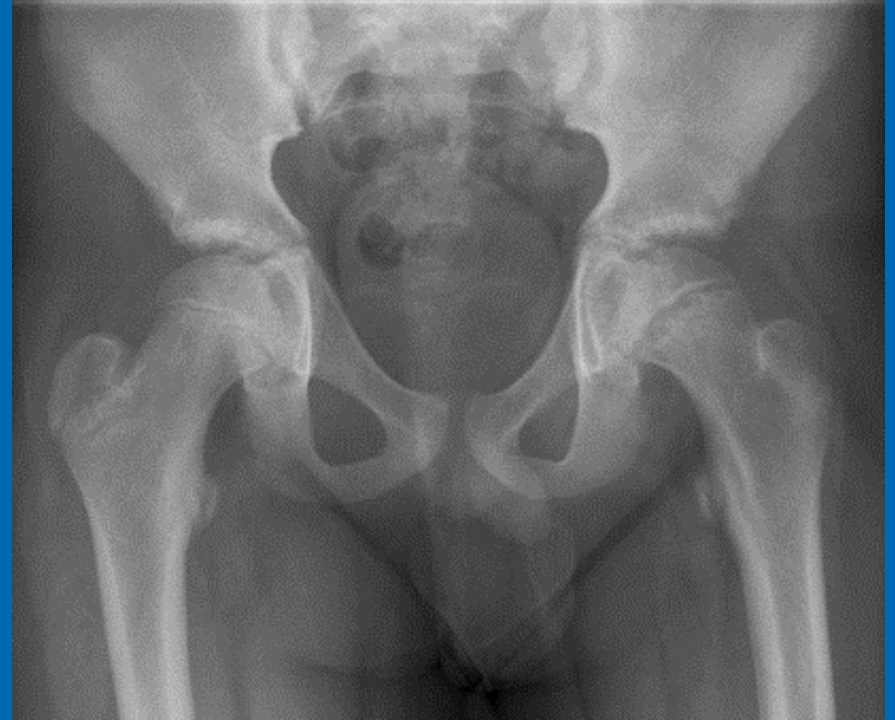
**Slipped Capital Femoral Epiphysis
AKA SCFE**



How to Make the Diagnosis:

When to be wary

- Male:Female 2:1.4
- Age 10-16
 - Average for boys 12-13
 - Average for girls 11-12
- Obesity is single greatest risk factor
- Present with variable pain
 - Hip pain 52%
 - Groin pain 14%
 - Thigh pain 35%
 - KNEE PAIN 15-50%



How to Make the Diagnosis: When to be wary

- Vague knee pain
- 10-16 years old
- Normal knee exam
- Normal knee imaging
- LIMP
- **OBESITY**



How to Make the Diagnosis: Examination

- Trendelenburg gait or abductor lurch
- Limited hip range of motion, pain with internal rotation
- Loss of hip internal rotation, especially in flexion
- “Obligatory external rotation”
- Affected leg crossed over the other in flexed, abducted and externally rotated position



Treatment

- In Situ screw fixation “Hip pinning”
- Goal: stabilize physis until growth is complete
- Prophylactic fixation of the contralateral hip in younger patients



What if it gets missed?

SCFE can progress to become unstable, essentially a pediatric hip fracture

Risk of osteonecrosis

Stable SCFE <10%

Unstable SCFE 25-50%

Severe SCFE and Osteonecrosis rapidly progress to osteoarthritis.



Source: <https://musculoskeletalkey.com/>



Ankle Case



Case 9: 13 year-old male

Chief Complaint: Right ankle pain

History of Illness: 13 year-old male complains of right ankle pain and swelling after crashing his dirt bike. He is unable to bear weight because of pain. He was helmeted and denies pain elsewhere in the extremities.

Past Medical/Surgical/Family/Social History: non-contributory

Medications/Allergies: none

Physical Exam: Age-appropriate male in no distress, marked swelling of the right ankle, no lacerations or abrasions. Limited ankle ROM. Tenderness diffusely in the ankle, primarily over the anterior ankle. Compartments soft. Motor, sensation and perfusion normal.



Imaging



Source: <https://musculoskeletalkey.com/ankle-fractures-10/>



Diagnosis?

**Salter-Harris III fracture of the
distal Tibia, AKA Tillaux fracture**



How to Make the Diagnosis: History Tips

The Tillaux fracture is one of 2 fractures that are considered “transitional” fractures. The other is the Triplane fracture

- These fractures are only present during the adolescent years while the distal tibial physis is in the process of closing.
- The anterolateral portion of the physis is the last to close and so it is susceptible to fracture



How to Make the Diagnosis: X-ray Tips

- Always get AP, lateral and **Mortise** views of the ankle
 - The fracture may be difficult to see on the AP and more apparent on the Mortise
- Check the lateral x-ray for anterior displacement



How to Make the Diagnosis: X-ray Tips

- Check the lateral physis for subtle widening



Treatment

Immobilize

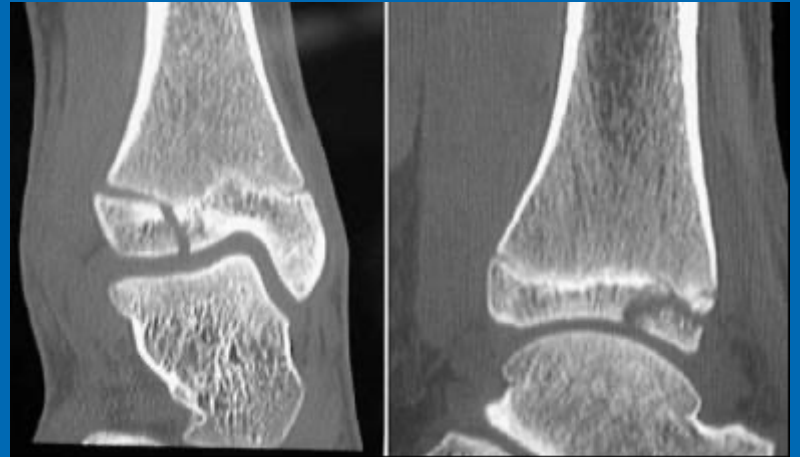
- Short leg posterior splint with stirrup
- Strict **non-weight bearing**

CT Scan:

- Provides necessary detail of joint surface

Refer/Consult

- Ideally should be seen by specialist within 7 days of injury



What if it gets missed?

- Articular fractures are all at risk for post-traumatic arthritis, the risk is increased in cases of nonunion and malunion
- Joint fluid bathes the fracture, preventing healing and resorbing bone



Summary of Tips

Elbow

- A good physical exam will clue you in on what to x-ray and where to look
- High quality x-rays are critical
- Consider contralateral and oblique views
- The radial head should always point to the capitellum
- A non-accidental trauma work-up is indicated for all elbow physeal separations

Compartment Syndrome

- Remember the 3 A's
 1. Anxiety
 2. Agitation
 3. Analgesic need increasing



Summary of Tips

Hand

- Blood at the nail fold is an open fracture until proven otherwise
- Thorough irrigation, reduction and antibiotics for Seymour fractures
- Always use absorbable suture (i.e. Chromic)

Hip

- Be wary of knee pain in 10-16 year olds with a limp

Ankle

- Always get an AP, lateral and Mortise
- Watch out for transitional injuries



Resources

The Royal Children's Hospital Melbourne Fracture Guidelines:
<http://www.rch.org.au/clinicalguide/fractures/>

General Orthopedic Information:
www.orthobullets.com



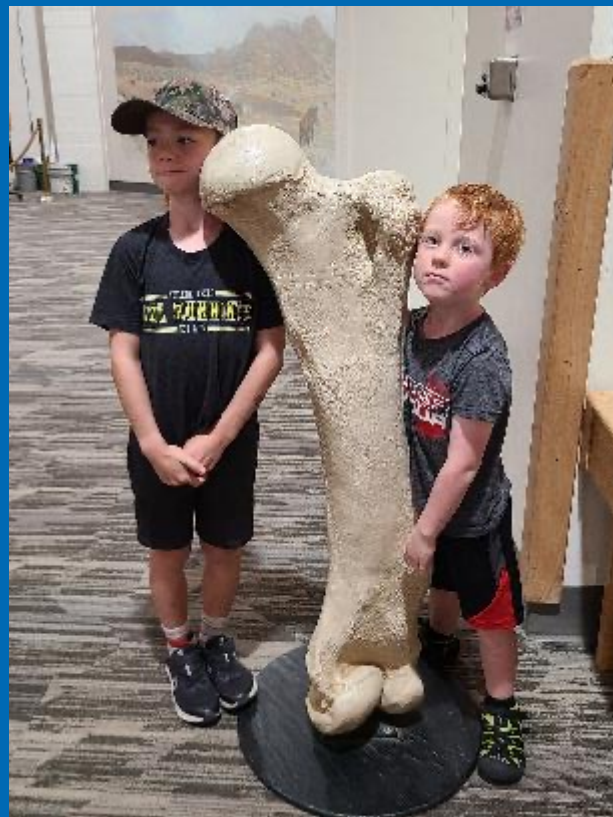
References

1. Appelboam A. et al Elbow extension test to rule out elbow fracture: multicentre, prospective validation and observational study of diagnostic accuracy in adults and children. *BMJ*. 2008 Dec 9;337:a2428.
2. Skaggs DL, Mirzayan R. The posterior fat pad sign in association with occult fracture of the elbow in children. *J Bone Joint Surg Am*. 1999 Oct;81(10):1429-33.
3. Lincoln TL, Mubarak SJ. “Isolated” Traumatic Radial Head Dislocation. *J Pediatr Orthop*. 1994 Jul-Aug;14(4):454-7.
4. Bae DS, Kadiyala RK, Waters, PM. Acute compartment syndrome in children: contemporary diagnosis, treatment, and outcome. *J Pediatr Orthop*. 2001 Sep-Oct;21(5):680-8.
5. Reyes BA, HO CA, The High Risk of Delayed Treatment of Open Seymour Fractures: Salter-Harris I/II or juxta-epiphyseal Fractures of the Distal Phalanx With Associated Nailbed Laceration. *J Pediatr Orthop*. 2017 Jun;37(4):247-253.
6. Rockwood and Wilkins Fractures in Children. 7th Ed. 2010



Comments? Questions?

aaron.boyles@childrenscolorado.org



Children's Hospital Colorado
Here, it's different.™