

Non-Accidental Trauma Part 1:

The Skeletal Survey in Non-Accidental Trauma: Initial and Follow-up Imaging

Educational Module
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Objectives

- Overview of the skeletal survey
- Utility of the follow-up skeletal survey
- Overview of developmental variants
- CML look-alikes
- Other findings on the skeletal survey

Pre-Test Questions

TRUE OR FALSE

1. The skeletal survey includes 2 orthogonal views of each bone
2. Physiologic periosteal reaction is limited to the diaphysis of the long bone
3. A helpful way to distinguish a metaphyseal spur or beak from a classic metaphyseal lesion is get a follow-up image to assess for change
4. Fractures are the most common physical injury in non-accidental trauma
5. Cupping and irregularity of the distal ulna indicates rickets, even if other metaphyses are normal

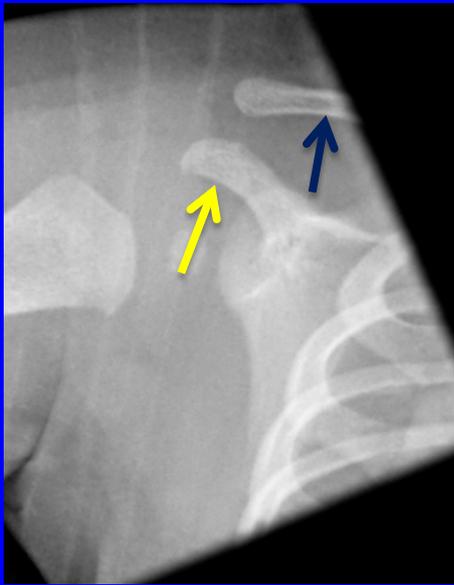
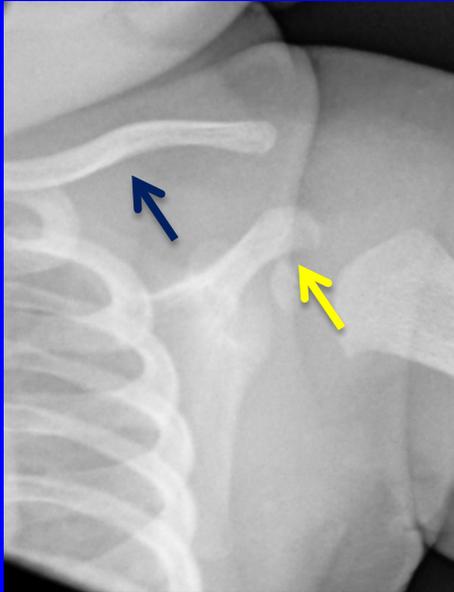
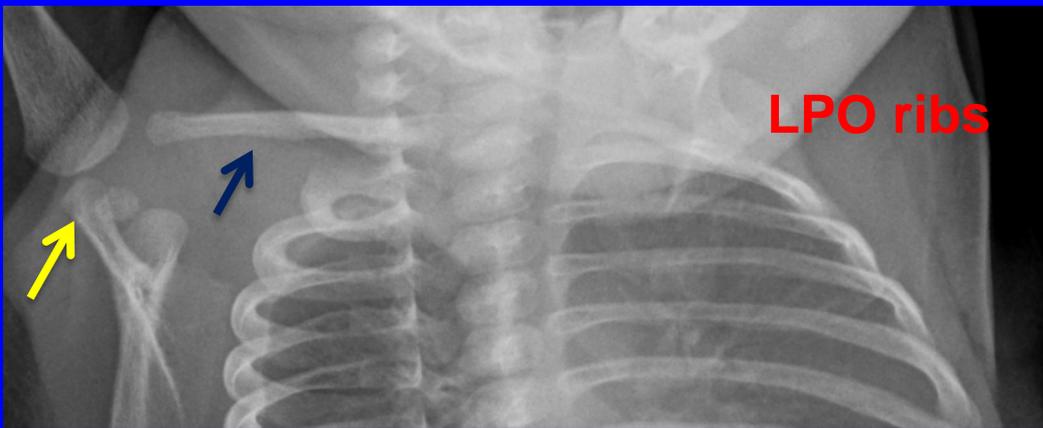
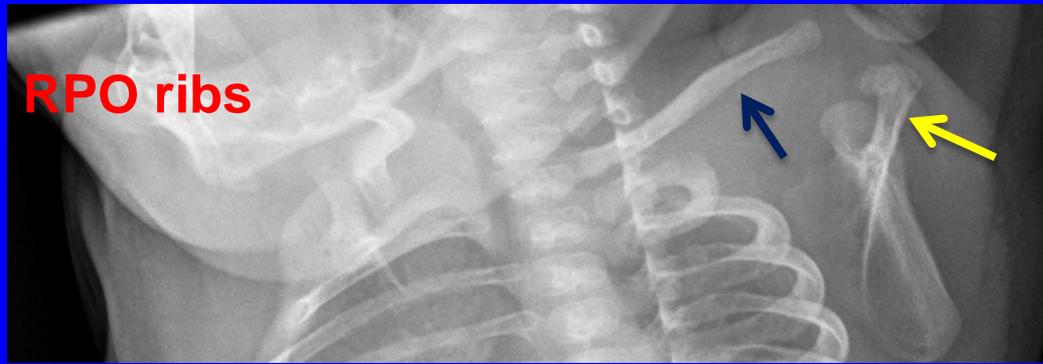
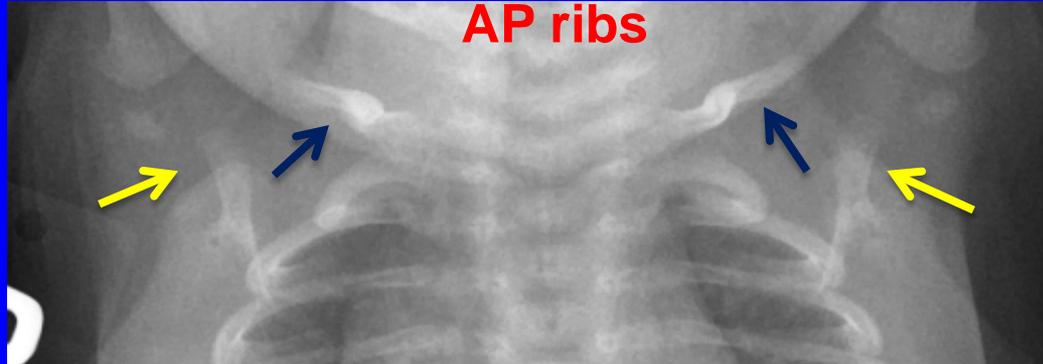
Skeletal Survey—a *Screening* study for non-accidental trauma

- Dedicated AP view of every bone in the body (except clavicle and scapula-see next slide)
- Lateral view of skull and entire spine
- Bilateral posterior oblique ribs \leq 2 years of age

Do cone down x-rays as needed

Assess bone mineralization

Orphan Bones: clavicle and scapula. However, they are seen on multiple images—take advantage of these!!



Follow-up Skeletal Survey (2 to 3 weeks after initial SS)

- Skull, spine and pelvis are omitted
- Typically done in infants, even those with demonstrated fractures on initial SS
- Helps sort out questionable findings on initial SS:
ie. ? CML vs developmental variant
- Occult injuries may become apparent: long bones, ribs CML's, subperiosteal hemorrhage

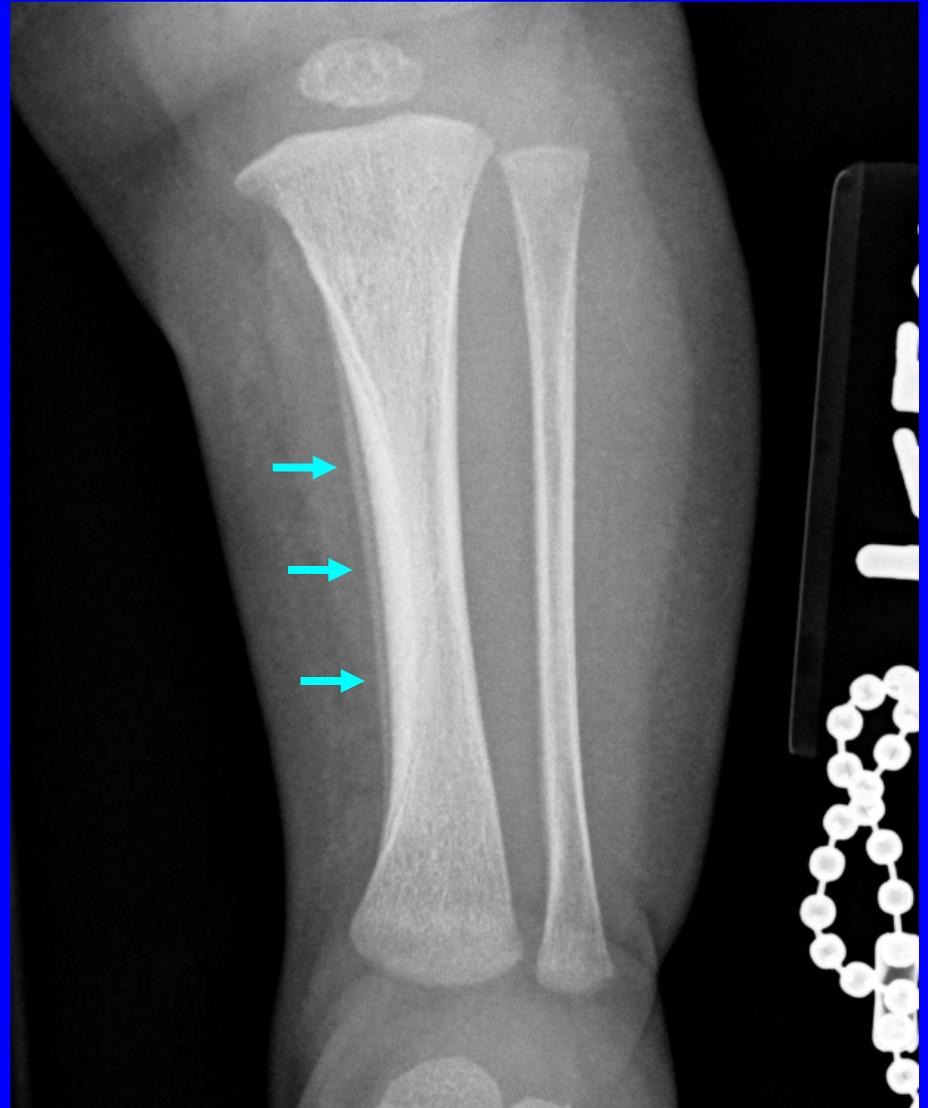
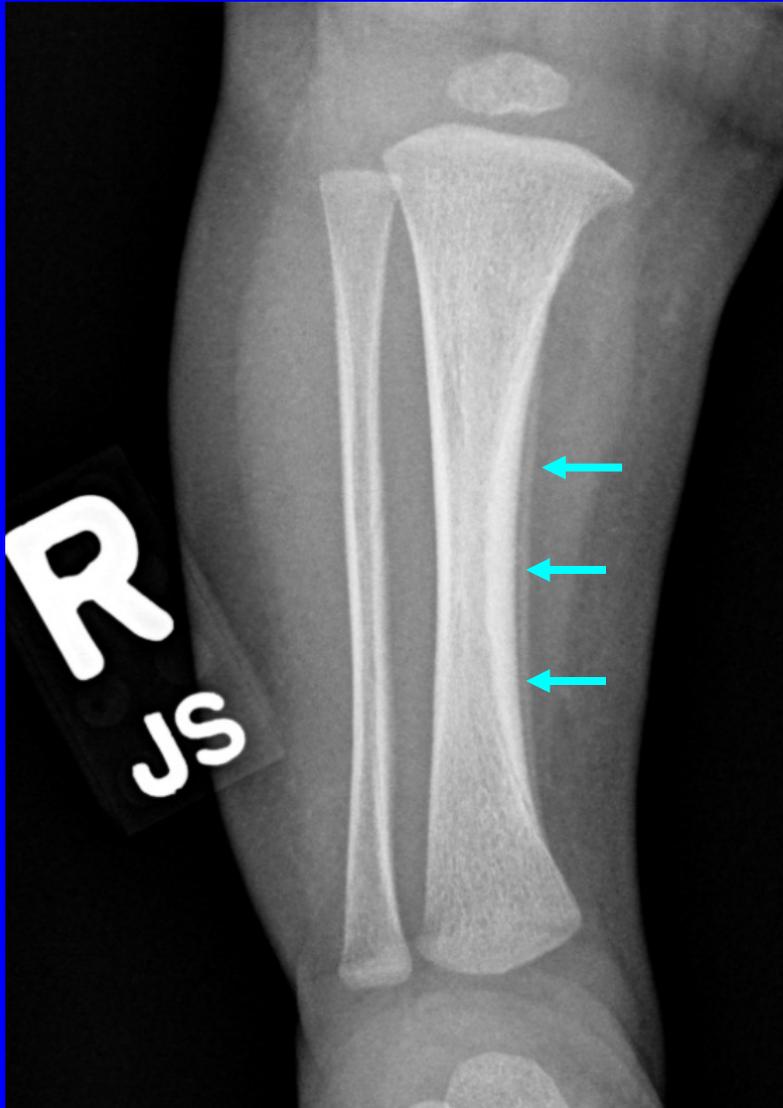
I. Developmental Variants

1. Physiologic periosteal reaction
2. Cortical waviness and thickening proximal radius diaphysis
3. Cupping and irregularity distal ulna metaphysis (also fibula)
4. Protuberance proximal medial tibial metadiaphysis
5. Flaring and cupping anterior rib ends
6. Pseudoepiphysis or accessory epiphysis of acromion

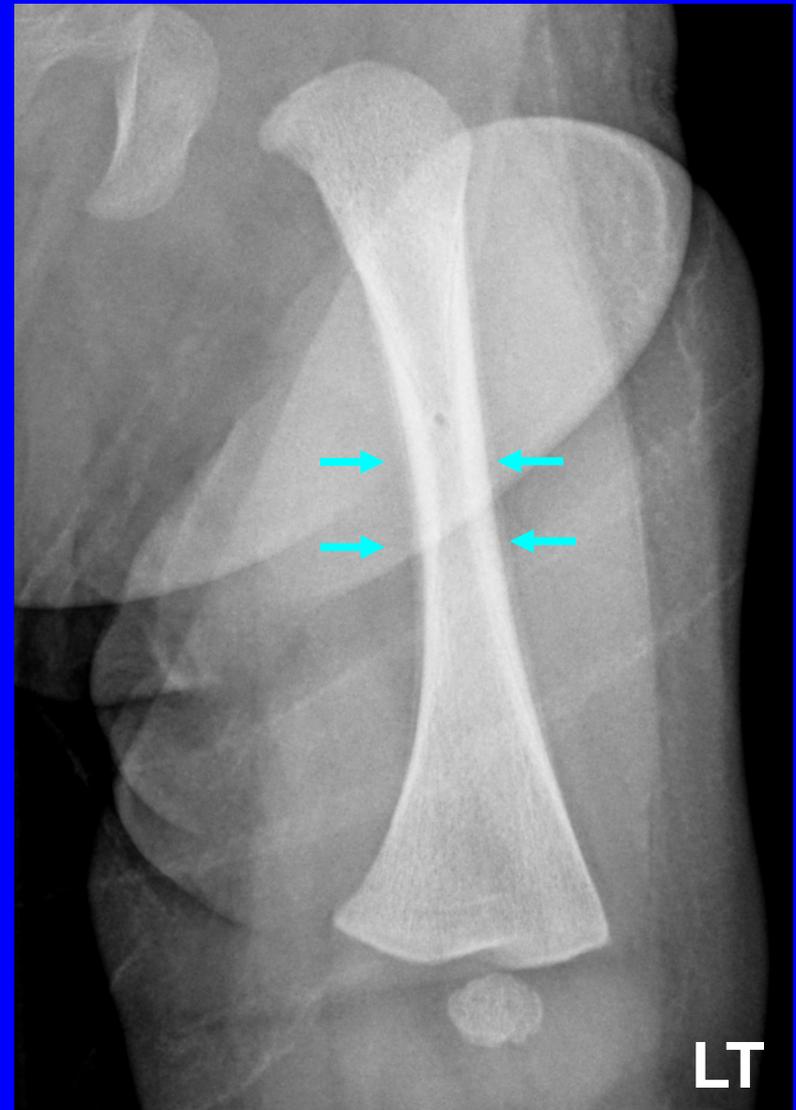
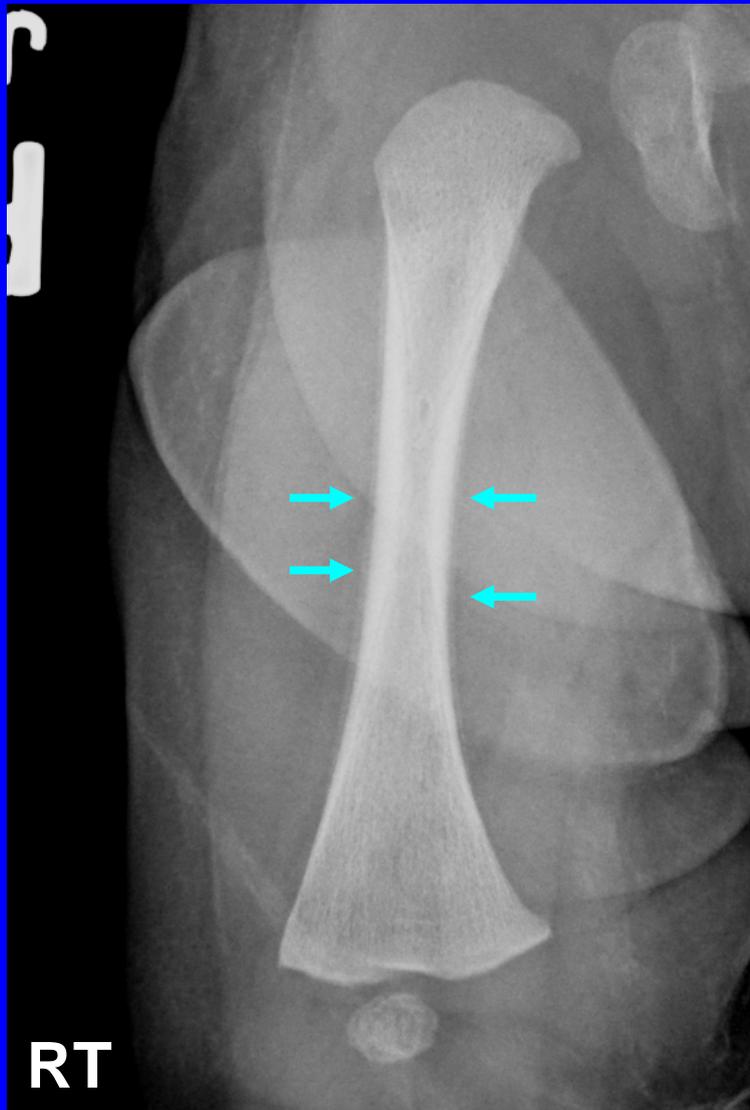
1. Physiologic periosteal reaction

- Typically seen in ages 1 to 4 months (although anecdotally, can be seen in later infancy as well)
- Tibia most common site, followed by femur, humerus, and other long bones
- Only diaphyseal in location; metaphyseal periosteal reaction is always abnormal!

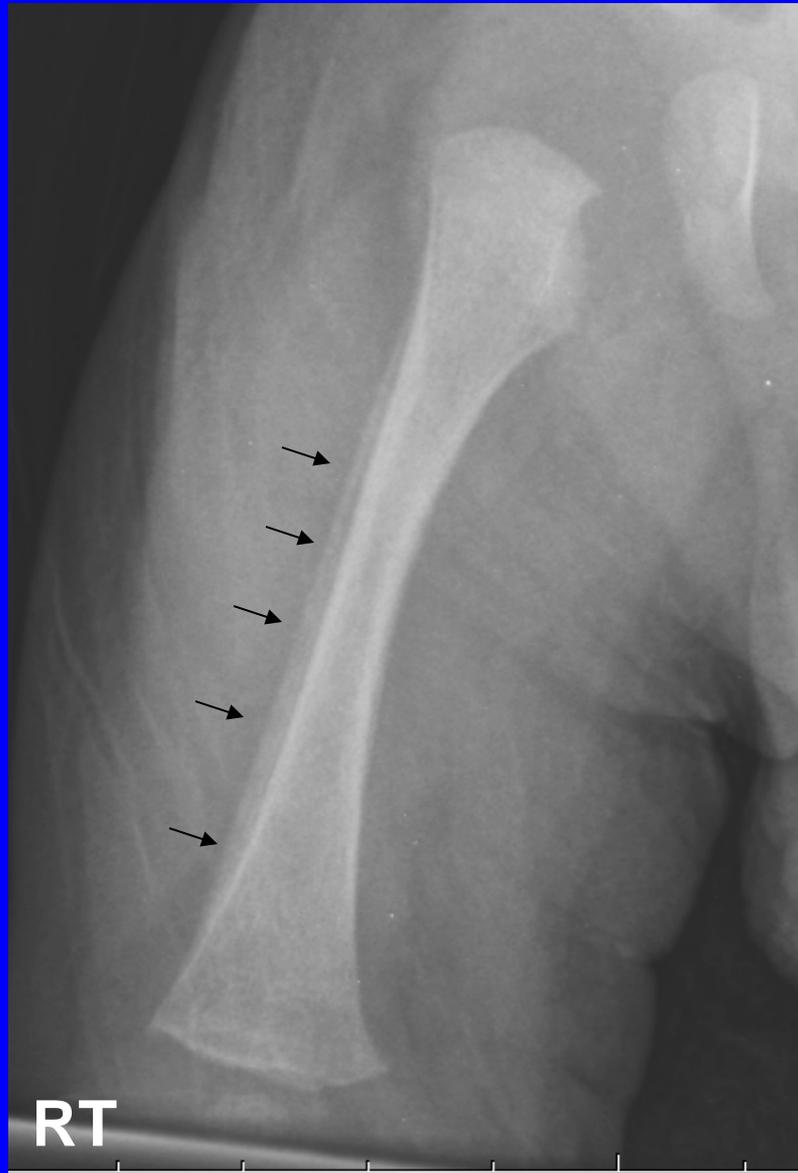
Physiologic periosteal reaction bilateral medial tibia diaphysis in a 1 month old



Physiologic periosteal reaction bilateral medial and lateral femur diaphysis in the same 1 month old



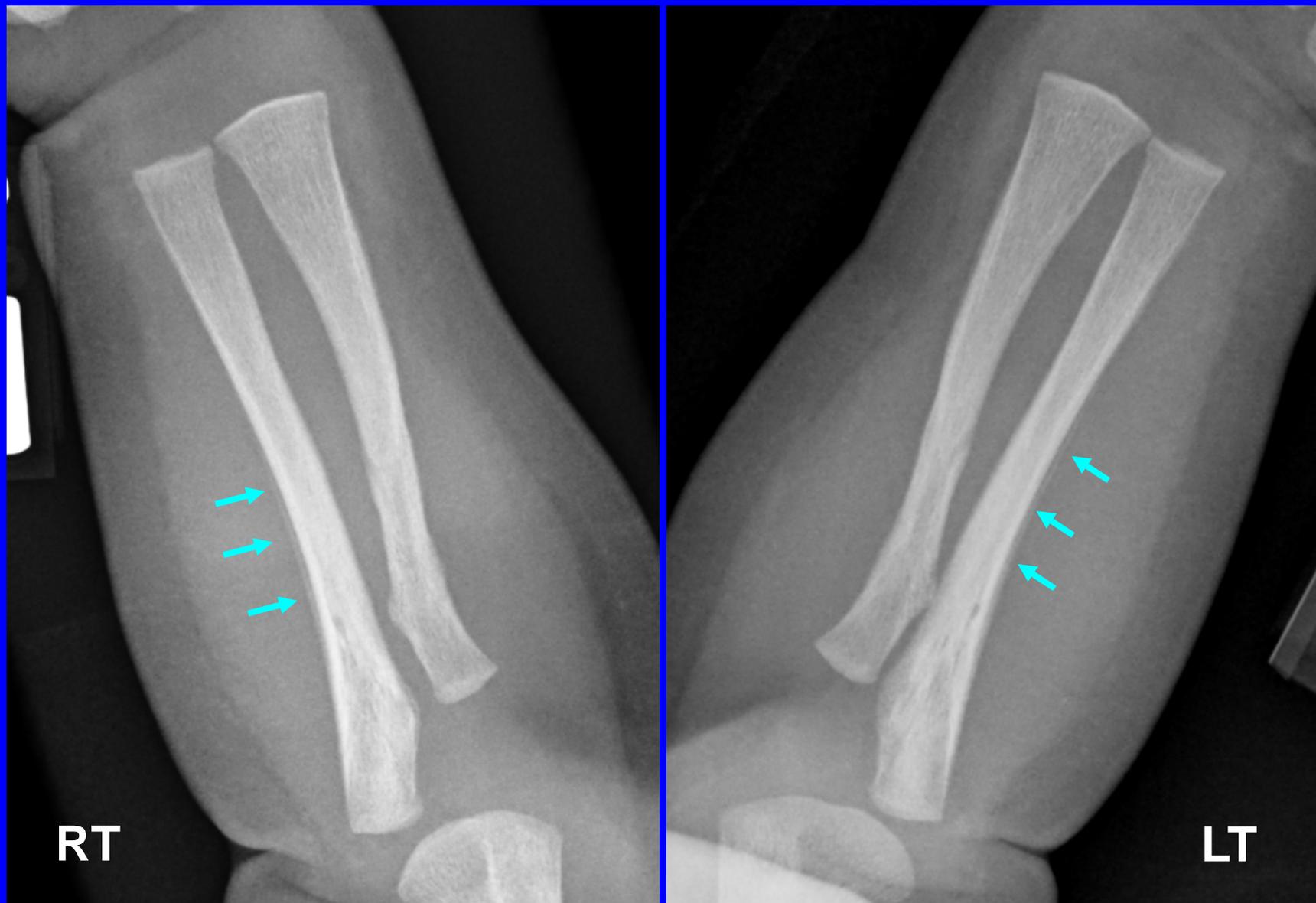
Asymmetric periosteal reaction bilateral femur;
however, remains diaphyseal!



Faint physiologic periosteal reaction bilateral humerus



Physiologic periosteal reaction bilateral ulna



Abnormal periosteal reaction: extends to and is centered at the metaphysis



2. Cortical waviness and thickening proximal radius diaphysis

3 month old with cortical waviness and thickening bilateral proximal radius diaphysis



Cortical thickening and waviness of radius shaft

Resolution with age



3. Cupping and metaphyseal irregularity distal ulna

- Seen in about 20% of infants
- Looks like rickets, however other long bone metaphyses are normal
- May also have associated spur
- May also be seen in the proximal fibula

Cupping and metaphyseal irregularity of bilateral distal ulna in a 2 month old



**Looks like rickets.... However
the radius is normal**

Cupping and metaphyseal irregularity of distal ulna in two different patients

1 month old

5 month old

Note normal radius metaphysis

Cupping and metaphyseal irregularity of bilateral distal ulna in a 6 month old with associated spurs

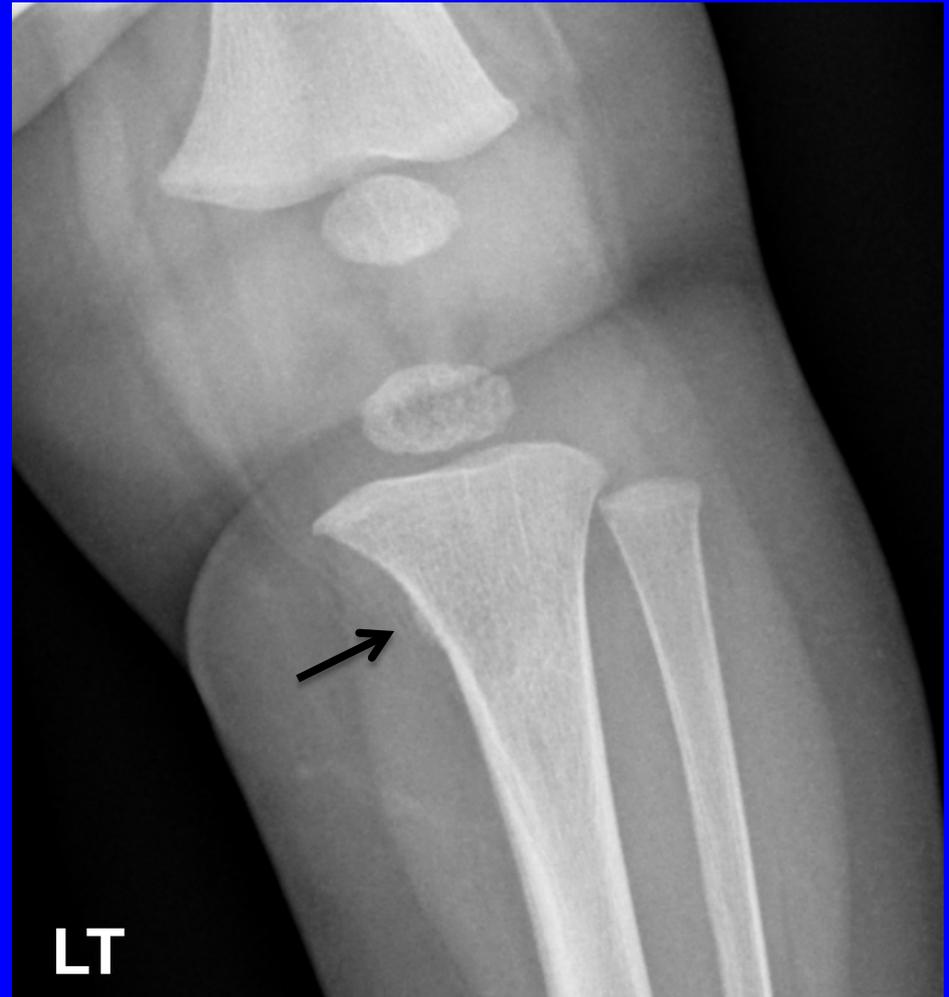
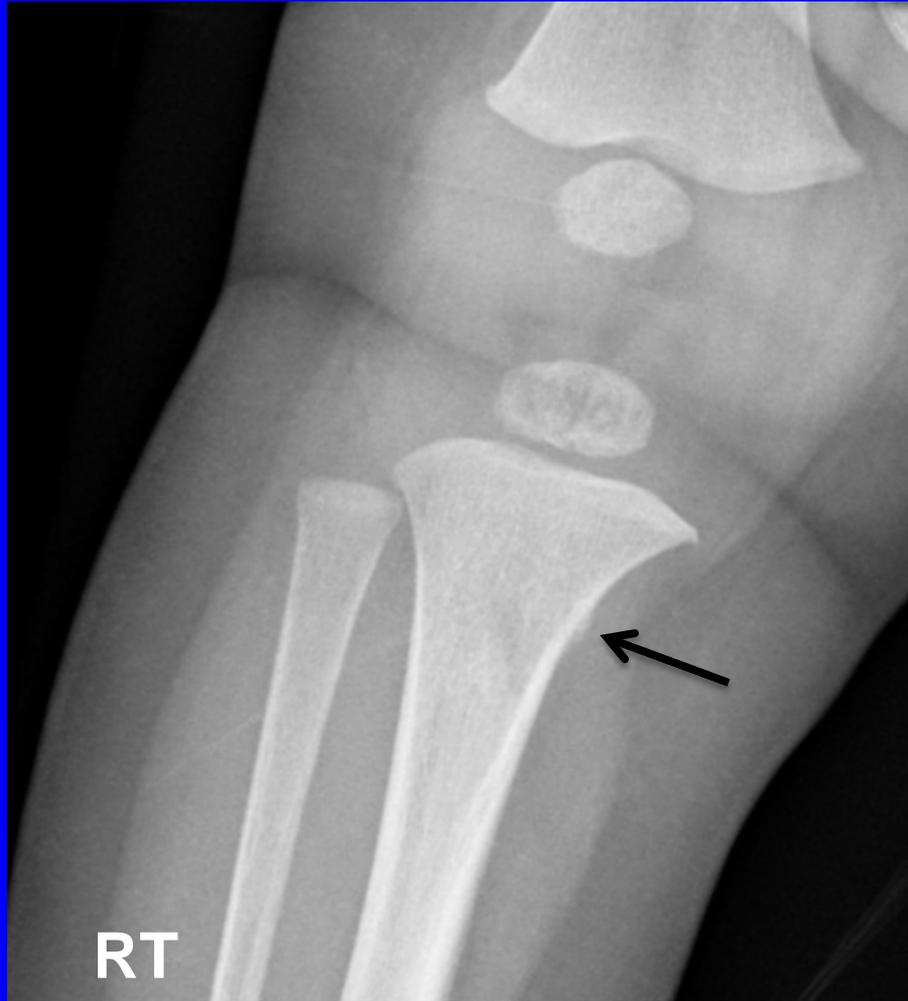


Note normal radius metaphysis

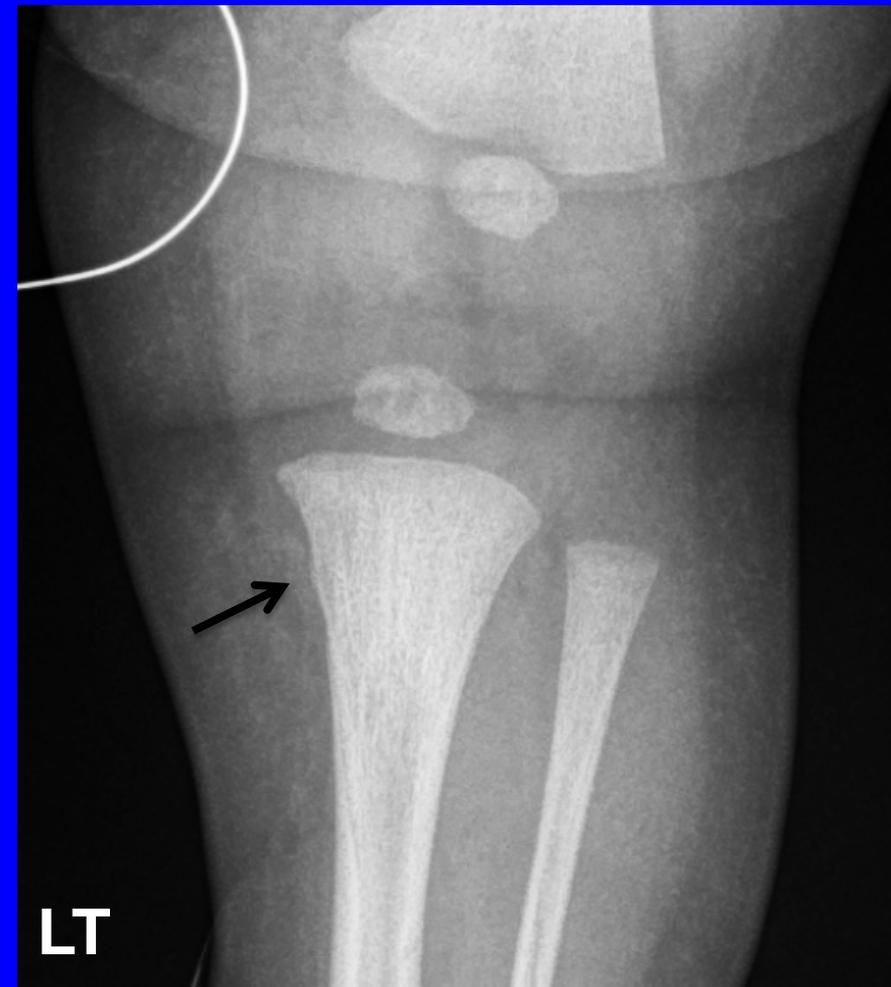
4. Protuberance of medial proximal tibia metadiaphysis

- May be confused with a buckle fracture
- Bilateral in 25% of cases
- May have a fluffy or smooth appearance
- More accentuated when leg x-ray is taken in slightly internal oblique position (instead of true AP)

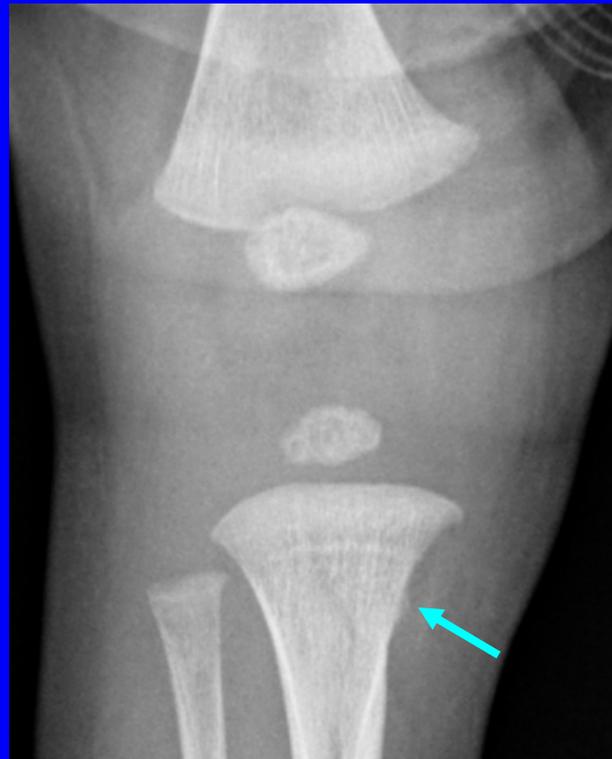
Focal protuberance medial proximal tibia metadiaphysis
bilateral— fluffy appearance



Focal protuberance medial proximal tibia metadiaphysis
unilateral on the left –smooth appearance



Focal protuberance medial proximal tibia metadiaphysis
Not as visible when the AP view is in true AP position
(True AP position: slight overlap of proximal tibia and fibula)



RIGHT



LEFT

Slightly obliqued AP view



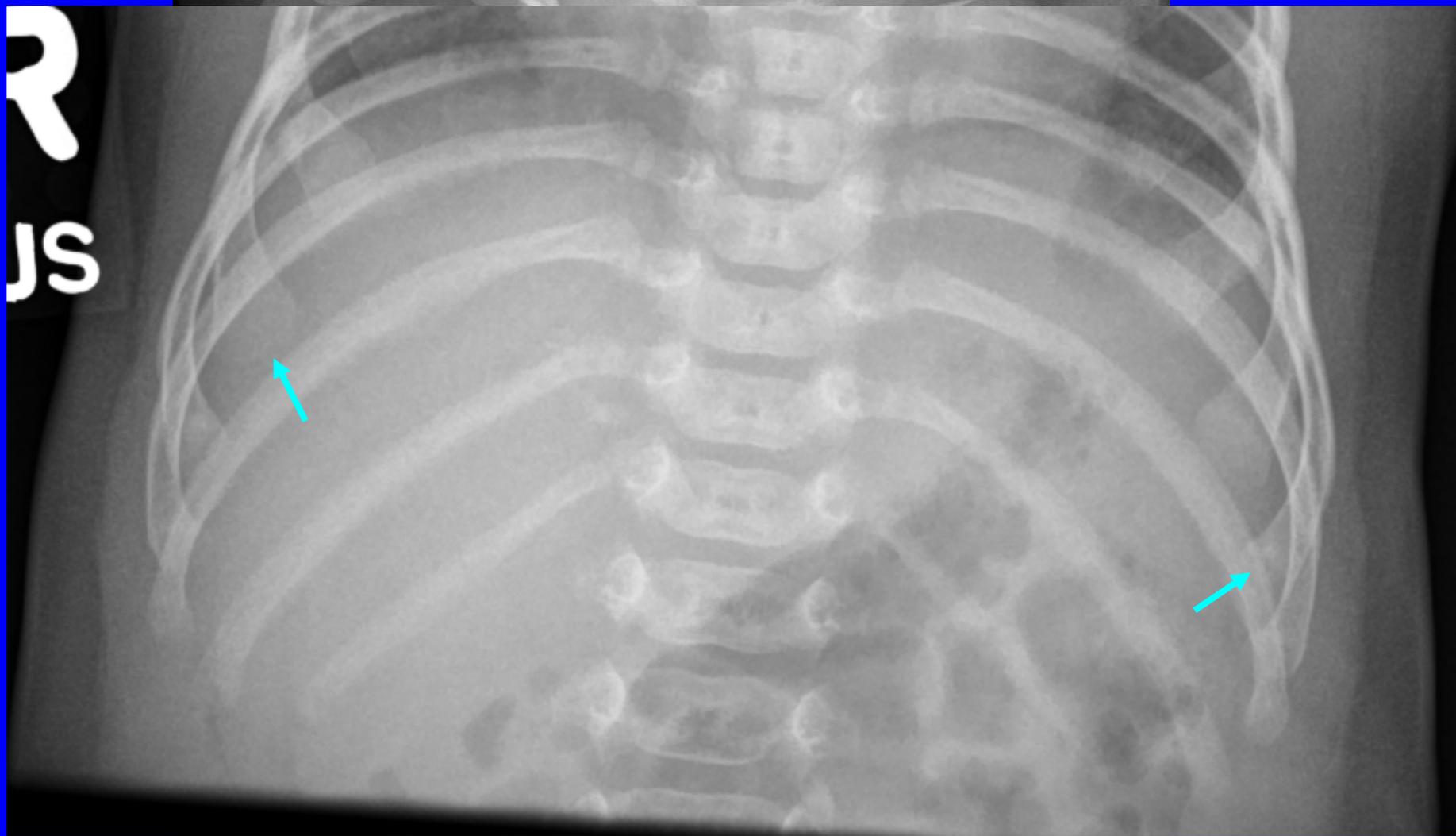
REPEAT LEFT

True AP view

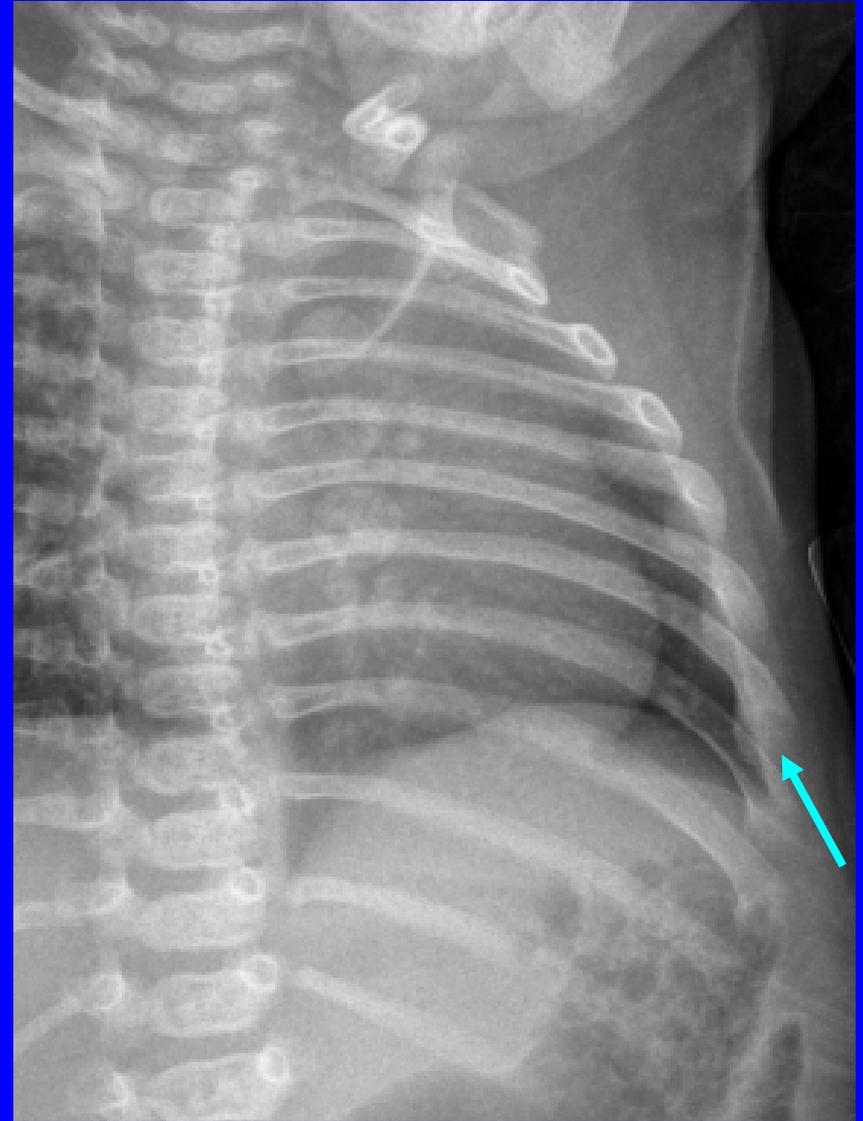
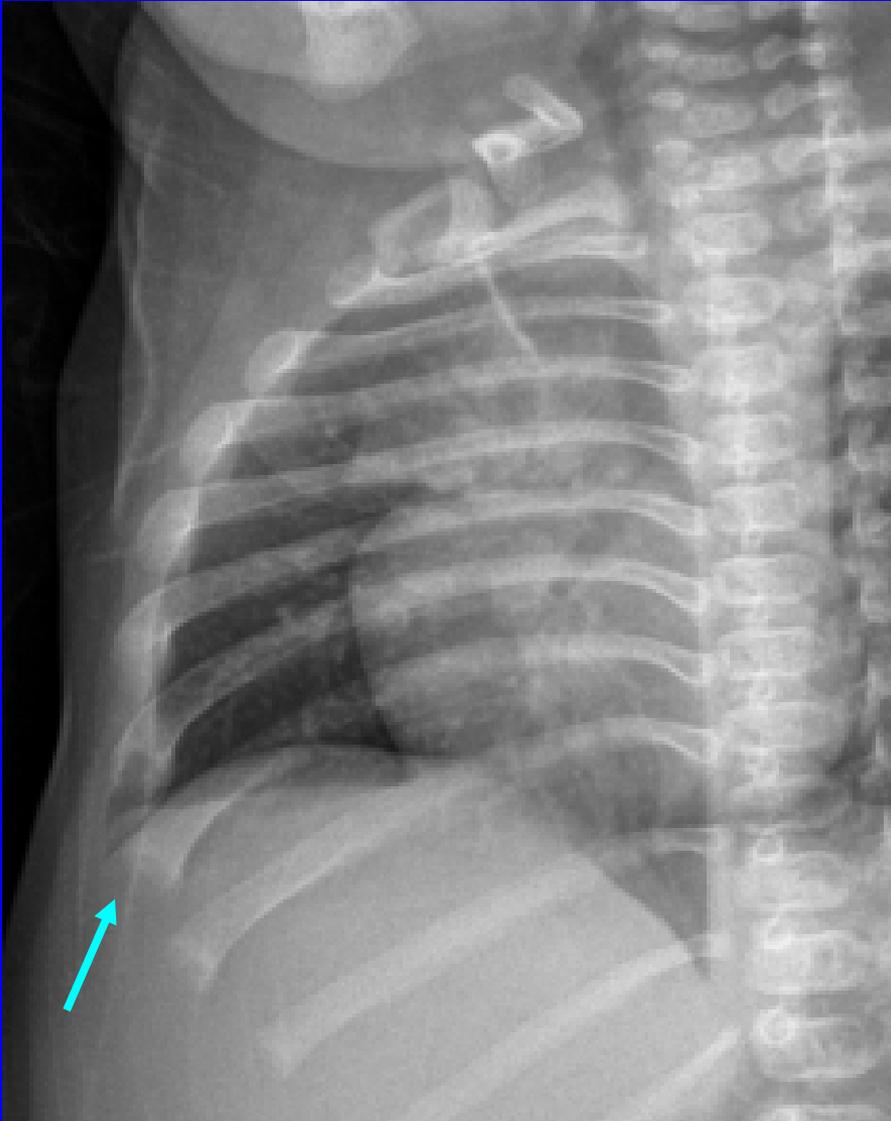
5. Flaring/cupping of anterior rib ends

- Seen in very young infants
- May be seen best on oblique views
- May have a mildly spiculated appearance on CT

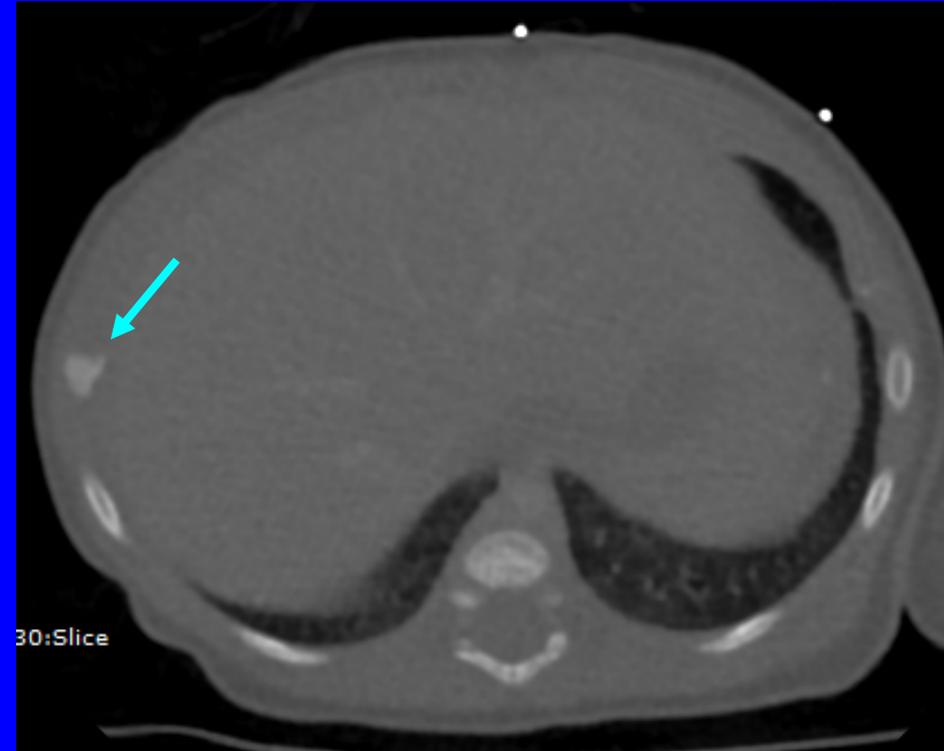
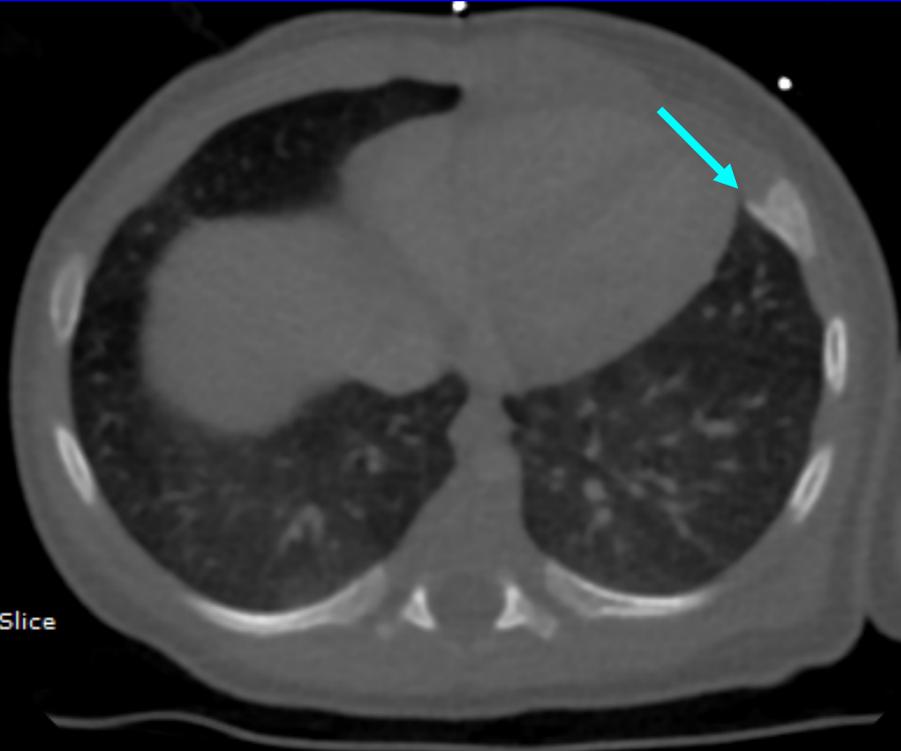
Flaring of anterior rib ends in a 36 day old infant



More cupped appearance of anterior rib ends in a 55 day old infant—bilateral oblique ribs



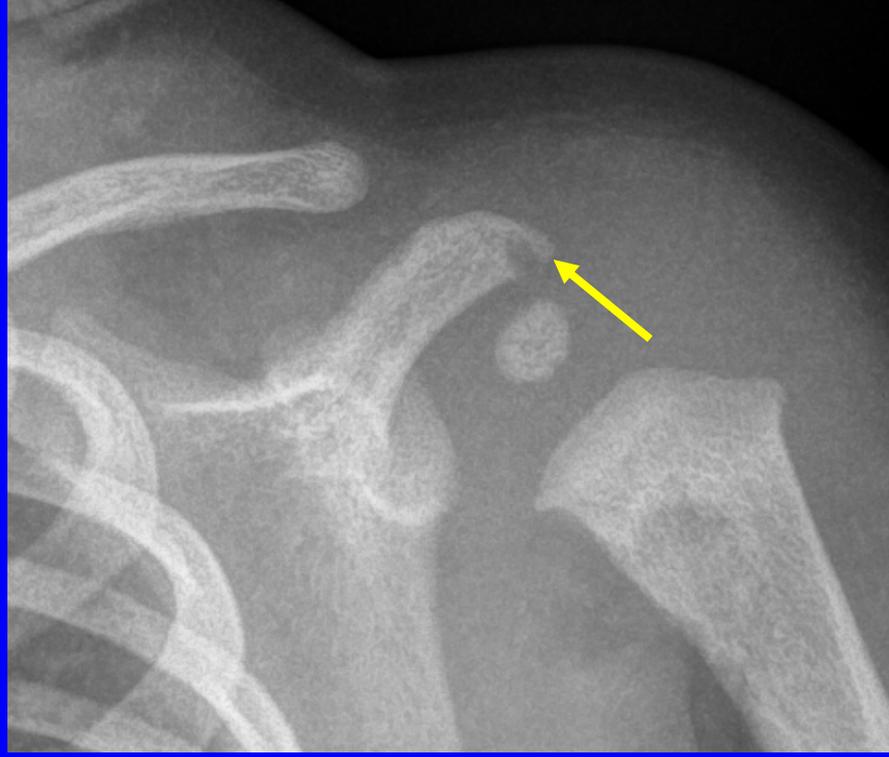
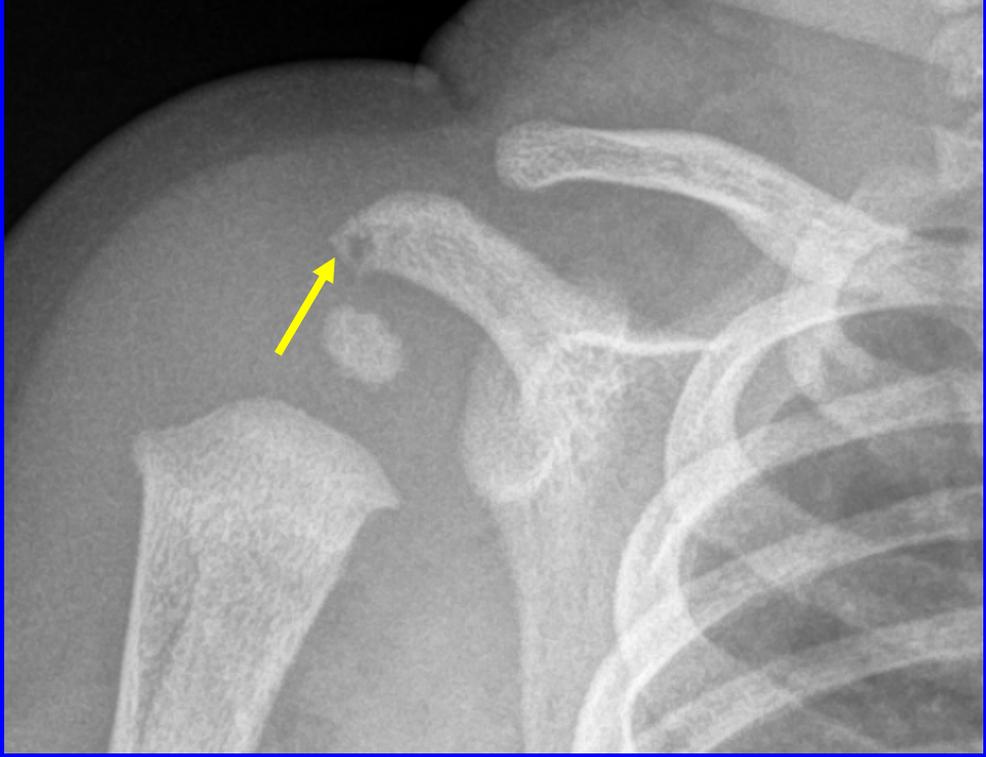
Cupped and slightly spiculated appearance of anterior rib ends in a 50 day old infant—abdomen CT



6. Pseudo- or accessory epiphysis of acromion

- Unilateral or bilateral; may be asymmetric
- Adjacent to tip of acromion; various shapes and sizes
- May be confused with fracture of acromion; however unlike a fracture, will remain unchanged on follow-up skeletal survey;

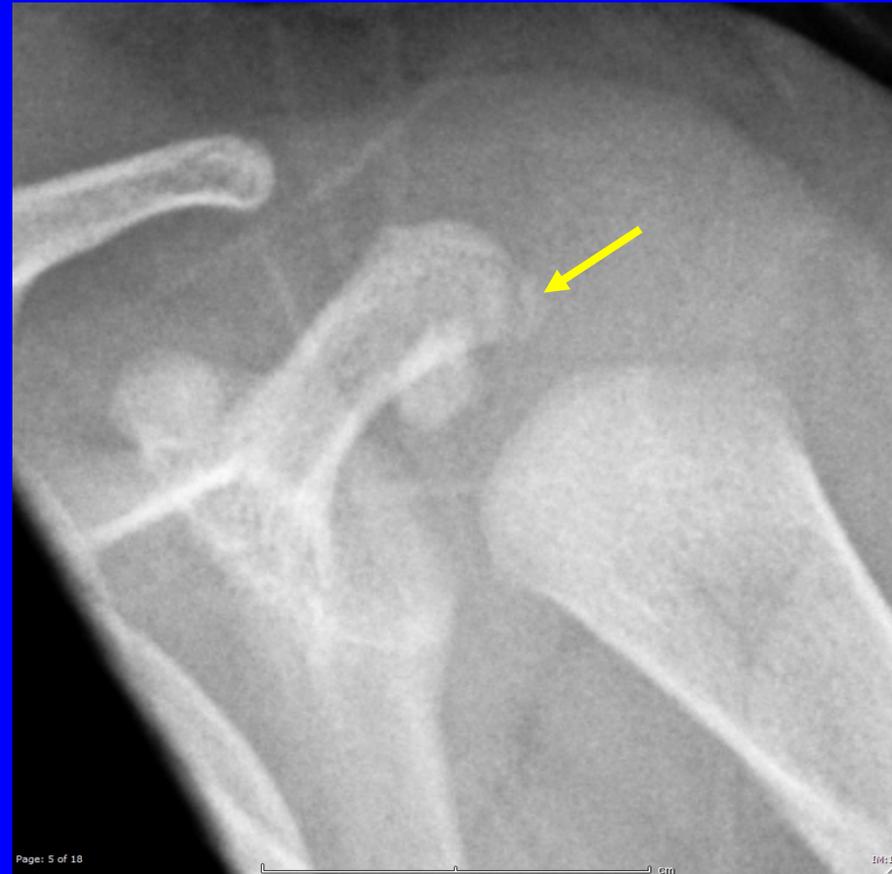
Bilateral accessory epiphysis of the acromion--6 mos old



LEFT accessory epiphysis of the acromion--5 mos old
with genital injuries **stable on follow-up**



12/13/16

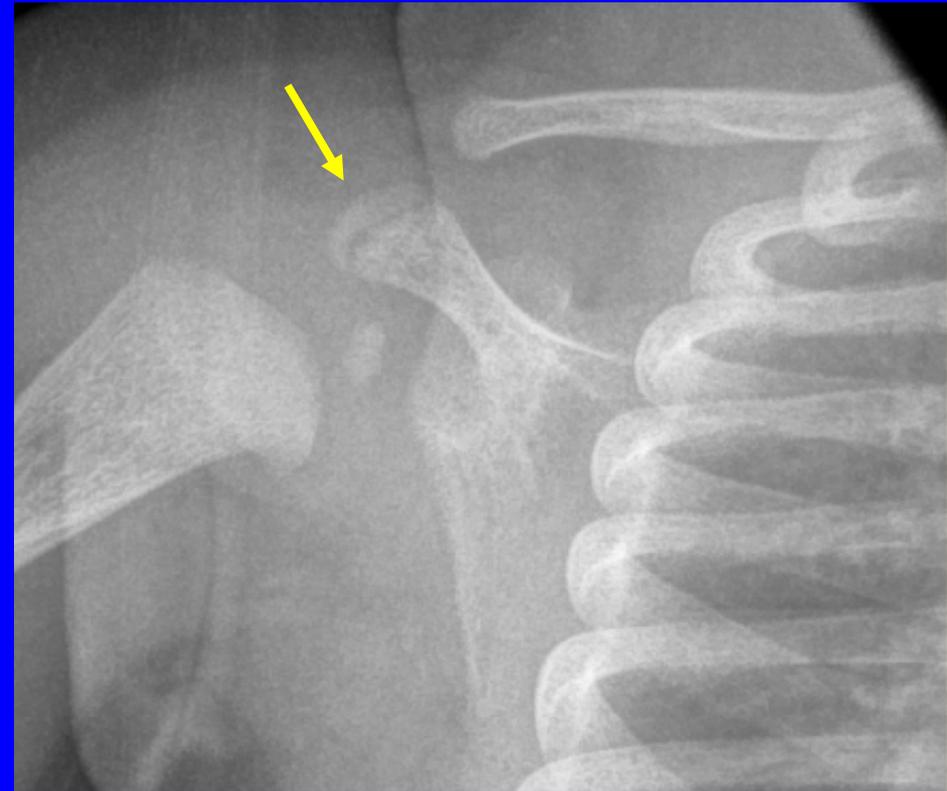


12/29/16

**RIGHT accessory epiphysis of the acromion-- 3 mos old
with subdural hematoma **stable on follow-up****



1/24/15



2/11/15

Two different patients with unilateral accessory epiphysis of the acromion. Different shape and size.



II. CML look-alikes

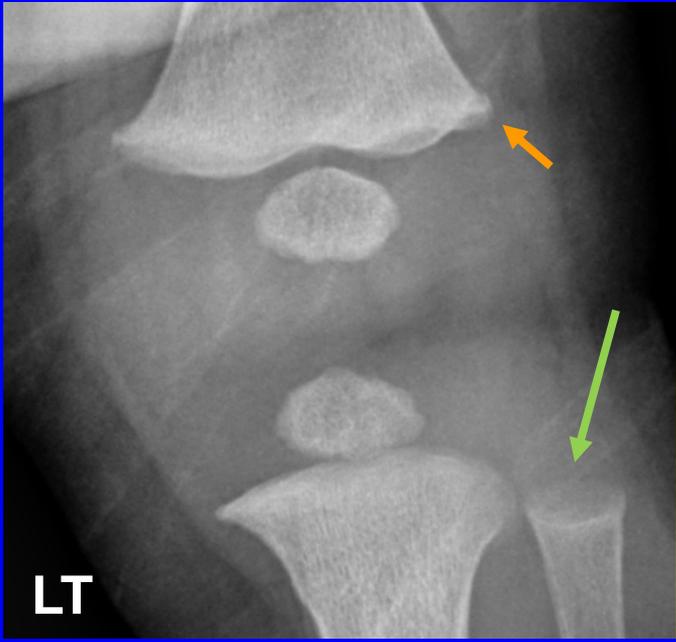
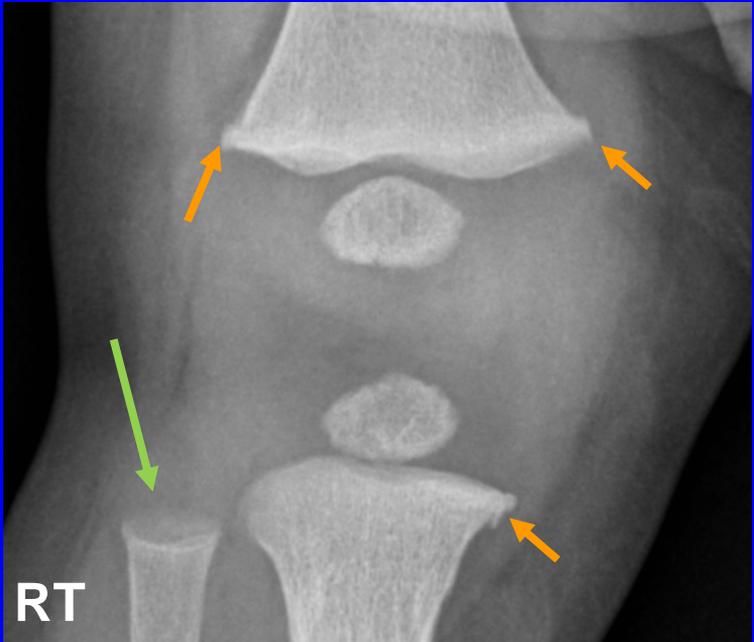
(remember, CML is a lesion of infancy, unusual to see past 12 mos of age)

1. Metapyseal beaks and spurs
2. Prominent perichondrial ring
3. Metabolic: rickets; abnormal copper metabolism
4. Chondrodysplasias

1. Metaphyseal beaks and spurs

- Unilateral or bilateral
- Looks like an extra piece of bone extending beyond the metaphysis; *no lucent line in the metaphysis as seen with CML*
- Will remain without significant change on follow-up skeletal survey

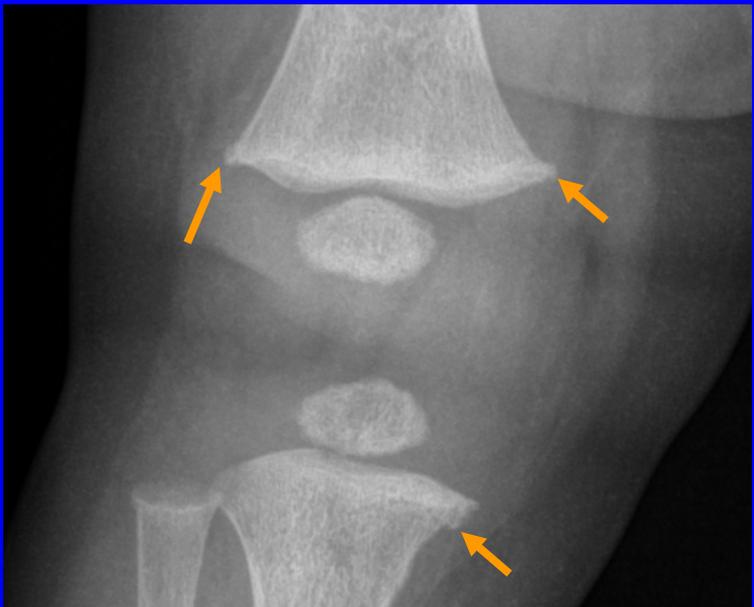
Metaphyseal irregularity: 3 mos old. **No change on F/U**



Metaphyseal spurs

Initial x-rays

One additional dev. variant?



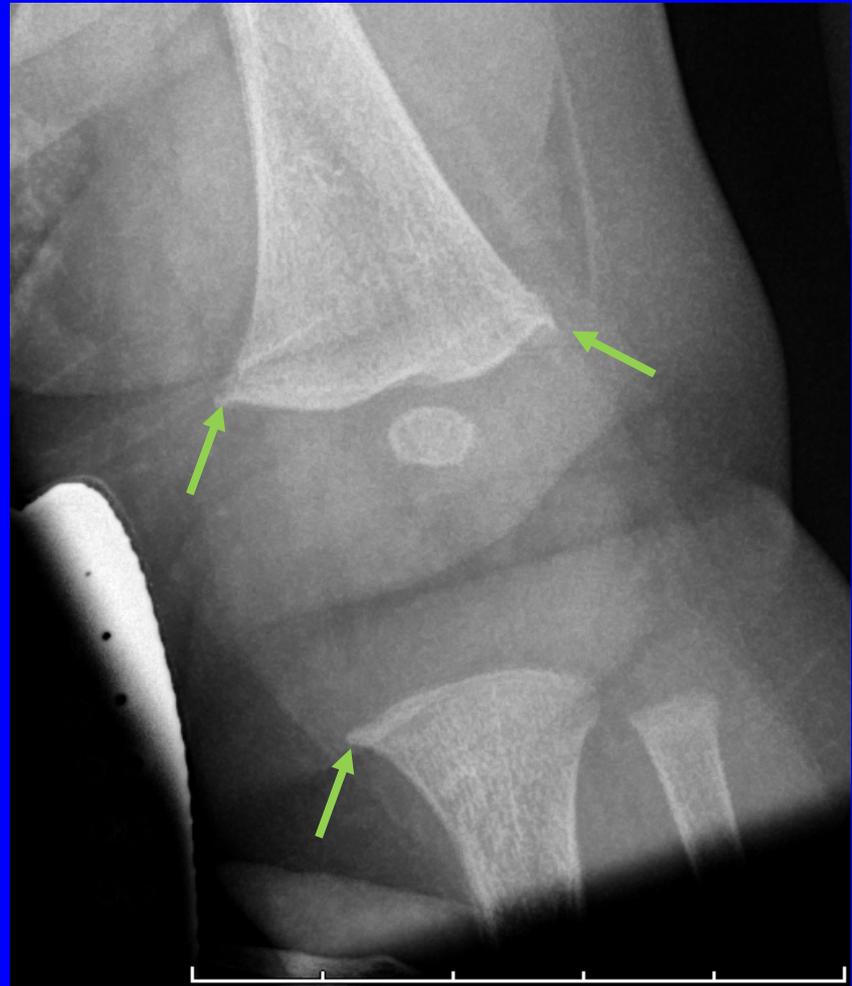
Cupping bilat proximal fibula

Follow-up 15 days later

Metaphyseal irregularity: 3 mos old with abusive head trauma. **No change on F/U** Metaphyseal beaks



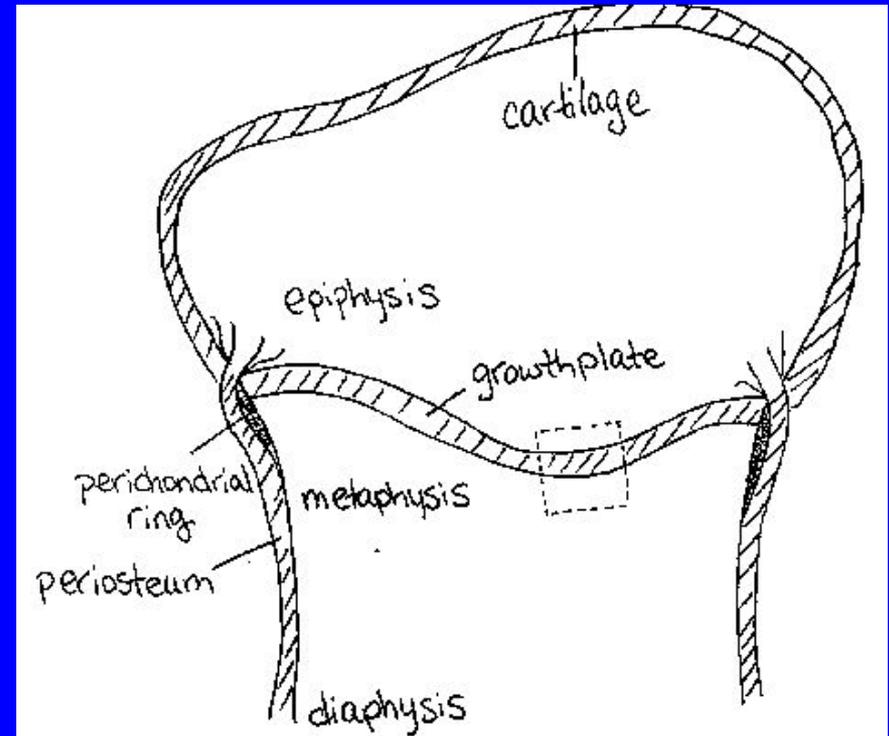
Initial SS



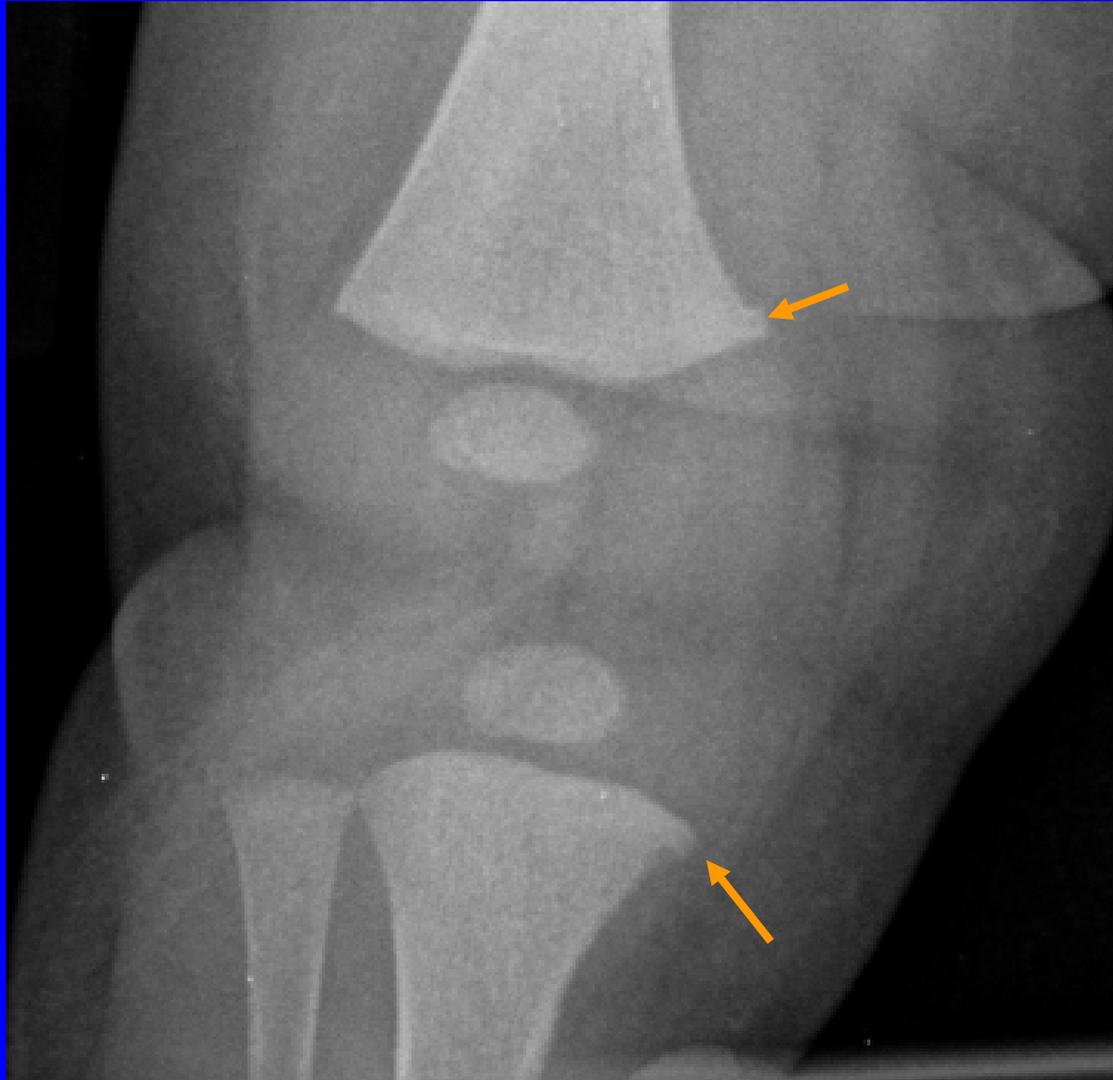
Follow-up SS

2. Prominent perichondrial ring

- Causes a *squared* appearance of the metaphysis.
- Seen most often around the knee and wrist.
- Seen more often in ages *beyond infancy*



Prominent perichondrial rings in a 57 day old



Prominent perichondrial rings: bilateral in two different patients



15 mos old

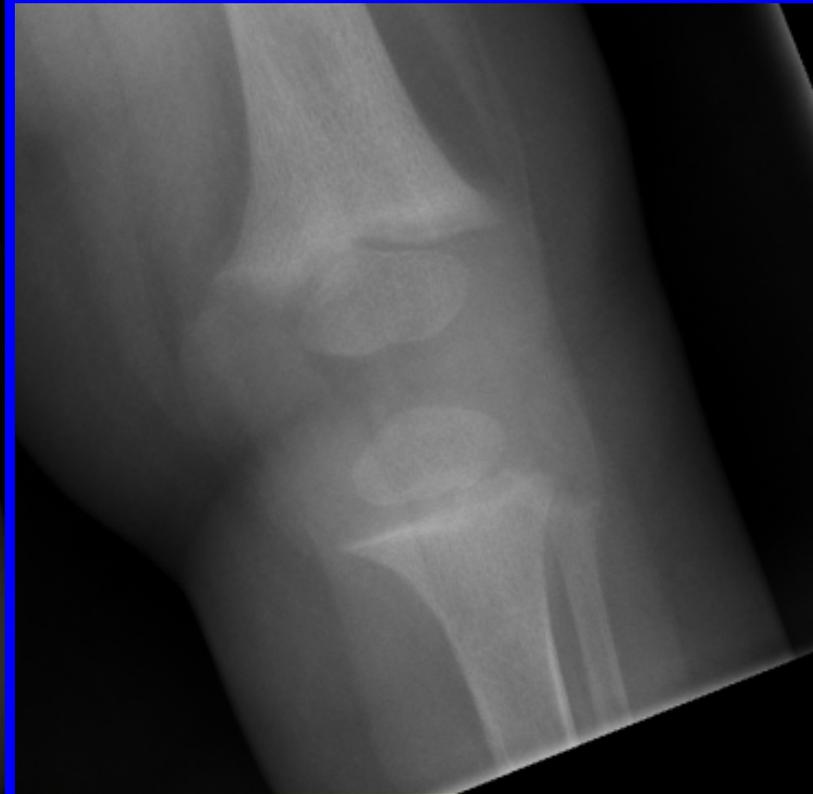
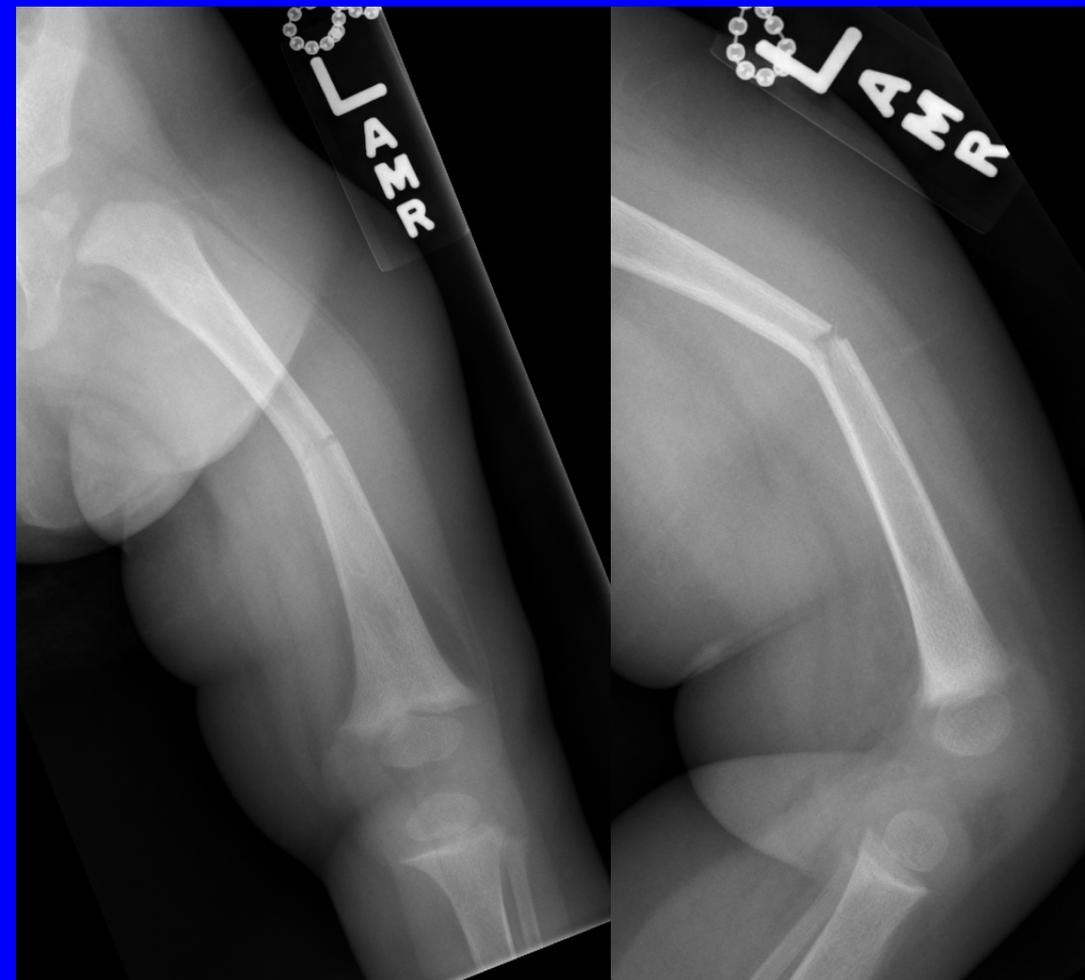


13 mos old

3. Metabolic bone disease

- Rickets—metaphysis is frayed, cupped and widened
- Bones may be demineralized or have a coarsened trabecular pattern
- Will affect all metaphyses of long bones, most prominent around wrist and knees

8 month old with acute LT femur fracture.
Findings consistent with rickets distal femur and
proximal tibia.



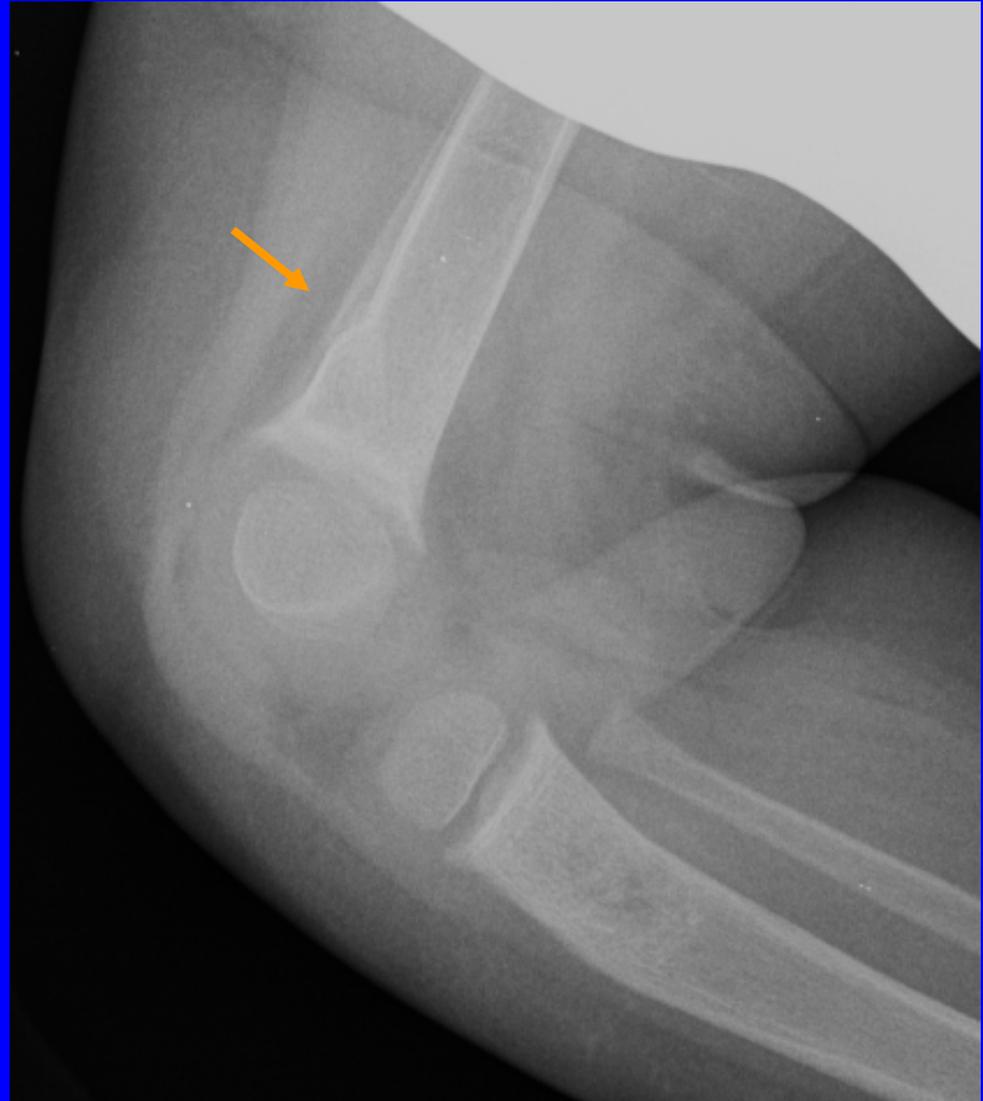
Same patient: 8 month old with acute LT femur fracture.
Rickets in distal tibia/fibula and distal radius/ulna.
Coarsening of the trabeculae.



14 mos old with limp.

Rickets with healing insufficiency fx distal femur.

Coarsening of the trabecula



Same patient. 14 mos old with limp. Rickets— bilateral wrists



7 mos old with MEDNIK syndrome—abnormal copper metabolism—note bowing distal tibia and fibula, demineralized bones



POP QUIZ: 4 different patients



III. Other Findings

1. Soft tissue swelling
2. Evidence of intraosseous line placement

1. Soft Tissue Swelling

- Don't forget to look at and *comment on* the soft tissues in your dictation.
- Localized soft tissue swelling is important information for the child abuse pediatrician.
Cutaneous injuries are the most common injury in physical abuse.
- *Diffuse* soft tissue edema is not uncommon in an infant who is in the ICU and is usually related to fluid resuscitation.

3 year old with multiple abrasions and bruises.
Bilateral thigh swelling and CK of 26,000



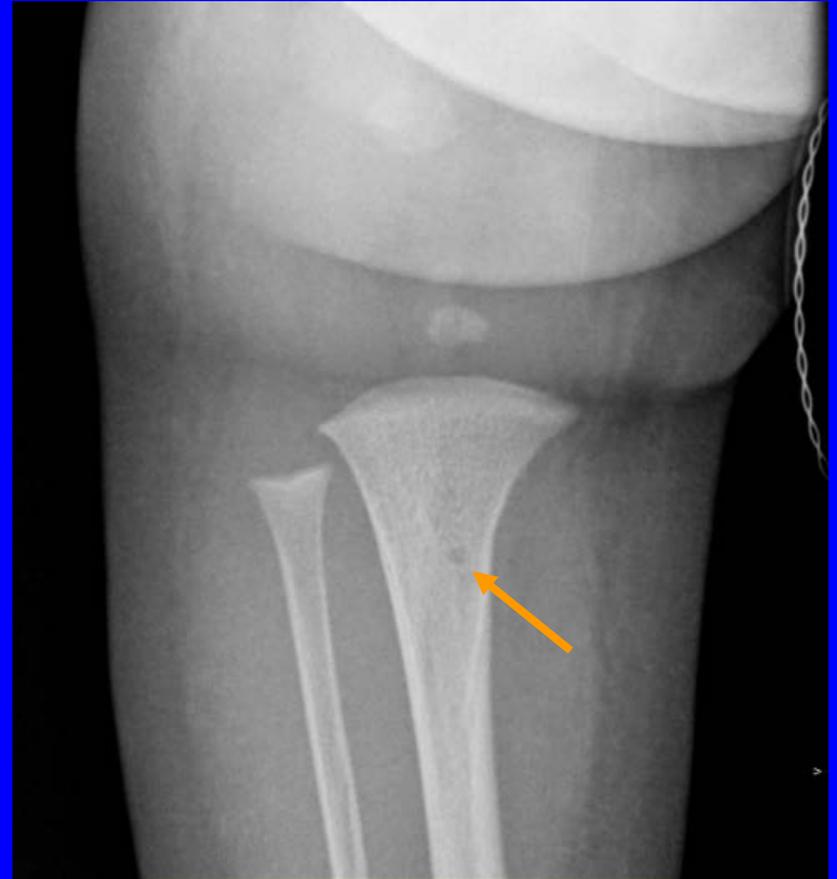
2. Evidence of Intraosseous line placement: proximal tibia

- Usually in an infant who has been resuscitated in the field
- Proximal tibia metadiaphysis—rounded well demarcated lucency
- May be bilateral or may have more than one in the same bone

Intraosseous line placement: 2 different patients with abusive head injury

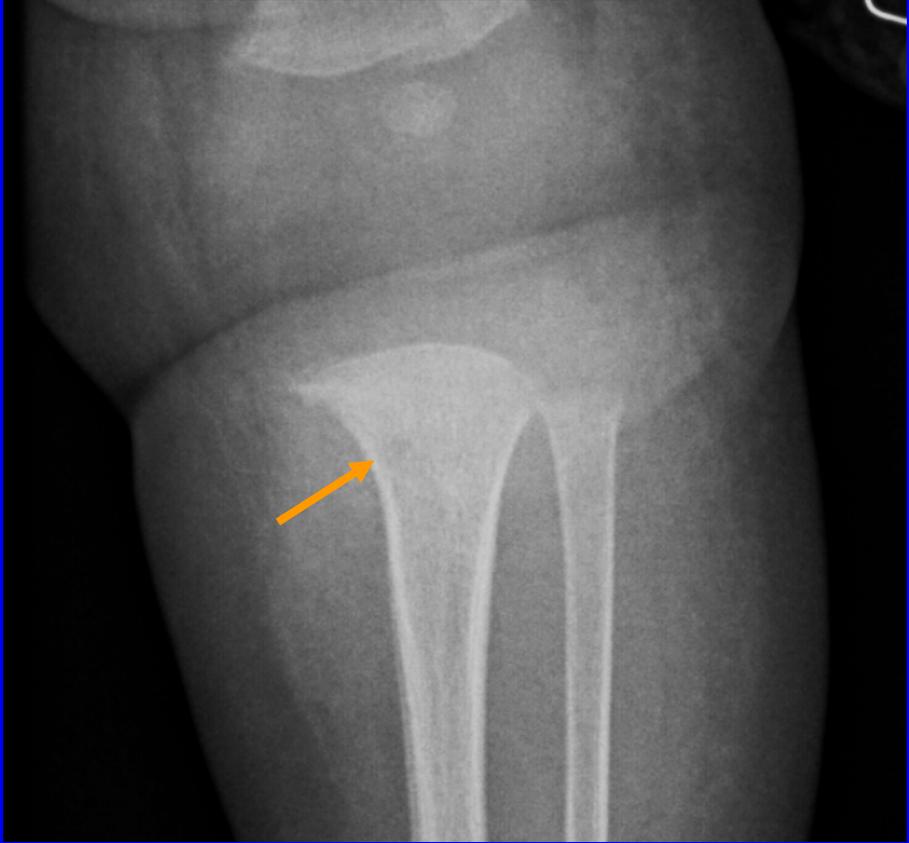
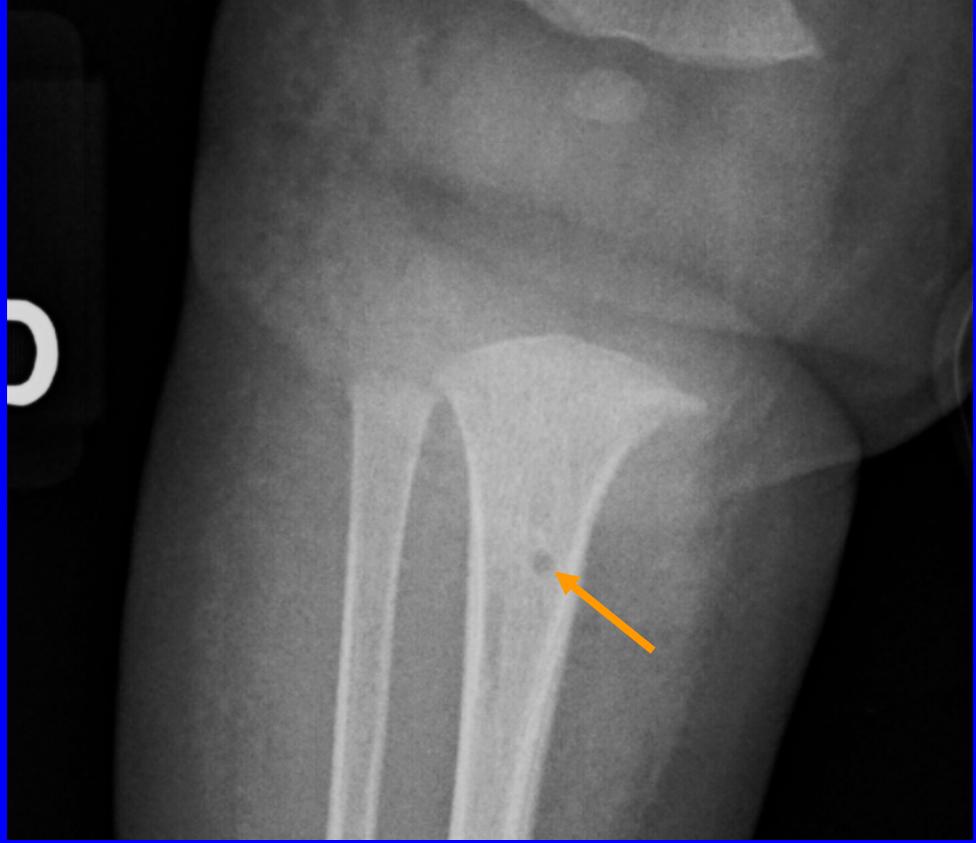


4 mos old

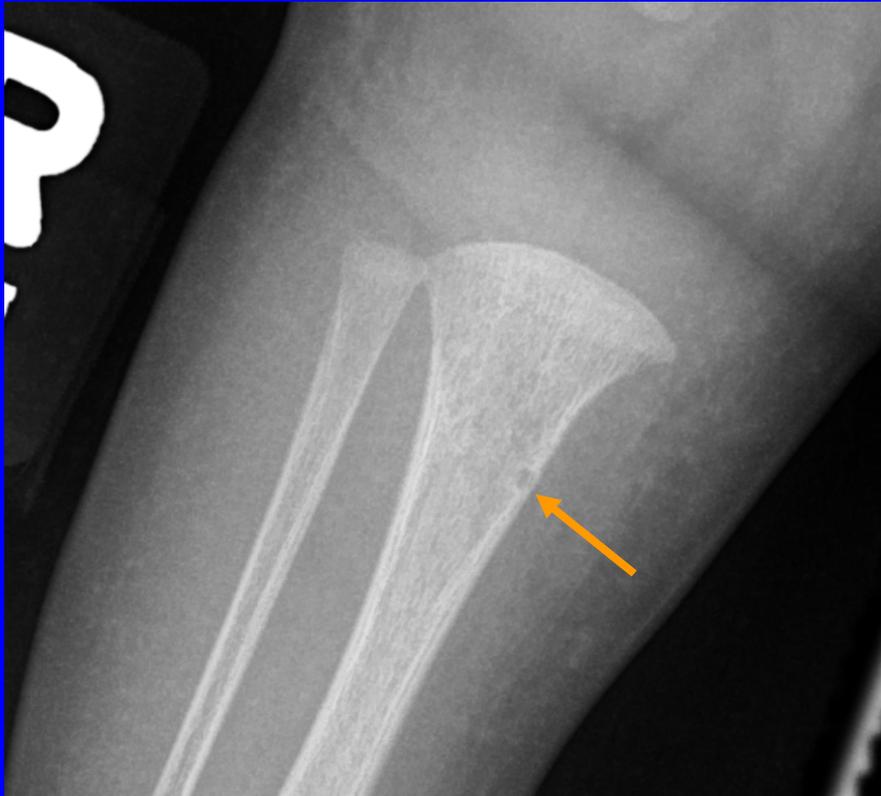


3.5 mos old

Intraosseous line placement: Bilaterally in a 4 mos old with abusive head injury



Intraosseous line placement: Bilaterally in a 3 mos old with abusive head injury; 2 on the LEFT



Examples of Additional Findings on Follow-up Skeletal Survey

Image from initial
Skeletal Survey



Image from f/u
Skeletal Survey



Image from initial
Skeletal Survey



Healing proximal
radius fx

Image from f/u
Skeletal Survey



10/10/16

Healing 1st
metatarsal fx



10/26/16



2/8/16

Healing bowing
fibula fx



2/22/16

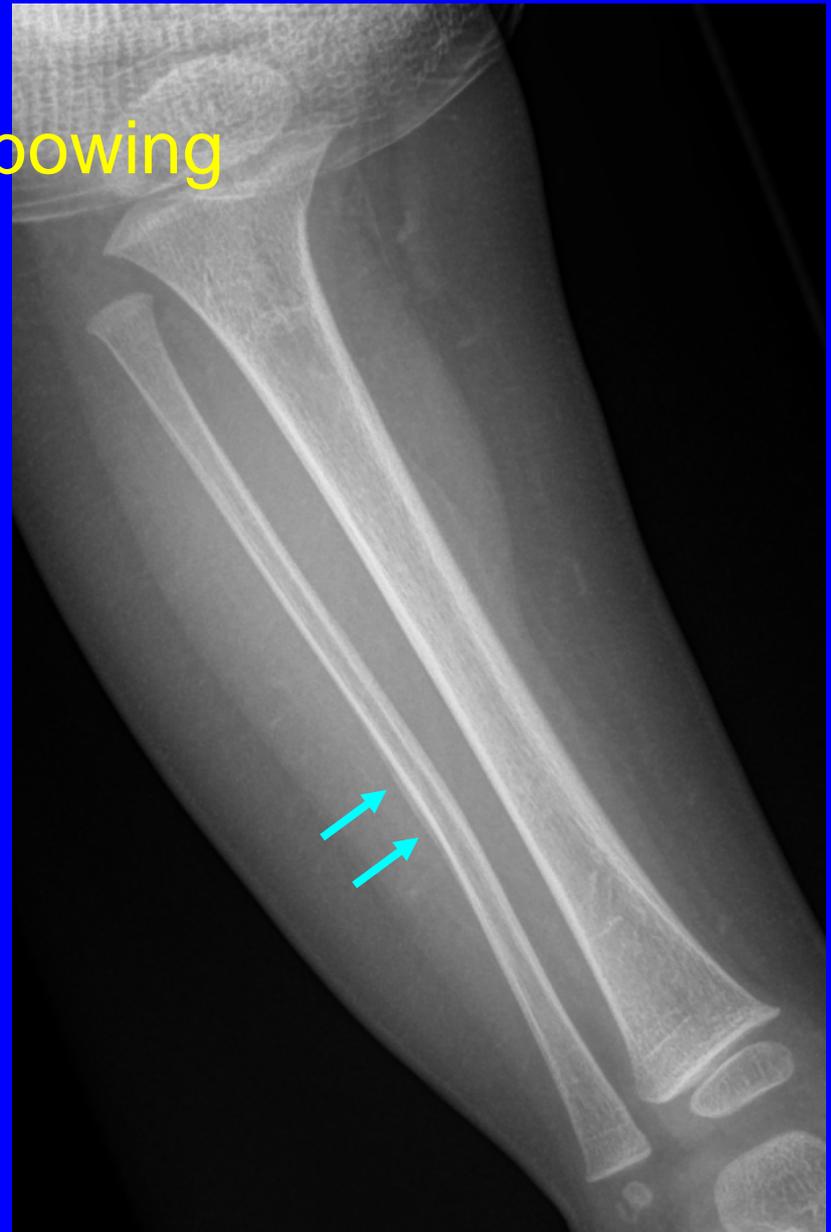


Image from initial Skeletal Survey

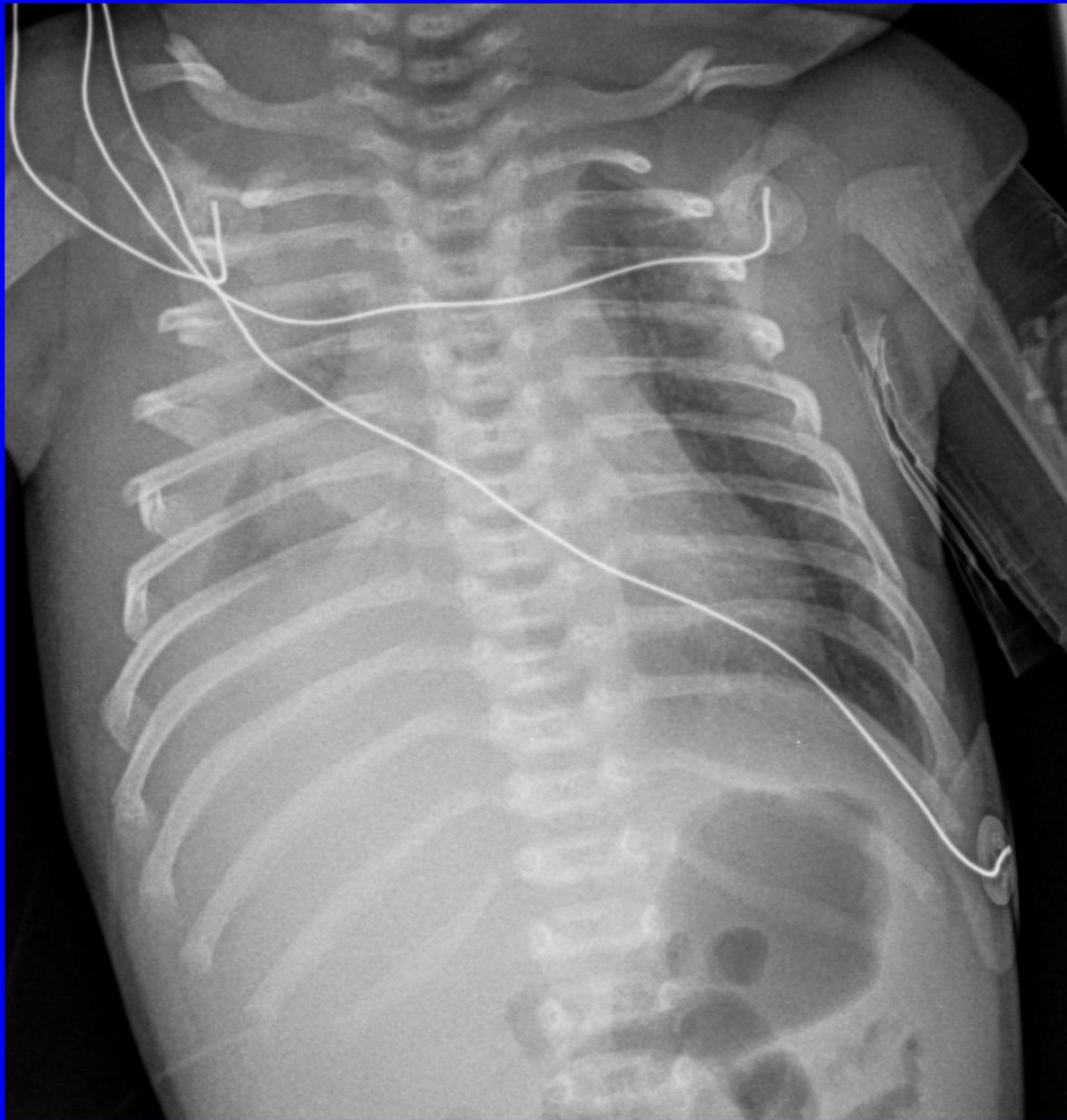


Image from follow-up Skeletal Survey



Newly
apparent
healing rib
fractures

(every
fracture
counts!)

Image from initial
Skeletal Survey

Image from f/u
Skeletal Survey

Newly apparent CML

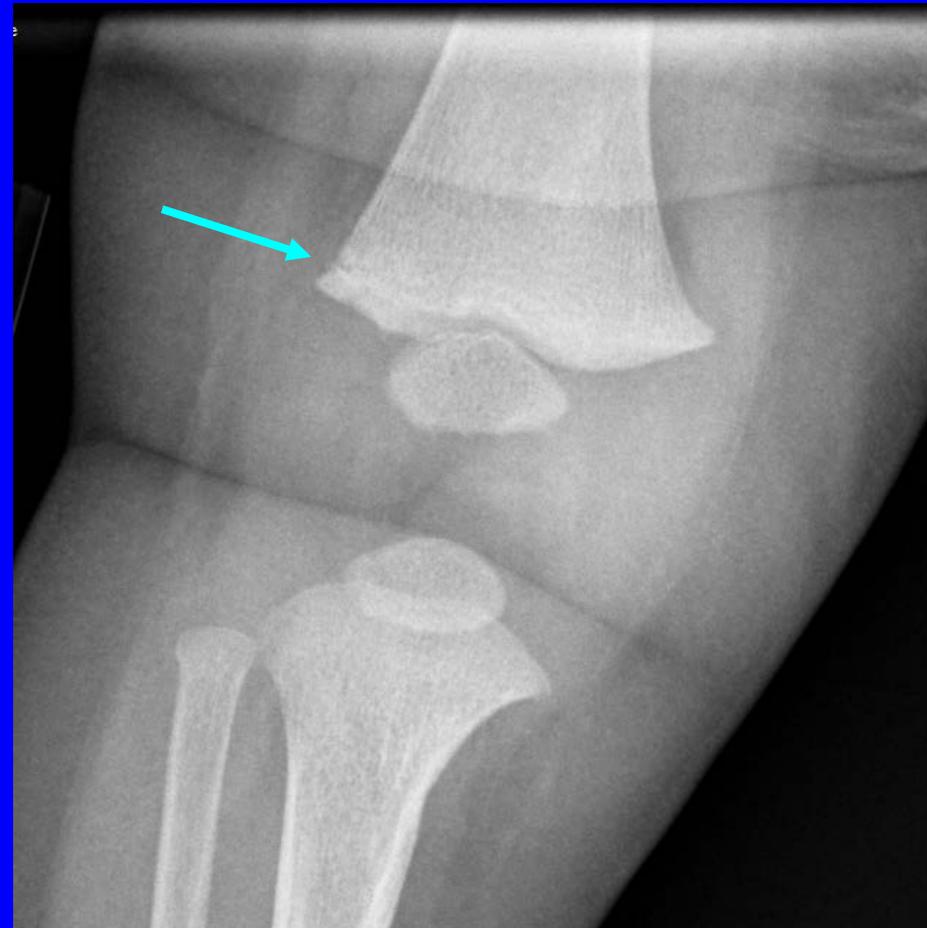
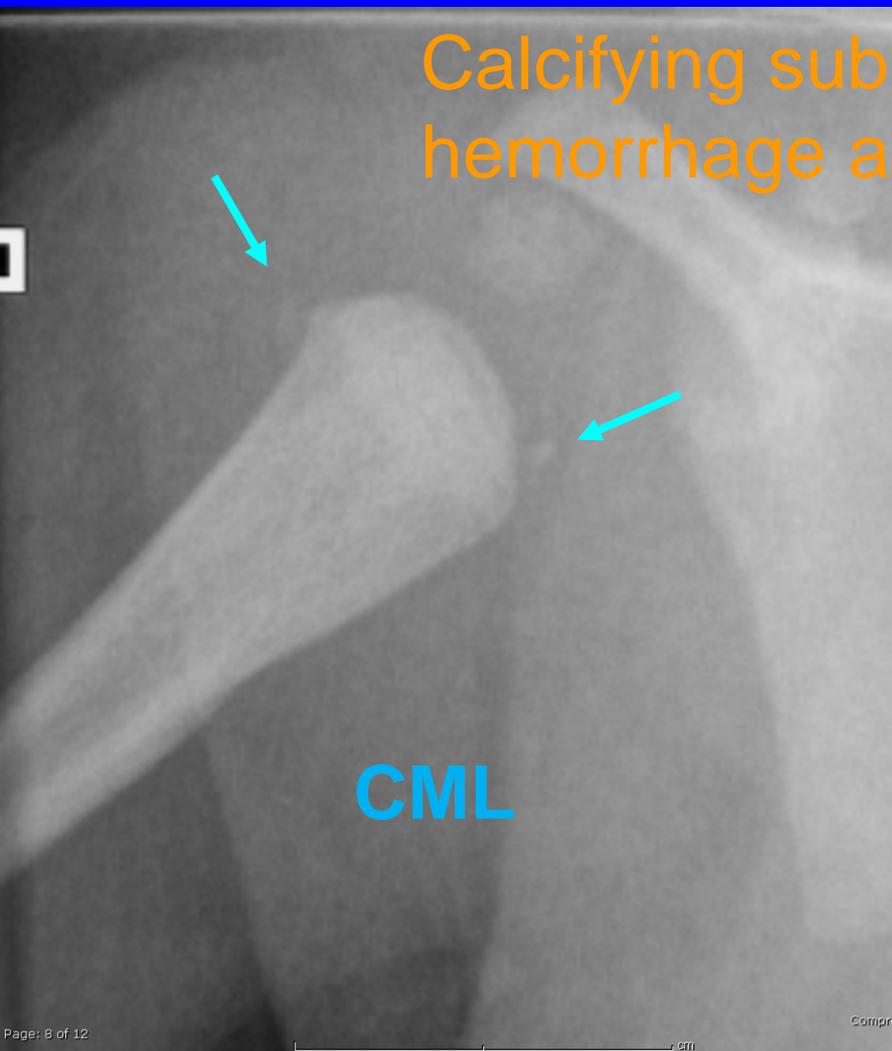
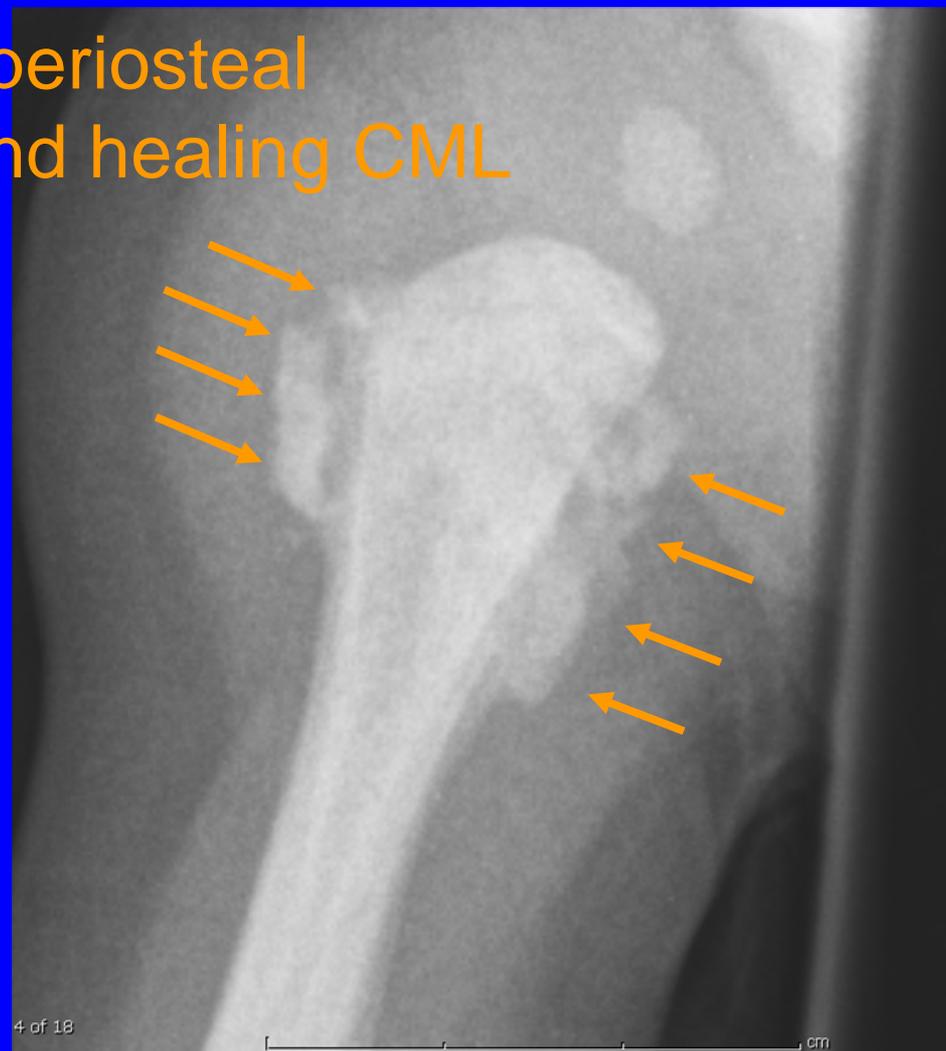


Image from initial
Skeletal Survey



1/29/08

Image from
f/u Skeletal Survey



2/11/08

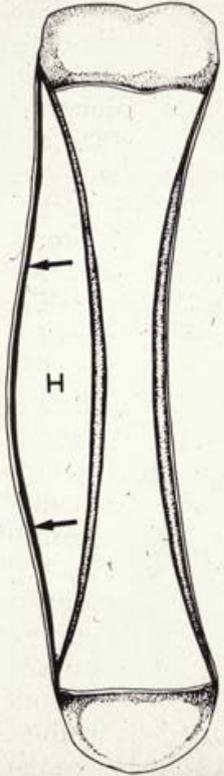
Subperiosteal Hemorrhage

Periosteum: loosely applied in infants.

When a bone is subjected to shearing forces, may result in a *subperiosteal hemorrhage* – same mechanism as a CML.

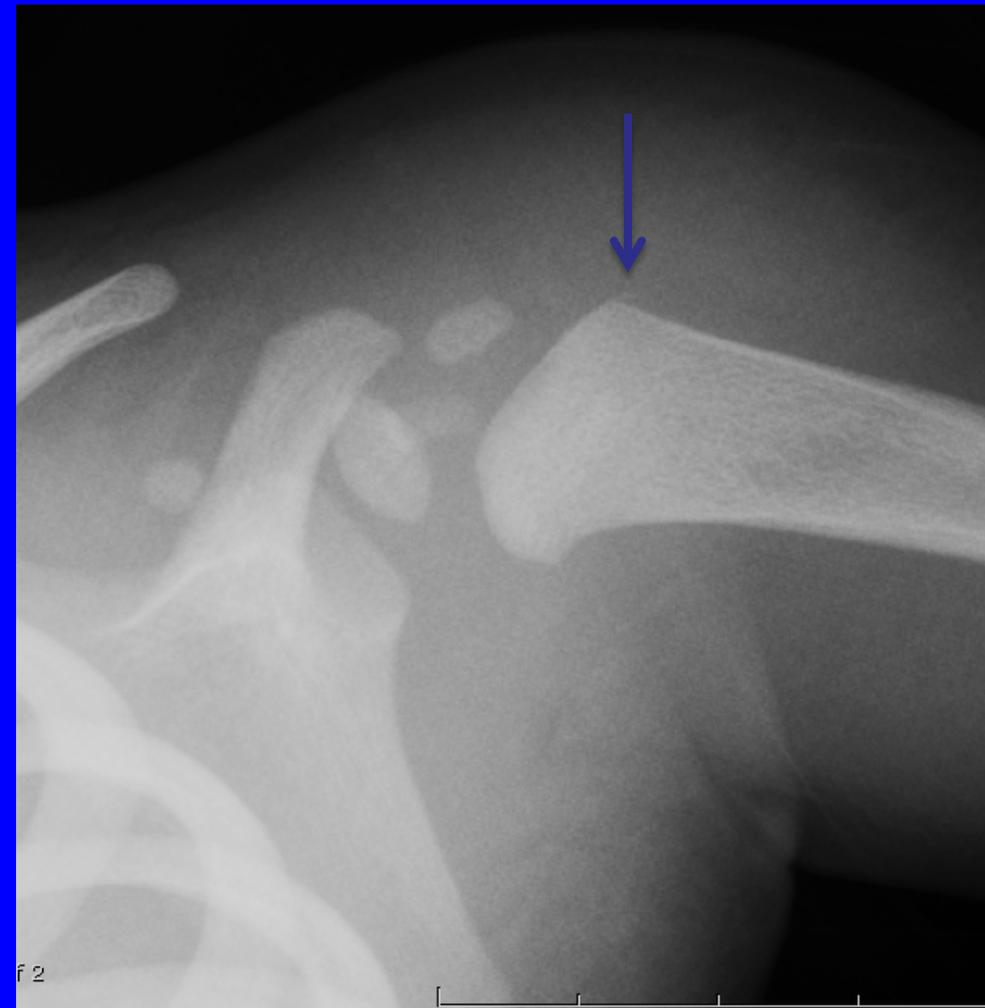
So CML may be associated with a subperiosteal hemorrhage, which becomes apparent *only upon healing on f/u imaging*: amorphous calcification of the blood situated *slightly away* from the bone.

Most often seen in the humerus and femur.



4 mos old not moving LT arm: cone down from LT humerus series

Calcifying subperiosteal hemorrhage and healing CML



Initial SS



F/U SS

Summary

- Initial and follow-up skeletal survey imaging and utility of the f/u skeletal survey
- Common developmental variants on the skeletal survey
- Mimickers of CML's
- Other findings on the survey: focal soft tissue swelling; intraosseous line placement

Post-Test Questions

TRUE OR FALSE

1. The skeletal survey includes 2 orthogonal views of each bone: **FALSE**
2. Physiologic periosteal reaction is limited to the diaphysis of the long bone: **TRUE**
3. A helpful way to distinguish a metaphyseal spur or beak from a classic metaphyseal lesion is get a follow-up image to assess for change **TRUE**
4. Fractures are the most common physical injury in non-accidental trauma **FALSE**
5. Cupping and irregularity of the distal ulna indicates rickets, even if other metaphyses are normal **FALSE**

References

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3. Zimmerman et al. Utility of follow-up skeletal surveys in suspected child physical abuse evaluations. Child Abuse and Neglect 2005
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5. Kwon et al. Physiologic subperiosteal new bone formation: prevalence, distribution, and thickness in neonates and infants. AJR 2002
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