FRACTURES IN ABUSED CHILDREN
MECHANISMS AND ESTIMATES OF AGE

VFPMS Seminar 2019
Anne Smith, Director VFPMS
Background
What do we want to know?

Does bone injury exist?

What pattern/type of injury is this?

Are there other injuries? (Bone / otherwise)

  What is the mechanism of injury?
  What forces caused it/ contributed?
  Timing? How long ago did it happen?

Does the ‘explanation offered’ account for the injury?
If not, why not? What might better explain it?
How do we know what we know?

- Forensic pathology – child homicides
  - Anatomical pathology and Histology
- Radiology
- Clinical forensic medicine (cause of injury)
- Population Health (epidemiology)
- Orthopaedic surgery
- Research – biomechanics / forces and physics
- Accidental bone injury – patterns of injury and healing
- Metabolic & genetic disease states (abnormal bone)
- The courts – criminal justice system
- The media

There is much we still do NOT know, but we are learning!
6 favourite references

Bilo RAC, Robben SGF, vanRijn RR Forensic Aspects of Paediatric Fractures Differentiating Accidental Trauma from Child Abuse 2010 (Springer)

Kleinman P., Diagnostic Imaging of Child Abuse 3rd ED (Mosby)

Offiah and Hall, Radiological Atlas of Child Abuse 2009 (Radcliffe)

WCPSRG Core-Info @ http://www.core-info.cardiff.ac.uk/fractures/index.htm

Carole Jenny, Child Abuse and Neglect; Diagnosis Treatment and Evidence

Child Homicides: Fractures are common

90% CAN fatalities aged < 5
41% CAN fatalities aged < 1
 Majority CAN deaths have healing #

Many have NO external signs of injury

Complex skull # (brain injury common fatal injury in < 2yo)

NB Rib # = common

P. Kleinman
Serious Assault (physical abuse)
Fractures are common

Some studies of Physically Abused children - 11% - 53% have#

Diaphyseal # > metaphyseal # (4:1)

Metaphyseal # around knee and ankles > other limb joints

Bruising > isolated diaphyseal # tranverse > spiral

Of Shaft #, middle 1/3 (50%) distal 1/3 (41%)

Most common long bone (tibia, femur, humerus)
Kondis 2017 Missed Fractures in Infants Presenting to the Emergency Department With Fussiness.

- 3732 charts reviewed, 279 infants with fractures
  - Most common injuries were multiple types of fractures followed by extremity and rib fractures.

- 18 (6.5%) of 279 infants had prior ED visit for fussiness without obvious source.
  - Of these, 2 had a witnessed event causing their fracture, and therefore the fracture was not considered concerning for abuse.
  - The remaining 16 had fractures concerning for abuse.
  - Mean age was 2.5 (SD, 1.2) months.
  - Fifteen (83%) of 18 infants were 3 months or younger at the time of the fussy visit. The mean interval between the first and second ED visits was 27 days (median, 20 days).
Revision: Anatomy of Long Bone


Metaphysis
What forces injure bones?

Today = Mechanical forces
- Compression
- Stretching (tensile)
- Shearing
- Direct blow
  - $F=MA$
  - $F/SA \sim$ tissue damage
- Bending
- Rotation / Torsion (twisting)
- Acceleration/deceleration
- Indirect loads via muscles and joints

Stress = $F/A$

Strain = along length

Stress/strain curve $\rightarrow$
- Yield point
- Stiffness $\sim$ elasticity
DIRECT INJURY MECHANISMS

Eg. Long bones (diaphysis)
- Tapping (blow on small Surface Area)
- Crushing (high force on large area)
- Penetrating (high force on small area)
- Penetrating explosive (high force – lots of tissue damage)
INDIRECT INJURY MECHANISMS
(Mediated via tendons, ligaments & other tissues)

Eg. long bones (diaphysis)
- Transverse fracture - tensile force (eg patella #)
- Oblique - axial compressive force (distal femur #)
- Spiral - torsional force (tibia)
- Spiral with small butterfly - bending force (humerus)
- Transverse oblique with large butterfly - axial compression and bending (tibia)
How do children’s bones differ from the bones of adults?

- Softer, more elastic
- Structure of bone matrix matures with age
- Growth plates at ends of long bones
- Metabolism differs
- More cartilaginous
- Vascular differences
- Poorly attached periosteum along shaft of long bones
- Ligamentous laxity (less rigid supports around joints)
- Different response to forces
- Differing fracture patterns
How do children’s bones react to mechanical forces?

Greenstick #
  – Torus #, Buckle #

Corner fracture = Bucket handle fracture
  – Epiphyseal-metaphyseal #

Periosteum tightly anchored to epiphyseal cartilage
  – traction/torsional forces pull the periosteum
What is the Classic Metaphyseal Lesion (CML)? (Kleinman’s term)

planar micro-fractures
at the metaphyseal-
epiphyseal regions
in the immature primary
spongiosum layer
disc with thin centre and
thicker outer rim
typically described as “bucket handle” and “corner fractures”)}
Figure 4a. Acute CML in a fatally abused 2-month-old child

Figure 4b. Acute CML in a fatally abused 2-month-old child

Figure 5a. Subacute CML in a fatally abused 7-week-old boy

Figure 5b. Subacute CML in a fatally abused 7-week-old boy

Figure 6a. CML in an abused 2-month-old girl

Figure 6b. CML in an abused 2-month-old girl

Figure 7a. Tibial CML in an abused 10-week-old girl

Figure 7b. Tibial CML in an abused 10-week-old girl

Subperiosteal new bone (SPNBF)

Periosteum poorly attached to bone shaft in infants

Strongly attached to cartilage at epiphysis

Promptly clinically obvious at epiphysis?? Silent at diaphysis?

5-14 d thin layer SPNBF – Xray

Nonspecific for abuse
  – (breech(Snededecor)
    – Infection, trauma, metab, other)

May hint at # (eg tibia)

Forces
Pulling twisting, used as handle for shaking, flailing limbs when shaken + direct blows
Common bone injuries seen in abused children

BEWARE
- Classic Metaphyseal lesions
- Rib fractures, esp posterior

- Rare
  - Scapular
  - Spinous processes
  - Sternal

BE ALERT
- Multiple fractures (esp bilateral)
- Fractures of different ages

Uncommon
- Epiphyseal separations
- Vertebral body #/subluxations
- Digital #
- Complex skull #
Common but Nonspecific (seen after BOTH abuse & accidents)

SPNBF
Clavicle #
Long bone shaft #
Linear skull #
How do children’s bones heal?

Osteonal bone healing
- Primary bone healing or primary gap healing (no callus)
- Secondary bone healing with callus formation

Non-Osteonal bone healing
- Callus or gap heals with fibrous tissue that differentiates into lamellar or woven bone (UNCOMMON in children)

Dead bone serves as a mechanical stabiliser until it is remodelled

Remodelling requires weight bearing (Wolff’s law)

Spiral and oblique fractures heal more rapidly than transverse fractures (greater surface area of fracture ends / less surrounding soft tissue damage)

Structure and mechanical properties are completely restored (unlike skin and tendon)

Local factors influence rate of healing (blood flow, coexisting tissue damage)
4 phases of bone healing (Radiol)

1. **Induction phase** (RECENT FRACTURE)

Time of injury to the appearance of new bone at the fracture site.

Inflammatory response may last a few days and reveal itself on x-ray in the form of **soft tissue swelling** with displacement and **obliteration of normal fat and facial planes**.

A fracture line that might initially appear **sharp** can gradually become less well defined + blurs the fracture margins.

A nuclear medicine scan and MRI scan may detect **subperiosteal** changes that are not yet evident on x-ray.
2. **soft callus** ( + subperiosteal new bone = fluffy white visible on Xray) EARLY SIGN OF BONE HEALING

In infants this can occur within approximately 7 to 10 days, later (10 to 14 days) in older children.

By approximately 10 days, a **cellular collar** surrounds the fracture site.

Woven bone calcifies approximately 10 to 15 days after injury.

Exuberant callus formation can be a sign of fracture instability, and/or repetitive injury.
3. **hard callus = HEALING FRACTURE**

Forms when periosteal and endosteal bone begins to convert to **lamellar bone**. Very white on Xray.

This phase begins in infants at 14 to 21 days at the earliest, and peaks at 21 to 42 days.

11-year-old girl with fracture of mid radius. Anteroposterior radiograph shows periosteal new bone (*arrows*) separated from underlying cortex by thin radiolucent line. Ref. *Radiographics*
4. **Remodelling** occurs with gradual correction of deformity.

**ADVANCED HEALING**

Begins at approximately 3 months and peaks at 1 to 2 years

Heals completely and appears indistinguishable on x-ray from a bone that has not been injured.

Healing generally occurs more rapidly in younger infants

The rate at which bones heal, and remodelling occurs, varies according to the child's age, the anatomy of the injured bone, the site and nature of fracture (including the degree of angulation and separation of bone segments), and metabolic processes that enable healing of bone injury.
Skeletal survey (NO babygram!)

Skull (SXR)
- AP and lateral, plus Towne’s view for occipital injury.
- SXRs should be taken with a skeletal survey even if a CT scan has been performed.

Body:
- AP frontal chest (including clavicles)
- Oblique views of the ribs (left and right)
- AP Abdomen with pelvis and hips

Spine:
- Lateral spine - cervical and thoraco-lumbar

Limbs:
- AP humeri, AP forearms
- AP femurs, AP Tib/fib
- PA hands and AP feet

Supplemented by:
- Lateral views of any suspected shaft fracture.
- Lateral coned views of the elbows/wrists/knees/ankles may demonstrate metaphyseal injuries in greater detail than AP views of the limbs alone. The consultant radiologist should decide this, at the time of checking the films with the radiographers.

Brain imaging:
- CT (brain and bone windows) is the method of choice in the acute phase.
- A linear skull fracture may not be identified on CT (on bone windows)
Bone Scan

“HOT SPOTS”

Subtle bone injury,
Infection,
Inflammation,
Soft tissue trauma,
Growing epiphyses
and other pathological
causes of increased uptake
of radio nucleotide

Bone scans have little place
in fracture dating as they
become positive within 7
hours and can remain
positive for up to one year

Additional radiology?

CT chest (rib #?)

Coned views of suspicious sites

Re-examination of hot spots - radiographs

Repeat Xrays in 2+ weeks (eg to see whether callus has developed at site of suspected fracture)

Occasionally = MRI (spinal injury?)  CT?  USG?  PET?

NB CONSIDER /INVESTIGATE FOR POSSIBLE HEAD TRAUMA and abdominal trauma
Decision – making

no test = no radiologist’s report = no utility

When & why order medical imaging?

Older child
- No few skin injuries
- Single recent fracture
- Likely accidental (common)
- Explanation compatible with accident

Don’t do the test

Do the test

Infant
- Other injuries suggest assault
- Fracture specific for assault
- Serious condition? AHT

Serious
condition
AHT

Fracture
specific
for assault

Other
injuries
suggest
assault

Explanation compatible with accident

Don’t do the test

Do the test
What factors do we balance?

- Sedation
- OOHC/Foster care while awaiting final result
- Unsafe until all results known
- Predict risk
- ALARA Image Gently
- Duration
- Sufficient information SAFE
- Most information BEST
- Combination of test modalities
- Quick final result, no delay
- Reliable result Confidence
- One test
- Minimal cost
- Available FACILITY & EXPERTISE
- Radiation dose SS =0.2 mSv (Berger 2016)
- IV Needle/Discomfort parental anxiety
- COST
- WORK Pressure on departments MI
- DON’T MISS ANY NO DEATHS
**Recommendations (just 2 of many)**

**Kemp 2006 Systematic review**
Neither as good as the two combined.
- BS missed skull, metaphyseal & epiphyseal #
- SS missed rib fractures.
- Repeat SS 2 weeks = significant additional information about tentative findings, the number and age of fractures.
- Significant occult # in children under 2-years old.

SS or BS alone is inadequate to identify all fractures.
- Find out what is best - SS that includes oblique views, SS and BS, a SS with repeat SS or selected images 2 weeks later or a BS plus skull radiography and coned views of metaphyses and epiphyses.

**Nguyen 2018 - Review last 6 years**
- Re BS - increased diagnostic yield in anatomically complex locations, such as the ribs, scapulae, spinal column, pelvis and hands and feet
- Positive sites require confirmatory radiographs
- Re CT - Contrast-enhanced CT of the chest and abdomen is the mainstay for imaging of thoraco-abdominal injuries.
- (18F-NaF) positron emission tomography, with its high spatial resolution, has advantages in bone imaging

**Radiation**
- SS (<2yo) = 0.8 mSv.15
- BS = 3 mSv in all age groups

**Kemp et al** Which radiological investigations should be performed to identify fractures in suspected child abuse? Clin Radiol. 2006 Sep;61(9):723-36.

### Variant 1: Suspected physical abuse. Child ≤ 24 months of age. Neurologic or visceral injuries not clinically suspected. Initial imaging evaluation.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL</th>
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<tbody>
<tr>
<td>X-ray skeletal survey</td>
<td>9</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>MRI head without IV contrast</td>
<td>6</td>
<td></td>
<td></td>
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<tr>
<td>CT head without IV contrast</td>
<td>5</td>
<td></td>
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<tr>
<td>Tc-99m bone scan whole body</td>
<td>4</td>
<td>This procedure is used as a problem-solving study rather than first-line.</td>
<td></td>
</tr>
<tr>
<td>MRI head without and with IV contrast</td>
<td>2</td>
<td>**</td>
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<tr>
<td>CT head with IV contrast</td>
<td>1</td>
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Note: Rating scale: 1, 2, 3 = usually not appropriate; 4, 5, 6 = may be appropriate; 7, 8, 9 = usually appropriate. IV = intravenous; RRL = relative radiation level.

### Variant 2: Suspected physical abuse. Child > 24 months of age. Neurologic or visceral injuries not clinically suspected. Initial imaging evaluation.

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<td>X-ray area of interest</td>
<td>9</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>CT head without IV contrast</td>
<td>5</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>X-ray skeletal survey</td>
<td>4</td>
<td>Consider this procedure in children unable to verbalize location(s) of pain.</td>
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<tr>
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</tr>
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</table>
CAN WE ESTIMATE DATE OF TRAUMA?

With what degree of certainty?
Estimate of time since injury
how we used to think...

Kleinman PK. Diagnostic imaging of child abuse. 2nd ed. St Louis: Mosby, 1998
Systematic review, 3 papers
189 children,
243 #,
56 aged < 5 years

Prosser I., Maguire S., Harrison SK et al., How old is the fracture? Radiological dating of fractures in children: a systematic review Am J Roentgenol 2005; 184; 1282-6
Papers on bone healing in children

INEXACT SCIENCE


Cumming WA. Neonatal skeletal fractures. Birth trauma or child abuse? J Can Assoc Radiol 1979;30:30-33

Hard callus and early remodelling is seen at 8 weeks in majority of cases

Early callus (calcified SPNBF) noted as early as 7 days (neonates)

Dating of fractures is an inexact science

The radiological features of bone healing are a continuum, with considerable overlap

Radiological estimates of time of injury are in terms of weeks rather than days. It is vital that all investigating agencies are aware of these broad time frames
Fracture dating: Prosser 2012

228 films of 82 # in 63 children (mean age, 4.8 years)

• Soft-tissue swelling in 59% at days 1-2 after fractures
• Periosteal reaction first seen at day 5/present in 62% between 15 and 35 days after the fracture
• Soft callus was first seen at day 12/prevalent in 41% between 22 and 35 days
• Hard callus and bridging began at day 19, increasing to 60% prevalence from 36 days onward
• Remodeling was observed only in fractures 45 days old or more

161 images of 37 long bone fractures in 31 patients aged 0-44 months.
Assessed:
- soft-tissue swelling
- subperiosteal new bone formation (SPNBF)
- definition of fracture line
- presence or absence of callus
- whether callus was well or ill defined
- and the presence of endosteal callus

RESULTS:
“Agreement between observers was only moderate for all discriminators except SPNBF. SPNBF was invariably seen after 11 days but was uncommon before this time even in the very young. In one case SPNBF was seen at 4 days.”

A CASE EXAMPLE

6 week old male, NVD, well baby, unexplained faint bruise & swelling R temporo-parietal scalp (edited out)

What would you do?
Investigations of occult bone injury

Controversies exist → towards a more nuanced view?

• SS + BS
• SS + SS (2 week interval)
• CDR – notable exceptions / Algorithms for investigations
• Advancing technologies – Chest CT / Whole body MRI
### Indications for Obtaining a Skeletal Survey

- All children <2 y with obvious abusive injuries
- All children <2 y with any suspicious injury, including
  - Bruises or other skin injuries in nonambulatory infants;
  - Oral injuries in nonambulatory infants; and
  - Injuries not consistent with the history provided
- Infants with unexplained, unexpected sudden death (consult with medical examiner/coronor first)
- Infants and young toddlers with unexplained intracranial injuries, including hemorrhage and hypoxic-ischemic injury
- Infants and siblings <2 y and household contacts of an abused child
- Twins of abused infants and toddlers

Diseases and conditions that affect collagen and/or bone mineralization can be included in the differential diagnosis of skeletal trauma due to abuse; identifying these diseases or...
Investigations for occult bone injury

SUSPECT NAI (AAP advice) when

• Fracture(s) in nonambulatory infants, especially in those without a clear history of trauma or a known medical condition that predisposes to bone fragility;

• Children with multiple fractures;

• Infants and children with rib fractures;

• Infants and toddlers with midshaft humerus or femur fractures;

• Infants and children with unusual fractures, including those of the scapula, classic metaphyseal lesions (CMLs) of the long bones, vertebrae, and sternum, unless explained by a known history of severe trauma or underlying bone disorder; and

• The history of trauma does not explain the resultant fracture.
SS in under 2yo (consensus view)

Necessary if a fracture is attributed to abuse, domestic violence, or being hit by a toy.

With few exceptions, SS is necessary without a history of trauma.

In children <12 months old, SS is necessary regardless of the fracture type or reported Hx with rare exceptions.
  – Distal radius/ulna # in ambulant child 9-11 mo + Hx fall
  – Distal tibial # in ambulant child 9-11 mo + Hx fall
  – Clavicle # in neonate

In children 12 to 23 months old, the necessity of obtaining SS is dependent on fracture type. (radius /ulnar + fall, tibia + fall, single linear skull # + fall, )

SS in child with bruises

Wood’s research study (consensus view expert panel)
• “inappropriate” for children <12 months old with non-patterned bruising on bony prominences

• SS was deemed necessary for infants <6 months old regardless of bruise location, with rare exceptions

• The necessity of SS in older children depends on bruise location.
  – According to the panelists, bruising on the cheek, eye area, ear, neck, upper arm, upper leg, hand, foot, torso, buttock, or genital area necessitates SS in children <12 months.

Joanne N. Wood, Oludolapo Fakeye, Valerie Mondestin, David M. Rubin, Russell Localio, Chris Feudtner  Development of Hospital-Based Guidelines for Skeletal Survey in Young Children With Bruises  Pediatrics Feb 2015, 135 (2) e312-e320; DOI: 10.1542/peds.2014-2169
FRACTURE LOCATIONS

Rib*
Skull*
Long bones

Rare fracture locations – high specificity for NAI
CML
SPNB
Rib # - when should I worry?

Differing levels of concern re NAI

1. Infant’s / child’s age
   - Infant > toddler > child

2. Location
   - Posteromedial > posterolateral > lateral > anterior

3. Number
   - Multiple (scattered vs in a vertical plane) > single rib #

4. Stage of healing
   - Same stage > varying stages of healing/ callus

5. Co-existing medical condition
   - Rickets, ex-prem, metabolic bone disease, renal or liver disease,
   - Suspicion re OI or Connective tissue disease
What do we know about skull fracture patterns in infants?
Skull # patterns

What can we infer from skull fracture patterns in infants?
   Bilaterality
   Y shape
   Crossing suture lines (Why are neonatal skulls different to older children’s skulls?)
   Ping pong #, depressed #

Stellate (star shaped) skull # - can we really infer that impact occurred at confluence of fracture lines?

What type of force? Dynamic versus static loading forces?
   – Impacts versus crushing forces

How many impacts? How many crushing events?
If impact(s) – then what surface(s) / object(s)

References
Biomechanics (limitations of non-biofidelic models, computer modelling)
Experiments with cadaver skulls (NB. recent research)
Observational studies – selection bias (neurosurgeon vs PEM vs pathologist) + publication bias?
Bilateral parietal skull fractures

Symmetrical linear skull #
What are possible mechanisms of injury?
• Crush between 2 surfaces
• Impact X 2
• Impact X 1?
  – If so, what impact site(s) on the skull?
  – What type of surface(s)

Yes, you do need to describe the surface and if an alleged fall, the height
And if an alleged crush – the weight of the person
And the position in which the infant was found…
Skull Fractures crossing suture lines

• If in continuity – is this one fracture or two?

• If not in continuity – what does this tell us?
  – Does this fracture pattern suggest more than one impact?
Diastatic fracture

Separation of the bone fragments = wide gap

Suture fracture = separation of the bone fragments at the suture site, i.e., the suture is fractured / lacerated / torn
  - Eg. Sagittal, lambdoid sutures

Raised intracranial pressure
Depressed skull fracture

Force exerted (energy transmitted) over small(ish) surface area

- Eg Hammer or heel of shoe hits skull
- Object impacts only small part of skull – fall onto toy

- Inward bowing of skull – inner table unable to sustain pressure
- May reflect shape of impacting object
- May see step between fracture segments or clear image of depressed fragment
- Sclerotic margin – # likely to be depressed
- 1/3 damage dura, ¼ damage cortex – risk post traumatic seizures
- 30% have intracranial injury – hhge, laceration, contusion, bone fragments

Differentiate skull depression from in-utero pressure (eg feet) in neonate
Ping pong skull fracture

Usually < 6 mo old

Mechanism?
- A special type of depressed skull fracture
- Malleable elastic infant skull

What happens to them over time?

Do you see them in toddlers and older children? If not why not?
Circular (concentric) fractures infants

- **Around** the point of impact — complete or incomplete circle
- High velocity, solid object
- Located at junction of in-bowing and out-bowing of skull

- Other round fractures
  - Impact - Hammer or round object,
  - Around foramen magnum - fall onto feet from height
  - Gunshot wound
Growing skull fracture

- AKA Leptomeningeal cyst
- Fracture skull + dural tear
- CSF pulsatile pressure / entrapment of meninges in fracture site
- so... follow up x-ray linear skull fractures in infants & young children

3 months later
https://radiologykey.com/fracture-and-hemorrhage/
Basilar skull fracture – rare in infants

- Diffuse head trauma – significant magnitude forces
- Signs include bruising behind mastoid (Battle sign), raccoon eyes, bleeding from ears
- Brain injury + check for spinal trauma
- Beware CSF rhinorrhoea, otorrhoea
- Risk of meningeal infection
Infant skull fractures

Infant skulls are more compliant than older children’s skulls

Outbending plays significant role in fracture process

Areas of transparency = vulnerable to fracture

# lines follow bony spiculae radiating out from ossification centres

Often # occur AWAY from site of impact
Infant skull fractures

Diastatic suture # common in newborns not older infants

Diastatic # (bone & suture) more common ~ contact with rigid than compliant interface

# initiate at bone-suture interface

Area of skull contact is greater rigid cf compliant interface

Length of # = more when rigid cf compliant interface
Crush injury to infant head

Base of skull # common when fatal crush by vehicle tyre
Bilateral & diastatic # = common overall

Brain tolerates static loading force better than inertial force
No DAI? RARE 2 in Lopez-Guerrero (2012)
Focal deficits / cranial N damage (6th, 7th, 8th)
Eye injuries – retinal hhges = possible

Russell and Schiller 1949. 15 case reports
– Lateral forces -> # crosses middle fossa and petrous temporal bone
– Ant-post forces -> # perpendicular to line of force, floor of ant cranial fossa
Fractures
• have sharp, nonsclerotic borders and may bifurcate.
• may cause diastasis of the sutures, often cross the sutures themselves, and increase in diameter as they approach a suture.
• Indirect signs such as overlying soft-tissue injuries, including hematomas, can support diagnosis.

Sutures
• join other sutures rather than cross them.
• do not cause diastasis of other sutures and, apart from the exceptions discussed earlier, remain relatively uniform in diameter.
• have a “zigzag” or interdigitating pattern with sclerotic borders.
Skull fracture vs. accessory sutures: how can we tell the difference? Emergency Radiology September 2010, Volume 17, Issue 5, pp 413–418

<table>
<thead>
<tr>
<th>Skull fracture</th>
<th>Accessory suture</th>
</tr>
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<tbody>
<tr>
<td>Sharp lucency with non-sclerotic edges</td>
<td>Zigzag pattern with sclerotic borders</td>
</tr>
<tr>
<td>Widens as it approaches a suture</td>
<td>No associated diastasis</td>
</tr>
<tr>
<td>Can cross adjacent suture lines</td>
<td>Merges with the adjacent suture</td>
</tr>
<tr>
<td>Often unilateral and asymmetric if bilateral</td>
<td>Often bilateral and fairly symmetric</td>
</tr>
<tr>
<td>Associated with some soft tissue swelling</td>
<td>No soft tissue swelling</td>
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</table>
Long bone fractures

- Femur
- Humerus
- Radius and ulna
- Tibia and Fibula
- Feet and hands

- No time to discuss in depth
- A large body of knowledge exists around determining causation
- Epidemiology of ACCIDENTAL fractures is well written in most standard orthopaedic text books
- Aetiology of Fractures (including assault) is in CHILD ABUSE textbooks and RADIOLOGY & PATHOLOGY textbooks.
- Seek advice for YOUR CASES
Spurs – extension of subperiosteal bone collar… not CML