
# Long Bone Fractures

Tagrid M. Ruiz-Maldonado, MD, MS, FAAP
Child Abuse Pediatrics | University of Utah
Attending Physician | Safe & Healthy Families

# Objectives

- Discuss clinical & radiologic features that help differentiate fractures due to abuse vs fractures due to accidental events

# Objectives

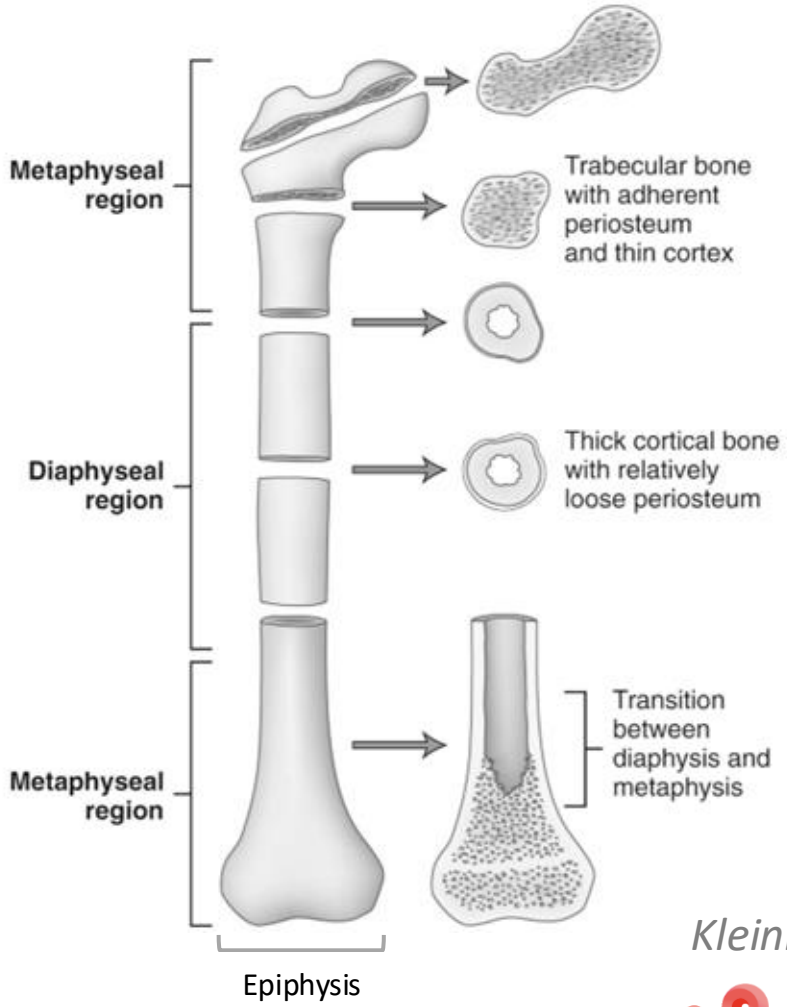
- Discuss clinical & radiologic features that help differentiate fractures due to abuse vs fractures due to accidental events
- Discuss the biomechanical and contextual characteristics of child development that influence the likelihood and pattern of fractures, emphasizing mechanism of trauma

# Epidemiology

- 2nd most common injury due to physical abuse
- Common injury of infancy and childhood
- Important risk factors:
  - age
  - development
- Fractures due to abuse:
  - 25% of fractures in infants <12 meses
  - 2.9% of fractures in children between 24-35 months

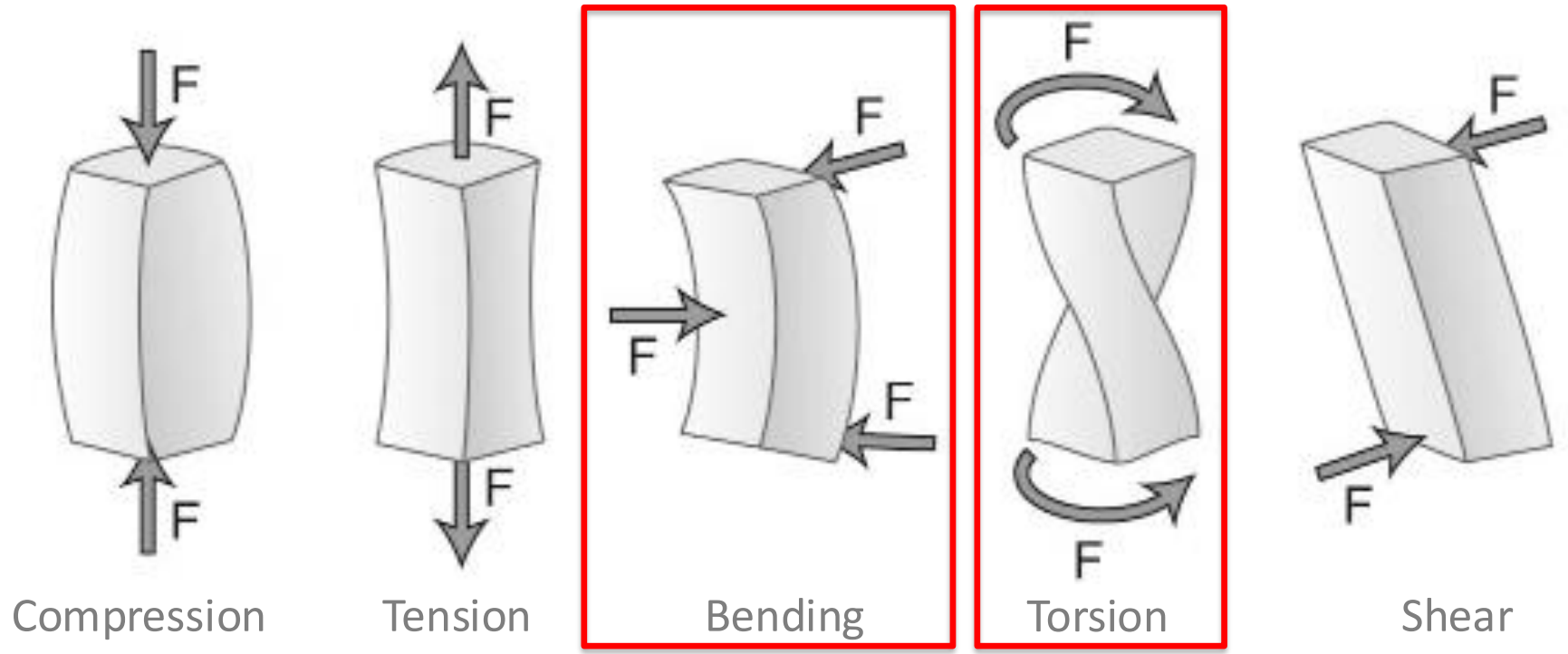
# Anatomical Review

- Two types of bone:
  - Compact (cortical)
    - Haversian microsystems
  - Spongy (trabecular)
    - Trabecular microstructure
- Differences in transmission of force and load tolerance




*Kleinman (3rd Ed)*

# Common types of forces or loads




*Jenny (1st Ed), 2011*

# Intrinsic and extrinsic factors

**Intrinsic Factors**

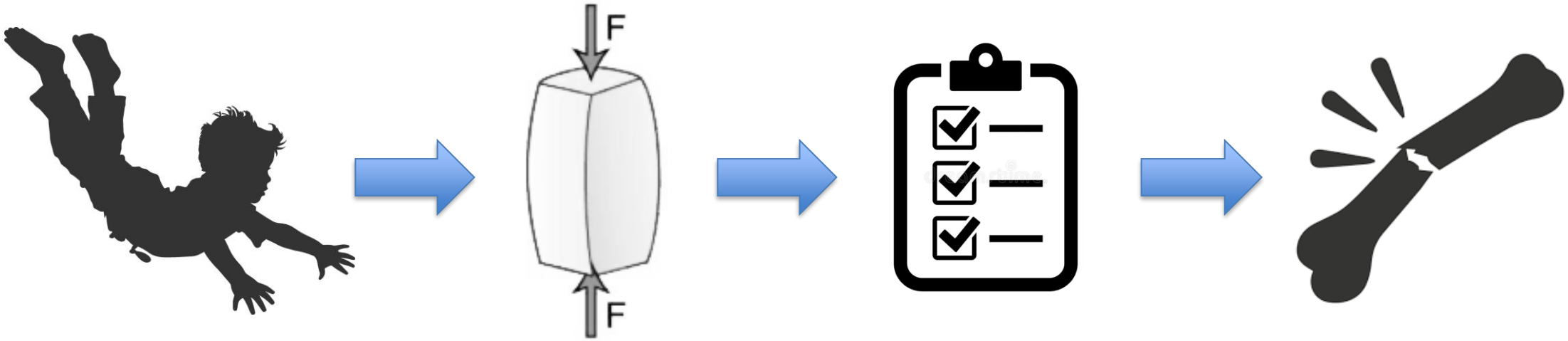
- Elastic modulus
- Anisotropy
- Bone density
- Bone geometry

**Extrinsic factors**

- Load characteristics
  - Direction
  - Location
  - Magnitud
- Rate of application of force
  - Dynamic vs static load

# For a fracture to happen:

1. Develop internal stresses in the bone
2. Overcome the bone's failure threshold



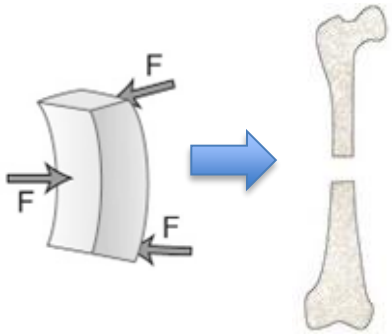

**1.** Trauma event

**2.** Load conditions

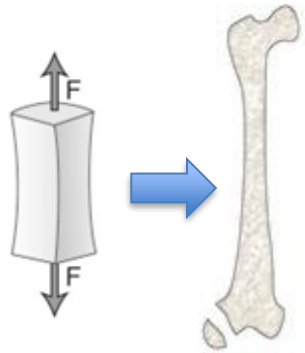
**3.** Internal stresses

**4.** Mechanical failure

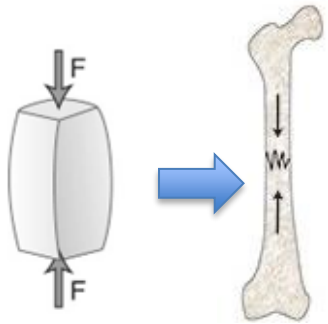
# Fracture morphologies



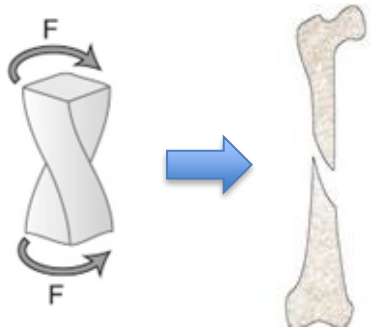

Bending → Transverse



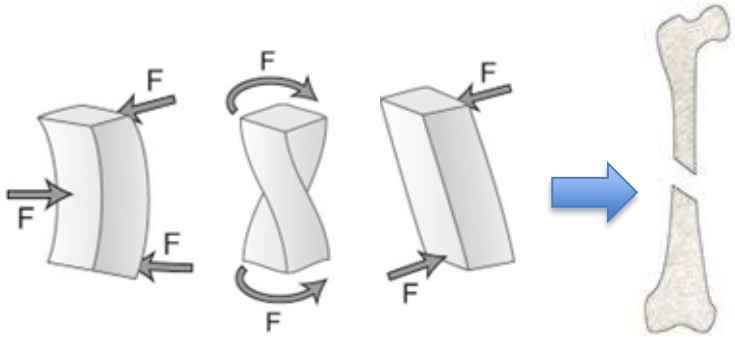

Tension → Avulsion



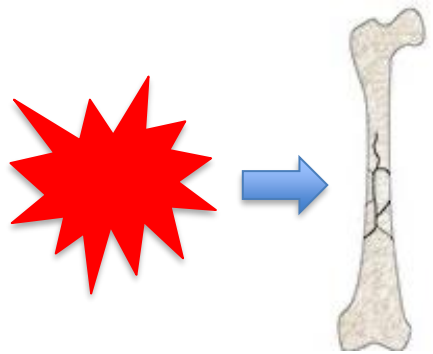

Compression → Impacted




Torsion → Spiral




Bending + Torsion +/- Shear → Oblique

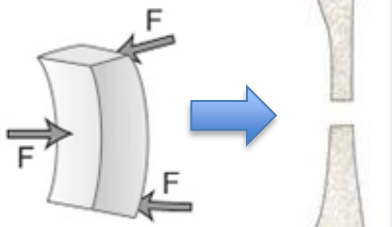


High energy → Comminuted

# An infant or child is **not** a small adult

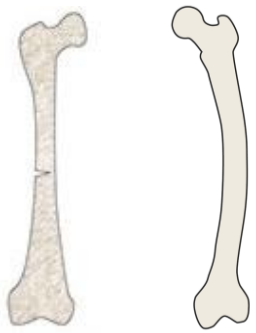
- Growth plates (physis, epiphysis)
- Greater number of bones
- Cortical bones less dense & more flexible
  - Greater proportion of collagen y cartilage
  - More robust and vascular periosteum
- Quicker remodeling and healing
- Motor ability evolves → load tolerance

# Pediatric fracture morphologies

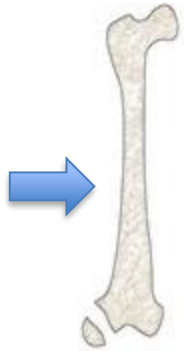





Bending → Transverse

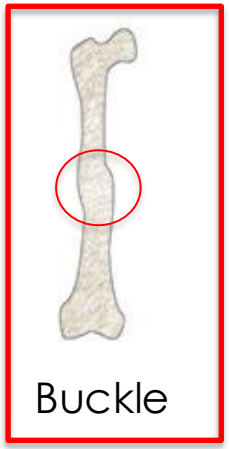


Greenstick | Bowing

Tension → Avulsion

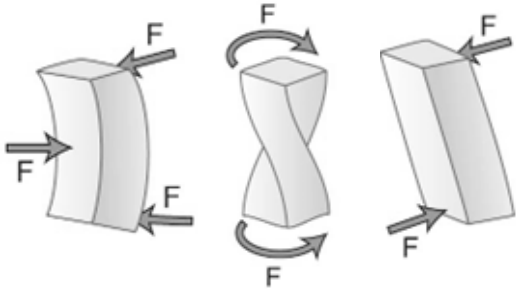

Compression → Impacted



Buckle

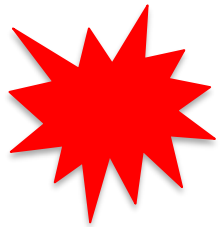

Torsion → Spiral

Toddler's fracture




Bending + Torsion +/- Shear → Oblique

| CML

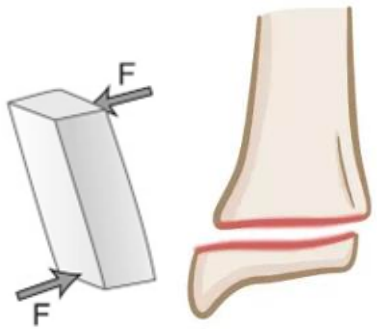


High energy → Comminuted

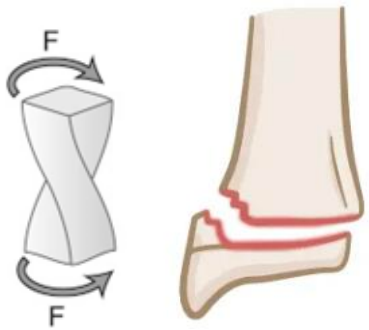
HEALTH
UNIVERSITY OF UTAH

Intermountain
Children's Health

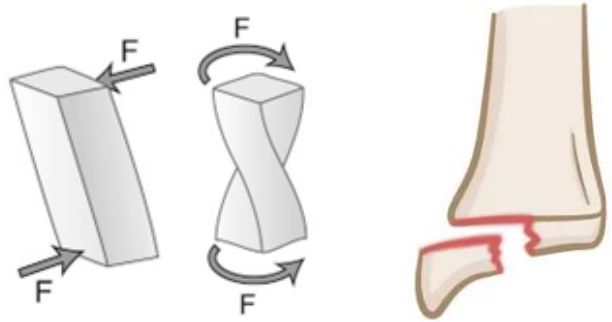
# Pediatric Morphologies: Salter Harris



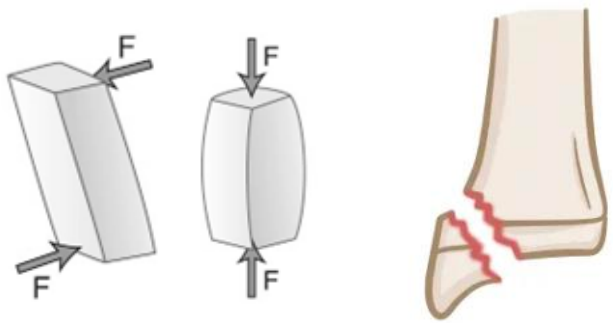

SH Type I



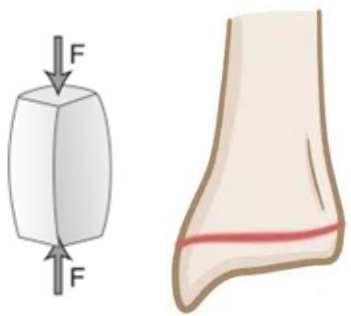

SH Type II




SH Type III




SH Type IV




SH Type V

*radiopaedia.com*

HEALTH UNIVERSITY OF UTAH

Intermountain Children's Health

# Fracture specificity

| High Specificity | Moderate Specificity | Low Specificity |
| --- | --- | --- |
| Classic metaphyseal lesions | Multiple | Subperiosteal new bone |
| Ribs (posteromedial) | +/- bilateral | Clavicle |
| Scapula | +/- different stages of healing | Long bone diaphysis |
| Vertebral spinous process | Epiphyseal separations | Skull – (simple, linear) |
| Sternum | Vertebral body | |
| | Digits | |
| | Skull (complex) | |
| | Pelvis | |

*Kleinman 2012 (3ra Ed)*

# To evaluate mechanism, I need to know:

- Event of history of trauma
- Age
- Development
- Bone(s) involved
- Location of fracture(s) on bone(s)
- Fracture morphology

# I also need to know…

- When was the **last time** the child was at their **baseline**?
- What happened **before** before that?
- What happened immediately **after**?
- How did the child **react**?
- How did the child act/behave during routine cares?
- Was an **object** involved?
- Was any other **person** present?

# Complete physical exam

- Skin exam
  - Sentinel injuries
  - TEN-4 FACESp
- Growth parameters
  - Head circumference

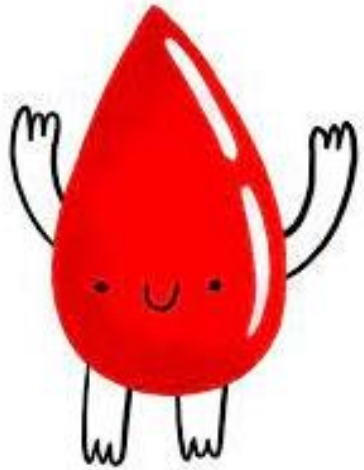
# Complete physical exam

- Bruising **does not** imply abuse
- Bruising **does** help me determine level of concern

*Valvano, 2009*

# Laboratory studies

- Calcium, ALP
- Magnesium, phosphorus
- Vitamin-D 25-OH, parathyroid hormone (PTH)

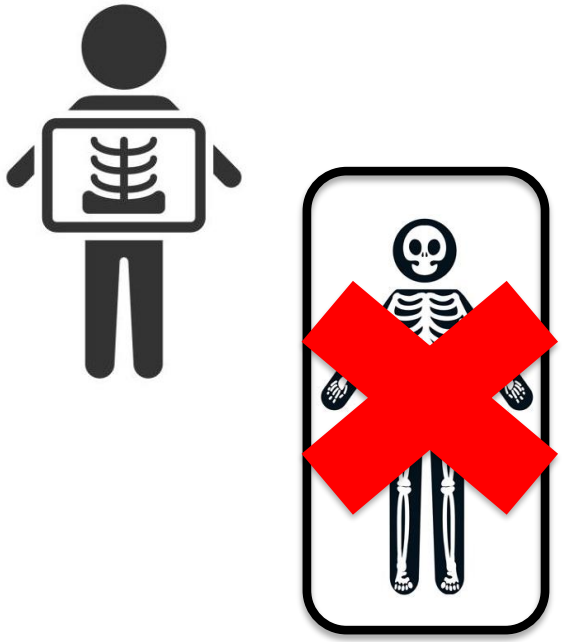


# Radiology studies

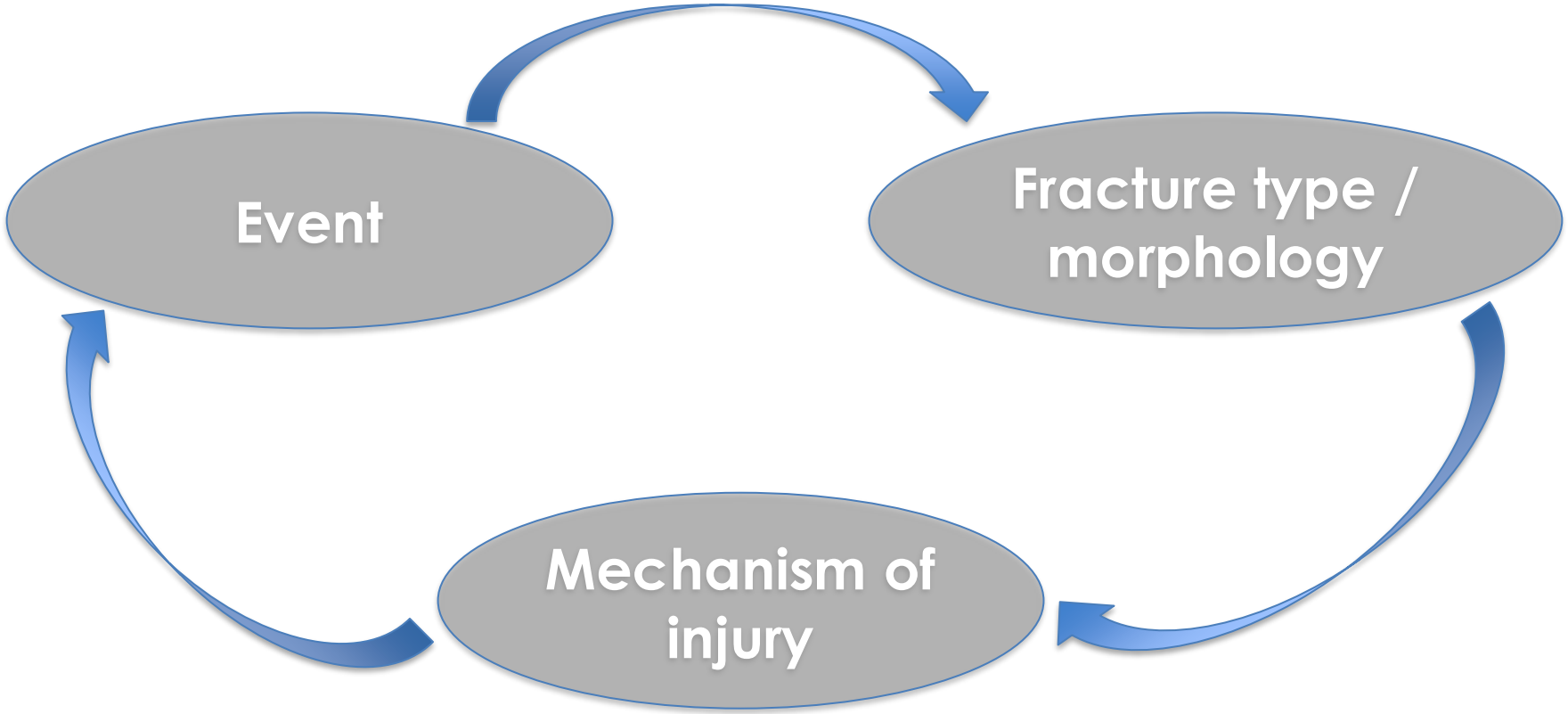
- Skeletal survey
  - Initial & follow-up in10-14 days
  - 21 specific images (AAP, ACR) **- Not a babygram!**

- Humeri (AP)
- Forearms (AP)
- Hands (PA)
- Femurs (AP)
- Lower legs (AP)
- Feet (PA) or (AP)
- Thorax (AP, left and right obliques)
- Cervical spine (lateral)
- Thoracic and upper lumbar spine (lateral)
- Lumbosacral spine (lateral)
- Pelvis (AP), to include mid lumbar spine
- Skull (AP and lateral)

*AAP 2015, ACR 2017*



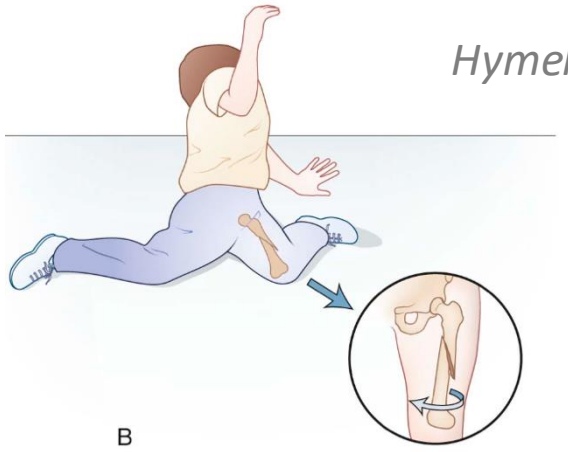
# Fracture evaluation



# Spiral fracture

- Spiral fracture = failure in torsion
- Femur is tolerant to axial loads
  → lower threshold to fail in torsion

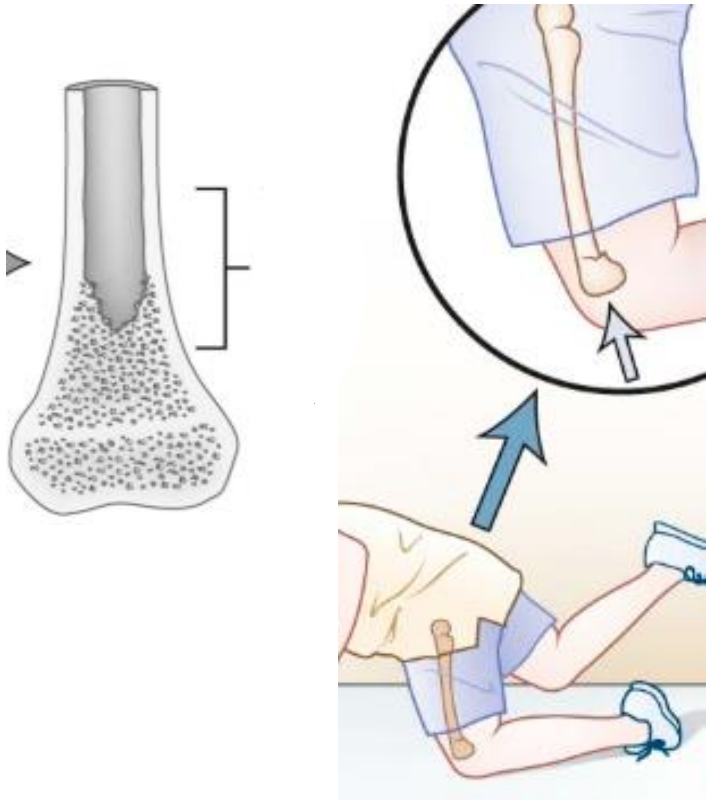
*Hymel & Jenny 1996*




*Jenny (1st Ed) 2011*

# Buckle fracture

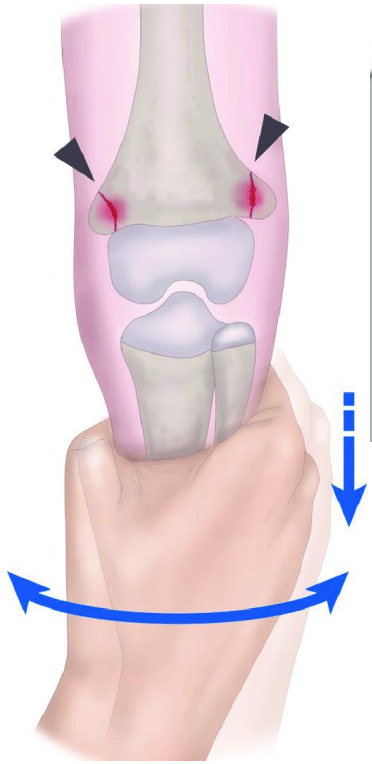
- Buckle fracture =
  failure in compression
- Implies an axial load
- At the meta-diaphyseal junctions
  - Trabecular compression
  - Cortical buckling



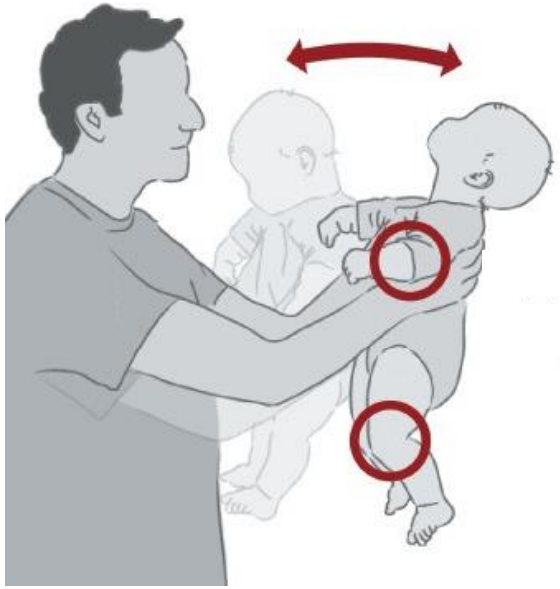
*Jenny (1ed Ed) 2011*

# Classic metaphyseal lesion (CML)

- Infants ≤6 months
- Interruption of the primary spongiosa at the metaphysis at the margin of the subperiosteal collar
  - Trabecular bone - No Haversian systems
- Shearing forces in transverse plane



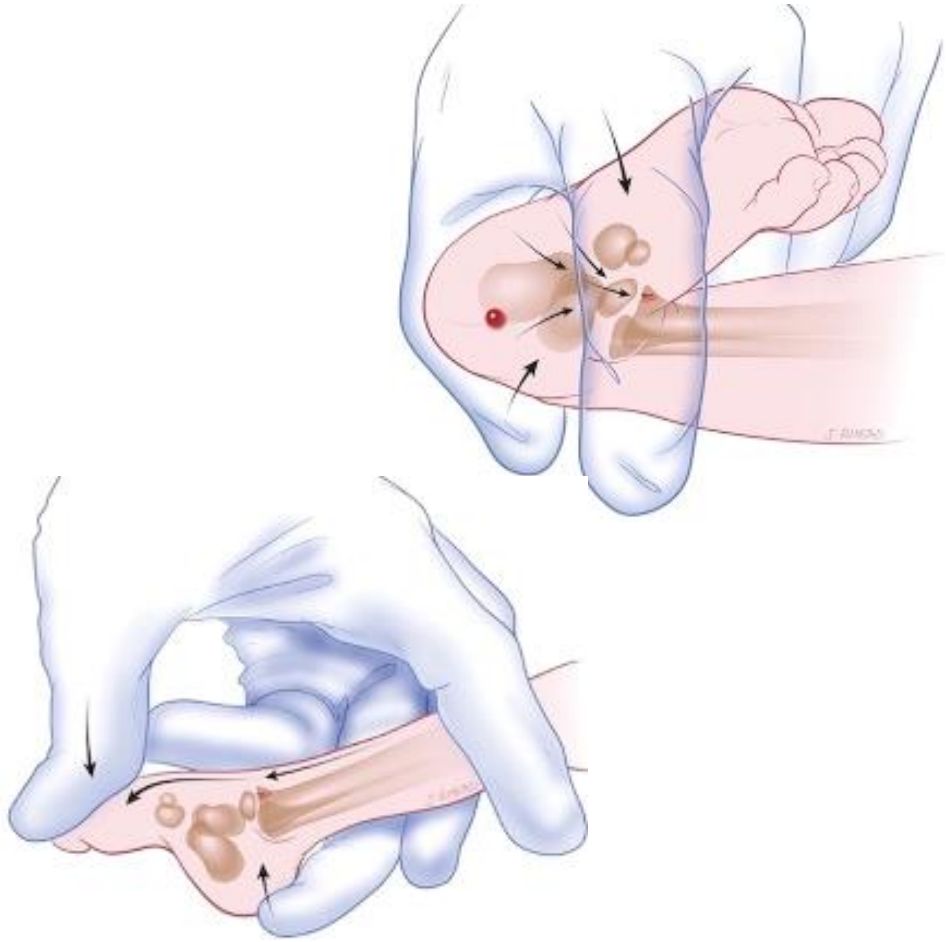
Jeon, 2020



Walker, 2016

# Classic metaphyseal lesion (CML)

- Breech delivery
- Cesarean delivery
- Clubfoot manipulation(Ponseti)
- IV line insertions
- Heelstick testing



*Ruiz-Maldonado, 2021*

# Remember…

**Any** fracture can be caused by **abuse**… 

…and **any** fracture can be **accidental**

**Is the history provided consistent with the mechanism of injury within the clinical context?**

# Let's talk about it

- Safety
- Transparency
- Collaboration
- Empowerment
- Humility

# Questions?

tagrid.ruiz@hsc.utah.edu

# Thank you!