Fractures in Pediatric skeleton

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Growth Plate → 1) longtin dual lenghtening. 2) Remodiling

Fractures in Pediatric skeleton

6.5 years pt, History of falling down, distal radius fracture, was treated with open reduction and internal fixation, she was casted, second week she got another trauma and got another fracture and see by her treating physician and he decided for conservative treatment

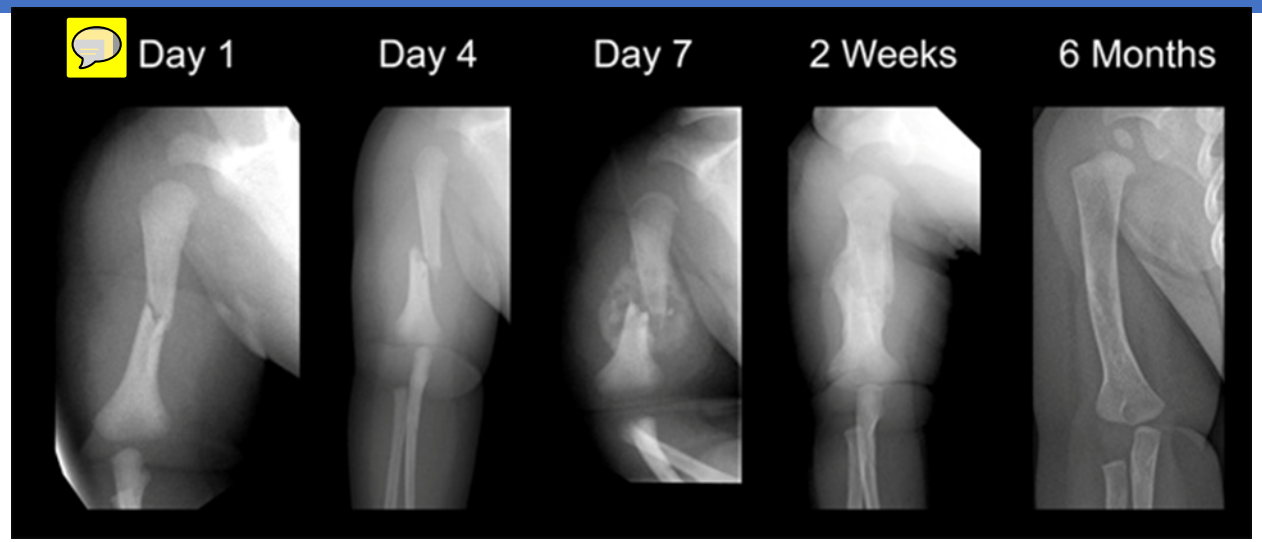
This pictures are 6 months after the initial injury, visible painless deformity, she has a scar of surgery (5-7 cm), forearm is deftormed

Either medical: conservative (and depend on bone remodeling), or give medical tx. Another option is surgical correction, with new general anesthesia, open the wound and + cut the bone and (osteotomy)

Fractures in Pediatric skeleton

- Understand the features of the immature skeleton
- Understand the anatomy of the physis in the immature skeleton
- List different types of growth plate fractures
- Recognize the difference of treating injuries in the growing skeleton, when not to operate ?
- Define the differences in the anatomy and the physiology of the growing skeleton
- List the indications for operative treatment in the growing skeleton
- Understand the different fixation techniques available to treat these injuries

Fractures in Pediatric skeleton

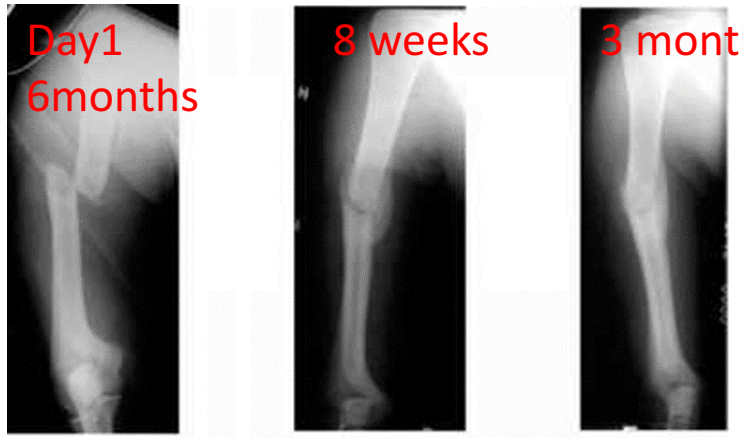


In pediatric age group: the distal end of the fracture is deviated laterally (valgus) but after healing it is medially positioned (mild varus). In adults, the varus deformity still can be seen in last X-ray, which means there is fully remodeling in adults

Pediatric
no displacement due to 2nd Periustrem
Remodiling better

All secondary ossification centers not seen immediately after birth, except distal femur epiphysis that might be seen after birth.
The arm has 6 secondary ossification centers (4 on distal humerus: capitulum, trochlea, medial epicondyle and lateral epicondyle. In addition to proximal radius and olecranon).
All these 6 centers won't be visible after birth, so if there was fracture in them they won't appear on X-ray, so in this case we should do further investigation such as mri or athrogran

Radial head



Adult
2nd assification seen immediatly, complete displacement

CRITOE → Lateral Epicondyle
↓ medial EPI

https://www.rch.org.au/fracture-education/fracture_healing/

https://www.barnardhealth.us/humeral-shaft/v-nonoperative-management.html

Reduce → Immobilization → Remodeling (but think of type of fracture you can cancel any step)

Fractures in Pediatric skeleton

Tacker or Tores fracture ←

Peds

toddler

Adults

Both pts has hx of falling down

→ Not fracture like adult it's bended bone fracture

The blood supply in peds is very huge so the healing will be very fast and the risk of nonunion is very minimal, there is exceptions (if fractured AVN will occur): neck of femur, lateral condyle in elbow,

not green stick fracture (separation of cortix & bended otherside)

http://www.pmmonline.org/page.aspx?id=848

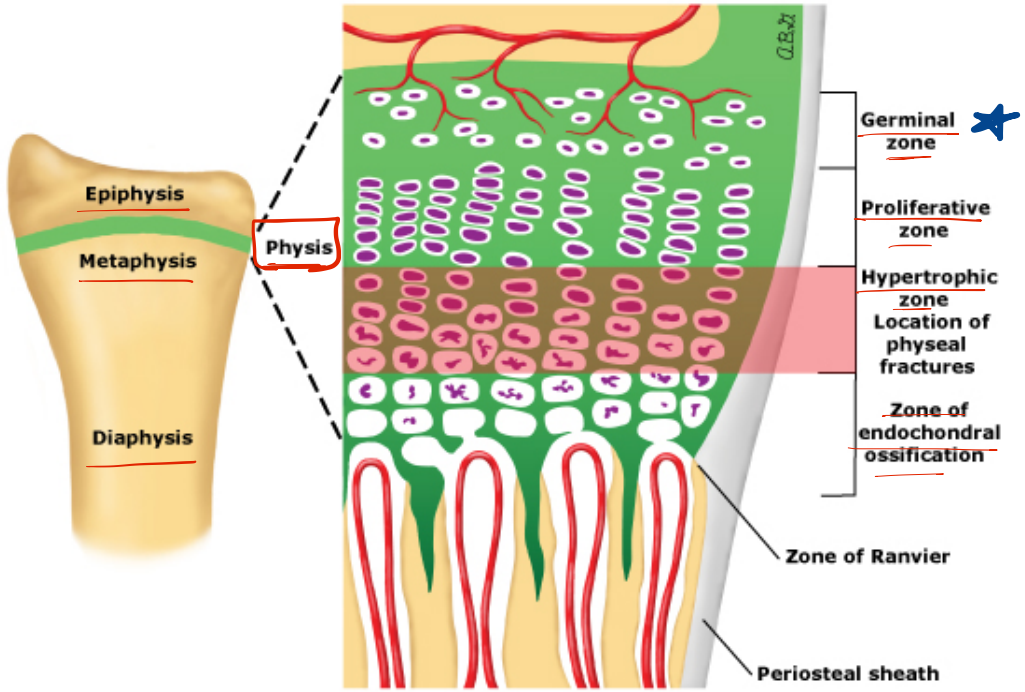
file:///C:/Users/Flinaro/Downloads/Outcomes_of_Severe_Comminuted_Distal_Radius_Fractu.pdf

Fractures in Pediatric skeleton

Anatomical Peculiarities

- It's presence is a major difference
- GP is stronger than bone
- Provide perfect remodelling power
- Injury may cause deformity

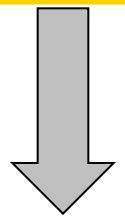
Metaphesis to Diaphysis growth



https://ukemigquickhit.wordpress.com/2012/10/01/salter-harris-fractures/

Fractures in Pediatric skeleton

- **Bone:**
- lower modulus of elasticity



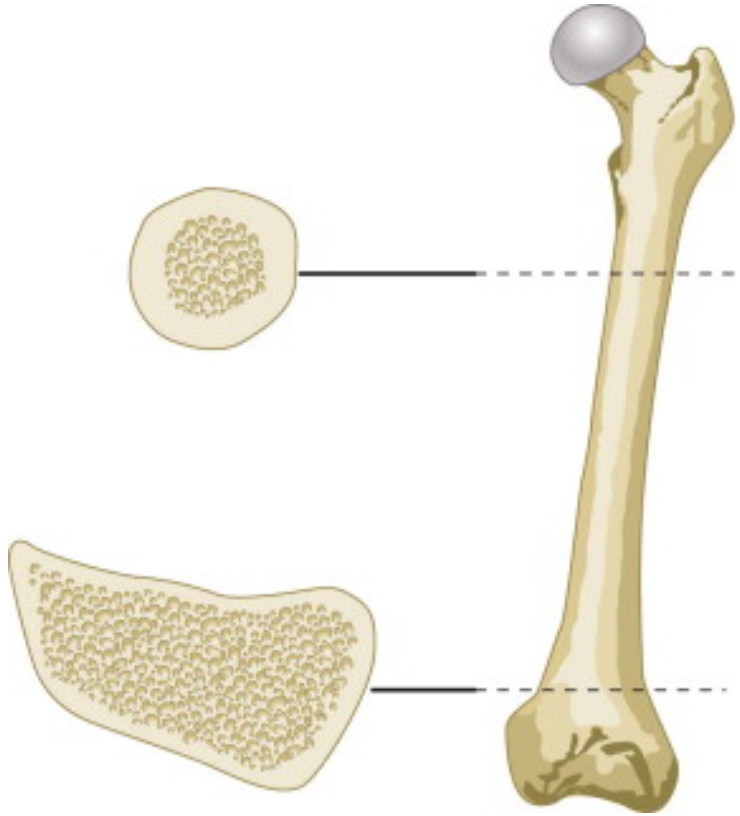
more susceptible to bending forces

Hard intensity ↓ Easy broken

low elasticity ↓ bending

Fractures in Pediatric skeleton

- Increased cancellous bone
  - reduces tensile strength
  - reduces tendency of fracture to propagate
    - Less comminuted fractures

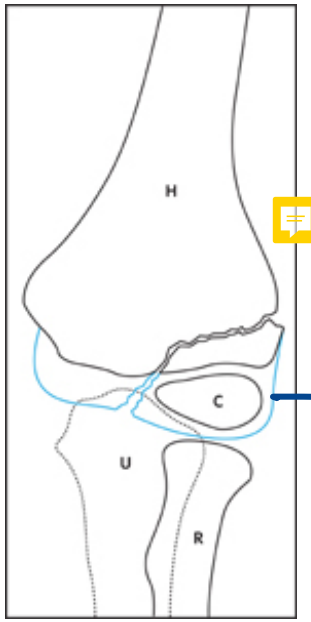


Fractures in Pediatric skeleton

- **Cartilage:**
  - Increased cartilage:bone ratio

→ difficult x-ray evaluation

→ size of articular fragment often under-estimated



Capitulum

Fractures in Pediatric skeleton

- **Periosteum:**
- Metabolically active

- Thickness and strength
  intact periosteal hinge affects
  fracture pattern
  may aid reduction

A B

Concave side more probable to be the injured side.

Fractures in Pediatric skeleton

- **Age related fracture pattern**
- Infants: diaphyseal fractures
- Children: metaphyseal fractures
- Adolescent: epiphyseal injuries

long segment of bone

less occification

more than ossification

ossification

Fractures in Pediatric skeleton

Most common non contact injury in Ped. avulsion fracture (small bony fracture at tip of tibial head (eminense)
" " " " " " Adults ACL

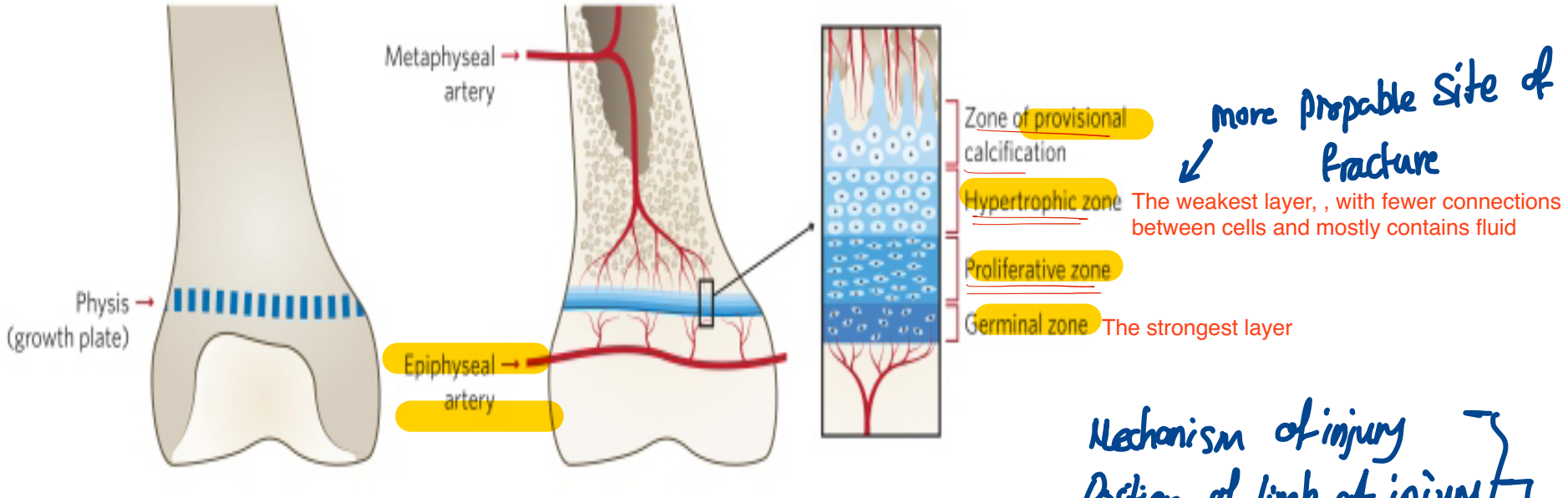
- **Physiology:**
- Better blood supply

  rare incidence of delayed and non-union

Most Common Presenting Pediatric necrosis is femur head (supplied by end arteries so any distruption can cause necrosis)

Fractures in Pediatric skeleton

Anatomy of the growth plate



more probable site of fracture

The weakest layer, , with fewer connections between cells and mostly contains fluid

The strongest layer

https://www.rch.org.au/fracture-education/growth_plate_injuries/Physeal_growth_plate_injuries/

Mechanism of injury
Position of limb at injury
decide if the injury continue up or down

Fractures in Pediatric skeleton

Physeal injuries

- Account for ~25% of all children's fractures.
- More in boys.
- More in upper limb.
- Most heal well rapidly with good remodeling.
- Growth may be affected

Fractures in Pediatric skeleton

- Less than 1% cause physeal bridging affecting growth.
  - Small bridges (<10%) may lyse spontaneously.
  - Central bridges more likely to lyse.
  - Peripheral bridges more likely to cause deformity

  - Avoid injury to physis during fixation.
  - Monitor growth over a long period.
  - Image suspected physeal bar (CT, MRI)

Fractures in Pediatric skeleton

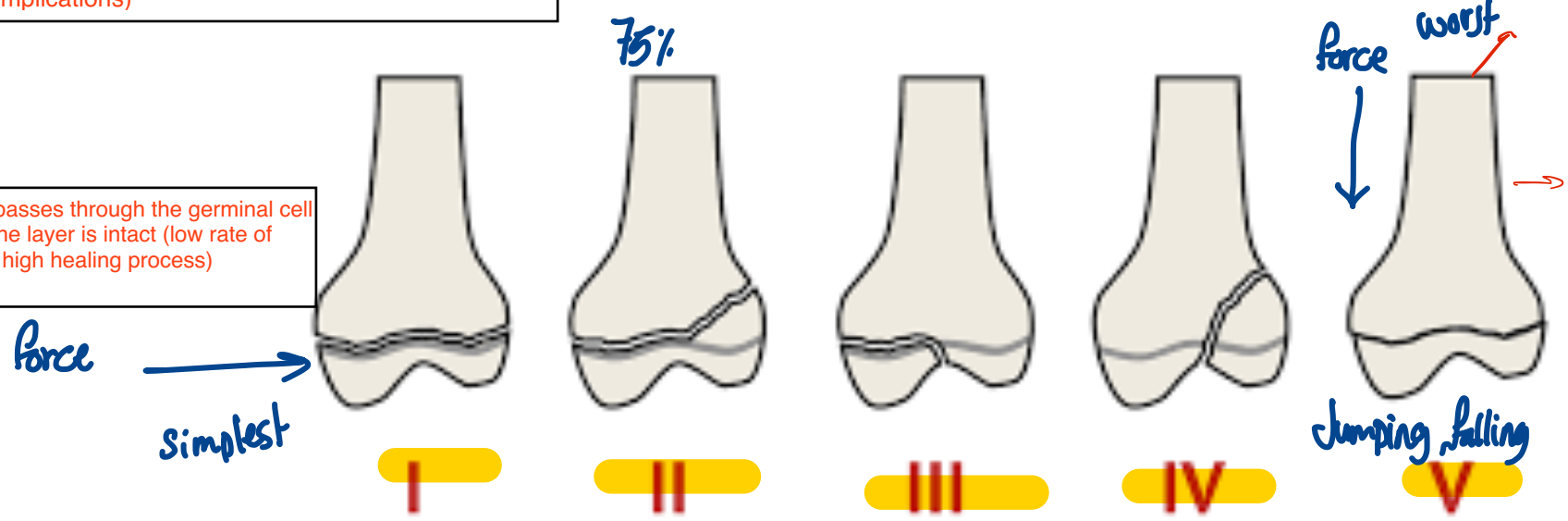
According to mechanism of injury and involvement of germinal cell layer (if we lose this layer we will lose everything, if any other layer got disrupted the germinal cell layer will replace the defect but germinal layer disruption cannot be replaced)

Were is the germinal cell layer present? Comes directly beside the epiphyseal area (so any injury that pass toward the epiphyseal area will have bad complications)

Classification:

Salter harris

In 3 and 4 the fracture passes through the germinal cell layer, while in 1 and 2 the layer is intact (low rate of complications and very high healing process)
Class 5 is compressed



Shearing force : parallel to the injury

Axial loading / compression forces

>1% will occur in future

you'll not see initially anything on x-ray → functional injury, cells are compressed & Die, it won't appears on x-ray before 6 months

∀

Tx : immobilization

Fractures in Pediatric skeleton

9 year old child, hx of FOOSH, came to ER, in AP view X-ray nth seen, he has severe pain, limited motion and tenderness.

On lateral view, there is a saulter haris type one fracture .

Salter haris type 1 has 2 subtypes: one of them is completely non diplaced on lateral view, the other subtype is displaced

7 years old boy has hx of falling down, has visible deformity, X-ray shows radius fracture (type 2), in addition to a fracture in the ulna (greenstick fracture)

Green stick fracture is peculiar to peds age group; Any upper limb fracture in peds need 3 weeks to heal, you know that by seeing callus on x-ray on both sides of injure, greenstick fracture usually we see the fracture on the convex side (tensile side) while the other side got fractured under compression. If you do x-ray on 3 weeks you'll see callus on the concave surface (compressive side) , so you need to wait for futher 3 weeks for the oher side to heal (fracture needs 6 weeks to have good union.

Note: if any fracture touches the growth plate is considered growth plate injury regardless of its extension

Fractures in Pediatric skeleton

type 3 SH

need further Xray. to see Growth plate

14 years: transitional time between Ped & Adult

Avulsion fracture

Transitional Ankle Fractures: Juvenile Tillaux and Triplane Fractures

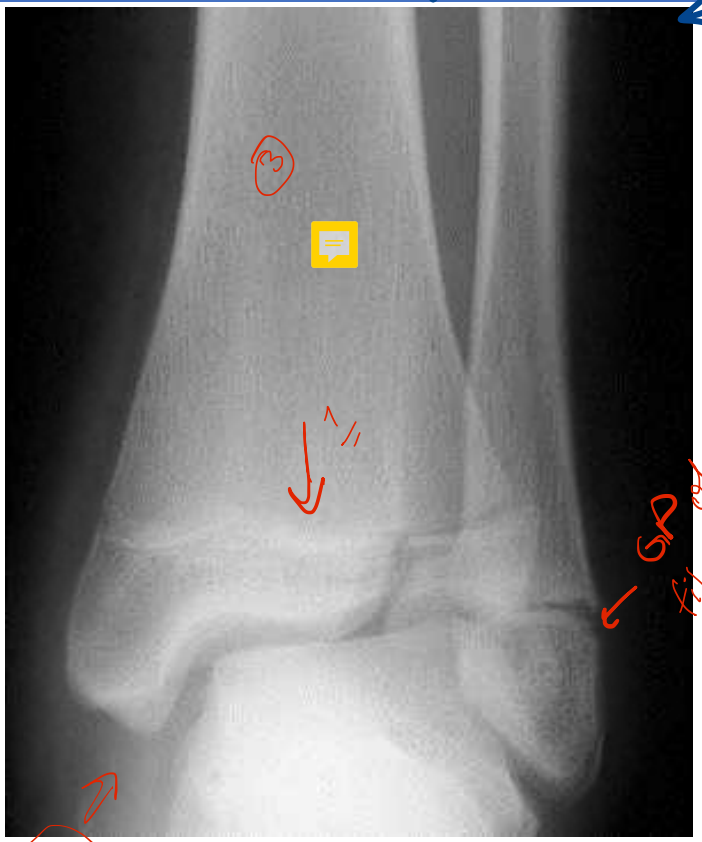
Jeanne M. Franzone

Joshua E. Hyman

The closure pattern of the distal tibial physis renders the distal tibia prone to unique fracture patterns during the adolescent growth phase. The distal tibial physis closes at approximately age 14 in girls and age 16 in boys. Physeal closure takes place gradually during the preceding 18 months in a specific order. The central region is the first area to close, then the anteromedial aspect, then the posteromedial aspect, and lastly the lateral aspect. Specifically, the anterolateral region of the physis is the last area to close. The combination of unfused areas of relative weakness being prone to fracture and the relative strength of the stabilizing ankle ligaments being greater than that of the physis sets the stage for transitional fractures of the distal tibia including juvenile Tillaux and triplane fractures. Such fractures do not fall neatly within the Dias-Tachdjian classification system.

The juvenile Tillaux fracture is a Salter-Harris III fracture of the anterolateral part of the distal tibial epiphysis. An external rotation force to a supinated foot causes avulsion of the anterolateral distal tibial epiphysis with anterolateral displacement due to the pull of the anteroinferior tibiofibular ligament. The juvenile Tillaux fracture was originally described by Kleiger and Mankin in 1964 with reference to the Tillaux fragment identified in the setting of lateral tibial avulsion fractures in cadavers by the French surgeon Paul Jules Tillaux in 1892. Juvenile Tillaux fractures constitute approximately 3% to 5% of pediatric ankle fractures.

Triplane fractures were initially described by Johnson in 1957 and by Marmor in 1970 and account for 5% to 15% of pediatric ankle fractures. They are also external rotation injuries, but they are constituted of multiple fracture lines. In the sagittal plane, there is a fracture line through the joint surface and the epiphysis (akin to the Salter-Harris III fracture of the juvenile Tillaux pattern); there is also an axial plane fracture through the distal tibial physis, and in the coronal plane, the fracture line exits through the metaphysis. Many variants have been described including two-part, three-part, and four-part triplane fractures. The two-part fracture pattern is the most common in which a large posterolateral epiphyseal and posterior metaphyseal fragment remains one fragment. In a three-part lateral triplane fracture, the smaller anterolateral epiphyseal fragment is fully detached, and in a four-part triplane fracture, the anterior epiphysis splits into two fragments (Fig. 12-1).



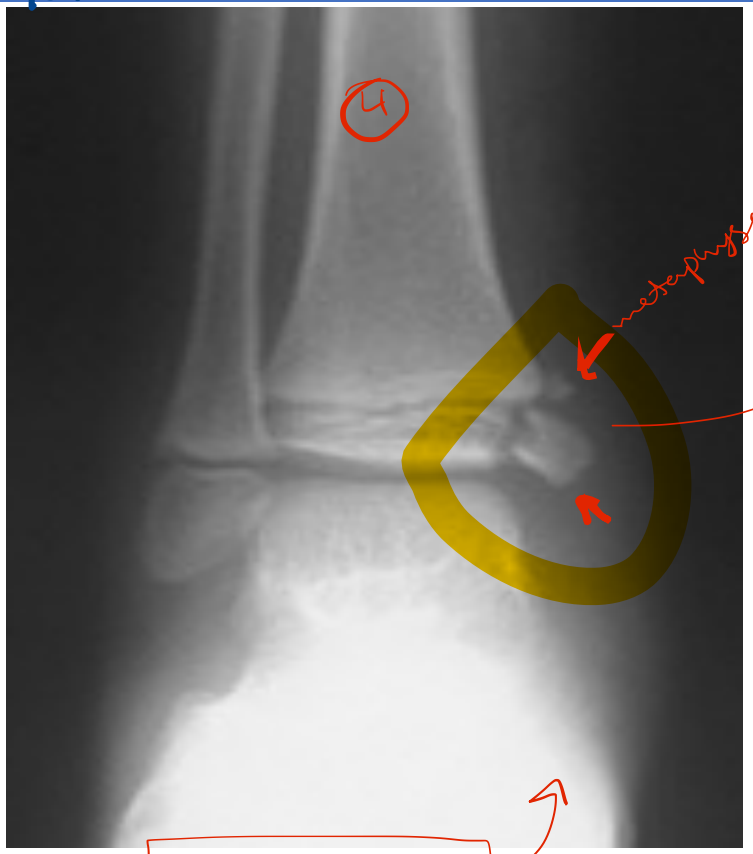
Diff

GP of fibula

Tillaux

Transitional type of fracture (telox fracture)
Ligaments are stronger than bone
in peds and vice versa in adults

axial & Sagittal plane fracture



metaphysis

will appear as one piece, Bigger than what's seen in X-Ray

Triplane

Sagital plane then go up / on other display You don't See the fracture

Fractures in Pediatric skeleton

Prognostic factors

- the treatment. → physician can cause bigger injury
- the severity of injury Salter harris
- the patient's age The younger the age the better the renodeling and healing if salter haris 1 and 2 (with considering the Severity)
- the physis injured → depend on joint (each joint has Growth Potential)

GP in proximal humerus is 4-5x more involved in growth than distal, while distal radius has higher growth potential, distal femur and proximal tibia has higher growth potentials. Note: bone tumors prefer areas of Higher prowth plate potential .

Fractures in Pediatric skeleton

The power of remodeling

Factors affecting remodeling potential of ALL Pediatric #

- **Years of remaining growth** – most important factor
- **Position in the bone** – the nearer to physis the better
- **Plane of motion** – greatest in sagittal, the frontal, and least for transverse plane
- **Physeal status** – if damaged, less potential for correction
- **Growth potential of adjacent physis**
  - e.g. proximal humerus better than distal humerus
  - & distal radius better than proximal radius

Diaphyseal are least remodeling capability

if deformity

type 1 Best remodeling

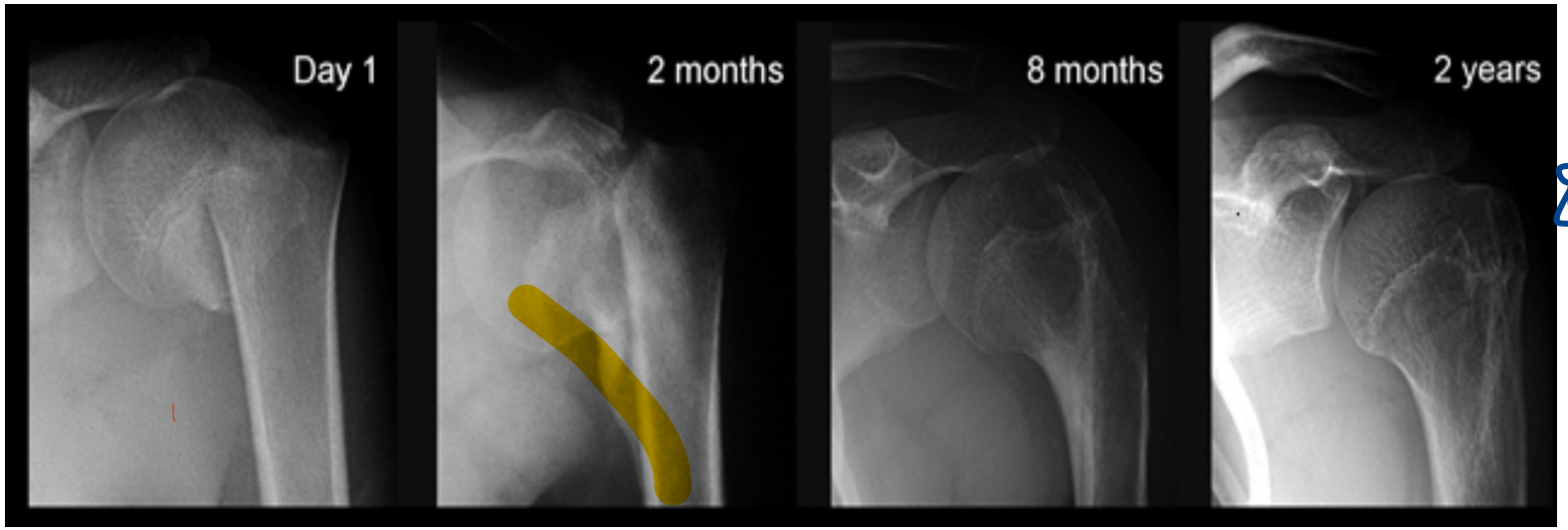
The shoulder joint can move in all ways, so wherever your fracture is it has good remodeling

Fractures in Pediatric skeleton

- **Growth potential of adjacent physis**

  e.g. proximal humerus better than distal humerus

10 years old pt has a fracture in proximal humerus, metaphyseal injury, with proximal migration and varus deformity, what we can do?
Nth needed (high growth potential, physeal intact, ...) we depend on remodeling,



should → wide range of movement, high vascularity & Growth Potential ... → factors that suggest Supportive treatment

Fractures in Pediatric skeleton

6 months
↓
we must see Growth Plate
to see healing

Slower correction on AP view

Rapid correction on lateral view

same case as slide 1

why no need for surgery?

1) skeletally young.
2) fracture is in the Distal radius where growth potential is ↑↑
3) GP is still open with no invasion / calcification.
4) Deformities are on AP & Lateral planes.

Fractures in Pediatric skeleton

→ 1 year follow-up

- Lateral view there is complete remodeling, still there is slight deformity on AP view, but there is good time remaining for it to remodel-

Fractures in Pediatric skeleton

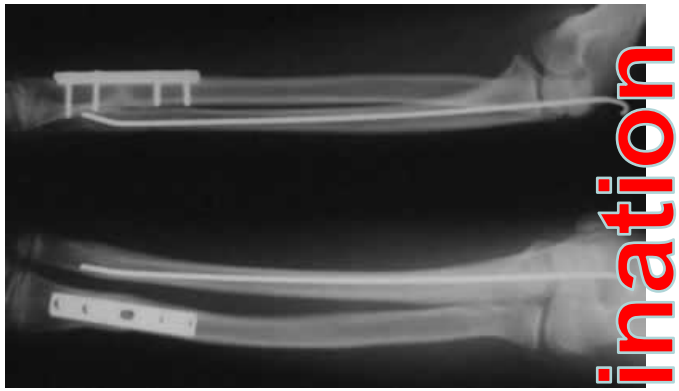
Indications for operative fixation

- Open fractures (soft tissues)
- Displaced intra articular fractures
  (Salter-Harris III-IV) → Anatomical reduction with absolute stability
- fractures with vascular injury
- ? Compartment syndrome
- Fractures not reduced by closed reduction
  (soft tissue interposition)
  or reduction lost with follow up
- Unstable diaphyseal fractures

Fractures in Pediatric skeleton

You can use whatever you want but you must be safe

Methods of fixation



Combination from all

- Casting - still the commonest
- K-wires
  - most commonly used
  - Metaphyseal fractures *imp*
- Intramedullary wires, elastic nails
  - Very useful
  - Diaphyseal fractures *imp*
- Screws
- Plates – multiple trauma
- IMN - adolescents
- Ex-fix → in open fracture mainly

Fractures in Pediatric skeleton

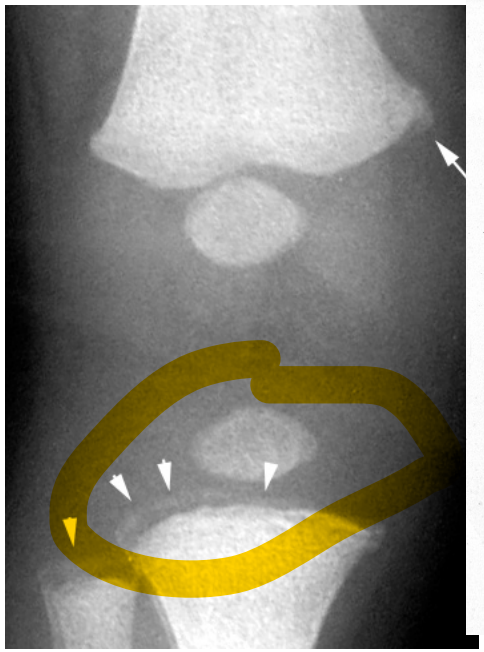
Complications

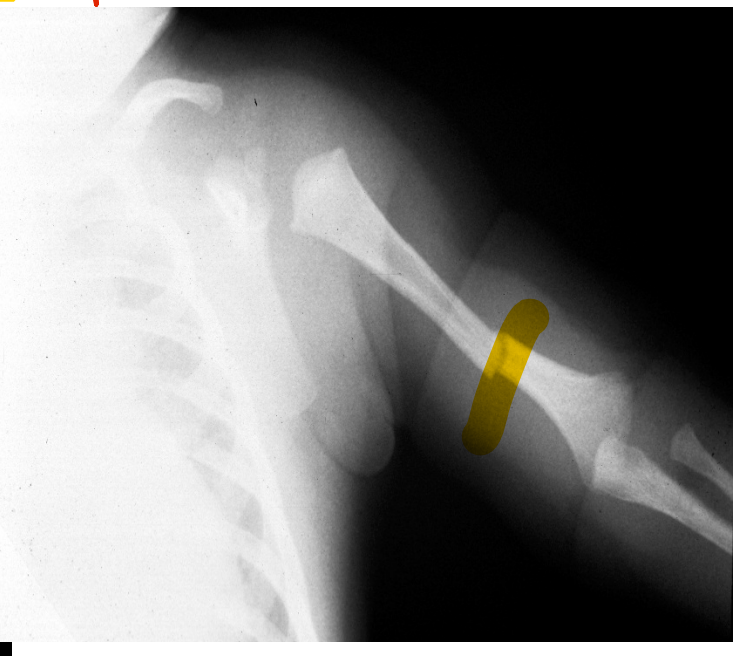
- Ma-lunion is not usually a problem
  (except cubitus varus)
- Non-union is hardly seen
  (except in the lateral condyle)
- Growth disturbance – SH III. IV, V & too many times of manipulation
- Vascular – volkmann's ischemia
- Infection - rare

Fractures in Pediatric skeleton

Child abuse

* Rule : Any child with transverse fracture in humerus & femur below age of 3 is child abuse until proven otherwise.





Fractures in Pediatric skeleton

Take-home messages

- The child is not a small adult
- High capability of rapid healing
- Remodeling for deformities is high if :
  - In the plane of motion
  - long growth remaining

Fractures in Pediatric skeleton

Take-home messages

- Respect physeal injuries
  - Avoid multiple reduction attempts
  - Follow closely if nonoperative
  - Anatomic reduction for articular fracture
  - Smooth K-wires when crossing the physis
  - Screws parallel to physis
- **Be aware of possible child abuse**