RADIOLOGY
TEAM 435

Radiological anatomy of the skeletal system

[Color index: Important ★ | Notes | Extra | Editing file]

- **Objectives:**

➢ Normal radiological anatomic landmarks
➢ System of analyzing findings "Where to look & What to look for"
➢ Recognize features of certain disease entities

- **Resources:**

❖ Doctor's slides
❖ 433 team
❖ 434 team

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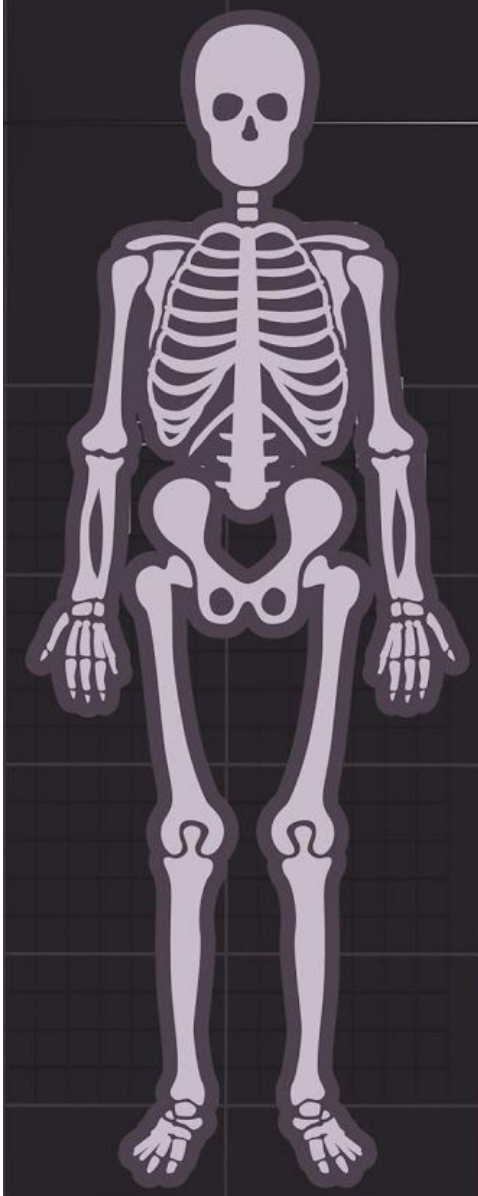


Introduction

❖ IMAGING OF THE MUSCULOSKELETAL SYSTEM:

1- PLAIN FILM:

- it is the corner stone
- Most bone diseases can be diagnosed by plain film
- Certain areas: shoulder, pelvis may need further analysis.
- CT is better than MRI for bone trabeculae and surrounding structure.
- ★ the most important modality used in screening. It is almost always the first modality to be used in MSK (in case of bone tumor, bone fracture,..etc)

2- COMPUTED TOMOGRAPHY :

- Useful in complex skeletal trauma and always prior to bone surgery.

-We can see everything in CT but most importantly is bone . most commonly used for fraction assessment (have good resolution between cortex and soft tissue and the inner aspect of the bone itself you can see it very well) very important in the preoperative planning especially in complex trauma.
-It is good for bone but not good for bone marrow (MRI is better because you can see the fat and the fluid in the marrow, in CT all are the same).
-Just remember CT is for fracture and complex trauma

3-MAGNETIC RESONANCE IMAGING:

- Useful in bone, joint, soft tissue
- bone marrow changes, the joint, the capsule of the joint, surrounding structures

-MRI is good for everything but not good for fracture because the bone resolution does not show you the cortex very nicely, but it shows the marrow very well.

- ★ Most importantly, it is used for soft tissue. It has an excellent soft tissue resolution, it shows you the tendon, ligaments and cartilage.
- ★ Any sport injury we use MRI to look for ligaments and tendons.

4-ULTRASOUND:

- Tendons/Ligaments/muscle
- Detect fluid collections around joints or within muscles.
- Soft tissue masses and cysts.

-Its used is limited in MSK because of bone, the bone will *reflect the image* and you cannot see anything else
- Very good in seeing structures around the joint (ligaments and tendons) also muscles injuries are seen very clearly in US
- we do mix of both US and MRI. If the patient comes with a history of a trauma or a mass we do a screening US to see if it is fluid or cyst or solid before MRI.

- ★ Used mainly for soft tissue around the joint and superficial structures

5-ANGIOGRAPHY:

- it is rarely used
- Vascularity
- Mapping
- Embolization

-It is not really a diagnostic tool in MSK
- Used previously when the quality of CT and MRI were not that good to map the tumor and see its vascularity but Nowadays it is not used that frequently, because CT and MRI are good.
-Most likely it is used preoperatively like when the patient is appointed to surgical resection or fixation with tumor that has a lot of blood supply, we do embolization before the procedure to block the blood supply of tumor

6- NUCLEAR MEDICINE:

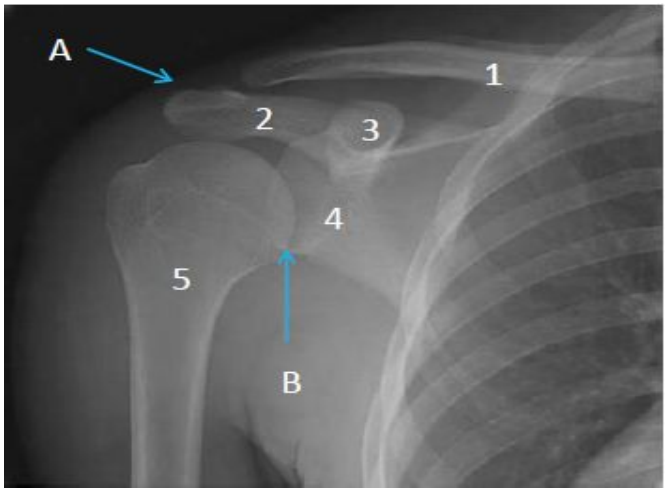
- Bone scan is very sensitive but is relatively non-specific
- Used mainly for two things (infection and metastases)

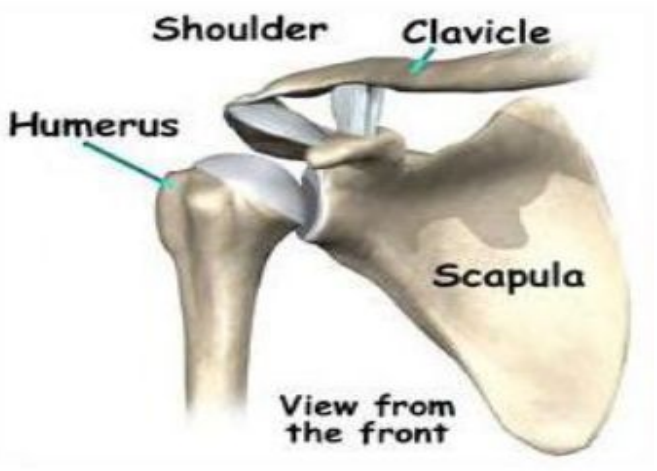
-Very sensitive in detecting and picking up stuffs in bone but not very specific -when you do bone scan for mets you can see mets everywhere but you wouldn't know where it's coming from or what kind of pathology it is-.
- Most likely used for screening of 2 things: 1- Infection like osteomyelitis because there is certain isotopes that are specific for infection 2- Quick screening method for detecting metastasis especially in prostate cancer for males and breast cancer in females because they have sclerotic mets and it is very sensitive in bone scan.

❖ **Interpreting Images** "Where to look & What to look for"	
Where : •Cortex of the bone •Margins of the bone •Articular surface of the joint •Junction between the cortex and the medulla •Pediatric: epiphyseal plate	What: • Bone density • Bone texture • Distortion /displacement of normal structures

Musculoskeletal Radiological Anatomy imp

❖ Anatomy of shoulder



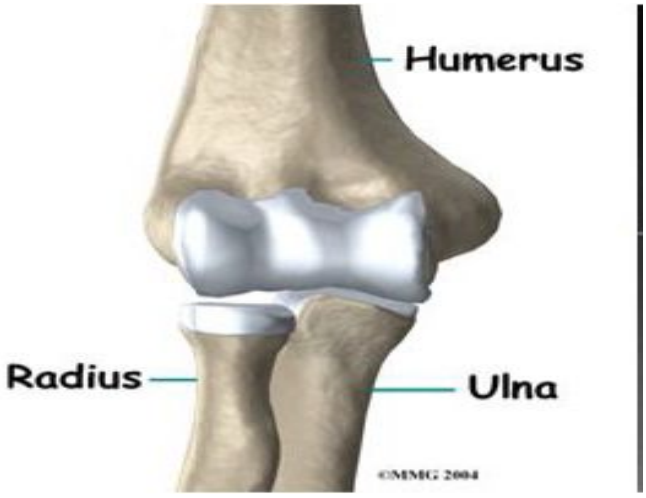


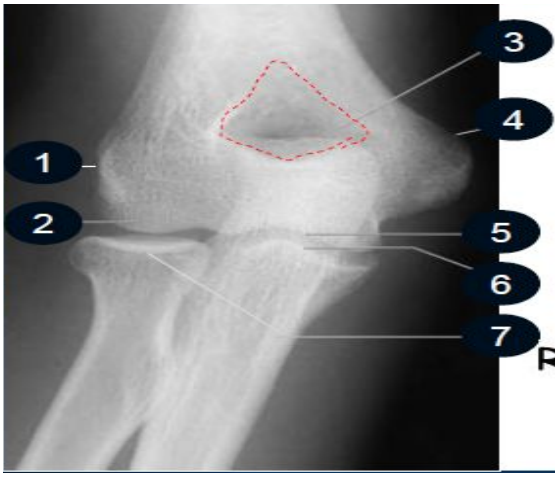
A-Acromioclavicular joint B-Glenohumeral joint -the correct and the medical term for shoulder joint-

1-Clavicle 2-Acromion process 3-Coracoid process

4-Glenoid process -the bone that articulates with humerus- 5-Humerus

❖ Anatomy of the Elbow:





1-lateral Epicondyle 2-Capitulum 3-Olecranon Fossa 4-Medial Epicondyle

5-Trochlea -articulates with ulna- 6-Coronoid Process -part of the ulna- 7- Radius Head

- in the elbow the biggest bone is ulna(medial) but in wrist it is radius(lateral)
- Capitulum is part of the lateral epicondyle that articulates with radius

❖ Elbow joint in different ages

-The point from these picture is not to determine the exact age , but only to differentiate between the child and adult joints.

-in the child the bone density is low ,the joint space is bigger and there is growth plate.

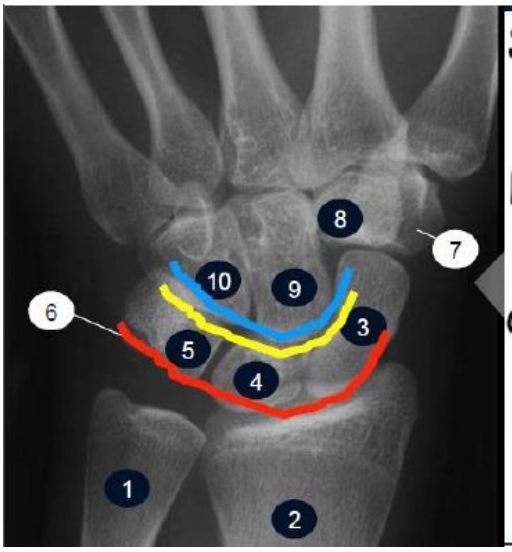
-In the first picture, we cannot see the radial head because it is not ossified so you have bigger joint space

-In the second picture, trochlea is now developing and you can see capitulum that started to fill the space and you can see the black line which represents the growth plate.

-In the third picture, everything is fused, sometimes you see white line representing previous growth plate

-In hand x-ray of newborns you might not see any carpal bones, just tiny dots (the ossification center is there but still cartilaginous)

❖ Anatomy of the wrist



1-Ulna
2-Radius
3-Scaphoid
4-Lunate
5-Triquetrum
6-Pisiform
7-Trapezium
8-Trapezoid
9-Capitate 10-Hamate
(8 Carpal bones :
4 proximal, 4 distal)

❖ Carpal bones (Mnemonic) :

She Looks Too Pretty , Try To Catch Her

-One of the important things when you look at wrist x-ray is to look to the orientation of the carpal bones

-The carpal bones form 2 Us, all should be nice smooth shape.

-When the alignment is disturbed, you should consider ligamentous injury or subluxation or dislocation of the carpal bones

for practical aspect not for exam

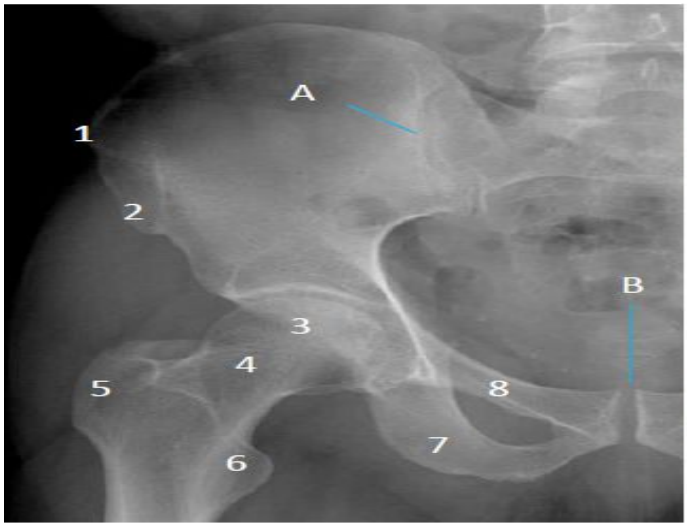
Three carpal arcs should be traced:

- along the proximal row of carpal bones; proximal aspect.
- along the proximal row of carpal bones; distal aspect.
- along the capitate and hamate proximally.

These three lines should remain unbroken

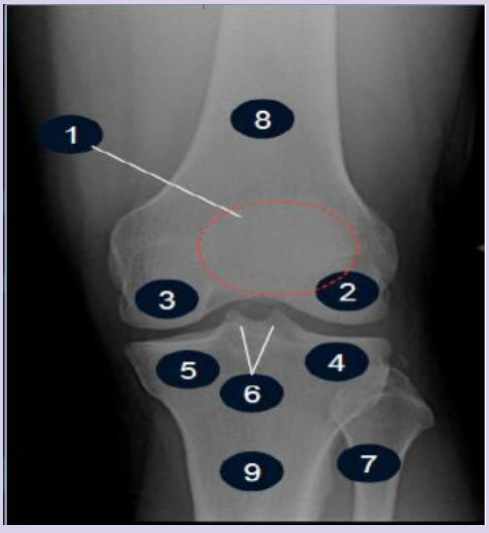
*The lines is used to determine any fracture and dislocation of carpals

❖ Anatomy of Pelvis and hip joints



A-Sacro-iliac Joint B-Symphysis Pubis 1-Superior Anterior Iliac Spine
2-Inferior Anterior Iliac Spine 3-Femur Head 4-Femur Neck 5-Greater Trochanta
6-Lesser Trochanta 7-Ischium 8-Superior Pubic Ramus

❖ Knee Anatomy

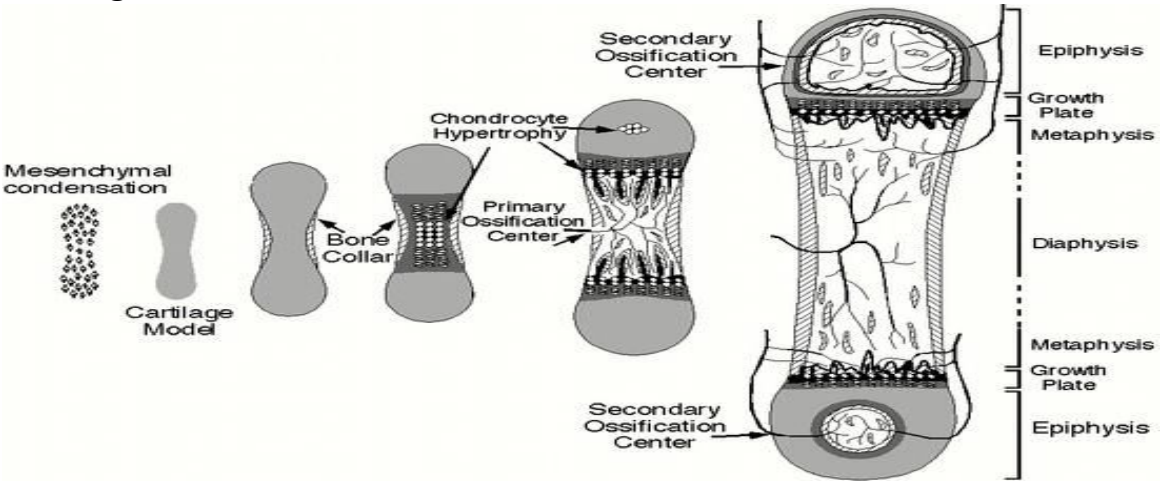


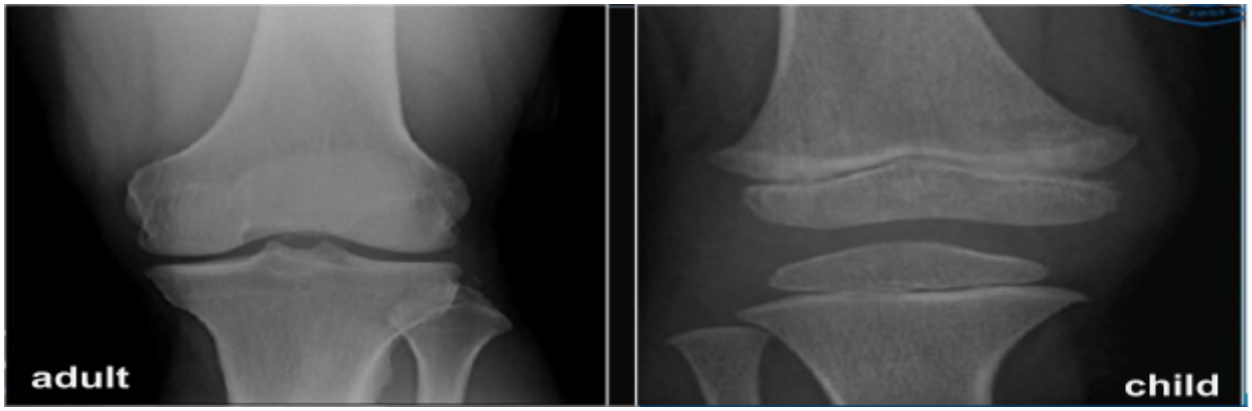
1-Patella 7-Fibula
2-Lateral condyle 8-Femur
3-Medial condyle 9-Tibia
4-Lateral tibial plateau
5-Medial tibial plateau
6-Tibial eminence

*Tibia (medial) is bigger than fibula

Tibial eminence = tibial spine

❖ Phases of bone growth



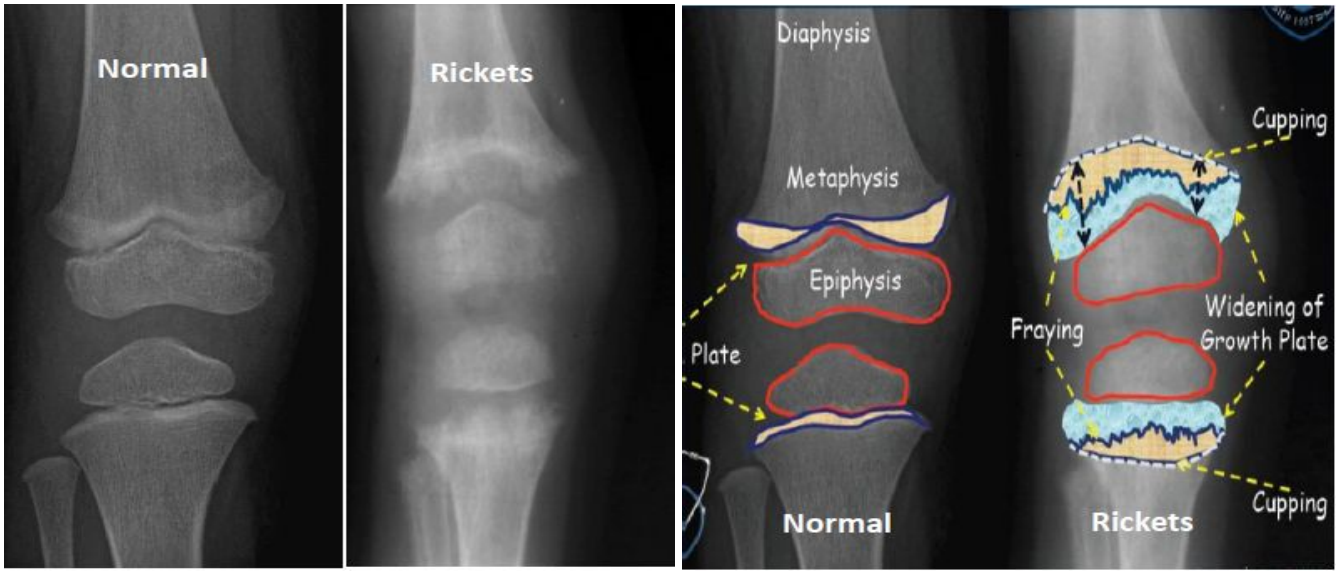


-In the first picture: joint space is small and everything is fused and the white line represents previous growth plates

-In the second picture: the joint space is bigger, bones keep growing until the child reaches his potential and everything will fuse.

-Different bones have different ages of fusion, not all have the same age of bone fusion -some 8,12,16,...-

❖ Normal knee and Rickets



The difference between normal knee and Rickets is :

-Concave outlines
-bone density changes
-Borders are not sharp, ill defined
-Trabeculeis hazy, hazy texture
-Growth plate is widened
-Metaphyseal margin is irregular
-Cartilage invaginatesthe bone
-Patella is normally not ossified in a pediatric patient

-Metaphysis: instead of having smooth convex surface metaphysis is more concave (cupping of metaphysis)

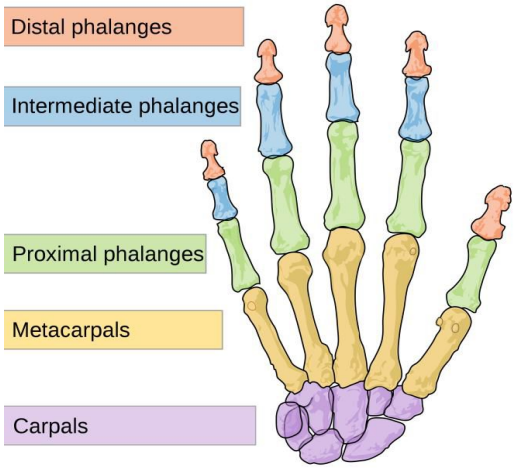
-Instead of having smooth borders, the borders are very irregular and we call that "Fraying"

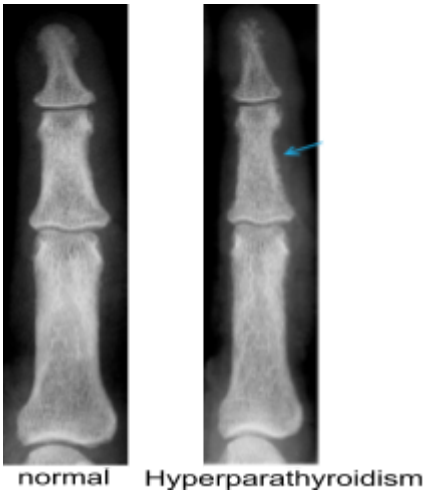
-Growth plate instead of being small, here is wide space

-Look at the soft tissues around it looks very dense and the bone itself it looks brighter "denser"

Hyperparathyroidism

- The hallmark of hyperparathyroidism is bone resorption in the radial aspect of middle phalanges of index and middle finger.





-First thing to do is to follow the cortex to detect any abnormality (fracture or any disruption) then we look at the center of bone (tumor or erosion)

-The edges of bone are fluffy, and there is small piece of bone is missing here, and when you look at the tufft there is multiple holes in it

-This is called resorption of the bone and it is always related based on this pattern to hyperparathyroidism

Musculoskeletal Pathology

Congenital - Arthritis -Metabolic -Trauma - Infectious - Hematological -Neoplastic

❖ MUSCULOSKELETAL RADIOLOGICAL TRAUMA: TERMINOLOGY IN BONE TRAUMA

DISLOCATION vs. SUBLUXATION	CLOSED vs. OPEN FRACTURES	GREENSTICK vs. TORUS FRACTURES
Dislocation: complete separation of the joint surface (no articulation at all) Subluxation: partial displacement of the articular surface but there still remains some articulation (even if the joint is only articulating by 10% is considered subluxation)	Closed fracture: the usual fracture Open fracture: some people think open fracture means bone is exposed and you can actually see it, it doesn't necessarily be like that. As long as the skin barrier is exposed completely and there is a tract reaching to bone that considered as open fracture. (when the wound reaches the bone and there is a direct contact between air and bone)	these happen in pediatrics because their bones are softer and have different architectures

PHYSEAL INJURIES	STRESS FRACTURES	PATHOLOGICAL FRACTURES
-Or growth plate injuries -Very specific fracture that occurs in pediatrics -The most common fracture in pediatric	-Normal bone that has been put in a lot of stress that is not used to. "when you suddenly decided to run a marathon and your body is not used to it, so you have a higher chance to get this type of fracture in your metatarsals because your bones are not used to this amount of stress. That is why you have to do things gradually. -March soldiers fracture	-Fracture that occurs in abnormal bone with minimum stress or trauma -Anything that weakens the bone or weakens the architecture of bone (metabolic bone disease like osteoporosis or osteopetrosis -even a simple cyst that takes up space in the bone causing the bone to be weak-), so even small trauma can lead to fracture).

❖ BASIC PRINCIPLES IN RADIOLOGY OF BONE TRAUMA

1. Two perpendicular views.

-Almost always we do 2 or sometimes 3 views (everything in x-ray is so deep, so we might miss a lot of things when we do only 1 view)

almost always AP and lateral views and sometimes oblique view to look at specific bone

-Sometime when you look at 1 view everything looks normal but when you see lateral view there might be dislocation.

2. Radiograph should include the joint nearest to the trauma.

-It is important because there is something called the paired bone concept. any place in your body that especially has 2 bones together (radius -ulna, tibia-fibula) and the pelvis you have a whole ring and everything is connected together. "it is almost impossible to break only one bone considering them connected all together, so you almost always have 2 fractures or fracture in one place and dislocation in somewhere else."

-If you have fracture in the forearm we almost always image the elbow and the wrist

-Same concept with the pelvis when you find fracture in the pubic ramus you almost always find fracture in the superior and inferior together

when you find fracture in the sacrum, you almost always find fracture on the other side and iliac bone

3. The paired bone concept.

4. The weakest link concept (Adult vs. Children).

-In adults, the soft tissues are weaker and bones are much stronger (in sport injury most commonly we see muscle tears, ligaments injury ...)

-In children actually neither bones or soft tissues are weak . the bone is very soft and very hard to break, bone keeps bend and bend and doesn't break very easily.

ligaments and tendon are very elastic they stretch a lot and don't tear off.

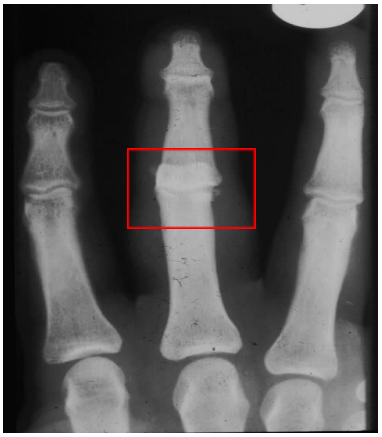
-the actual weak point in children is growth plate.

The weakest link:

- The soft tissue structures (muscles/ ligaments/ tendons) in Adults
- The physeal plate (growth plate) in Children

5. Comparison films.

-We look to previous films to see the progression of the disease, so we can decide is it something new, old, benign or malignant.



-In the first picture: in PIP joint the bones look overlapped but someone can argue that may be his finger is bent. a little bit of swelling in the soft tissue
-In the second picture: complete dislocation with proximal migration with fracture associated with it
-The worst is sometimes the patient might have dislocation but not necessarily associated with proximal migration (the bone is only directed forward), so you wouldn't see the overlap like here so it is harder to detect, that's why we have more than 1 view



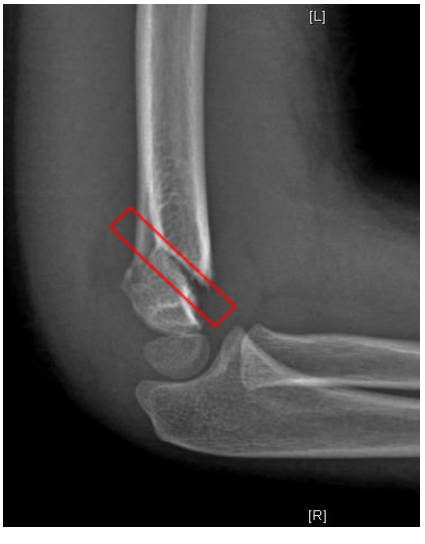

Abnormal

Normal

-In the front view: it looks like subluxation
-In the lateral view, it is completely out of the socket
humerus is completely dislocated from the radius and ulna (posterior dislocation --> we describe distal in relation to proximal)

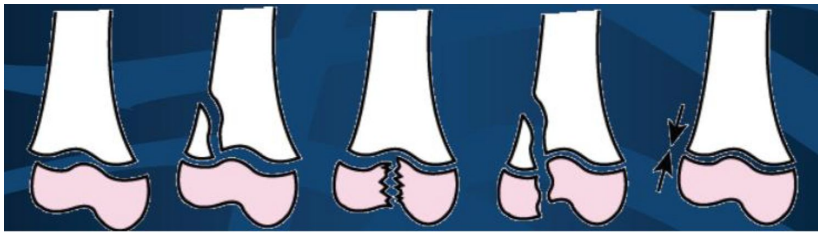
- **Child with trauma and swelling of the elbow**

-In the first picture: you wouldn't see the fracture because it is in the same plane as the x-ray
In the second picture: supracondylar fracture

❖ SALTER-HARRIS INJURIES

-all have fracture of the growth plate-



I II III VI V

In 1 and 5 you don't see fracture line in the bone itself , the only involvement is the growth plate

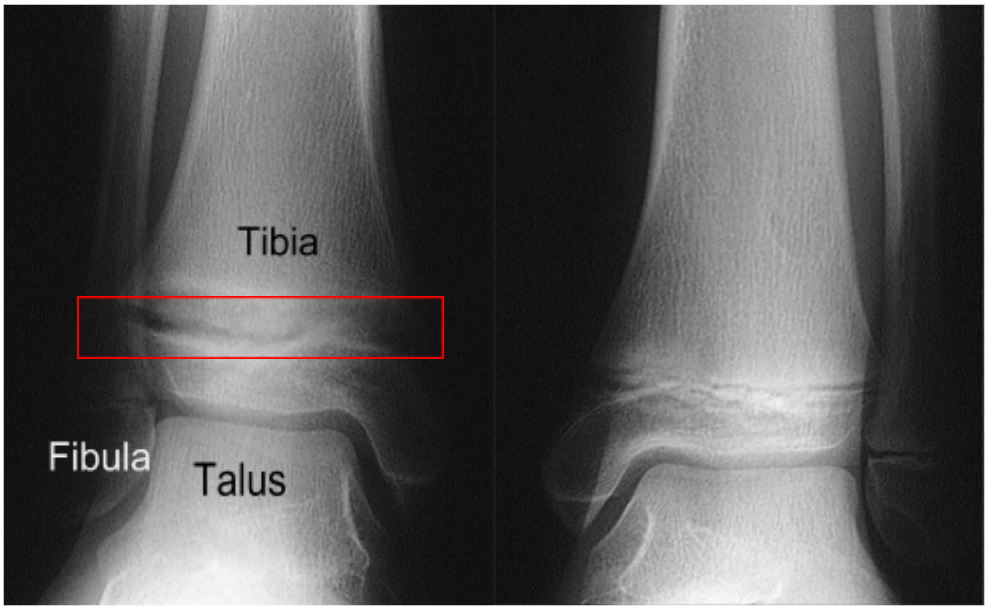
1 is widening of growth plate and 5 is compression of the growth plate

2,3,4 you see fracture lines

2 is metaphyseal fracture

3 is epiphyseal fracture

4 both metaphyseal and epiphyseal together



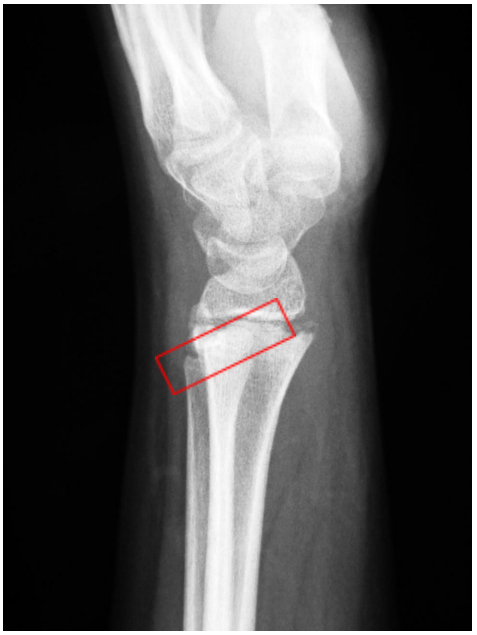
Salter-Harris 1 Normal

Traumatic Osteolysis of epiphyseal plate Salter-Harris injury Type1

It is hard to detect because growth plate is very variable from child to child, but when we suspect growth plate injury we do x-ray for other side to see what is normal for the child.

Traumatic Osteolysis of epiphyseal plate Salter-Harris injury Type 1 **same patient -Widening of growth plate-**

11 years old boy with swelling of wrist pain



Growth plate injury (Salter-Harris injury type II)

you don't see anything in the frontal view so always need lateral view

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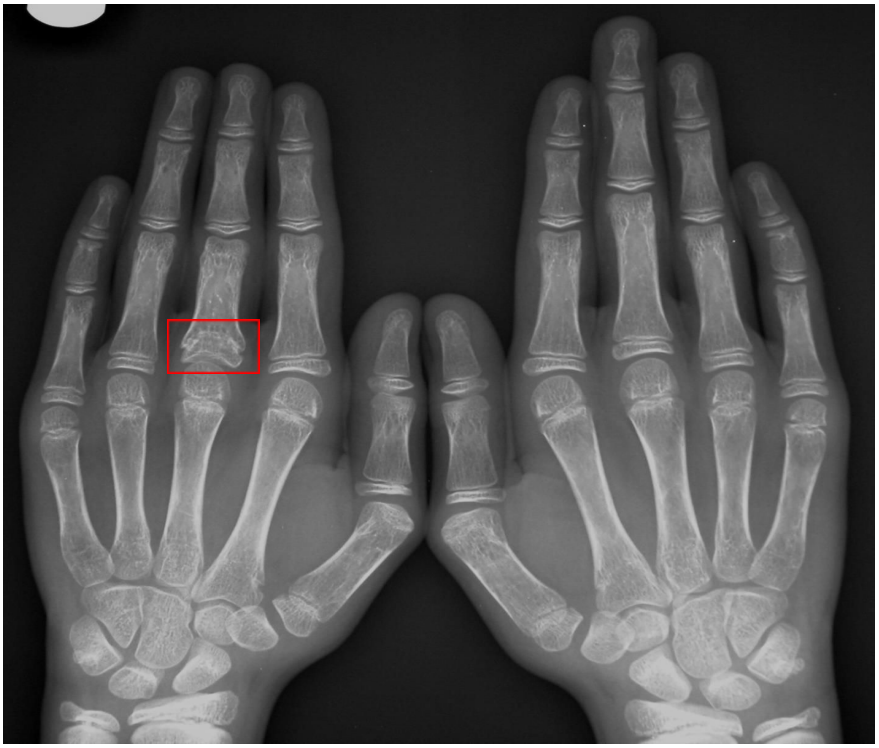
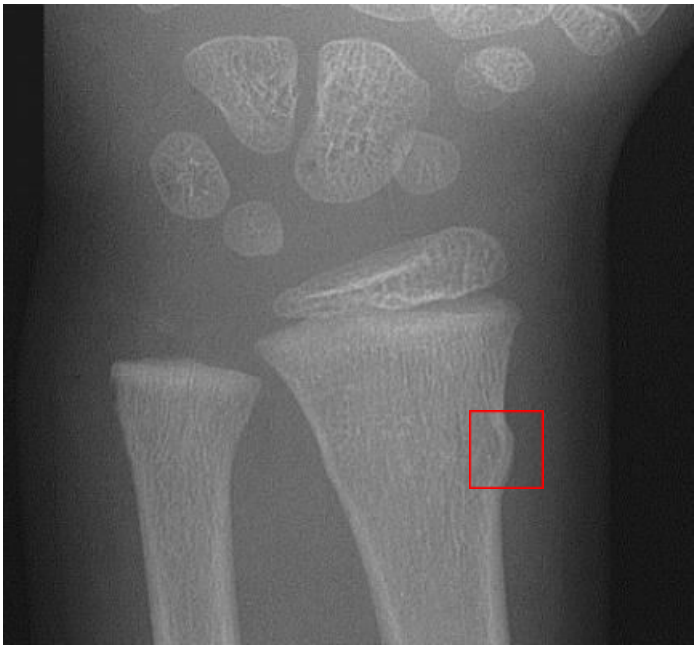
9 years old boy with pain



Salter-Harris injury Type V

In the picture joint is almost fused. the phalanx and the whole finger is shorter than the other side.
the worsts is type 5 because of much higher risk of growth plate fusion and premature closure and they get shortening of joint or bone.



Torus Fracture

-Different steps of fracture of a child bone
-If you take a piece of wood and if you are very strong or the stick is very thin it will crack --> that is the adult bone
- In a child --> if you bring a fresh stem from a tree and bend it bend it slowly it will not break but it gonna keep bending bending and bending until one point the outer edge will just pop
-Just follow the cortex especially in trauma, there is a pump here which is abnormal
-It is just buckling of the cortex and it is the initial phase and the rest of bone doesn't look so bad and if you keep bending the bone this will buckle a bit more and then you will have a break here but the other site is till resisting (greenstick fracture)

Greenstick fracture

If you keep bending the bone this will buckle a bit more and then you will have a break in one side but the other side is till resisting (greenstick fracture)

Bowing Fracture

If you keep bending, the fracture will extend a little bit and the other side of the fracture will start to bend and bow it wouldn't fracture, is still resisting

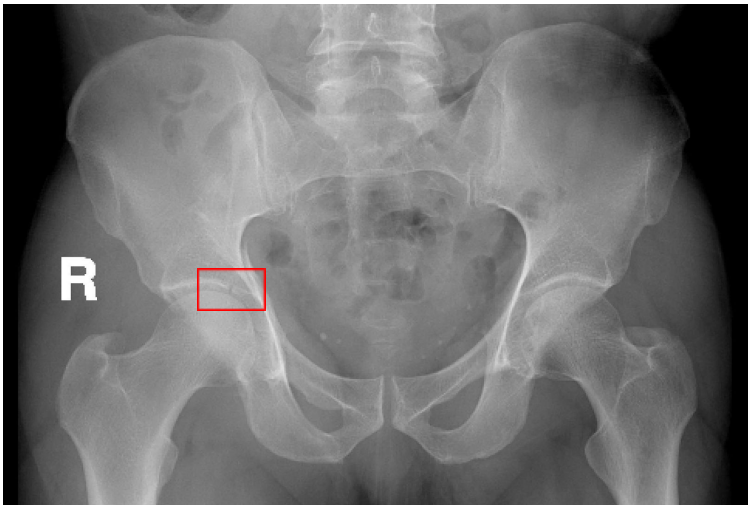
If you continue to bend eventually it will be complete fracture like adults.

-The sequence of bone fracture in children
Torus fracture → greenstick fracture → bowing fracture → complete fracture
*According to the stress the fracture can begin as torus, greenstick,...

55 years old patient limping with hip pain

Supra-acetabular fracture

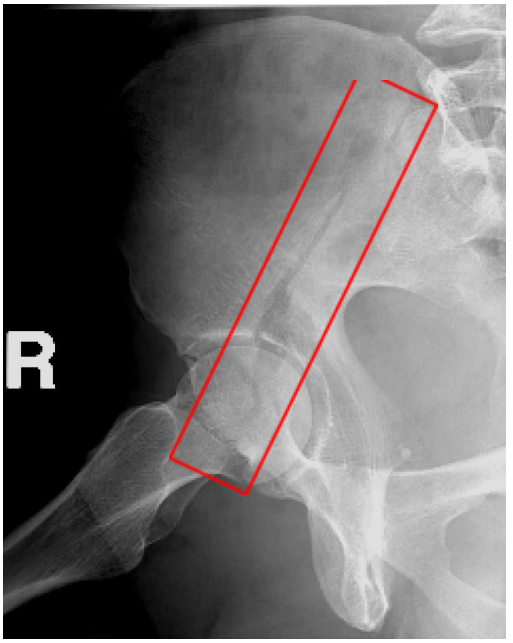
pelvic fracture is very hard to see, we use a lot of CTs because of so many bones here, but we use the same concept 'follow the Corteses'

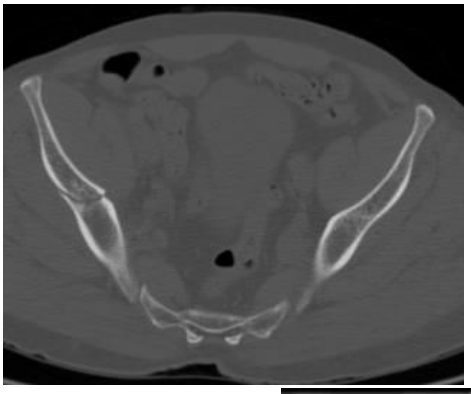


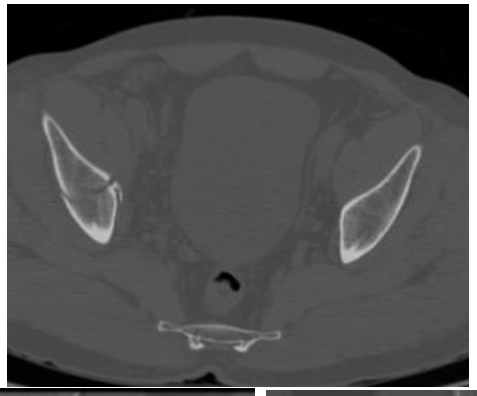
Supra-acetabular fracture

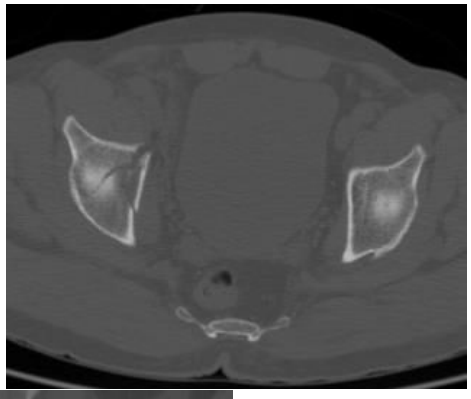
When you do oblique view is very clear.

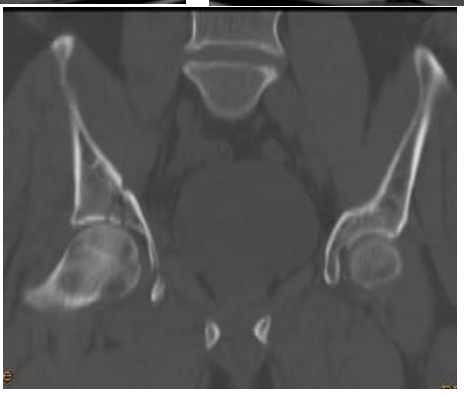
Fracture of iliac bone to the acetabulum. automatically we do CT or x-ray to the other side because we know there will be fracture in the other side (it is like a ring)

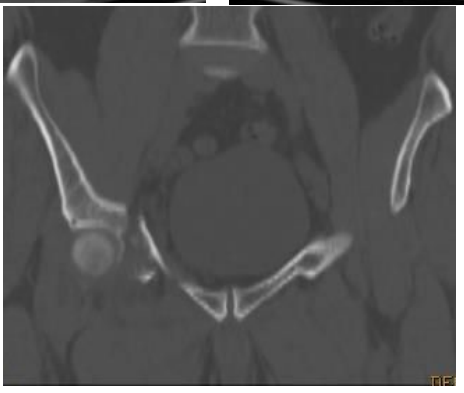










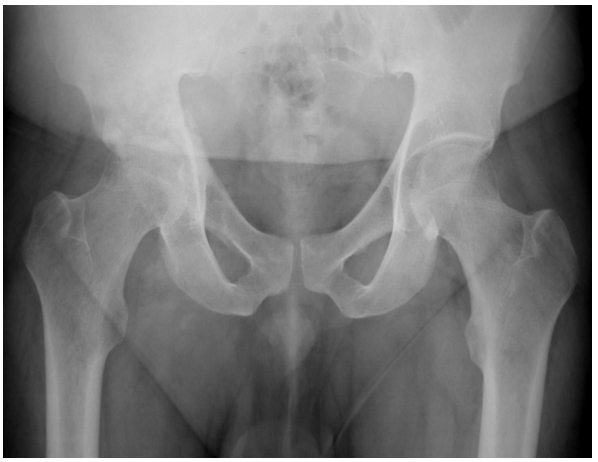


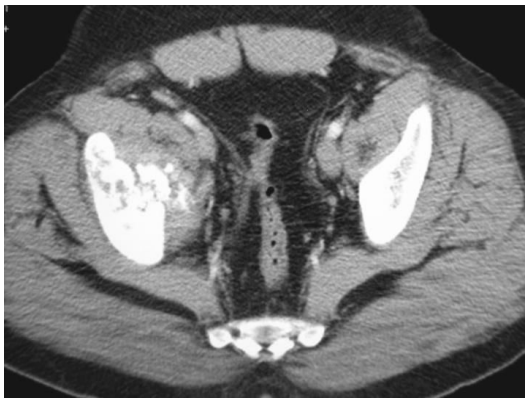
Supra-acetabular fracture

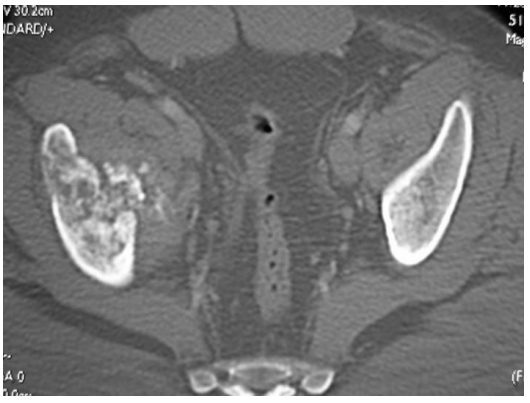
50 years old patient limping with hip pain

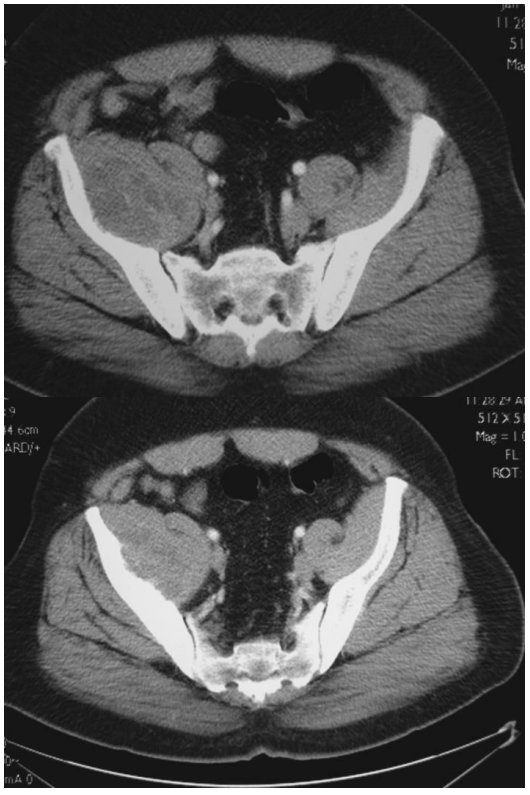
Supra-acetabular fracture

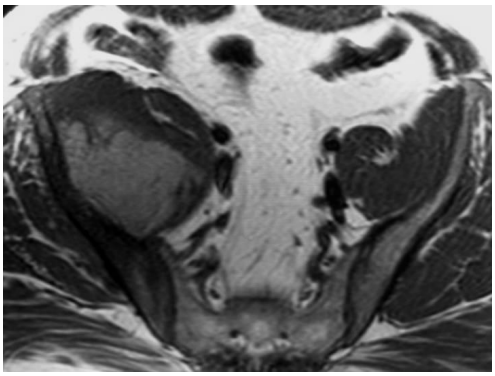
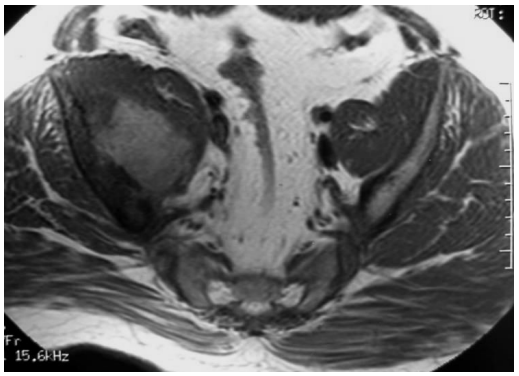
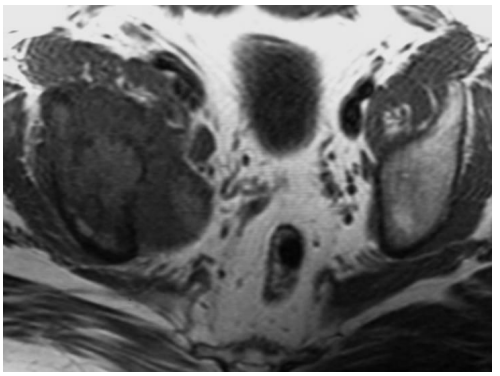
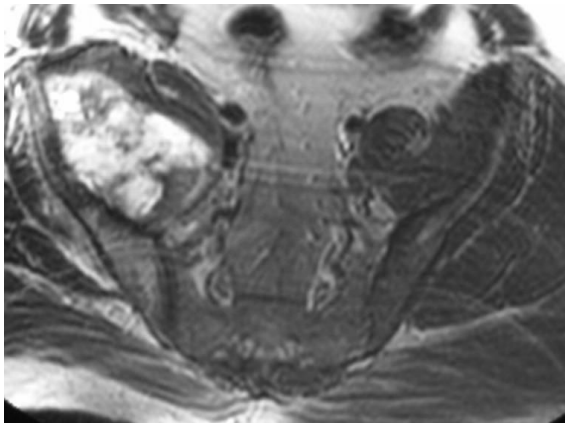
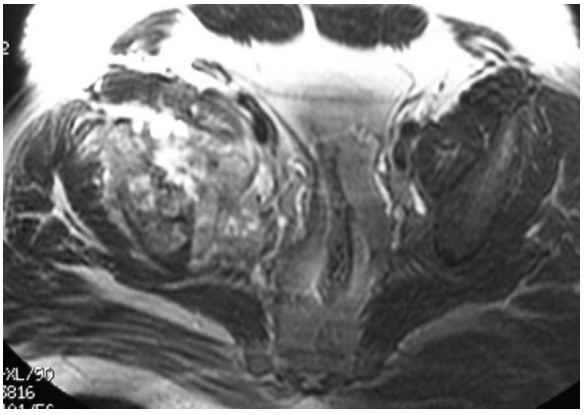
The bone in the right side of the patient is denser --> pathological fracture "you don't need to know the exact pathology but it ended up to be sarcoma"



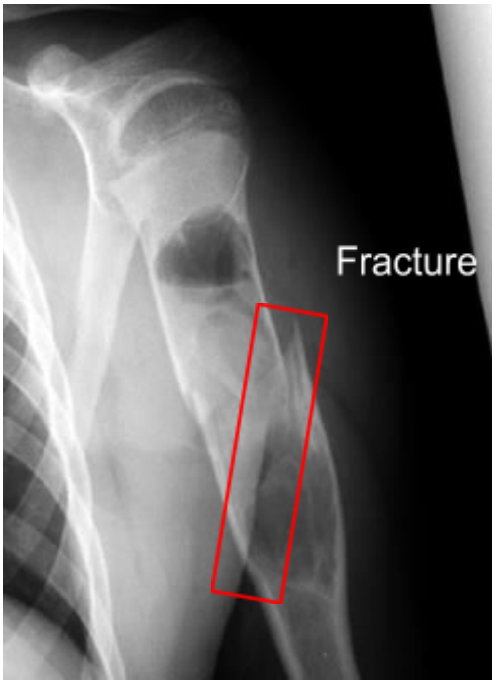






Supra-acetabular fracture due to sarcoma -pathological fracture-



Pathological fracture secondary to bone cyst

20 Years old lady finger pain

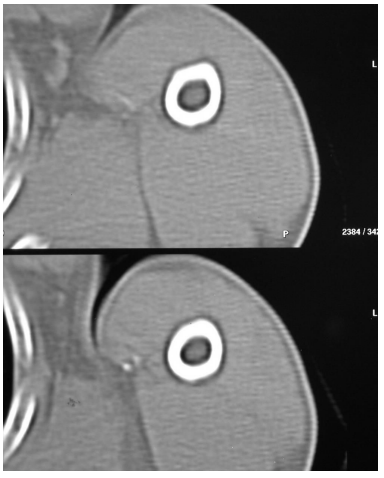
Pathological fracture due to cyst

Pathological fracture secondary to sarcoma

Pathological fracture due to sarcoma with Periosteal reaction (can look very differently depending on what disease it is)

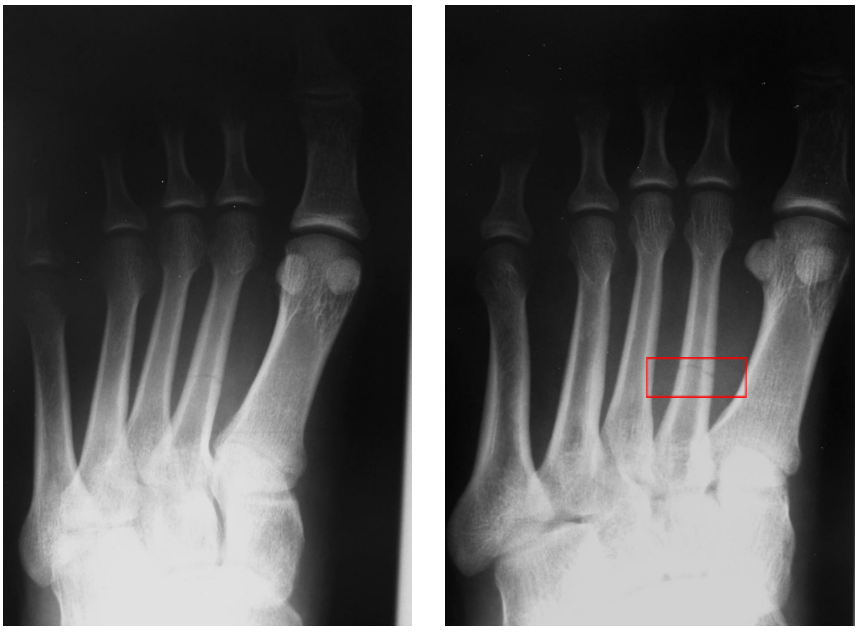
There are 3 types of periosteal reactions: one of them is aggressive which is related to cancer (sunburst periosteal reaction) there is bone proliferative process that body cannot resist

Axial view of CT showing periosteal reaction with abnormal bone

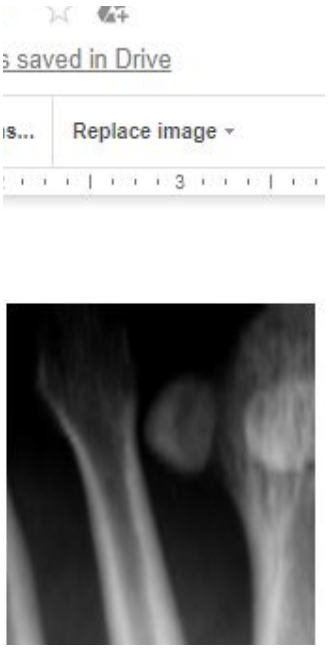


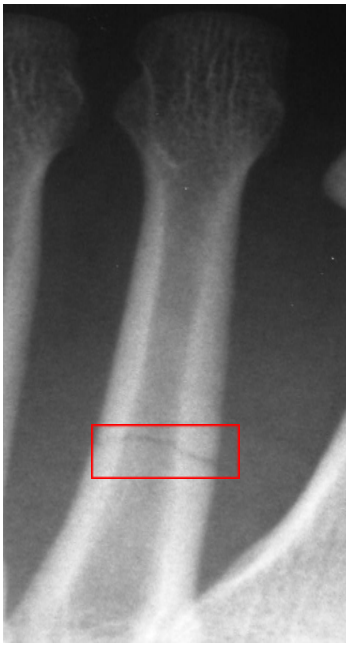
Stress fracture

If the a patient comes to ER with history of walking a lot with foot pain, you cannot ignore the second metatarsal bone"almost all the stress fracture occurs in the second metatarsal"
If you look to the x-ray and it looks normal, you cannot let the patient go to home if you suspect he has stress fracture without giving his specific instructions (not to weight bear) and we usually put him in cast for 2 weeks because if he has stress fracture and he continues to walk on it, it will turn into complete fracture, if it is detected early and protective measures were used it can heal very properly.
If you cannot see it on the x-ray we ask the patient to come back after 1-2 weeks and then we start to see the healing of fracture or the fracture becomes more obvious as you get some osteopenia around where the fracture is



Follow up of the same patient
You can have deformity and premature osteoarthritis if it is not treated early





Stress fracture after one week

Comparison between the previous pictures (when the patient presented and after 1 week)