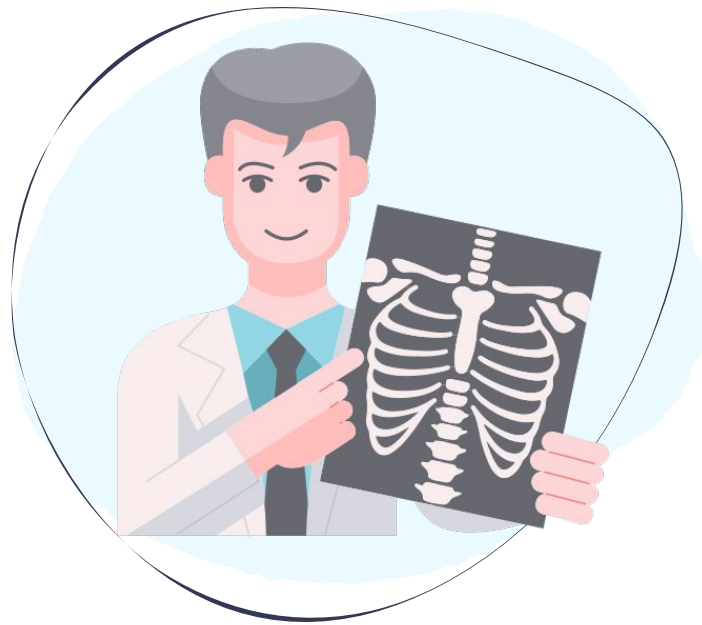




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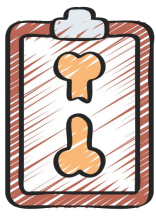


Diagnostic Imaging & Investigations

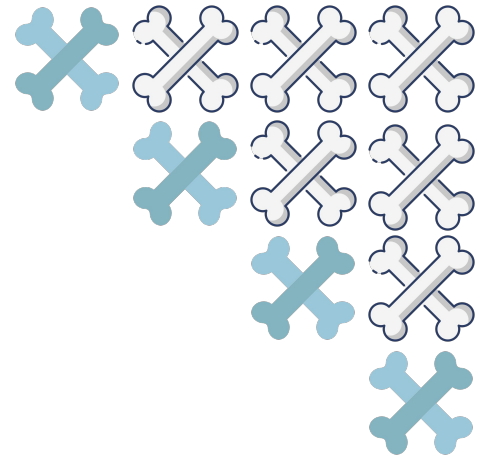
Dr. Motaz Alaqeel

Color Index:

-  Main Text
-  Important
-  441 Notes
-  Old Notes
-  Extra
-  



Objectives



Review a systematic approach to interpreting orthopedic X-rays.



Review the language of fracture description.

Study the **pictures** very well, in the exam most likely no questions will be from this lecture **BUT** it's important to answer other questions



Resources



How to Read an X-ray
By The Young Orthoped

X-ray Interpretation



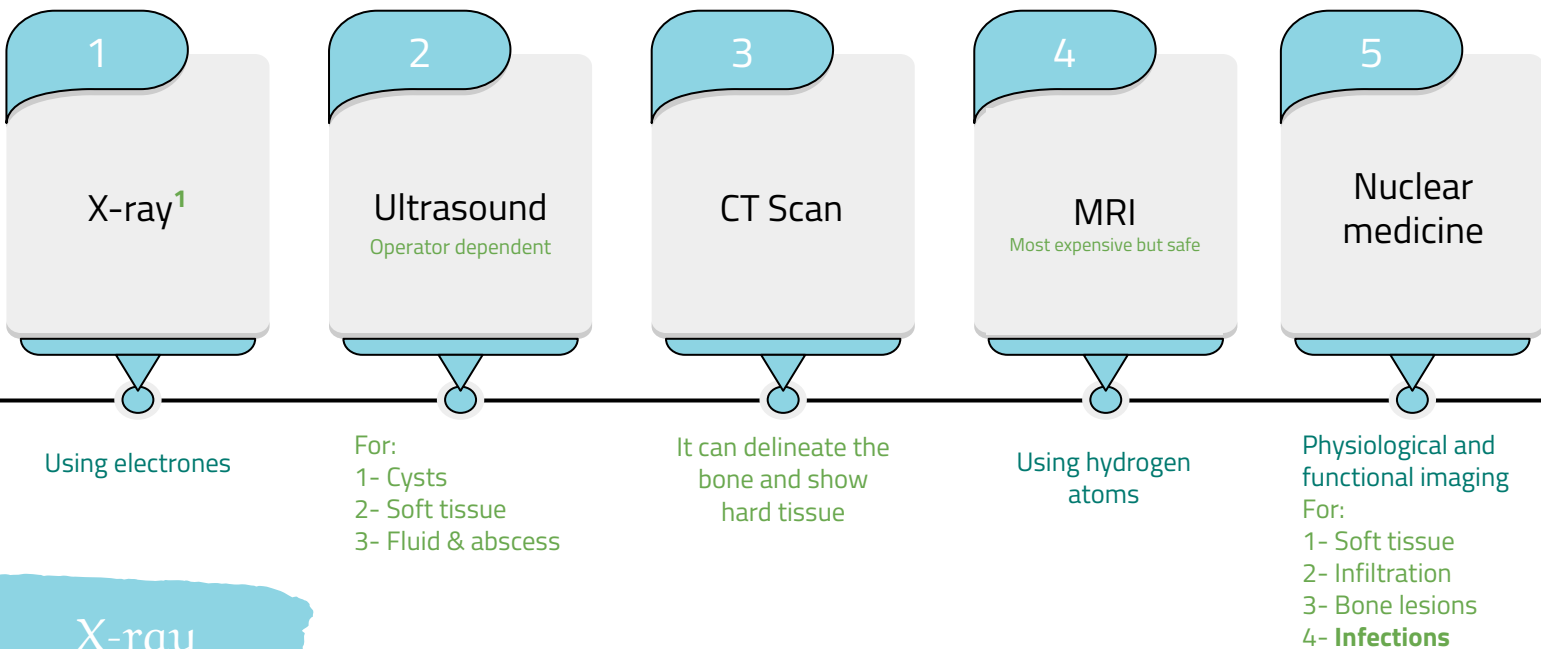
Introduction

- Medical decision making is a triad of:
 - History (from patients/records)
 - Physical examination
 - Confirming studies (imaging, labs, etc..)



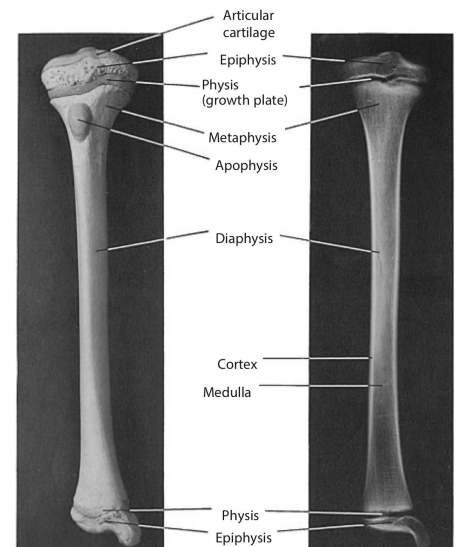
Imaging

You can increase imaging accuracy by adding contrast
DDH : occurs at the age of 2 weeks so we inject contrast to visualize the cartilage



X-ray

- 1- Radiation source. 2- Patient exposed. 3- Capture image. 4- Interpret image.
- Ionizing radiation source (radiation damages cells)².
- Capture image: (Films or Digital).
- Patient blocks transmission of radiation:
 - Soft tissue (**blocks/absorbs less**) → Black
 - Bones (**blocks/absorbs more**) → White
- Images interpreted by:
 - Radiologist or Orthopedist³.
- Best for:
 - Hard tissue
 - Bones
- It's often combined with other imaging modality.
- 3 Views are preferred: AP, Lateral and Oblique⁴.

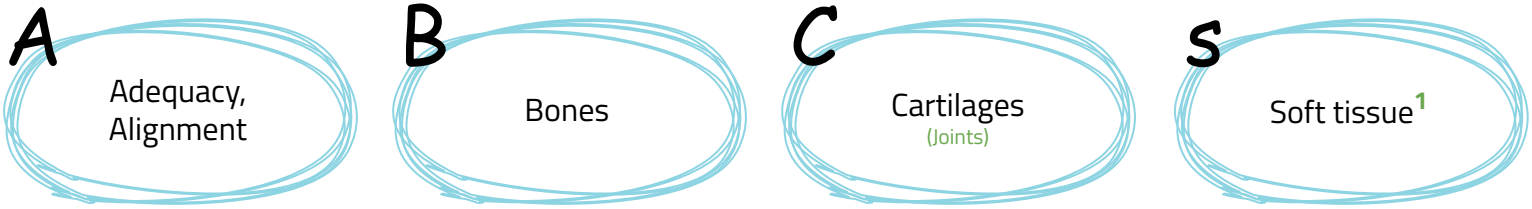


1- Carcinogenic only with high doses.
2- Even other specialties (family medicine, etc..) must have the basic skills to read X-rays.
3- Should be perpendicular to each other.
4- Most frequently used in orthopedics.



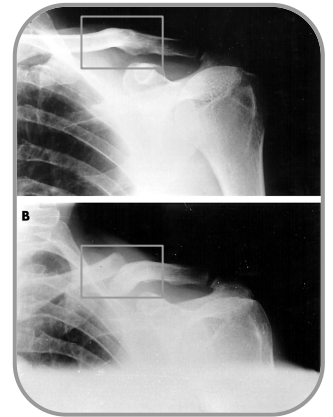
ABCs Approach to an X-ray:

- Pre-ABCs: start with identifying the patient, read provided info (patient's name, ID, date of the x-ray).
- Apply ABCs approach to every orthopedic film you evaluate.

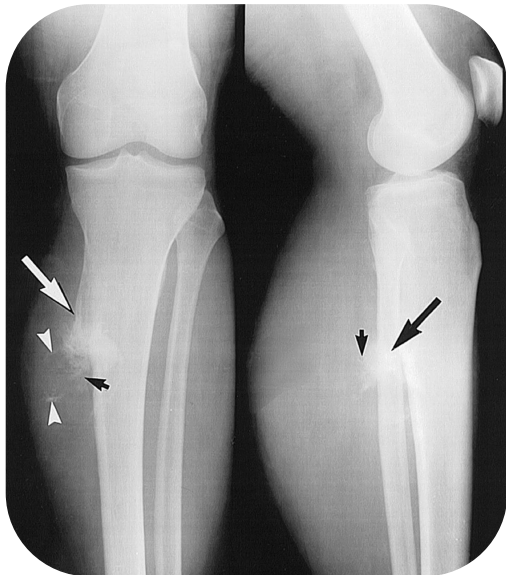


Adequacy

- **Never accept an inadequate X-ray.**
- **Two things to make sure we have in the film:**
 - 1- All X-rays should have adequate number of views:
 - 2 Views "minimum": AP (anterior-posterior) and Lateral
 - 2 Joints (joint above and joint below "both ends of the bone involved")
 - 3 Views are preferred
 - 2- All X-rays should have adequate penetration.



• Example: Applying ABCs



- A) Inadequate:** (One joint), and normal alignment (knee and leg are in good alignment).
- B) Abnormal:** Proximal-mid tibia (there is a medial lesion "bright ill defined mass" pointing (posteriorly) "only clear on lateral view") → here is osteosclerotic mass and projecting medially and posteriorly "prostomedial", and it's like spherical shape and borders are ill defined
- C) Knee joint:** Symmetrical joint space, no abnormalities, the articulation between (tibia, femur and patella) is good, no dislocation or subluxation.
- s) There is swelling.**

Alignment

There are 2 alignment lines
 1- Anatomical line
 2- Mechanical line

- It's the anatomical relationship between two bones on X-ray.
 - Bone alignment v.s. Other side.
 - Bone alignment relative to proximal and distal bones¹.
- Normal X-rays should have normal alignment.
- Fractures and dislocations may affect the alignment on the X-ray².



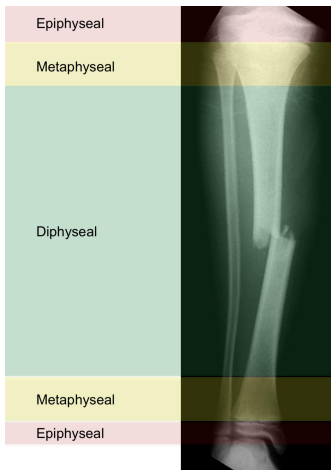
The weight goes in a line no matter the shape of the bone

1- For example swellings and calcifications (In abscess > Air-fluid level).
 2- At the end when I adopt this system I can tell for example: I'm looking at X-ray which is optimal (adequate) and that X-ray shows fracture in the femur and that fracture is displaced and the fragments are aligned, and the joint is dislocated and there is swelling.

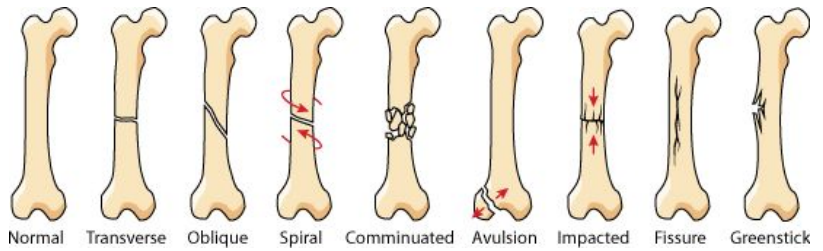


Bones

1. Identify bone (which limb?, which side¹?, which bone?, which part?)
2. Examine the whole bone for:
 - Discontinuity → fractures (not always a fracture, it might be a growth plate, if it's still confusing you, see the other limb).
 - Change in bone shadow consistency → change in density.
3. Describe the bone abnormality:
 - Location².
 - Shape.



Proximal 1/3
 Middle 1/3
 Distal 1/3



Each type of fracture indicates a certain cause of injury, for example:
 Torsion = Direct force
 Oblique = Bending force
 Spiral = Twisting

Picture

ABCs



- A)** Inadequate (only one view), not aligned (fracture).
 - B)** Tibia bone transverse fracture in the mid shaft (Diaphysis). We can't tell if it's right or left because it is not labeled.
 - It is a complete fracture.
 - There is medial displacement and angulation. (Because distal part is medial)
 - 75% displaced (75% of 2 ends not attached to each other) or 25% apposition.
 - C)** Joints are good.
 - s)** No swelling or soft tissue changes.
- Growth plate which is normal phenomenon in children, not a fracture (**Tibia**).



- A)** Inadequate (only one view and it's not showing one joint above and one joint below), not aligned (varus).
 - B)** Femur bone, oblique fracture in the mid shaft. We can't tell if it's right or left.
 - 80% displacement medially.
 - Apex: Angle tip = رأس العظم
 - C)** Can't comment
 - s)** No soft tissue rupture, No dirt or gas most likely a closed fracture
- (Femur) Can't determine if R or L unless mentioned



- A)** Inadequate (only one view and it's not showing one joint above and one joint below), not aligned.
- B)** Right femur bone fracture in the upper segment.
 - Medially displaced (100%).
 - Angulated about 30 degrees.
 - Distal part is tilted medially.
- C)** Can't comment on cartilage.
- s)** No swelling or soft tissue changes.

1- We can't determine the side, it should be provided on the image (left or right), don't guess in order not doing the surgery on the wrong limb.
 2- For long bones you can describe the segment whether it's (upper, middle or lower), (proximal, middle or distal), (epiphysis, diaphysis or metaphysis)

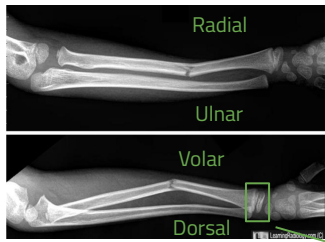


Picture

ABCs



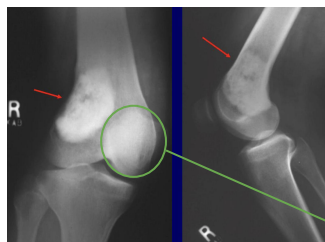
- A)** Inadequate not aligned, ones there is an angle there is no alignment.
- B)** Left humerus bone fracture in the upper segment or mid junction between upper and the middle.
 - This is spiral fracture.
 - Laterally (posterior) displaced 90%.
 - Angulated
- C)** Can't comment on cartilage.
- s)** No swelling, there is a cast shadow.
 - There is a splint in the posterior aspect of the bone (cast shadow).



- A)** Adequate: 2 views, joint above & below, exposure is adequate, alignment is valgus (lateral).
- B)** Incomplete mid shaft fracture. "Green-stick fracture" because (Lateral cortical line is intact & Bones are soft). In the forearm say ulnar or radial angulated.
 - Displacement of fracture: nothing.
 - Angulation: volar angulation.
- C)** Can't comment on the cartilage. This is child that's why I can see growth plate.
- s)** NO swelling.
 - growth plate which is normal phenomenon in children, not a fracture.



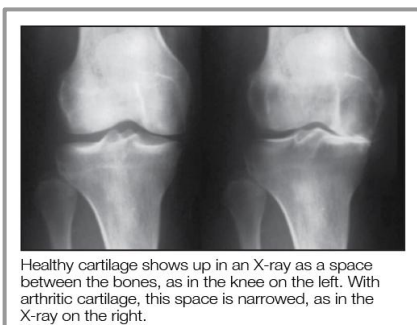
- A)** Inadequate but aligned (there is no fracture).
- B)** Humerus bone with well defined lytic bone lesion in the upper (proximal) segment, cortex is intact. In the upper part close to humerus head we see the normal growth plate not a fracture, most likely is a tumor.
 - No fracture.
- C)** Joints are good.
- s)** No swelling.



- A)** Inadequate: 2 views, exposure is inadequate = no joint above or below.
- B)** Sclerotic round shape lesion in the lower part of the right femur (Lateral epicondyle). There is area of radiolucency. Cortex is involved.
- C)** Can't comment on the cartilage.
- s)** No swelling.
 - The circle is the patella overlapping medial condyle shadow, not lesion.

Cartilage

- Joint spaces on X-rays, you can't actually see cartilage (itself directly) on X-rays.
- Widening of joint spaces → Signifies ligamentous injury and/or fractures.
 - (Also effusion, infection or bleeding).
- Narrowing of joint spaces → Arthritis.
 - (More pressure = ↑ surface area "osteophyte").



Healthy cartilage shows up in an X-ray as a space between the bones, as in the knee on the left. With arthritic cartilage, this space is narrowed, as in the X-ray on the right.

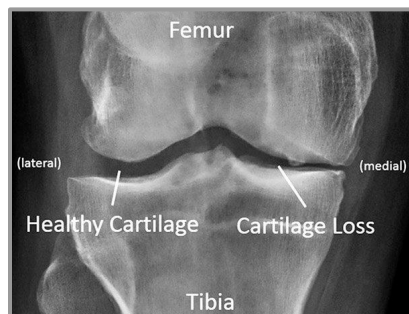
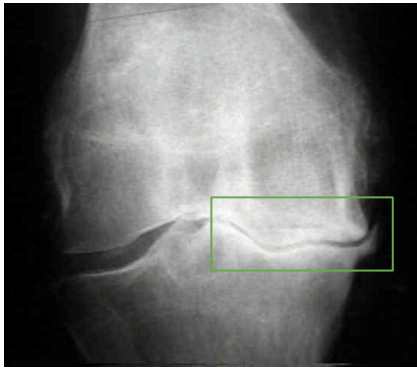


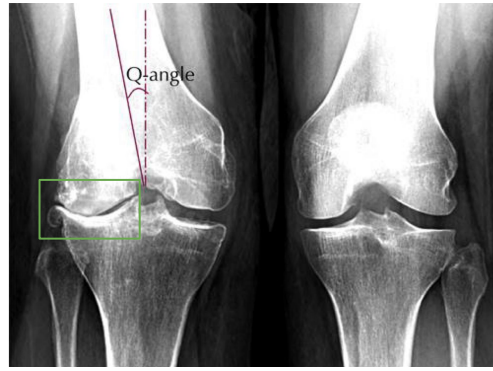
Figure 1



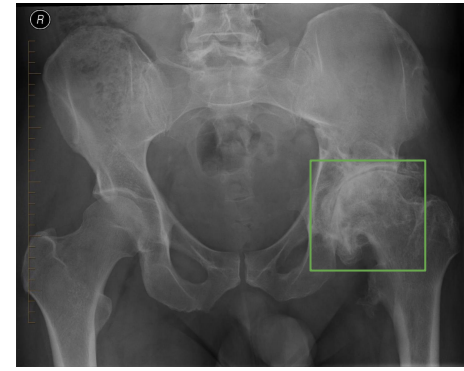
Figure 2



(Osteoarthritis of the knee)
 "Sclerosis and osteophyte"
 (In Rheumatoid arthritis we see juxtaarticular osteolysis compared to the sclerosis seen here)



(Osteoarthritis of the knee)
 - Osteophyte
 - Knee asymmetry
 - Subchondral sclerosis



(Osteoarthritis of the hip)
 - Decrease joint space
 - Osteophyte
 - Subchondral cyst

Arthritis in the knee/hip joint

Signs of osteoarthritis: **Must know these 4**

Asymmetric narrow joint space, osteophyte, subchondral sclerosis and subchondral cyst.

Soft tissue

Both cartilage & soft tissue are seen only by their shadow

- Soft tissue implied to look for soft tissue swellings and effusion.
- These can be signs of:

1 Trauma

2 Occult fracture¹

3 Infection

4 Tumors

Review the ABCs

A	Adequacy: Assess adequacy of X-ray which includes (proper number of views & penetration).
	Alignment: Assess alignment of X-rays.
B	Bone: Examine bones throughout their entire length for fracture lines and/or distortions.
C	Cartilage: Examine cartilages (joint spaces) for widening.
S	Soft tissue: Assess soft tissues for swelling/effusions.

1- When the fracture is difficult to detect it is called occult fracture (hidden fracture), and you can identify occult fracture by soft tissue assessment.



Language of Fractures

- Important for describing X-rays in medical terminology.
- Improves communication with orthopedic consultants.

Things you must describe (clinical and X-ray)

1- Open vs Closed fracture	2- Anatomic location of the fracture	3- Fracture line	4- Relationship of fracture fragments	5- Neurovascular status
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Open vs Closed Fracture

Closed Fracture	Open Fracture
Simple	Compound fracture.
	Cutaneous (open wounds) of skin near fracture site. Bone may protrude from skin.
	Open fractures are open complete displaced and/or comminuted.
	An orthopedic emergency, requires emergency orthopedic consultation. Bleeding must be controlled.
No open wound of skin near fracture	<p>Management</p> <ol style="list-style-type: none"> 1. IV antibiotics. 2. Tetanus prophylaxis. 3. Pain control. 4. Surgery for washout and reduction.

Anatomic Location of the Fracture

- Describe the precise anatomic location of the fracture (If it is left or right sided bone, name of bone, location: "Proximal-Mid-Distal" to aid in this, divide the bone into 1/3).
- Besides location, it's helpful to describe if the location of the fracture involves the joint space (intra-articular).



Intra-articular fracture of base 1st metacarpal.



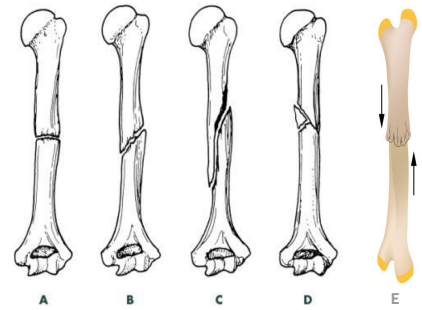
A closed left distal femur fracture with angulation Displaced laterally and posteriorly.






Fracture Line

• There are several types of fracture lines:

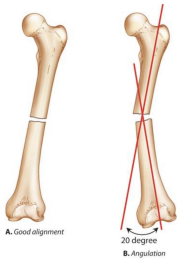
- Transverse fracture (A)
- Oblique fracture (B)
- Spiral fracture (C). *Spiral fractures heal faster due to more surface area*
- Comminuted fracture (D)
- There is also an impacted fracture (E) where fracture end are compressed together.



Transverse	Spiral	Comminuted
		
<p>Occurs perpendicular to the long axis of the bone. (This is a close mid-shaft transverse humerus fracture).</p>	<p>Occurs in a spiral fashion along the long axis of the bone. They are usually caused by a rotational force. (This is a closed distal spiral fracture of the fibula). <i>If there are two shadows, it's most likely spiral.</i></p>	<p>Are those with 2 or more bone fragments are present. Sometimes difficult to appreciate on X-ray but will clearly show on CT scan. (This is a closed right comminuted intertrochanteric fracture). <i>Pathologic fracture (Subtrochanteric right hip comminuted fracture).</i></p>

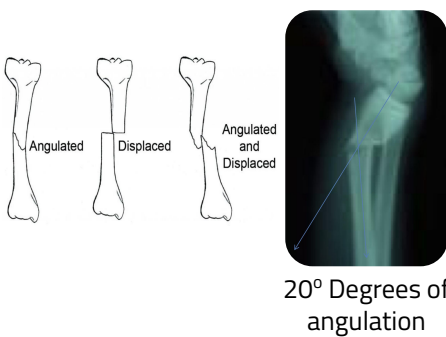
Relationship of Fracture Fragments

• Terms to be familiar with when describing the relationship of fracture fragments:



Alignment

Alignment is the relationship in the longitudinal axis of one bone to another



Angulation

Angulation is any deviation from normal alignment, it's described in degrees of angulation of the distal fragment in relation to the proximal fragment, to measure the angle draw lines through normal axis of bone and fracture fragment (*Medial angulation can be termed 'varus', and lateral angulation can be termed 'valgus'*)



0 = Complete vertical apposition

Non displaced fracture with full surface contact at the fracture plane



1 = Partial vertical apposition

Some contact between the fragments at the fracture plane is maintained

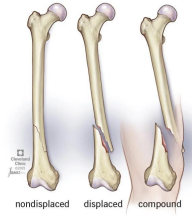


2 = Lost vertical apposition

No contact over the fracture plane remains



Oblique fracture



Apposition

Amount of end to end contact of the fracture fragments

Displacement

Use interchangeably with apposition (Translation = Displacement)
(e.g. if displacement is %40, then apposition is %60)

In AP view you comment by medial or lateral. In lateral view anterior or posterior displacement.

Bayonette apposition

Overlap of fracture fragments

Distraction

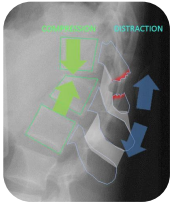
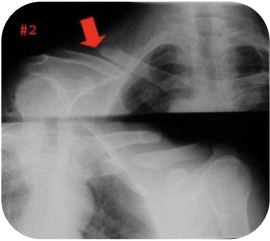
Displacement in the longitudinal axis of the bones (widening)

Dislocation

Dislocation for joints
Displacement for bones

Disruption of normal relationship of articular surfaces, named by the position of distal segment (Always describe distal relative to proximal part)

Clavicle is completely displaced with overlapping



(Anterior knee dislocation)
The articular surfaces of the knee no longer maintain their normal relationship.



Describe fracture fragments:

Answer:



This is a closed midshaft tibial fracture.

how do we describe the fragments?

- This is an example of partial apposition (note part of the fracture fragments are touching each other).
- Alternatively you can describe this as displaced $\frac{1}{3}$ the thickness of the bone. (Remember apposition and displacement are interchangeable, we tend to describe displacement)

Final answer: Closed midshaft tibial fracture with moderate (33%) displacement.

There are 2 fractures on this film: (bayonet apposition)

1. Closed distal radius fracture with complete displacement.
2. Ulnar styloid fracture which is also displaced.
 - The displacement is especially prominent on the lateral view highlighting the importance of multiple views.
 - There may be intra-articular involvement as joint space is close by.
 - Remember, remove all jewelry from extremity fractures.

Neurovascular Status

- Finally, when communicating a fracture, describe if the patient has any neurovascular deficits, and this is determined clinically (Before and after any procedure to protect yourself legally).



Review Language of Fractures

When seeing a patient with a fracture and the X-ray, describe the following:

1	Open v.s. Closed fracture
2	Anatomic location of fracture (distal, mid, proximal) and if fracture is intra-articular
3	Fracture line (transverse, oblique, spiral, comminuted)
4	Relationship of fracture fragments (angulation, displacement, dislocation, etc..)
5	Neurovascular status

Examples



- This x-ray demonstrates a lateral elbow X-ray (bone is normal).
- There is swelling anteriorly which is displaced known as a pathologic anterior fat pad sign.
- There is swelling posteriorly known as a posterior fat pad sign.
- Both of these are signs of an occult fracture although none are visualized on this X-ray.
- Remember, soft tissue swelling can be a sign of occult fracture!
- (Capsule of the joint pushes the soft tissue maybe collection of fluid?)
- The swelling may be caused by intra-articular fracture leading to hemorrhage. This will lead to fat displacement from the bone leads to fat pad sign.



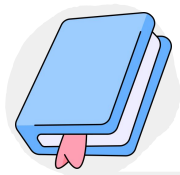
- If you follow ABCs, you will notice there are problems with alignment on this X-ray.
 - You will notice there are fracture lines through the 2nd, 3rd, and 4th metacarpals (these are 2nd, 3rd, and 4th midshaft metacarpal fractures).
 - In hand X-rays we can describe instead of medial and lateral we can say ulnar and radial (In this X-ray it's laterally "radially" displaced).
- A teaching point:** Notice the ring on this film. Always remove rings of patients with fractured extremities because swelling may preclude removal later.



- Oblique fracture of midshaft of right 4th middle phalanx with minimal displacement and no angulation.
- Remember to comment if open vs closed & neurovascular status.



- 1- Right midshaft tibia fracture displaced 1/2 the thickness of the bone without angulation, also there is bayonette appositioning of the fracture fragments.
 - 2- Right midshaft fibular fracture with complete displacement.
- Comment if the fracture is open vs closed & neurovascular status.



Fractures – General Principles

Fracture Description

1. Name of Injured Bone

2. Integrity of Skin/Soft Tissue

- closed: skin/soft tissue over and near fracture is intact
- open: skin/soft tissue over and near fracture is lacerated or abraded, such that fracture site can communicate with contaminants (i.e. outside environment or bowel)
- signs: continuous bleeding from puncture site, or fat droplets in blood are suggestive of an open fracture

3. Location

- epiphyseal: end of bone, forming part of the adjacent joint
- metaphyseal: the flared portion of the bone at the ends of the shaft
- diaphyseal: the shaft of a long bone (proximal, middle, distal)
- physis: growth plate

4. Orientation/Fracture Pattern (see Figure 4, OR6)

- transverse: fracture line perpendicular (<30° of angulation) to long axis of bone; result of direct high energy force
- oblique: angular fracture line (30°-60° of angulation); result of angulation and compressive force, high energy
- butterfly: triangular or wedge-shaped fragment resembling a butterfly; commonly between the two main fracture fragments in comminuted long bone fractures
- segmental: a separate segment of bone bordered by fracture lines; often the result of high-energy force
- spiral: complex, multi-planar fracture line; result of rotational force, low energy
- comminuted/multi-fragmentary: >2 fracture fragments
- intra-articular: fracture line crosses articular cartilage and enters joint
- compression: impaction of bone; typical sites are vertebrae or proximal tibia
- torus: compression of bony cortex on one side while the other remains intact, often seen in children (see Figure 50, OR45)
- greenstick: compression of one side with fracture of the opposite cortex, often seen in children (see Figure 50, OR45)
- pathologic: fracture through abnormal bone weakened by disease (e.g. tumour)

5. Alignment of Fracture Fragments (see Figure 5)

- non-displaced: fracture fragments are in anatomic alignment
- displaced: fracture fragments are not in anatomic alignment
- distracted: fracture fragments are separated by a gap (opposite of compression)
- translated: percentage of overlapping bone at fracture site
- angulated: direction of fracture apex (e.g. varus/valgus)
- rotated: fracture fragment rotated about long axis of bone
- shortened: fracture fragments are compressed, resulting in shortened bone
- avulsion: tendon or ligament tears/pulls off bone fragment

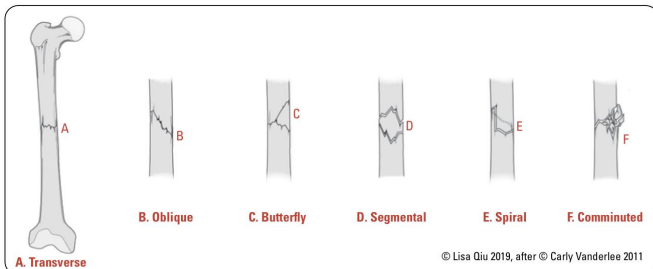


Figure 4. Orientation/fracture pattern

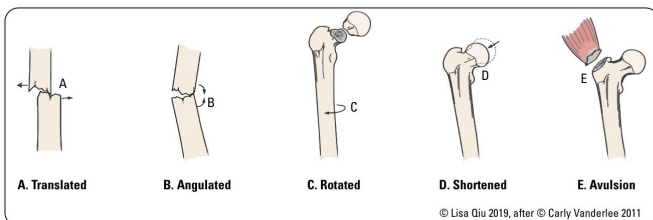


Figure 5. Alignment of fracture fragments

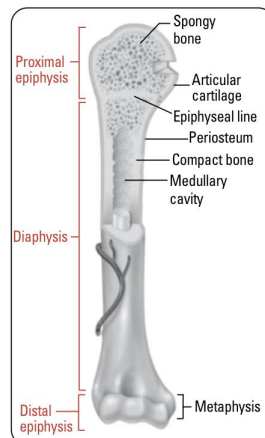


Figure 6. Schematic diagram of the long bone



Displacement

Refers to position of the distal fragment relative to the proximal fragment



Varus/Valgus Angulation

Refers to the distal segment of the bone compared to the proximal segment
Varus = Apex away from midline
Valgus = Apex toward midline



Quick Upper Extremity Motor Nerve Exam

“Thumbs Up”: PIN (Radial Nerve)
“OK Sign”: AIN (Median Nerve)
“Spread Fingers”: Ulnar Nerve



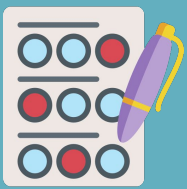
X-Ray Rule of 2s

2 sides = bilateral
2 views = AP + lateral
2 joints = joint above + below
2 times = before + after reduction



Sample Fracture Description

Closed (overlying skin integrity) spiral fracture (fracture pattern) of the distal third (location) of the left tibia (injured bone), with mild varus angulation, lateral translation and angulation (alignment of fracture fragments). The fracture does not extend to the joint surface



Quiz

Q1: What does this sign indicate?

A Occult fracture

B Inadequate X-ray

C Tumor

D Greenstick fracture



Q2: Describe the fracture line?

A Transverse

B Spiral

C Comminuted

D Oblique



Q3: Which of the following is a sign of osteoarthritis?

A Osteophytes

B Subchondral sclerosis

C Subchondral cyst

D All of them

Q4: Which fracture is most likely to occur when you apply a twisting force on the bone?

A Oblique

B Comminuted

C Transverse

D Spiral

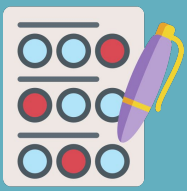
Q5: Overlap of fracture fragments is called?

A Bayonet apposition

B Dislocation

C Displacement

D Angulation



Quiz

SAQs

441:

No SAQs

439:

1. How to manage this type of fractures?

- 1- IV antibiotics.
- 2- Tetanus prophylaxis.
- 3- Pain control.
- 4- Surgery.



2. Describe the fracture.

Adequate AP X-ray showing a closed minimally displaced transverse fracture in the midshaft of the right tibia.



A 28 -years- old healthy individual fall from a house 2 hours ago. He landed on the right upper limb and presented with painful deformed arm and inability to move.

1. What is the abnormality shown?

- Right midshaft humerus transverse fracture.

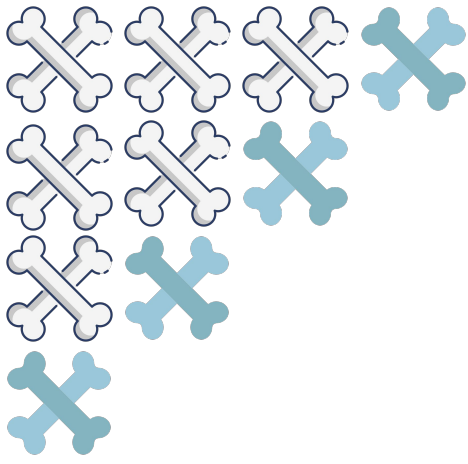
2. Is the radiograph shown adequate? If not, mention one reason?

- Not adequate, there is no lateral view.

3. Mention 2 fractures of the abnormality shown?

- 1- 50% displacement.
- 2- 30 degree angulation.





Team Leader

Abdulrahman Alroqi

Done by

Abdulrahman Alroqi
Fahad Alkhattabi

Organized by

Abdullah Alomran

وَفَقَّكُمْ اللَّهُ

