



Diagnostic Imaging & Investigations

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Objectives:

- Review a systematic approach to interpreting orthopedic x-rays
- Review the language of fracture description

Color Index:

Original text | **Doctor's notes** | Text book
Important | **Golden notes** | Extra

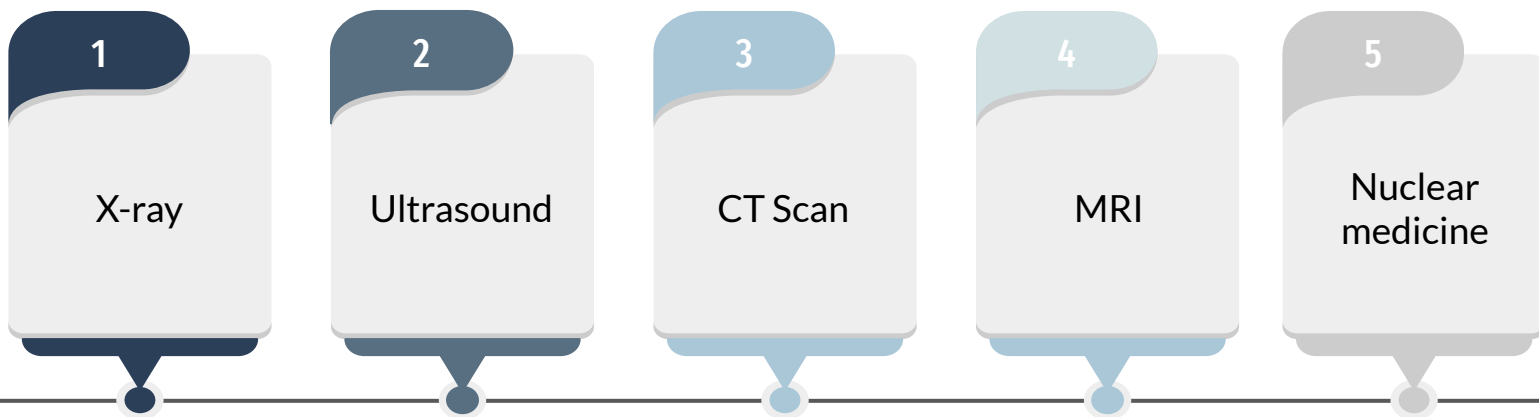
Introduction:

Medical decision making is a triad of:

- History
- Physical examination
- Confirming studies (Imaging, Labs, etc.).



❖ Imaging:



X-ray:

- Ionizing radiation source ➡ Radiation damages cells¹.
- Capture image: (films or digital).
- Patient blocks transmission of radiation:
 - ➔ Soft tissue (blocks/absorbs LESS) ➡ Black.
 - ➔ Bones (blocks/absorbs MORE) ➡ White.
- **Who interprets the images?** Radiologist or orthopedics.²
- Best for Hard tissue (bones).
- It's often combined with other imaging modality.
- 3 Views are preferred = AP, Lateral and Oblique³.



1- Carcinogenic only with high doses.

2- Even other specialties (family medicine...etc.) must have the basic skills to read Xrays

3- Should be perpendicular to each other.

ABCS Approach to an x-ray:

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



❖ Adequacy:

Never accept an inadequate X Ray

Two things to make sure we have in the film:

- 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)
- All x-rays should have adequate penetration.

Picture



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 is like spherical shape and borders are ill defined

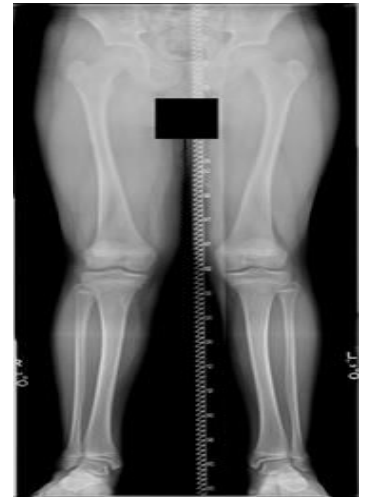
C: **knee joint**, symmetrical joint space, no abnormality, and the articulation between tibia, femur and patella is good.

S: **there is swelling.**

- 1- Joints.
- 2- for example swellings and calcifications. In abscess > Air-fluid level.
- 3- 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.

Alignment

- It's the anatomic relationship between two bones on x-ray.
- Bone alignment vs other side
- Bone alignment relative to proximal and distal bones ¹.
- Normal x-rays should have normal alignment
- Fractures and dislocations may affect the alignment on the x-ray ².



Bones

1. Identify Bone (Which limb?, which bone?, which part?)
2. Examine the whole bone for:
 - Discontinuity (Fracture).
 - Change in the bone shadow consistency > Change in the density.
3. Describe the bone abnormality:
 - Location ³
 - Shape

Types of Bone Fractures



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



Dark bone mass -> osteolytic
Bright bone mass -> osteosclerotic

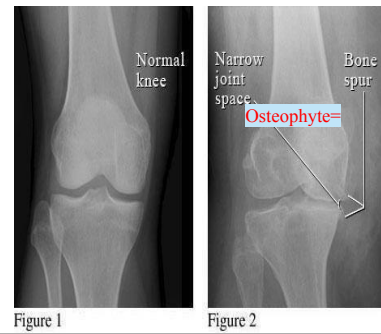
1- (How do we comment on this in bone fractures? By looking for Displacement and angulation. When we have a displacement or Angulation we comment on the DISTAL part in relation to the proximal part, to know if they are lateral or medial. (Dr said that commenting on the angulation location is a bit advanced for us but we'll see some examples in the next slide that will make them easier).

2- You can draw a line from the hip joint to the ankle to assess alignment. If the line crosses the knee from the middle it's good alignment.

3- for long bones you can describe the segment whether it's (upper or middle or lower), (proximal, middle, distal), (epiphysis, diaphysis, metaphysis)

Cartilage

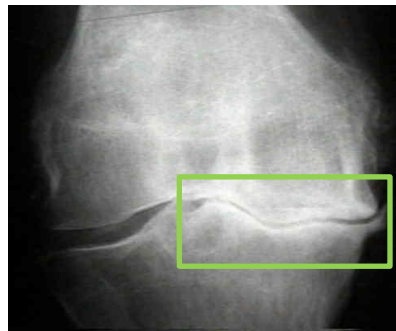
- Widening of joint spaces
↳ Signifies ligamentous injury and/or fractures¹.
- Narrowing of joint spaces
↳ **Arthritis**².



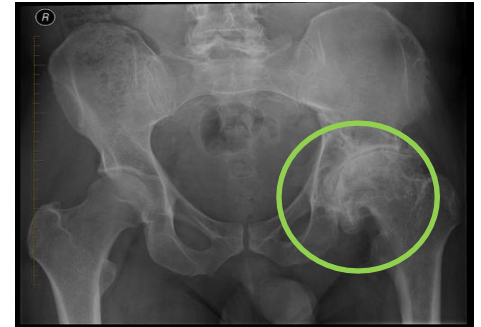
ABCS of the picture



osteophyte



Sclerosis and osteophyte
(In Rheumatoid arthritis we see juxta articular osteolysis compared to the sclerosis seen here)



- 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

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

1

Trauma

3

Infection

2

Occult fracture

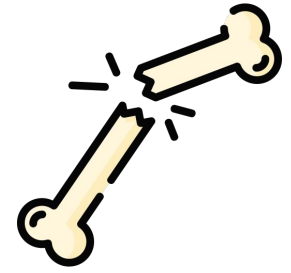
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Tumors

1- Effusion or bleeding.

2- More pressure = ↑surface area (osteophyte)

Language of fracture:



- 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
No open wound of skin near fracture	Open fractures are open complete displaced and/or comminuted
	An orthopedic emergency. Bleeding must be controlled
	Management: IV antibiotics , Tetanus prophylaxis , pain control, Surgery for wash out and reduction

❖ Anatomic location of the fracture

- Describe the precise anatomic location of the fracture.
- Include if it is left or right sided bone.
- Include name of bone
- Include location: (Proximal-Mid-Distal) To aid in this, divide the bone into 1/3rds.
- 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.

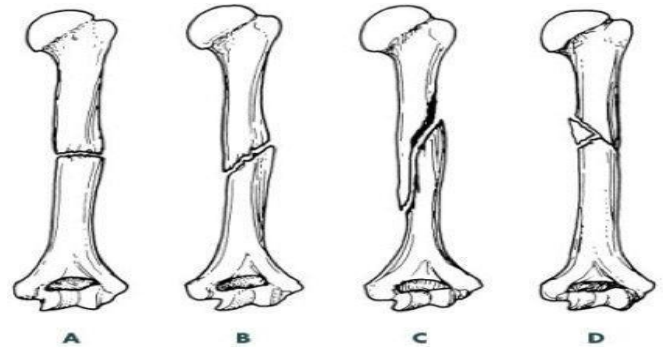


A closed left distal femur fracture with angulation
Displaced laterally and posteriorly




Fracture line

There are several types of fracture lines:

- Transverse Fracture (A)
- Oblique Fracture (B)
- Spiral Fracture (C)
- Comminuted Fracture (D)
- There is also an impacted fracture where fracture end are compressed Together.



Fracture line

Spiral	Transverse	Comminuted
		
<p>Occurs in a spiral fashion along the long axis of the bone. There are usually caused by a rotational force. (This is a closed distal spiral fracture of the fibula)¹.</p>	<p>Occurs perpendicular to the long axis of the bone. (There is a close mid-shaft transverse humerus Fracture)</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 R comminuted intertrochanteric fracture.¹)</p>

Relationship of fracture fragments

- Terms to be familiar with when **describing the relationship of fracture fragments**:
 - Alignment is the relationship in the longitudinal axis of one bone to another.
 - **Angulation** is any deviation from the normal alignment.
 - Angulation is described in degrees of angulation of the distal fragment in relation to the proximal fragment --- to measure angle draw lines through normal axis of bone and fracture fragment.³

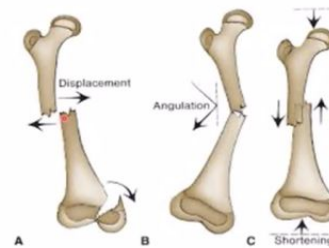
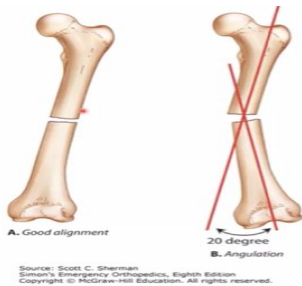
1- Pathologic Fracture (Subtrochanteric right hip comminuted fracture)

2-If there are two shadows, it's most likely spiral

3- Medial angulation can be termed 'varus', and lateral angulation can be termed 'valgus'.

Relationship of fracture fragments

- Apposition is the amount of end to end contact of the fracture fragments.
- **Displacement** is used interchangeably with apposition.
 - In AP view you comment by medial or lateral. In lateral view anterior or posterior displacement.
- Bayonet apposition: overlap of fracture fragments.
- Distraction: Displacement in the longitudinal axis of the bones. (widening)
- **Dislocation**: disruption of normal relationship of articular surfaces ¹.



Bayonet apposition

Clavicle is completely displaced with overlapping.



Dislocation

The articular surfaces of the knee no longer maintain their normal relationship.

✓ Dislocations are named by the position of the distal segment.

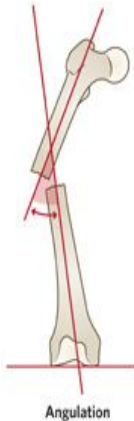


This is an Anterior knee dislocation.

¹- (Displacement and apposition are the opposite to each other, when we are commenting on displacement we're talking about the bones that are not touching each other, while in apposition we're commenting on the bones that are in contact with each other, for example 75% displacement means 25% apposition, 90% Displacement means 10% apposition and so on.)

Relationship of fracture fragments

Relationship of fracture fragment



20 Degrees of
angulation

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. (before and after any procedure to protect yourself legally)
 - This is determined clinically.

Bone



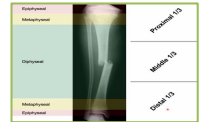
Growth plate which is normal phenomenon in children, not a fracture (Tibia).

ABCS of the picture

A: Inadequate (only one view) not aligned (fracture).

B: Tibia bone fracture in the mid shaft (Diaphysis). We can't tell is it right or left because it is not label.

- It is complete fracture.
- There is medial displacement and angulation.



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.

Medial



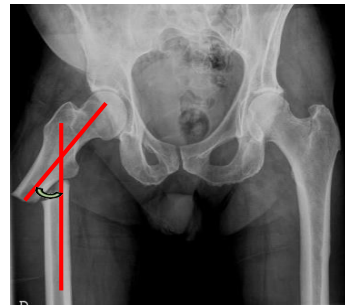
Lateral

(Femur)

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 is it right or left. 80% displacement medially.

Apex: Angle tip = رأس العظم



(Femur)

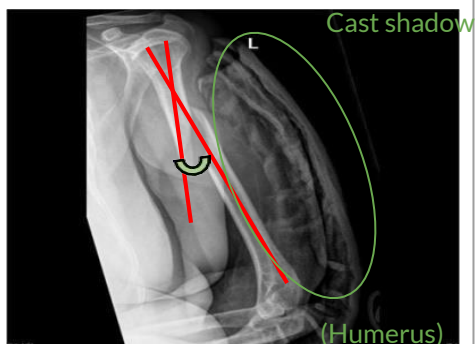
A: Inadequate (only one view and it's not showing one joint above and one joint below), not aligned.

B: Right femur bone fracture in the upper segment.

- Medially displaced. (100%)
- Angulated about 30 degrees.
- Distal part is tilted medially.

C: Cannot comment on cartilage.

S: No swelling or soft tissue changes.



(Humerus)

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: Cannot comment on cartilage.

S: No swelling, there is a cast shadow.

There is a splint in the posterior aspect of the bone.



(Humerus)

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.

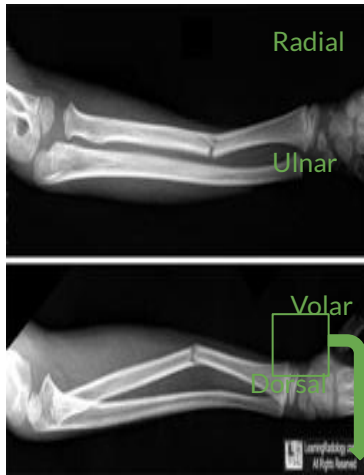
-No fracture.

C: Joints are good.

S: No swelling.

Neurovascular status

Bone



growth plate which is normal phenomenon in children, not a fracture.

ABCS of the picture

A: Adequate: 2 views, joint above & below, exposure is adequate.

Alignment: valgus (lateral).

B: Incomplete mid shaft fracture. (Green-stick fracture) because:

- o Lateral line is intact.
- o Bones are soft.

In the forearm say ulnar or radial angulated.

- o Displacement of fracture: nothing.
- o Angulation: volar angulation

C: Can't comment on the cartilage.

- o This is child that's why I can see growth plate

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.

- o The black circle is the Patella overlapping over medial condyle shadow. Not lesion.

Pre ABC, identify patient, read provided info .

A	1- Adequacy: Proper number of <u>views</u> & <u>penetration</u> .
	2- Alignment
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.

Exercise

- 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.

- o Remember, soft tissue swelling can be a sign of occult fracture!
- o (Capsule of the joint pushes the soft tissue maybe collection of fluid?)
- o The swelling maybe caused by intra-articular fracture leading to hemorrhage. This will lead to fat displacement from the bone lead to fat bad sign.



If you follow ABCs, you will notice there are problems with alignment on this x-ray (A).

B: You will notice there are fracture lines through the 2nd, 3rd, and 4th metacarpals.

- o These are 2nd, 3rd, and 4th, mid-shaft metacarpal fractures.

In hand x-rays we can describe instead of medial and lateral we can say ulnar and radial.

- o 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.



ANSWER:

Oblique fracture of mid-shaft of R 4th middle phalanx with minimal displacement and no angulation.

- o Remember to comment if open vs closed & neurovascular status



ANSWER:

R midshaft tibia fracture displaced 1/2 the thickness of the bone without angulation; also, there is bayonette appositioning of the fracture fragments.

R midshaft fibular fracture with complete displacement.

- Comment if the fracture is open vs closed & neurovascular status.



TORONTO NOTES

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 communicates with outside environment, or contaminated (i.e. 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 (Figure 4)

- 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 (Figure 50)
- greenstick: compression of one side with fracture of the opposite cortex, often seen in children (Figure 50)
- pathologic: fracture through abnormal bone weakened by disease (e.g. tumour)



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



Varus/Valgus Angulation
Varus = Apex toward midline
Valgus = Apex away from midline



Quick Motor Nerve Exam
"Thumbs Up": PIN (Radial Nerve)
"OK Sign": AIN (Median Nerve)
"Spread Fingers": Ulnar Nerve



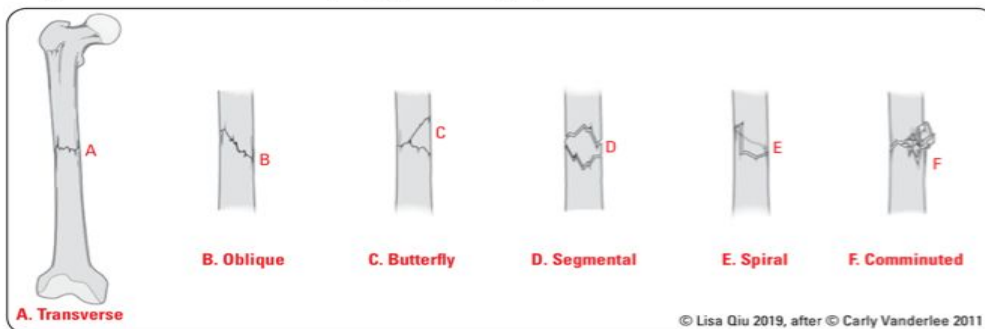
X-Ray Rule of 2s
2 sides = bilateral
2 views = AP + lateral
2 joints = joint above + below
2 times = before + after reduction



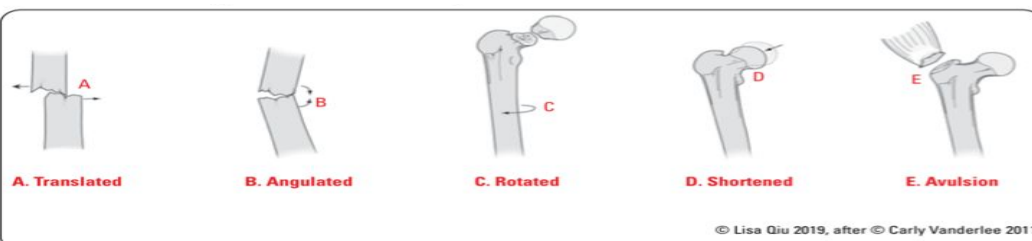
Sample Fracture Description
Closed (overlying skin integrity) spiral fracture (fracture pattern) of the distal third (location) of the left tibia (injured bone), with mild varus angulation, lateral translation and angulation (alignment of fracture fragments). The fracture does not extend to the joint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

5. Alignment of Fracture Fragments (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 impacted)
- translated: percentage of overlapping bone at fracture site
- angulated: direction of fracture apex (e.g. varus/valgus)



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- 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

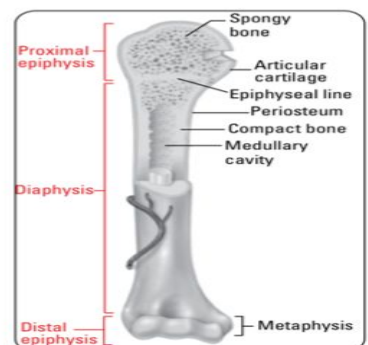


Figure 6. Schematic diagram of the long bone



Quiz

MCQ

Q1: What does this sign indicate?

- A. Occult fracture
- B. Inadequate x-ray
- C. Tumor
- D. Green-stick 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. Sub-chondral sclerosis
- C. Sub-chondral 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

SAQs

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 mid shaft of the right tibia.



Answers

Q1	Q2	Q3	Q4	Q5
A	B	D	D	A

THANK YOU

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