

X-RAY INTERPRETATION SKILLS

DIAGNOSTIC IMAGING AND INVESTIGATIONS



Lecture objectives

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

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References: Dr's slides & 436 team, Toronto Notes'2020'

INTRODUCTION

★ Medical Decision Making is a Triad of:

- History – from patients/records.
- Physical Examination.
- Confirming Studies (Imaging, Labs, etc.)

★ Imaging:

- X-ray.
- Ultrasound.
- CT Scan.
- MRI.
- Nuclear Medicine.

X-RAY

- Ionizing Radiation Source → (radiation damages cells). = carcinogenic (only with high doses)
- Capture Image: (films=old-fashioned or digital).
- Patient Blocks Transmission of Radiation:
 - Soft tissues (absorbs/blocks Less) → Black
 - Bones (absorbs/blocks More) → White
- Who interprets the images? Radiologist or Orthopedics.
- Best for:
 - hard tissue like (bones).
 - It is often combined with other imaging modality.

ABCS APPROACH TO AN X-RAY

- Apply ABCs approach to every orthopedic film you evaluate.

Pre ABC: start with identifying the patient, Read Provided info (Patient's name & ID, Date of the X-ray)

- A: Adequacy, Alignment
- B: Bones
- C: Cartilage = joints
- S: Soft tissue for example swellings and calcification. In abscess-> air-fluid level.

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.


★ **Adequacy:**

Two things to make sure that we have in the film:

All x-rays should have an adequate number of views:.


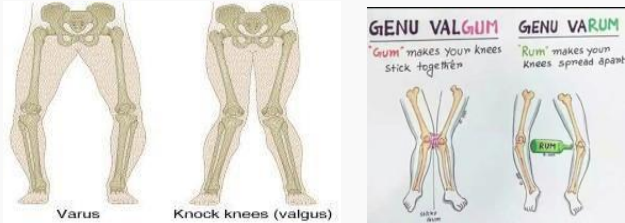
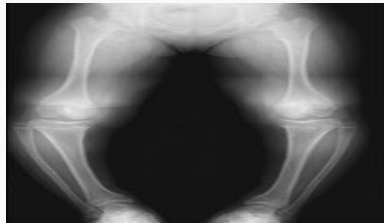
- 2 views "minimum": AP = Anterior-Posterior and lateral. (3 views preferred = 3rd view is oblique). The more the better. Should be perpendicular to each other.
- 2 Joints: Joint above and joint below. To detect any pathology. If we are targeting a Shaft ex: "tibia" we need to have both the knee and the ankle joints visible. If we are targeting a Joint (mid-shaft above and mid-shaft below), ex: "knee joint" we need to have mid-shaft of femur and mid-shaft of tibia/fibula visible.

All x-rays should have adequate penetration. Depends on the quality of x-ray. You've to see the cortical margin.

★ADEQUACY	ABCs of the picture
 <p>Inadequate although there is two views. Why? Here there's Only one joint ×</p> <p>I need to see the ankle.</p>	<p>A: <u>inadequate</u> and normal alignment (knee and leg are in good alignment).</p> <p>B: abnormal "proximal" 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</p> <p>C: knee joint, symmetrical joint space, no abnormality, and even the articulation between tibia, femur and patella is good.</p> <p>S: there is swelling.</p>

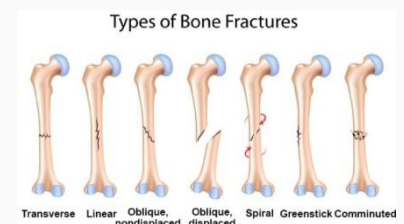
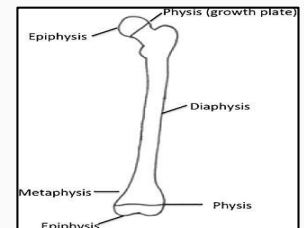
★ **Alignment:** Anatomic relationship between bones on x-ray.

- Bone alignment vs other side
- Bone alignment relative to proximal and distal bones (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).
- Normal x-rays should have normal alignment.
- Fractures and dislocations may affect the alignment on the x-ray.

★ ALIGNMENT	Extra
 <p>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.</p>	 <p>GENU VALGUM "GUM" makes your knees stick together GENU VARUM "RUM" makes your knees spread apart</p> 

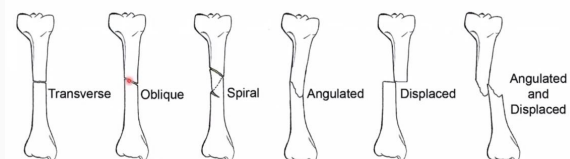
★ **Bones:**

1. Identify bone (Which limb, which bone, what part? Proximal middle or distal)
2. Examine the whole bone for
 - A. Discontinuity → fractures
 - B. Change in bone shadow consistency → change in density like bone mass
3. Describe bone abnormality
 - Location. for long bones you can describe the segment whether it's (upper or middle or lower), (proximal, middle, distal), (epiphysis, diaphysis, metaphysis)
 - Shape



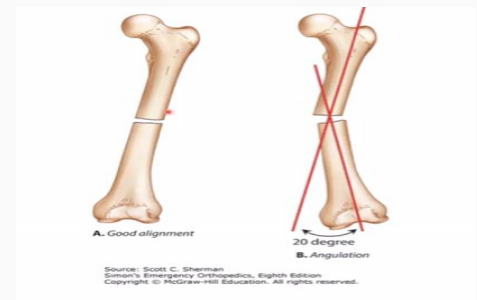
Each type of fracture indicates a certain cause of injury, for example Torsion = Direct force, Oblique = bending force, Spiral = Twisting.

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

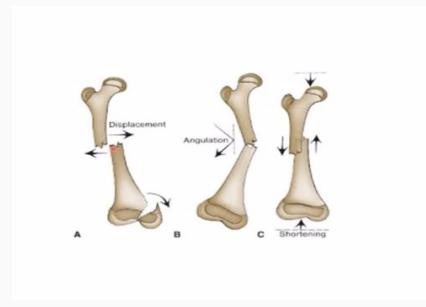


#Terms to be familiar with when **describing the relationship of fracture fragments**:

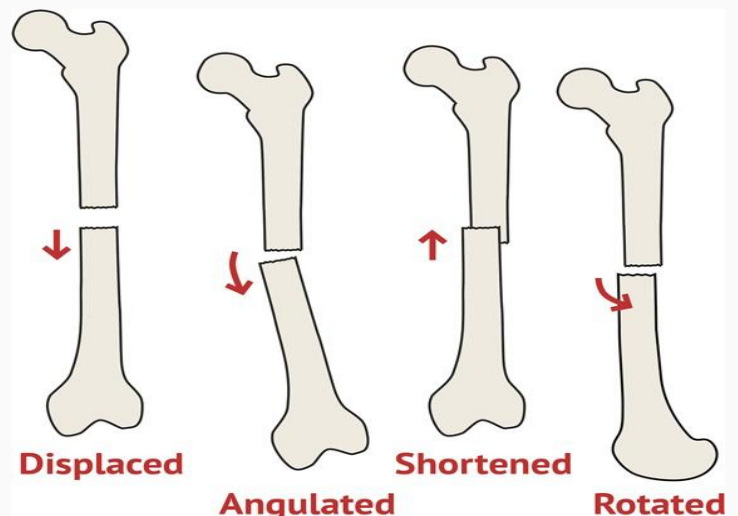
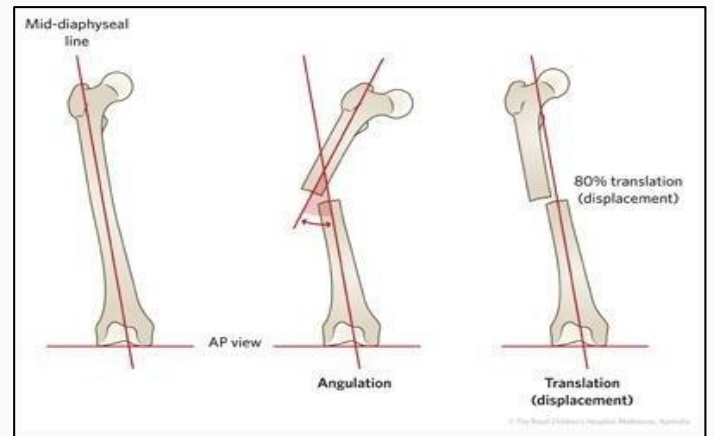
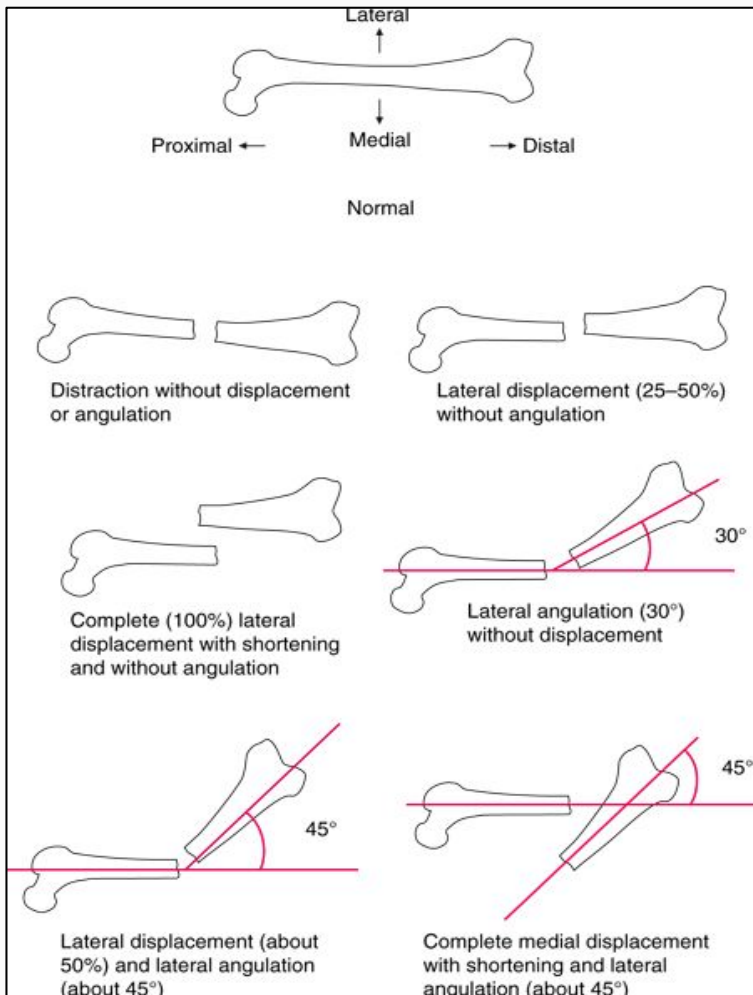
- Alignment is the relationship in the longitudinal axis of one bone to another.
- **Angulation** is any deviation from normal alignment:
 - Angulation is described in degrees of angulation of the distal fragment in relation to the proximal fragment --- to measure angle draw lines through normal axis of bone and fracture fragment.
 - Medial angulation can be termed 'varus', and lateral angulation can be termed 'valgus'.
- Apposition: amount of end to end contact of the fracture fragments.
- **Displacement**: use 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.
- Dislocation: disruption of normal relationship of articular surfaces.



(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.)



*Extra for better understanding:



★ C: **Cartilage:**

Joint spaces on x-rays, you cannot actually see cartilage on x-rays.

- Widening of joint spaces → Signifies ligamentous injury and/or fractures. (Effusion or bleeding)
- Narrowing of joint spaces → Arthritis. More pressure = ↑ surface area (osteophyte).

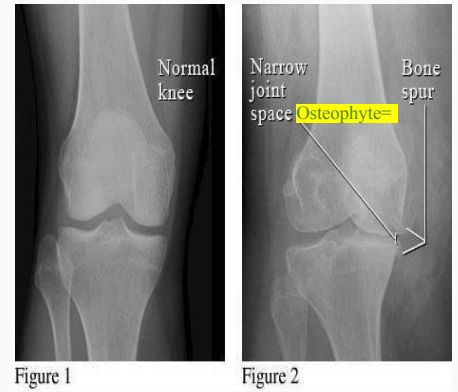


Figure 1

Figure 2

<p>osteophyte</p>	<p>Sclerosis and osteophyte (In Rheumatoid arthritis we see juxtaarticular osteolysis compared to the sclerosis seen here)</p>	<ul style="list-style-type: none"> - Decrease joint space - Osteophyte - Subchondral cyst.
<p style="text-align: center;">Arthritis in the knee & hip joint Signs of osteoarthritis: <u>Must know these 4</u> <u>Asymmetric</u> narrow joint space, osteophyte, sub-chondral sclerosis and subchondral cyst.</p>		

★ S: Soft Tissue:

Soft tissues implied to look for soft tissue swelling and joint effusions.

- There can be signs of:
 - Trauma.
 - Occult = hidden fracture.
 - Infections.
 - Tumors.

★ Bone (Tibia)

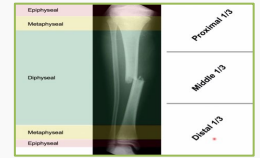
ABCs of the picture



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

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 lateral angulation.



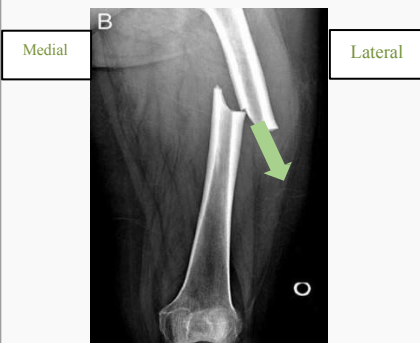
75% displaced (75% of 2 ends not attached to each other) or 25% apposition.

C: Joints are good.

S: No swelling or soft tissue changes.

★ Bone (Femur)

ABCs of the picture



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.

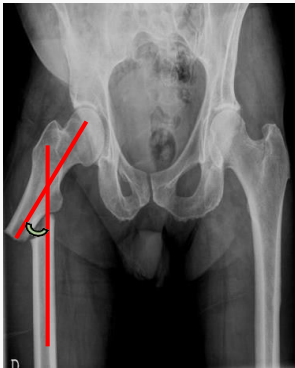
Apex facing laterally → laterally angulated.

Apex: Angle tip = رأس العظم البروكسيمال



★ Bone (Femur)

ABCs of the picture



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.

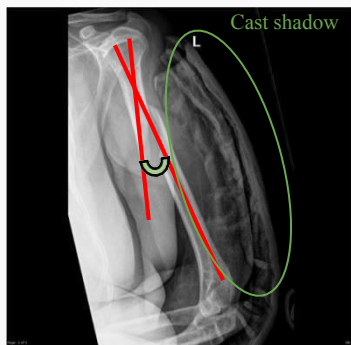
- Medially displaced. (100%)
- Laterally angulated about 30 degrees. "Apex facing laterally"
- Distal part is tilted medially.

C: Cannot comment on cartilage.

S: No swelling or soft tissue changes.

★ Bone

ABCs of the picture



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%.
- Medially angulated → Apex facing medially.

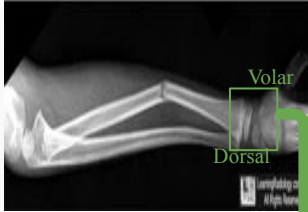
C: Cannot comment on cartilage.

S: No swelling, there is a cast shadow.

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

★ Bone (Radius)

ABCs of the picture



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

A: Adequate: 2 views, joint above & below, exposure is adequate.
 Alignment: valgus (lateral).
B: Incomplete mid shaft fracture. (Green-stick fracture) because:

- Lateral line is intact.
- Bones are soft.

In the forearm say ulnar or radial angulated.

- Displacement of fracture: nothing.
- Angulation: AP → medially angulated. L → posterior (dorsal) (apex is going anterior (volar), fracture fragment is going posteriorly to the ulna or olecranon)

C: Can't comment on the cartilage.

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

S: NO swelling.

“Volar and dorsal” instead of “anterior and posterior”

“Ulnar and radial” instead of “medial and lateral”

★ Bone (Femur)

ABCs of the picture



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.
C: Can't comment on the cartilage.

S: No swelling.

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

★ Bone (Humerus)

ABCs of the picture



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.

★ Review ABCs ★

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 #1

- 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.



Exercise #2

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.



LANGUAGE OF FRACTURE

- Important for use to describe x-rays in medical terminology.
- Improves communication with orthopedic consultants

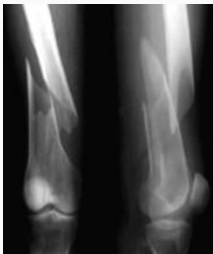
#Things you must describe (clinical and x-ray):

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

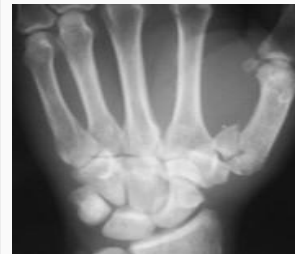
2– Anatomic Location of fracture

- 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 bone into 1/3rds

✓ Besides location, it is helpful to describe if the location of the fracture involves the joint space—intra- articular.



A closed left distal femur fracture with **angulation.**



Intra-articular fracture of base 1st metacarpal

3– Fracture line

Describe the type of fracture line.

○ There are several types of fracture lines:

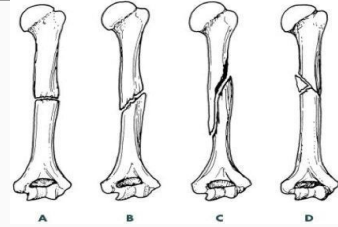
- A: is a transverse fracture.

- B: is an oblique fracture.

- C: is a spiral fracture.

- D: is a comminuted fracture. في جزء من العظم منفصل عن العظم الأساسي , more than one fracture

○ There is also an impacted fracture where fracture ends are compressed together.



Transverse fracture

Occur perpendicular to the long axis of the bone.

This is a closed mid- shaft transverse humerus fracture.



Spiral fracture

Occur 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.

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



Comminuted fracture


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.

Pathological fracture.

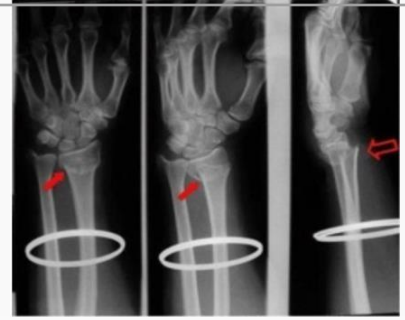
4– Relationship of fracture fragments

Terms to be familiar with – mentioned at the beginning of the lecture in [SLIDE 5](#) 

20 degree 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:

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.

- o Remember, remove all jewelry from extremity fractures.

Bayonette 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.

5– Neurovascular status

- 1- Finally, when communicating a fracture, **Describe** if the patient has any neurovascular deficits.
- 2- This is determined **clinically**

To review, when seeing a patient with a fracture and the x-ray, describe the following:

(TORONTO NOTES)

1. Open vs 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.

1- DESCRIBE THIS R MIDDLE PHALANX FRACTURE:

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



2- DESCRIBE THE FRACTURE:

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. o

- 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 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)
- pathological: 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



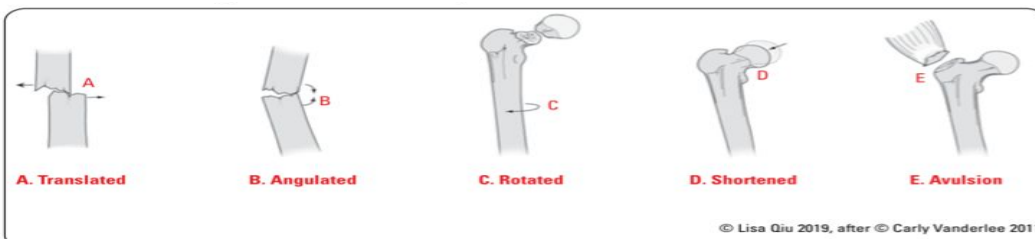
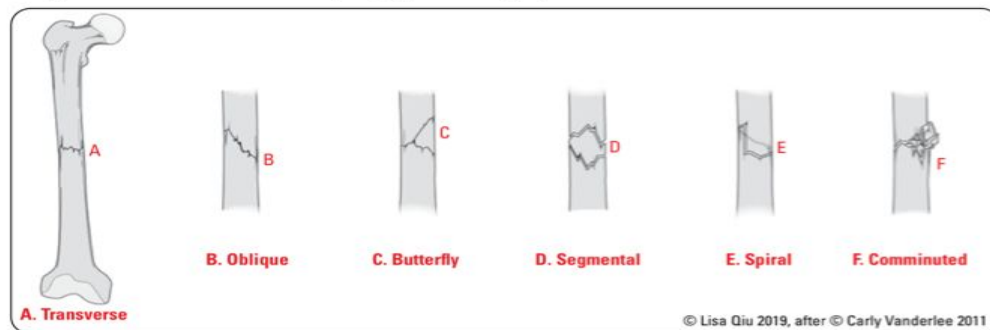
X-Ray Rule of 2s
2 sides = bilateral
2 views = AP + lateral
2 joints = joint above + below
2 times = before + after reduction



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)



- 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

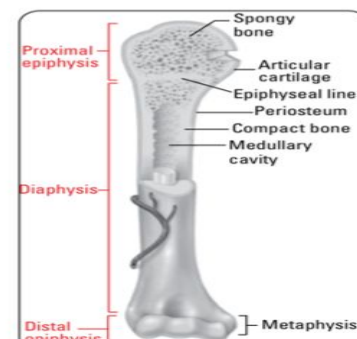


Figure 6. Schematic diagram of the long bone

