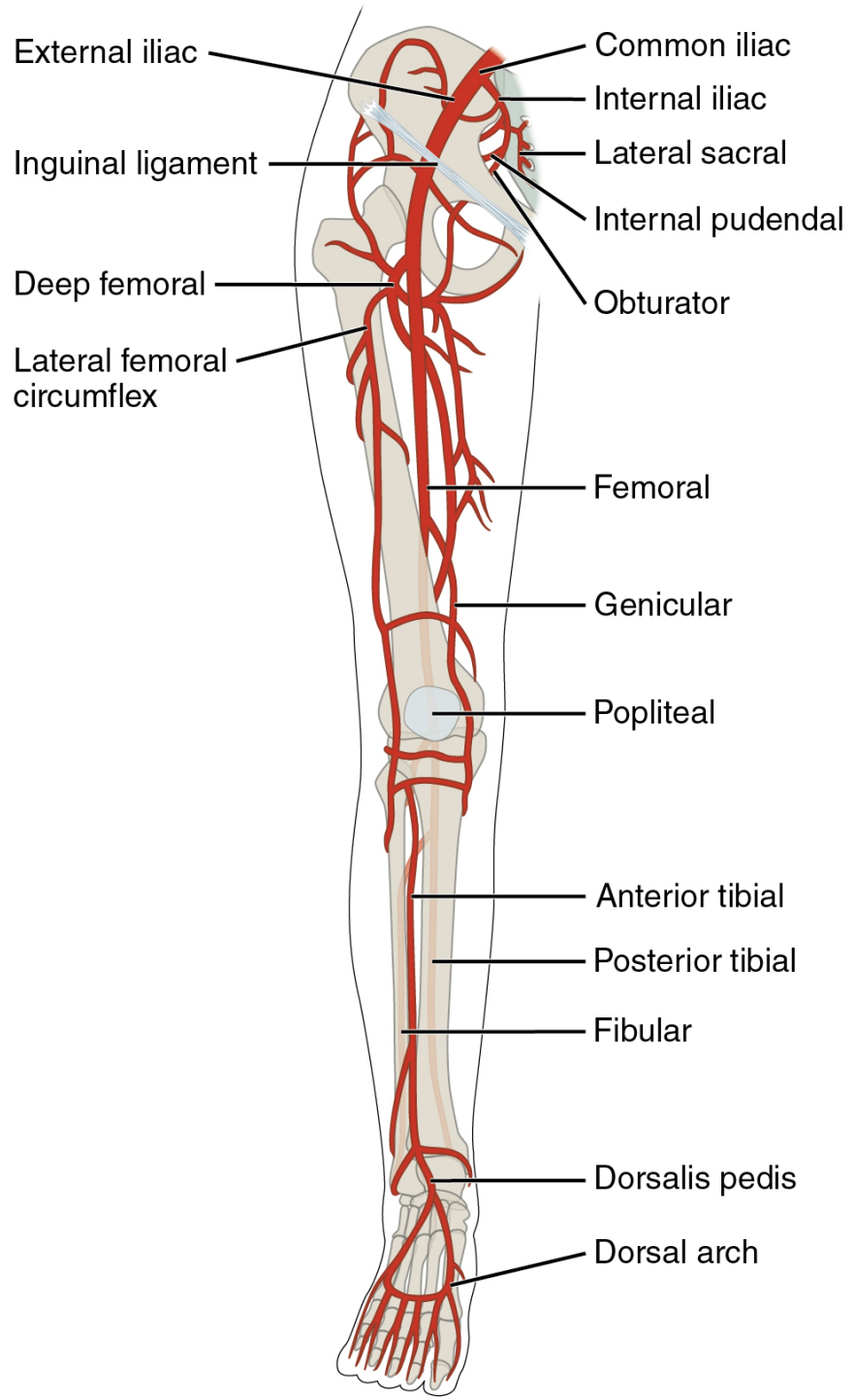


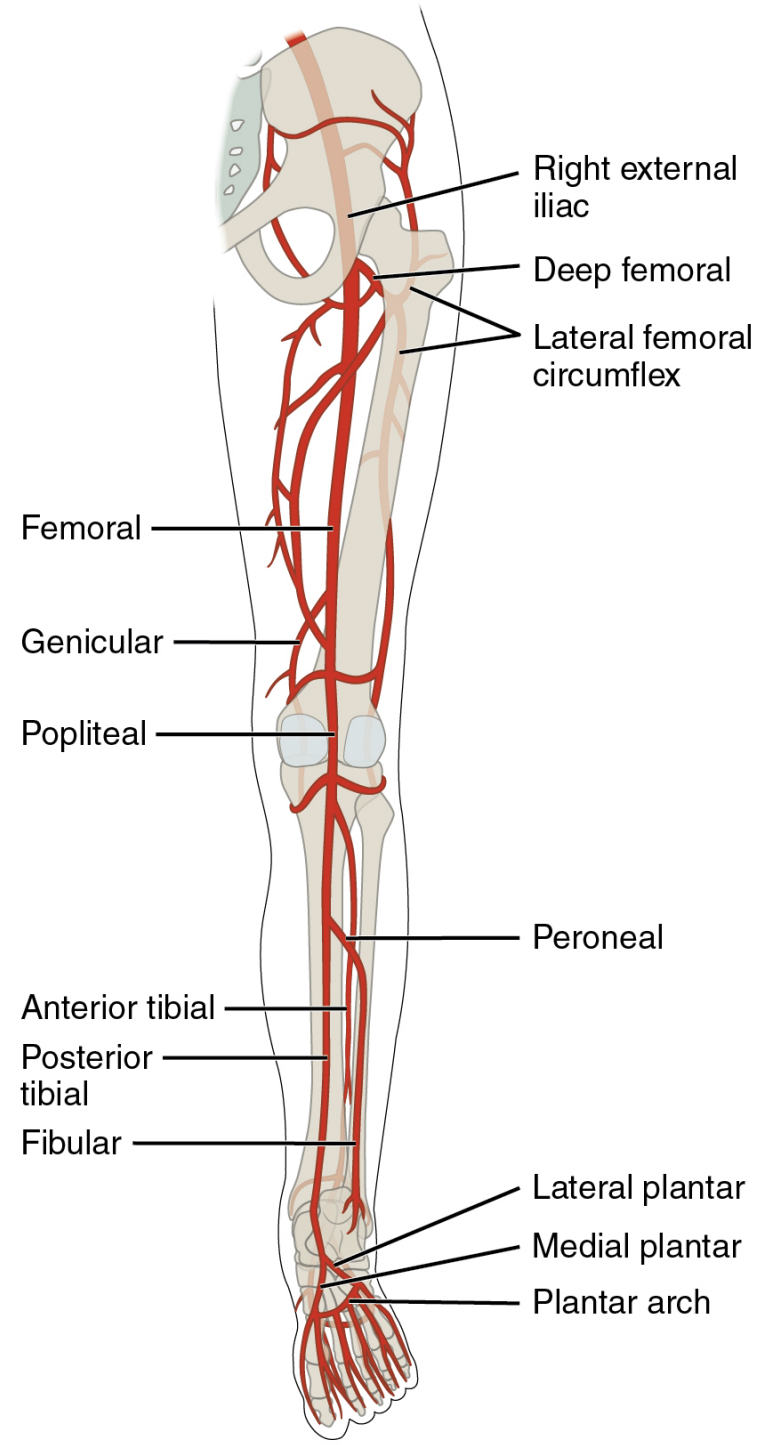
# Lower Limb Fractures 2

Abdallah Mufarrij

Siba Ryalat

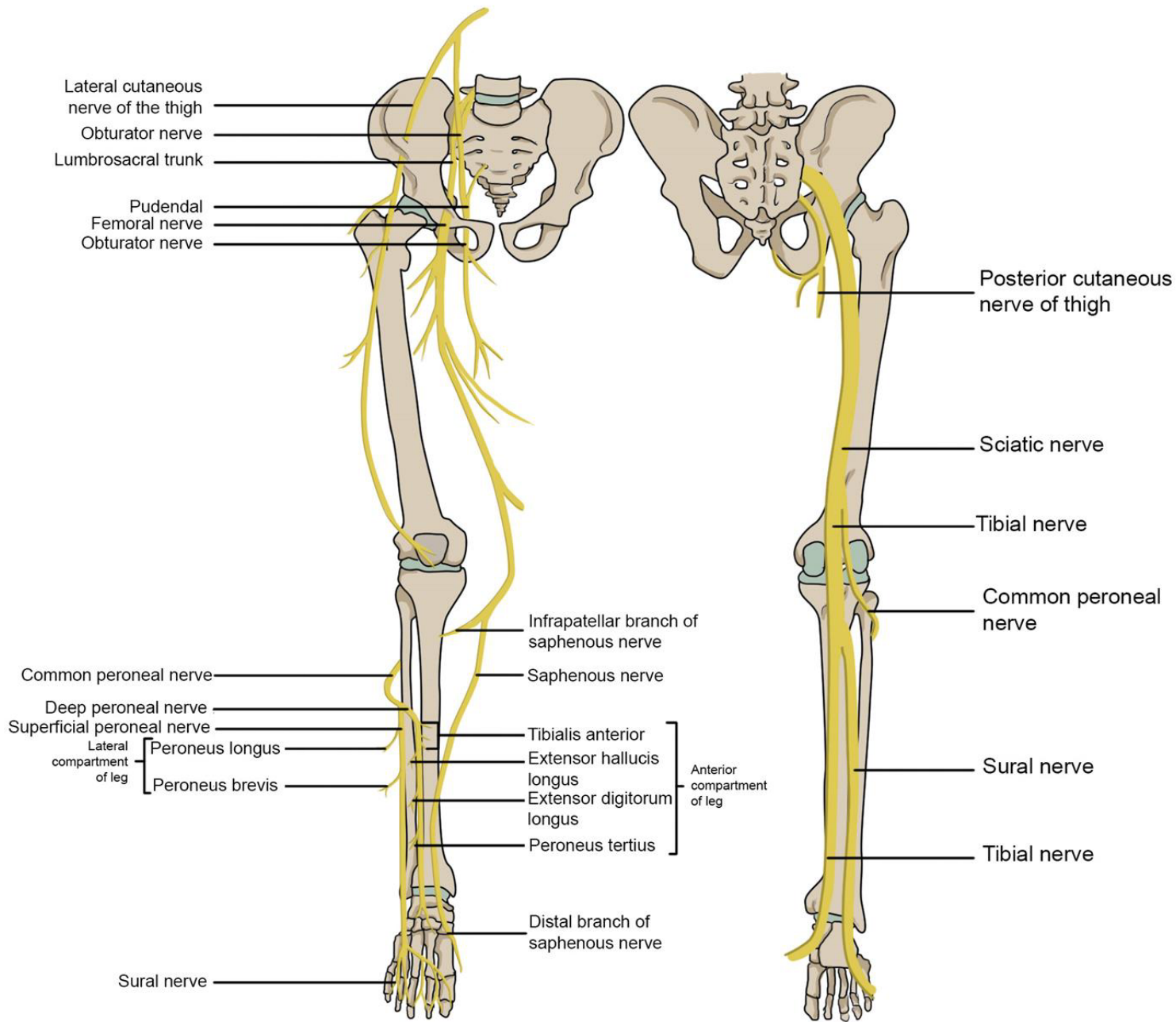


Anterior view



Posterior view

# Nerves of the Lower Extremities



Anterior view

Posterior view

# Femoral Shaft Fractures

The femoral shaft is well padded with muscles and this has

**Advantage:** protecting the bone from all but the most powerful forces, good healing

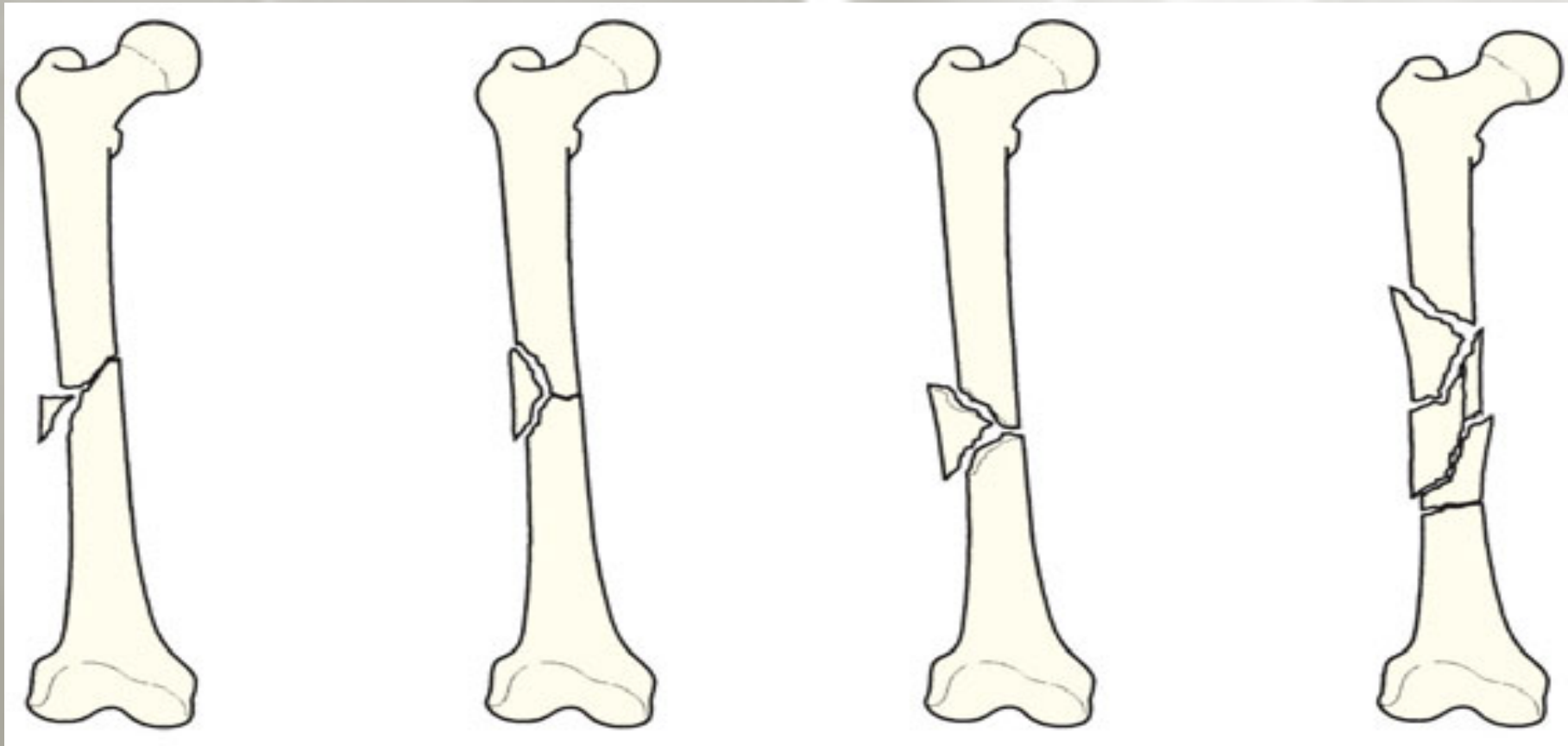
And a **disadvantage:** fractures are often severely displaced by muscle pull, making reduction difficult.

# Femoral Shaft Fractures

## \*Special features

- fracture of young adults and usually result from a high energy injury.
- Diaphyseal fractures in elderly patients should be considered pathological until proved otherwise.
- In children below 4 yrs of age **physical abuse** must be kept in mind.

# Winquist's Classification



1 - there is only a **tiny** cortical fragment

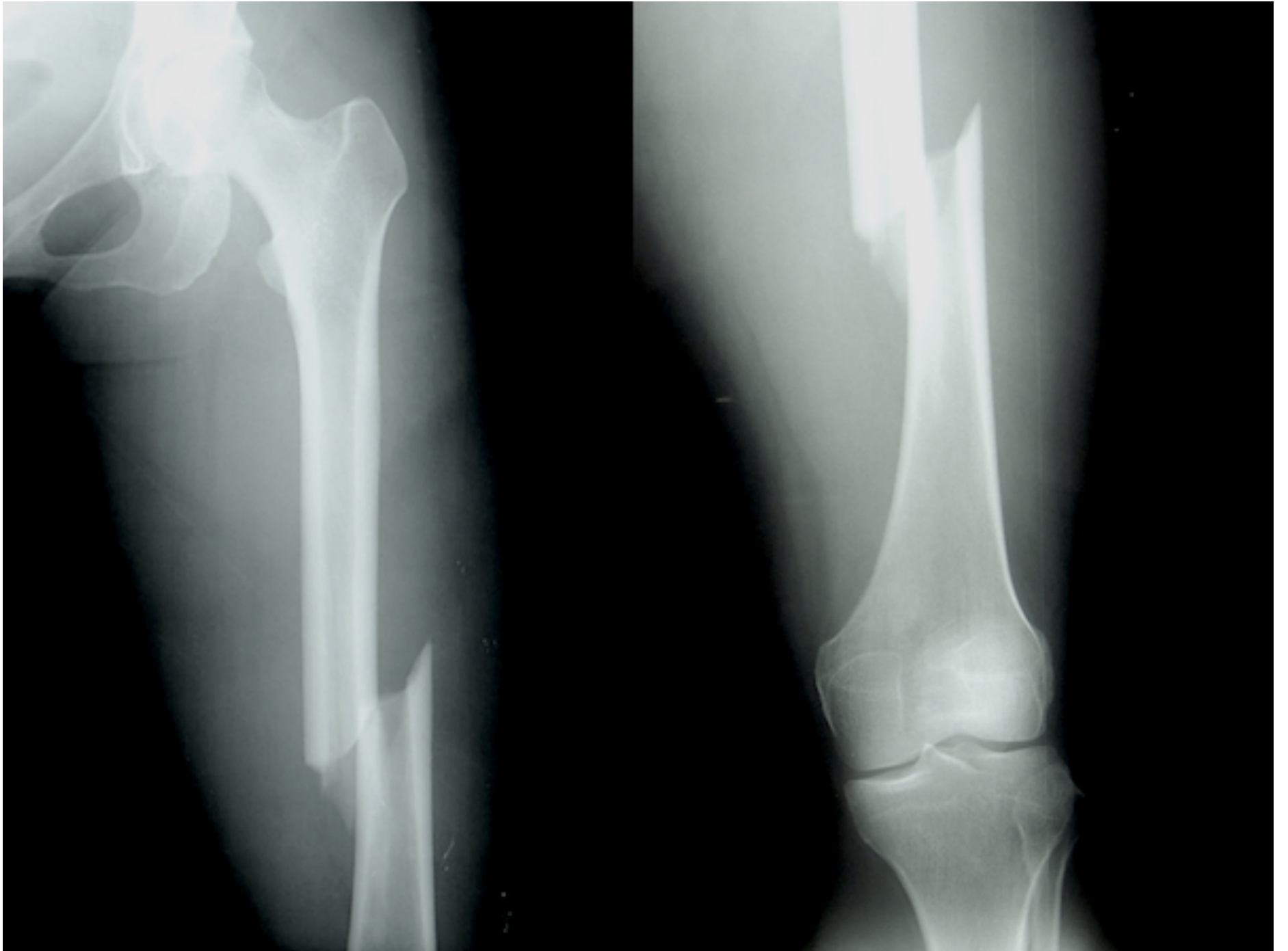
2- The '**butterfly** fragment' at **least** 50 % cortical contact

3- The butterfly fragment involves **more** than 50 % of the bone width

4- essentially a **segmental** fracture



Femoral shaft fracture in an abused 5-year-old boy. Frontal radiograph shows a transverse fracture of the diaphysis in femoral pin traction.





# Pathological femoral shaft fracture



## X-ray

- Most fractures of the femoral shaft have some degree of comminution, it is not always apparent on X-ray. It is a reflection of the amount of force involved in these injuries.
- Displacement may be in any direction.
- Sometimes there are two fracture lines separated by unbroken length of bone (segmental fracture).

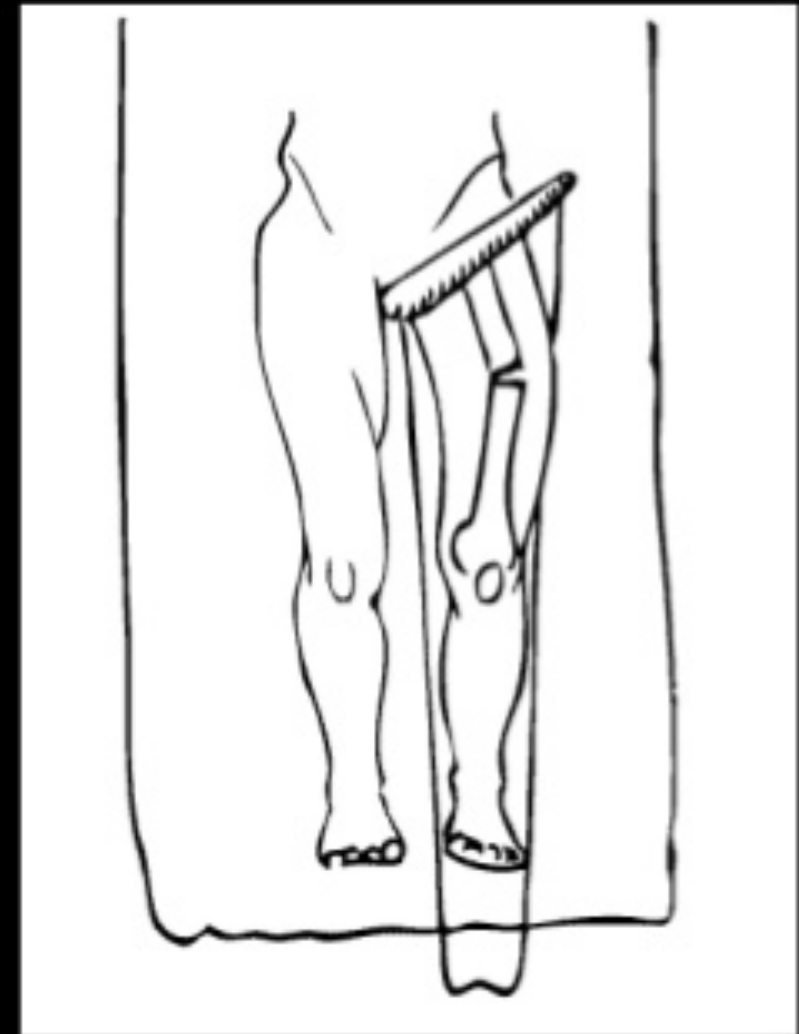
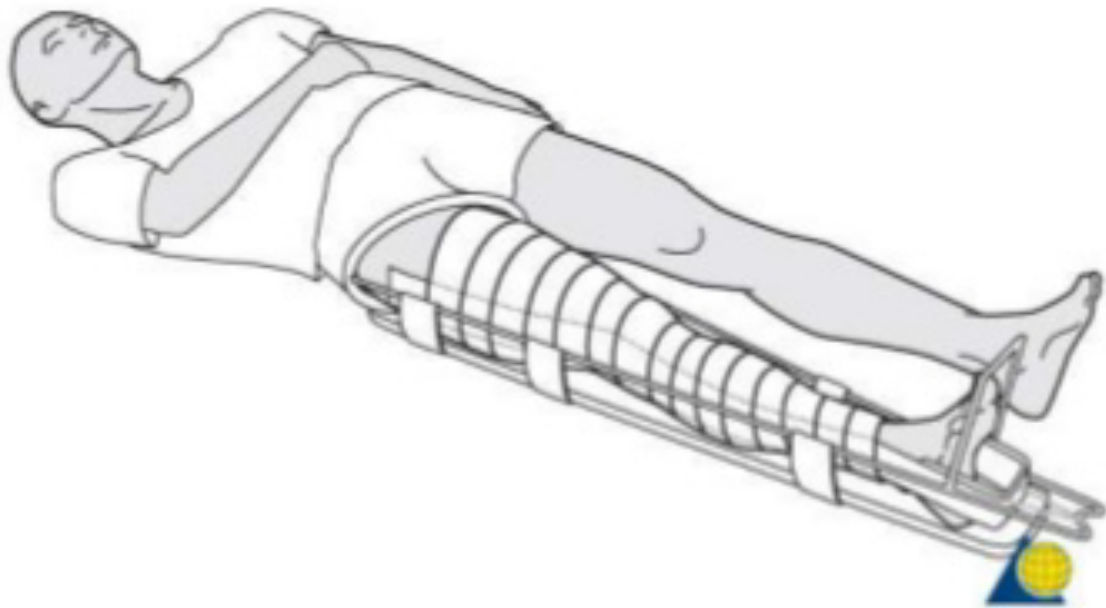


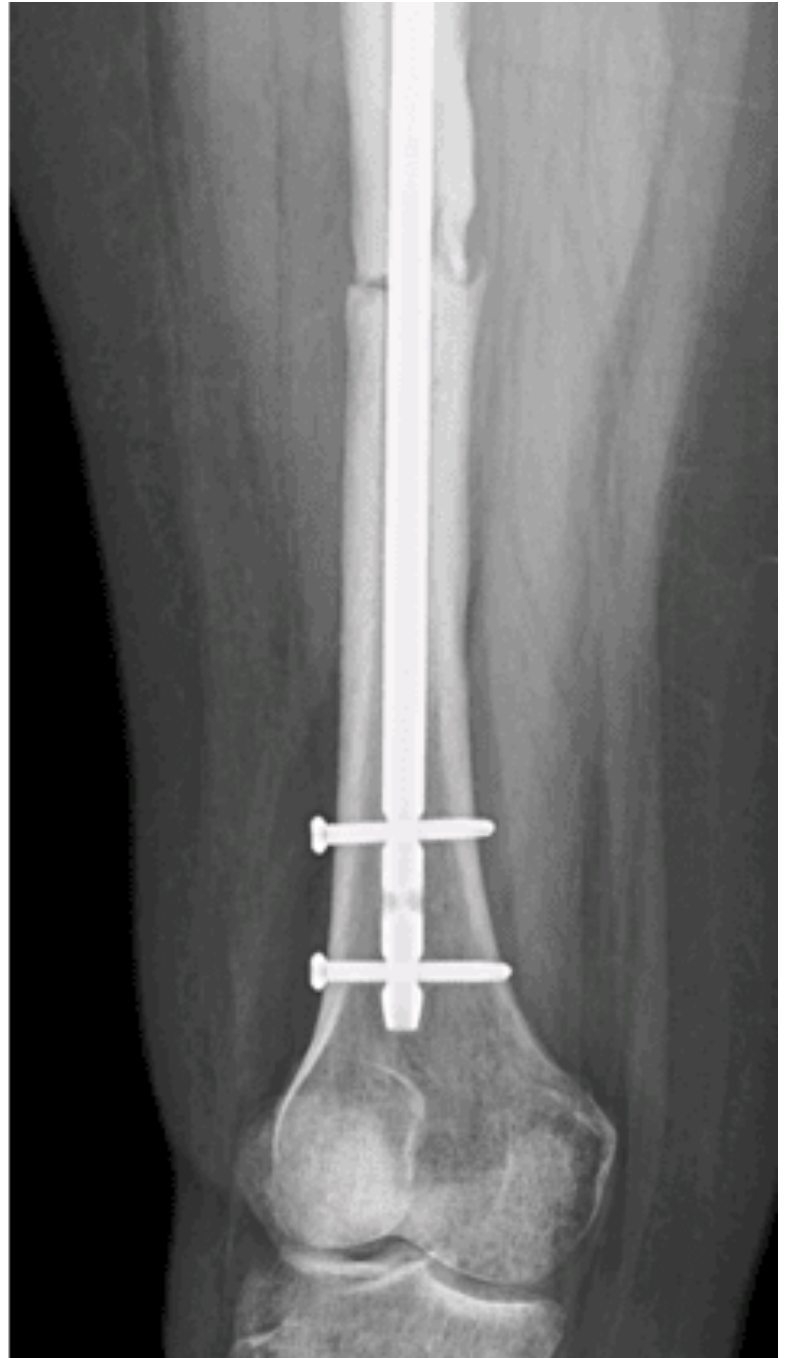
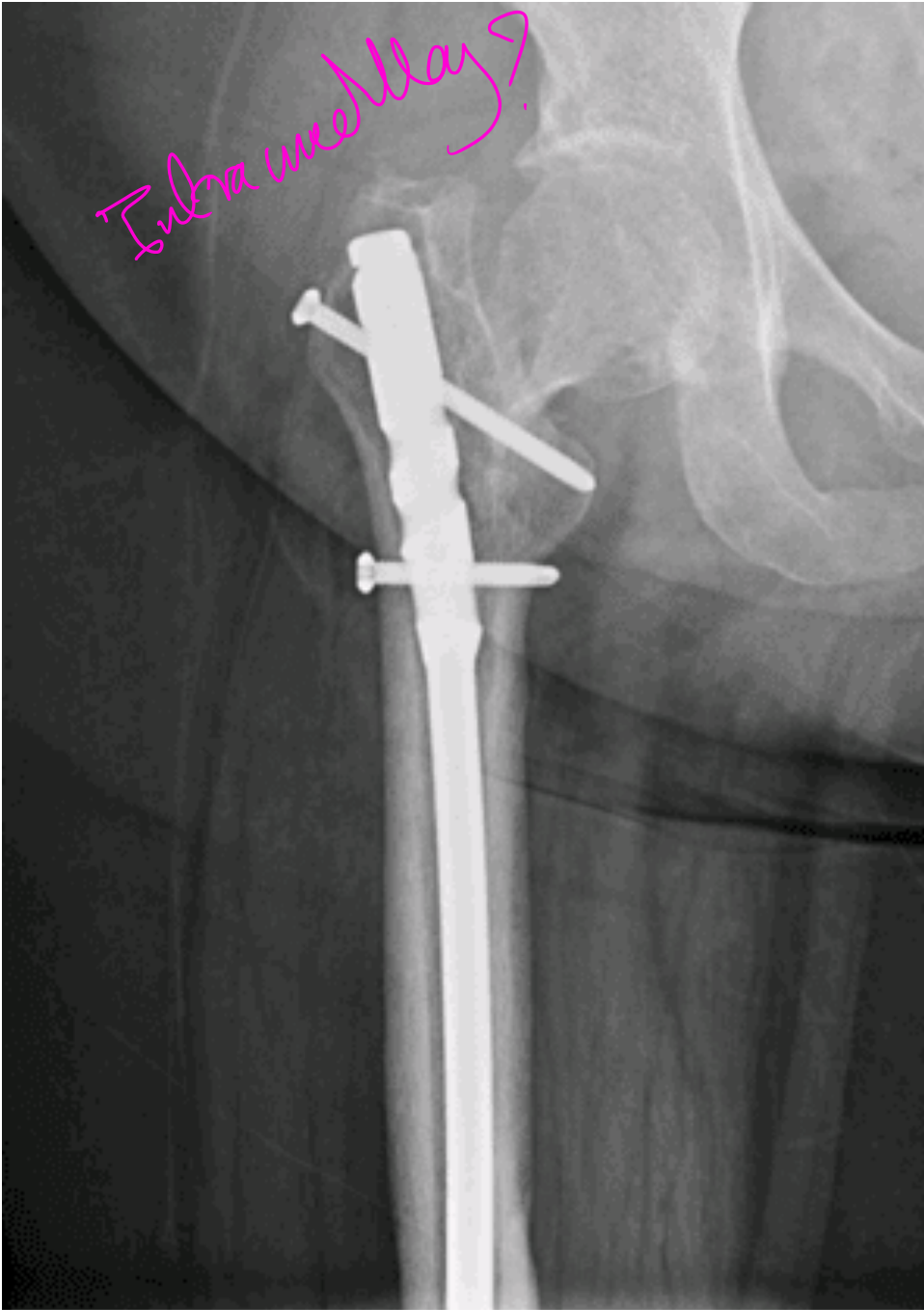


# Treatment

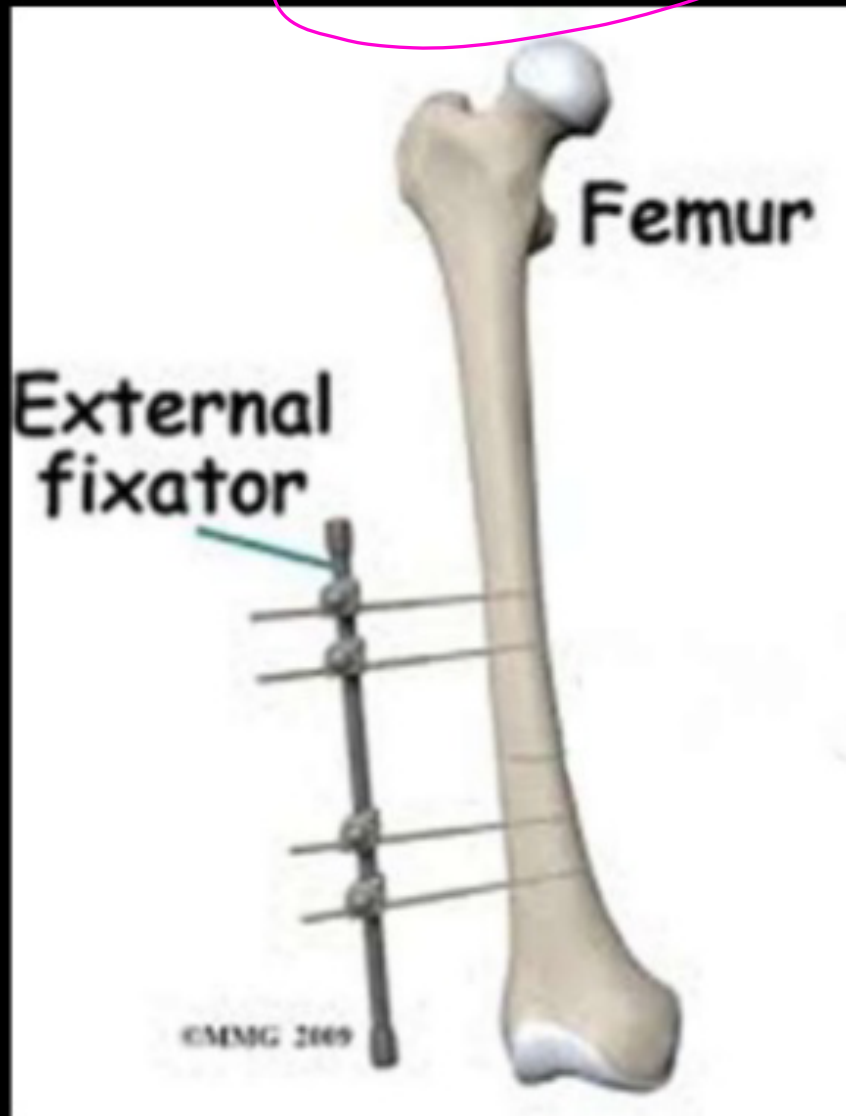
- The risk of systemic complications can be significantly reduced by early stabilization of the fracture.
- Traction can reduce and hold most fractures in reasonable alignment.
- The patient should be transported from the scene of the accident with the limb splinted.

# Thomas Splint Immobilisation before shifting the patient



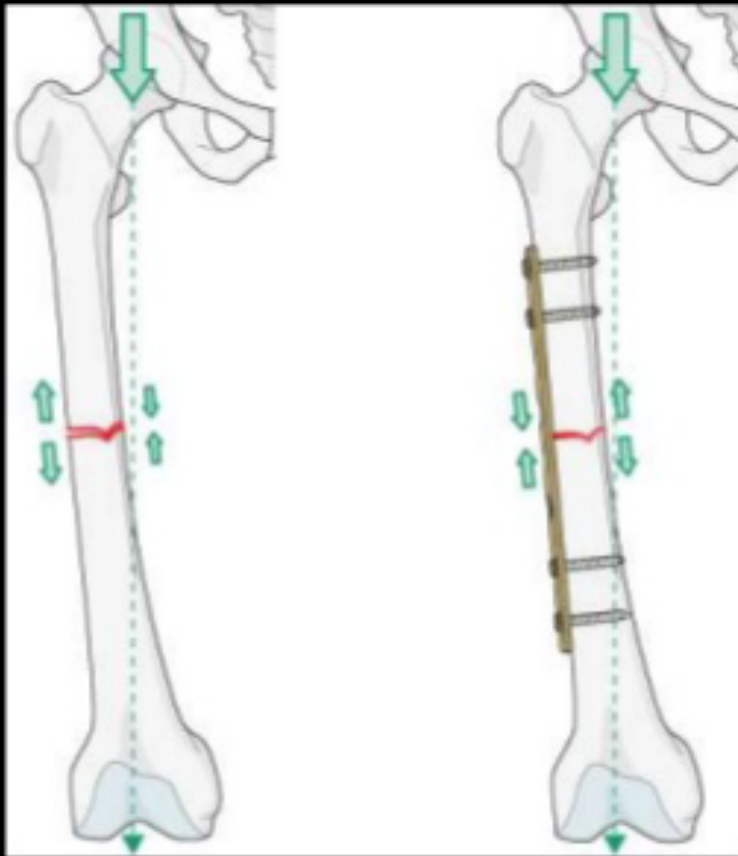


# External Fixation





# Plate Fixation



# Complications

1-vascular injury

2-thromboembolism

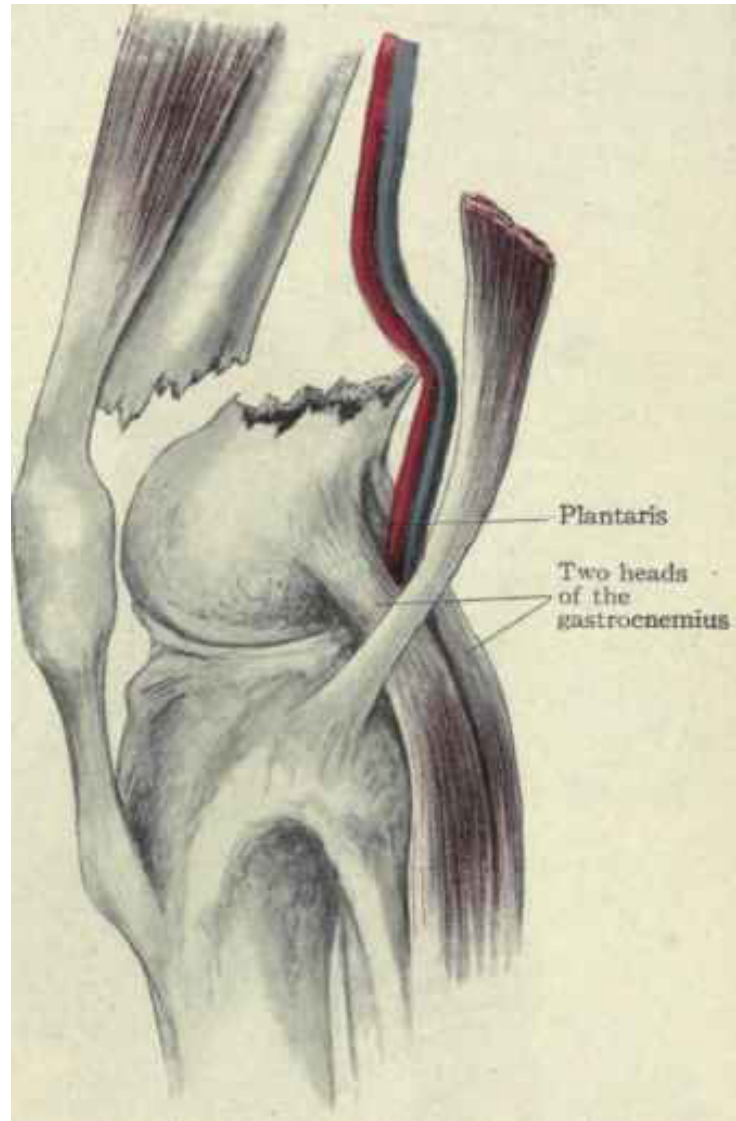
3-infection

4-delayed union or non union

5-malunion

6-general complications (blood loss, shock, fat embolism, ARDS,..)

# (Distal Fracture of Femur)



# Distal Fracture of Femur

They are seen in

1- young adults due to high energy trauma.

2- elderly, osteoporotic patients.

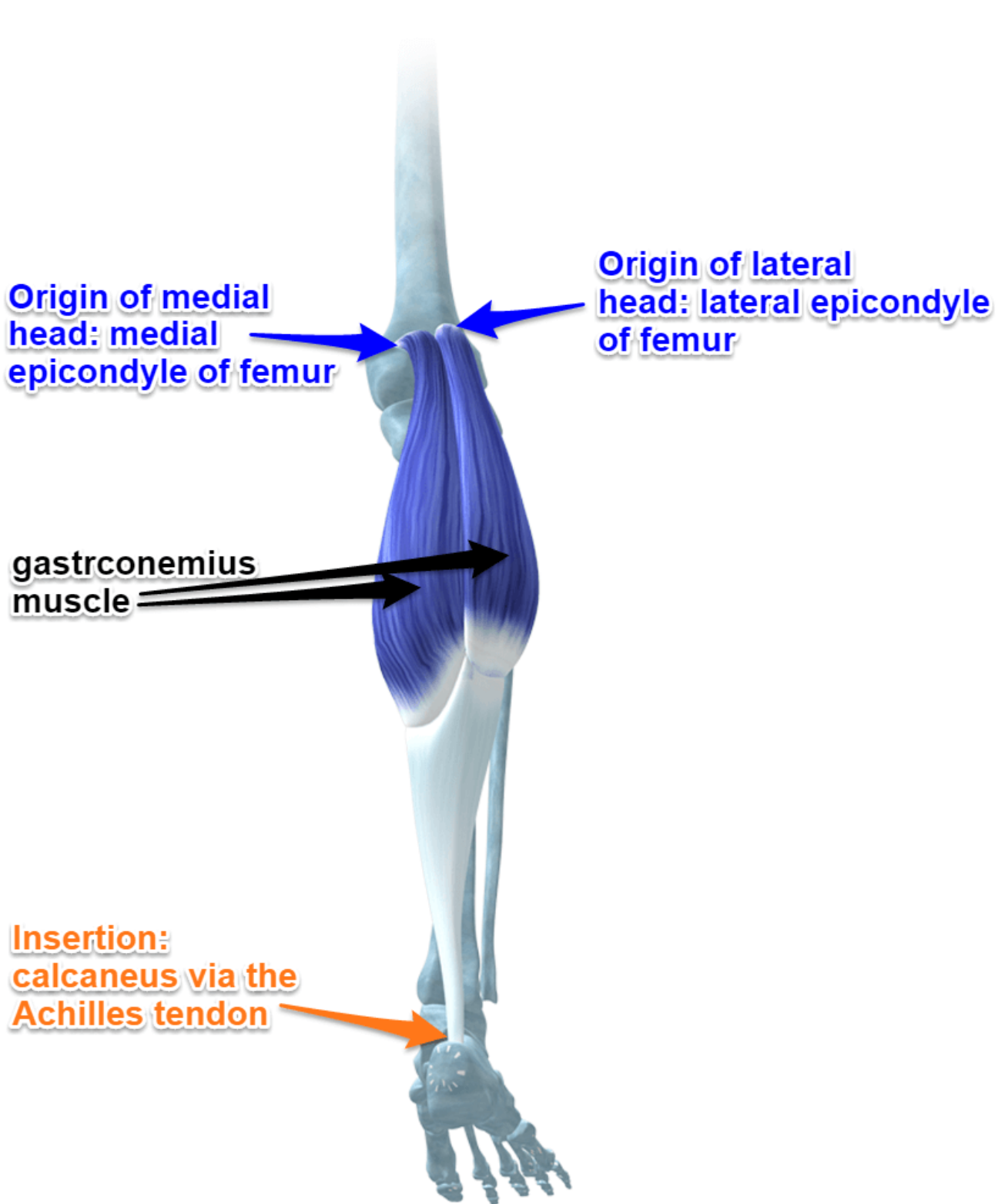
- Direct violence is the usual cause.
- The fracture line is just above the condyles but it may branch off distally between them.
- The pull of the gastrocnemius attachment may tilt the distal fragment backwards.

**Origin of medial head: medial epicondyle of femur**

**Origin of lateral head: lateral epicondyle of femur**

**gastrocnemius muscle**

**Insertion: calcaneus via the Achilles tendon**



# Special Features:

*distal femur fracture*

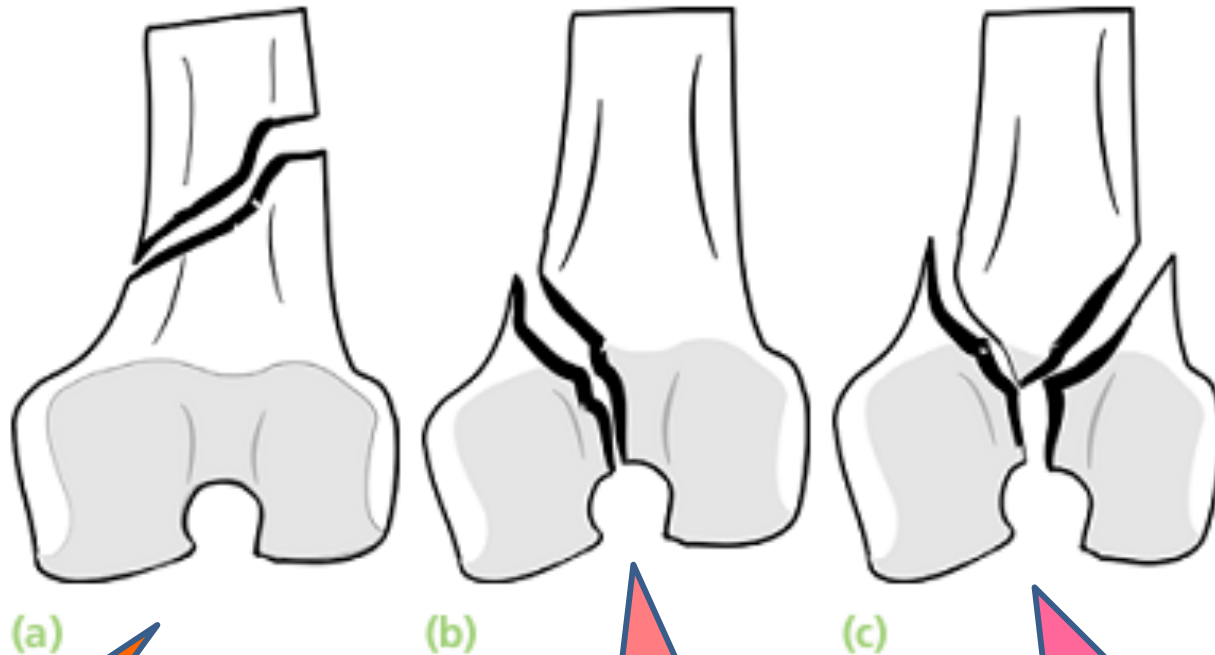
- The knee is swollen and deformed.
- Movement is too painful to be attempted.
- The tibial pulse should be always palpated.



## X-ray

- The fracture is just above the femur condyles and is transverse and comminuted.
  
- Distal fragment is tilted backwards

# AO classification



Type A fractures do not involve the joint surface

type B fractures involve the joint surface (one condyle) but leave the supracondylar region intact

type C fractures have supracondylar and condylar components.



Distal  
femur fracture



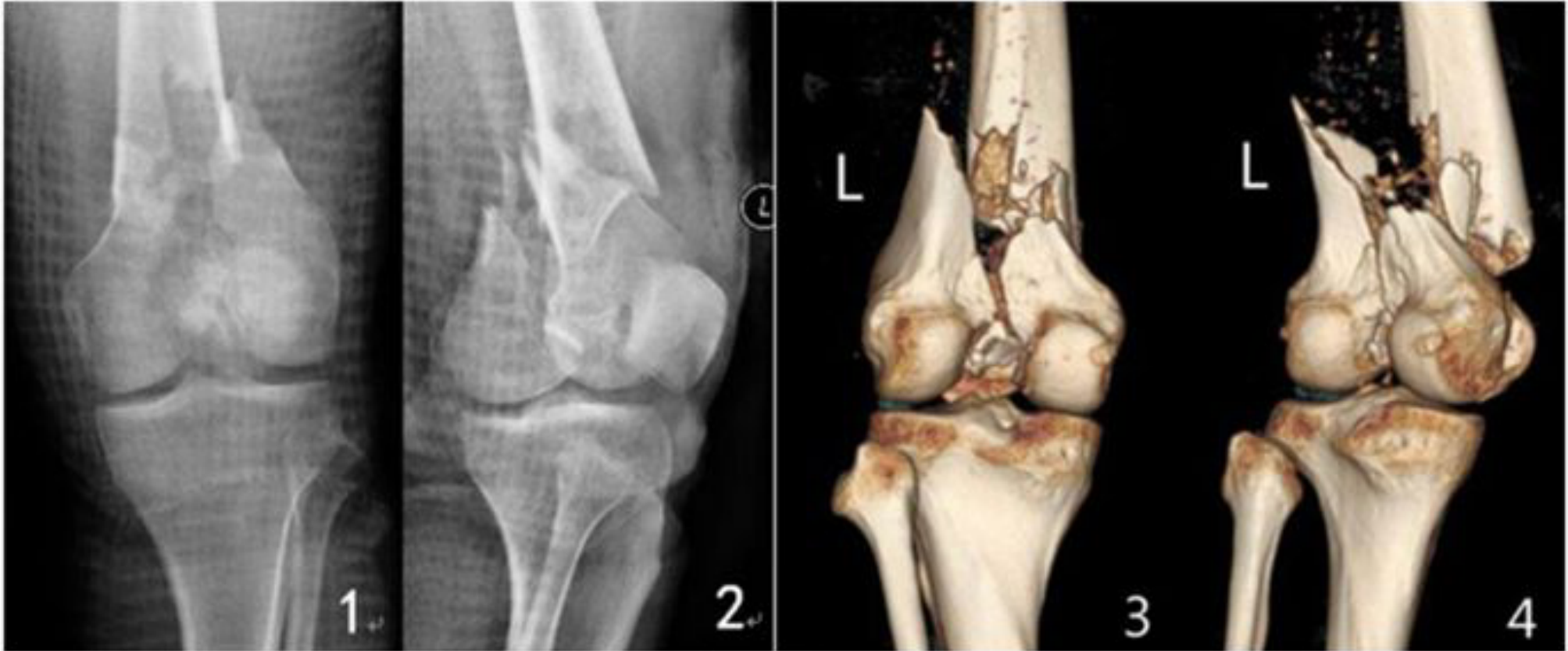
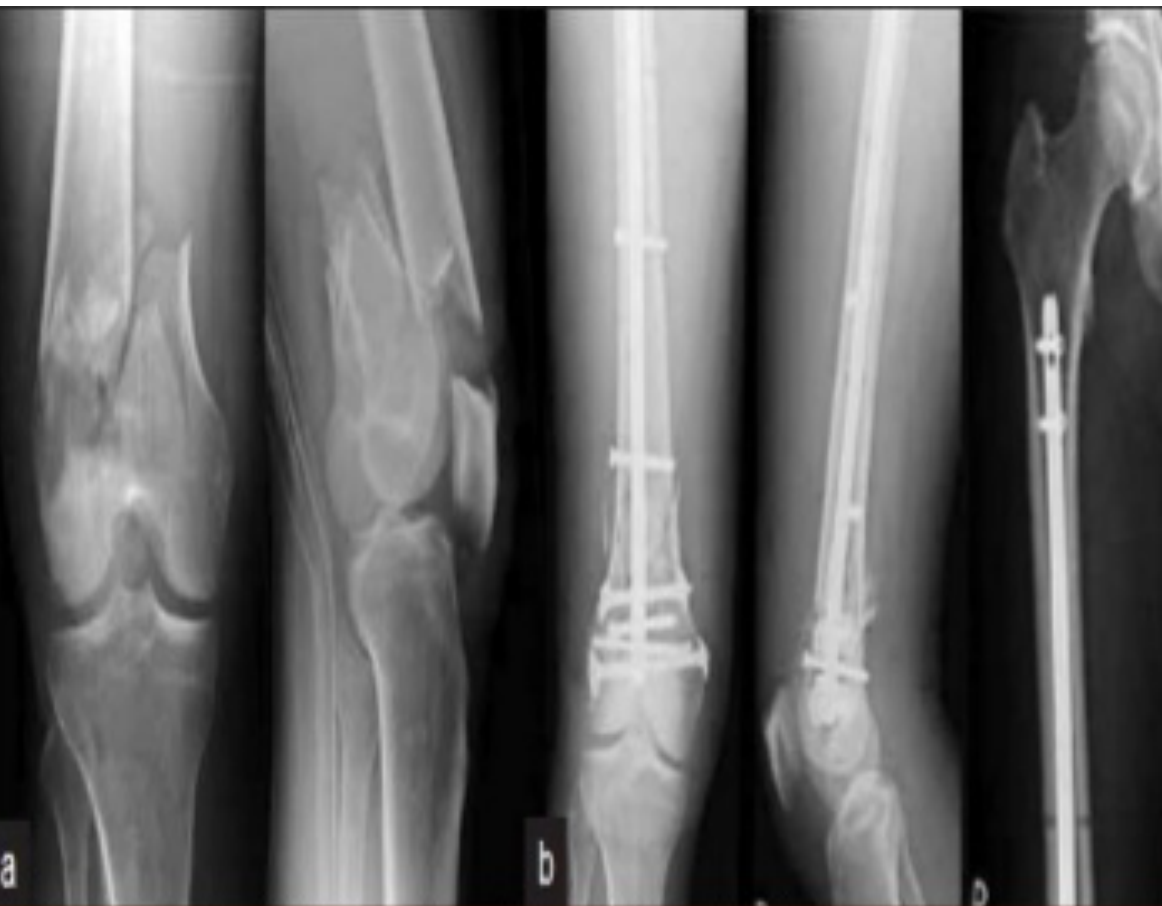




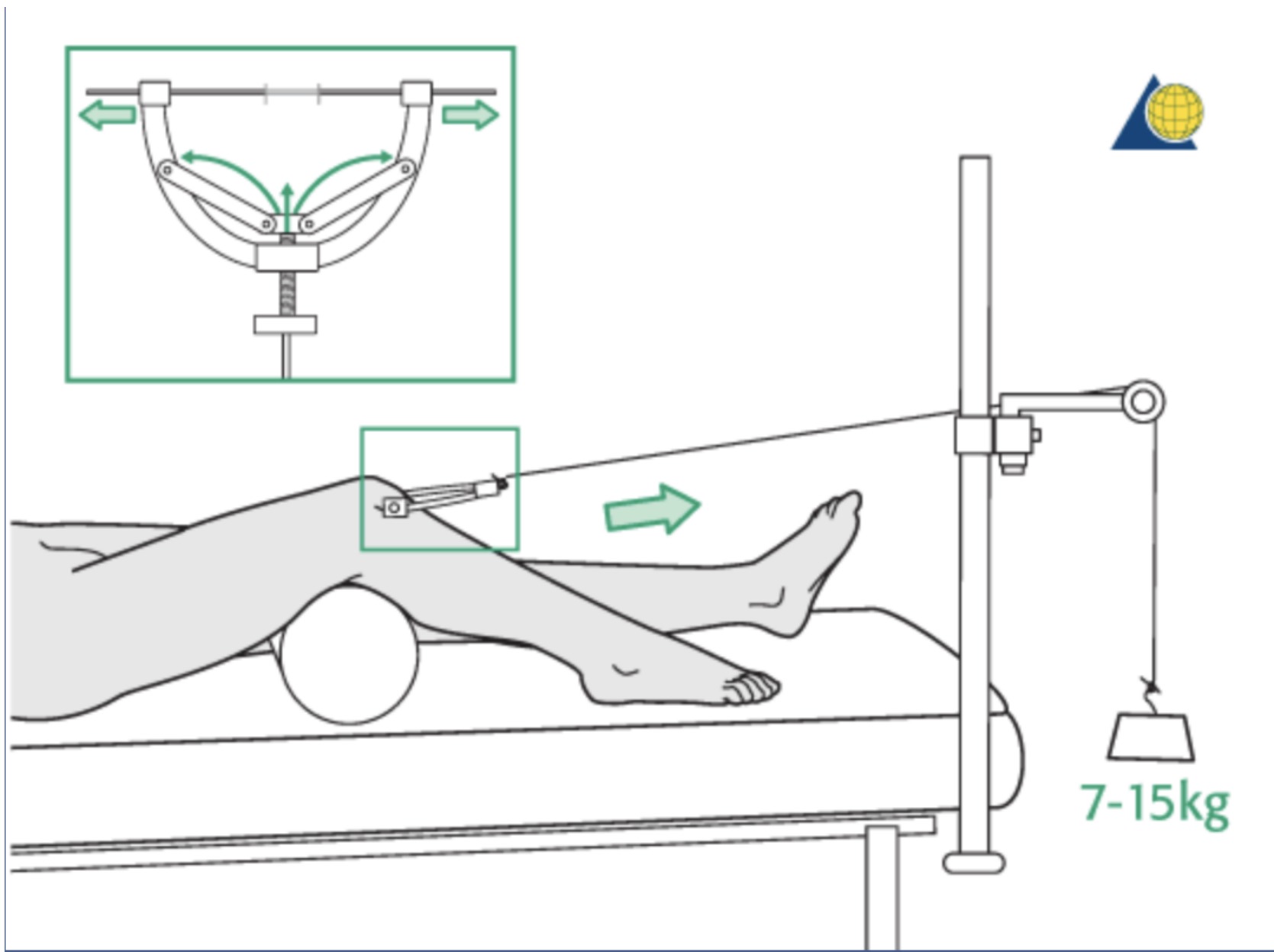
FIGURE 1 AP view of the knee joint showing a displaced fracture of the distal femur.



# Treatment

If the fracture is only **slightly displaced** and **extra-articular**, or if it **reduces easily with the knee in flexion**; it can be treated by skeletal traction through the proximal tibia.

The limb is cradled on a Thomas' splint with a knee flexion piece and movements are encouraged.

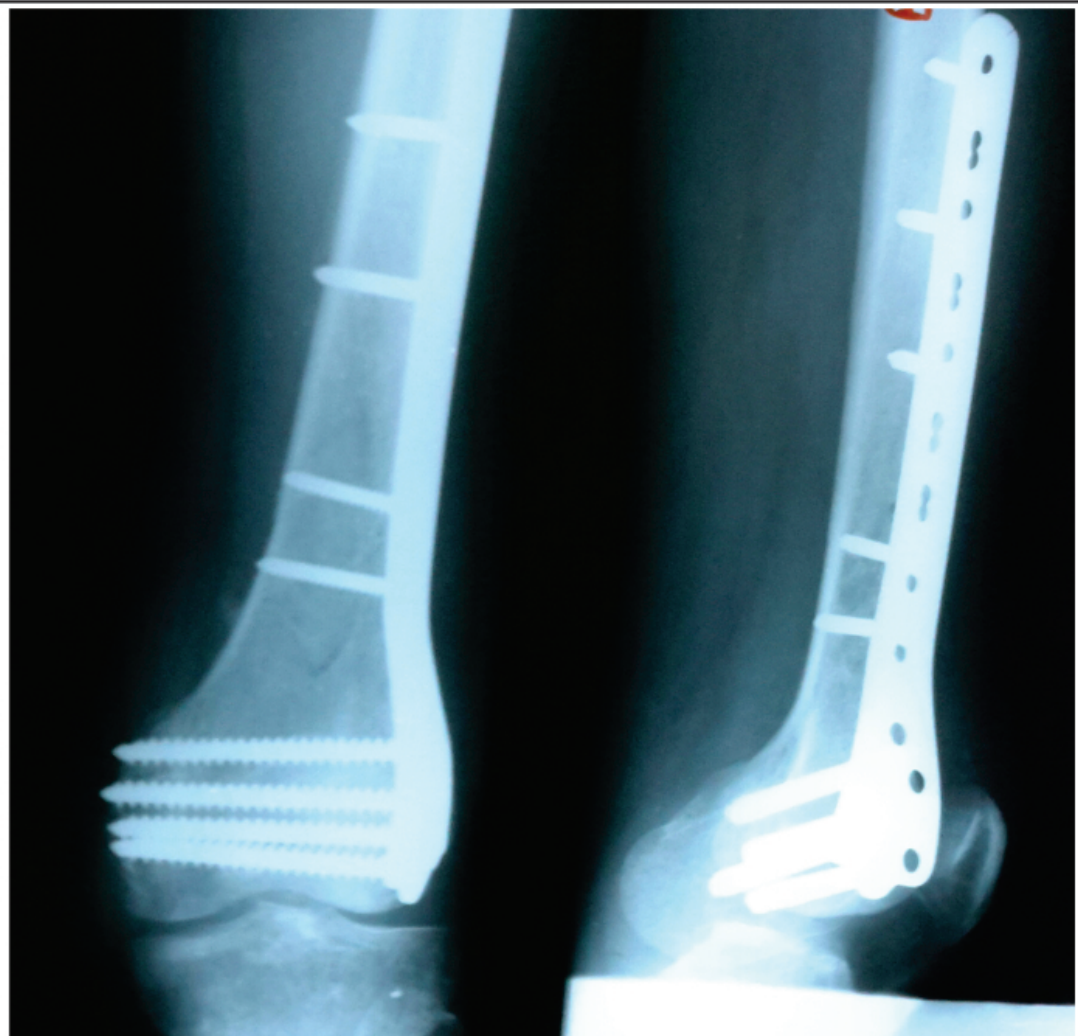


# Treatment cont.

- If the distal fragment is displaced by gastrocnemius pull a second pin above the knee and vertical traction will correct this
- After 4-6 weeks when the fracture is beginning to unite traction can be replaced by a cast brace .
- If closed reduction fails, open reduction and internal fixation with angled compression device may be successful.
- Locked intramedullary nails are also used for these fractures, they provide adequate stability even in the presence of osteoporotic bones.









# Complications

Joint stiffness

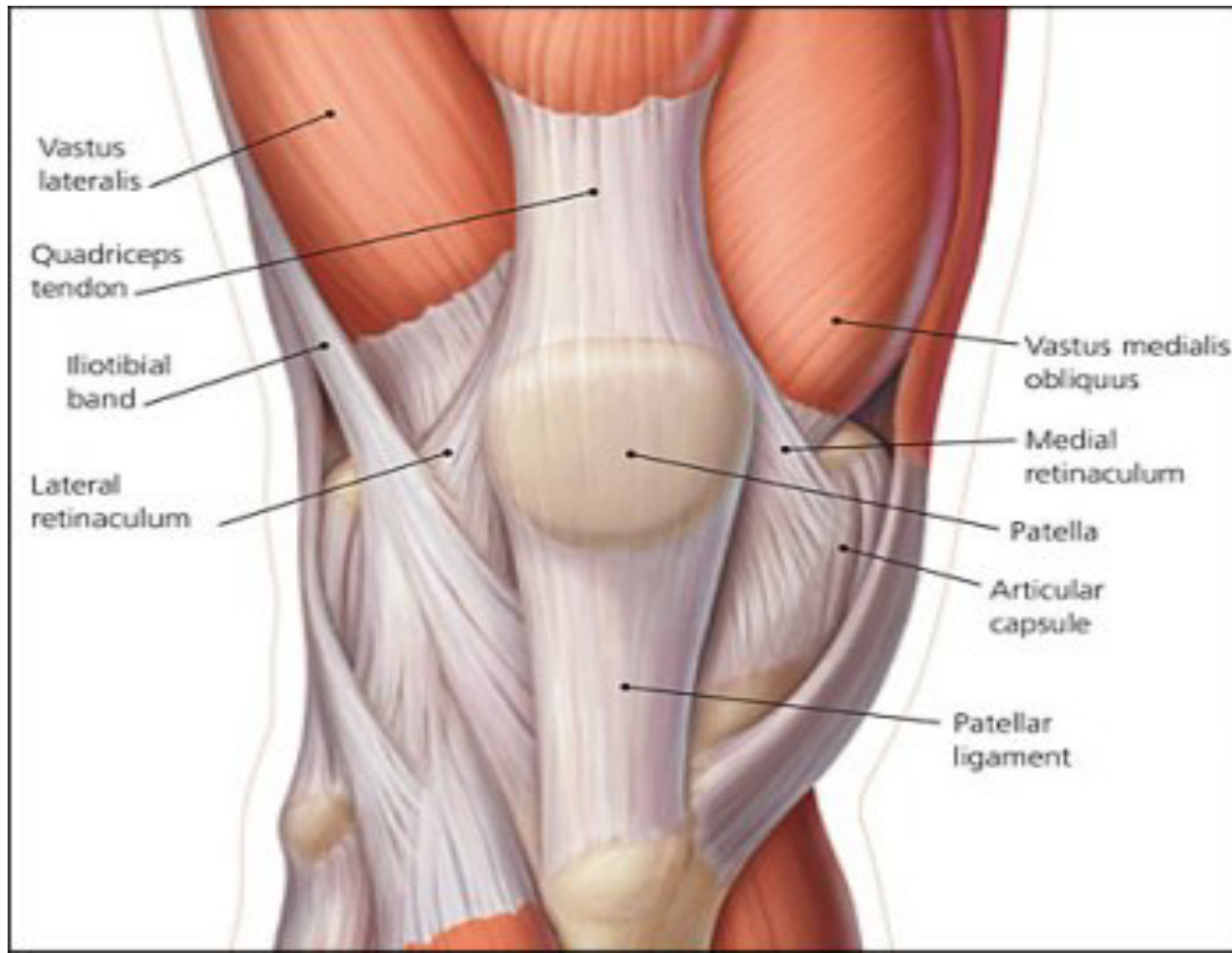
Non-union

Osteoarthritis

# The patella

the largest sesamoid bone, in continuity with:

- 1.the quadriceps tendon
- 2.the patellar ligament (also called the patellar tendon).
- 3.Insertion of vastus medialis and lateralis into the medial and lateral edges of the patella.




\*The extensor 'strap' is completed by the medial and lateral extensor retinacula (or quadriceps expansions), which bypass the patella and insert into the proximal tibia.

\* **The mechanical function of the patella is: to hold the entire extensor 'strap' away from the center of rotation of the knee, thereby lengthening the anterior lever arm and increasing the efficiency of the quadriceps.**

The key to the management of patellar fractures is the state of the entire extensor mechanism.

If the extensor retinacula are intact, active knee extension is still possible, even if the patella itself is fractured.

# Fractured Patella

- Three types of fractures:
  - 1. A direct blow causing undisplaced fracture across patella**
  - 2. A fall or a direct blow on front of the knee causing comminuted fracture**
  - 3. An indirect traction injury** due to forced, passive flexion of the knee while the quadriceps muscle is contracted causing a transverse fracture with a gap between the fragments  this causes the entire extensor mechanism to be torn across and active knee extension is impossible



Undisplaced



Transverse



Comminuted  
displaced

Separation of the fragments is significant if it is sufficient to create a step on the articular surface of the patella. In the case of a transverse fracture, if the gap is more than 3 mm wide.

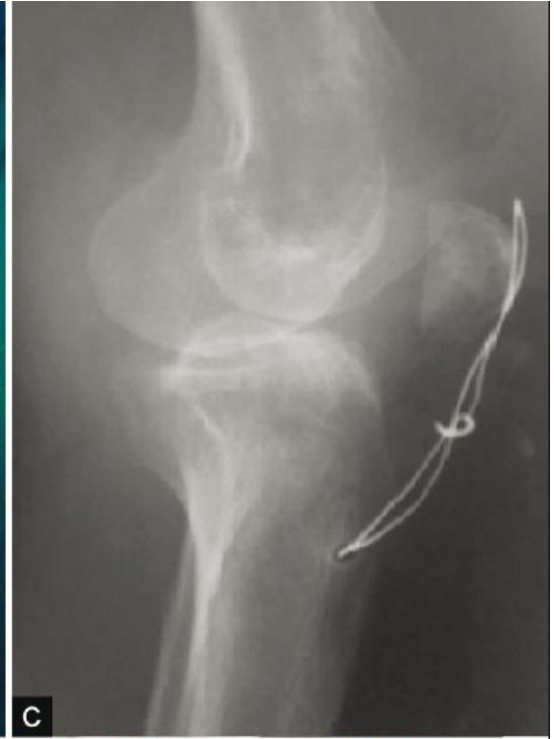
# Clinical Features

- Painful
- Swollen
- Sometime gap can be felt
- Usually Haemarthrosis (aspiration: blood and fat droplets)
- **Check if patient can actively extend the knee because this affects management.**

If the patient can lift the straight leg  quadriceps  
mechanism is still intact.

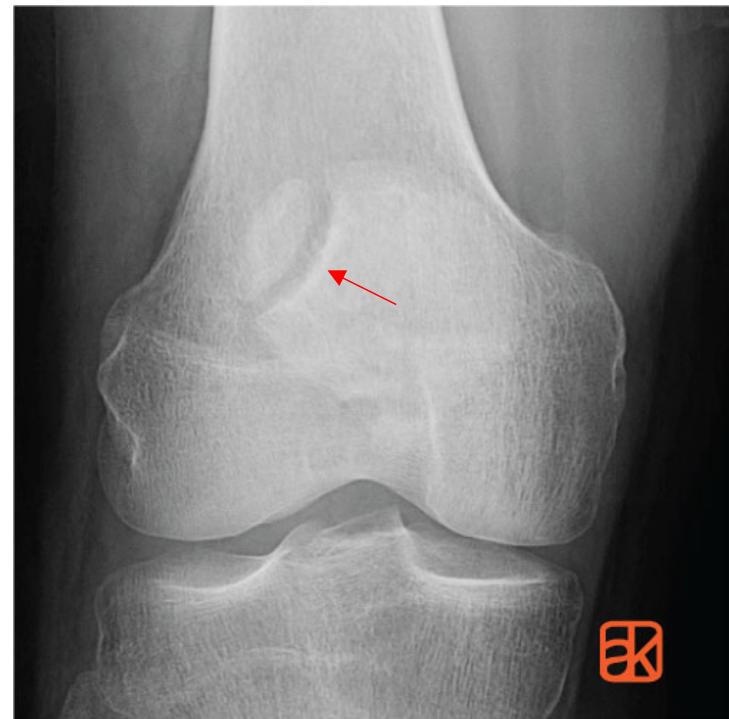
If this maneuver is too painful  active extension  
can be tested with the patient lying on his side





# Investigation

- **X-ray:**
  - The three types are usually clearly distinguishable
  - However, it is important not to confuse a fracture with a **congenital bipartite patella** in which a smooth line extends obliquely across the superolateral angle of the bone
  - Comparative x-rays of the opposite knee may help to distinguish normal from abnormal appearances in undisplaced fractures. **(2 limbs)**



# Treatment

- **Depends on state of extensor mechanism:**
  - **Undisplaced or minimally displaced crack with intact extensor mechanism:**

**Treatment is mainly protective.**

**1.Plaster cylinder holding the knee straight for 4-6 weeks**

**2.Quadriceps exercises are practiced every day**

if there is haemarthrosis threatening the skin>>  
aspirate it

## Non-operative management



Long cylinder cast



Extension splint/brace

Knee immobilize: **4-6 weeks**

**Weight bearing**

### Exercise

- Range of motion : **Straight-leg raises**
- Strengthening: **isometric quadriceps exercise**

# Treatment

## ➤ **Comminuted fracture with intact extensor expansions:**

Patient maybe able to lift the leg, however, the undersurface of the patella is irregular, and there is a serious risk of damage to patellofemoral joint.

1. Partial patellectomy might be required, with the fragments held by a circlage wire.
2. Then use back-slab
3. After back-slab, a hinged brace can be applied

# Treatment

➤ **Displaced transverse fracture: lateral expansions are torn and the entire extensor mechanism is disrupted**

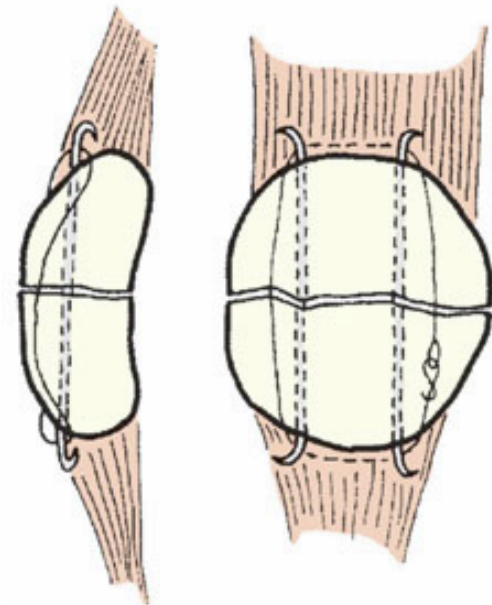
**1.Operation**, fragments held by internal fixation (tension band ) and **repair extensor expansions**

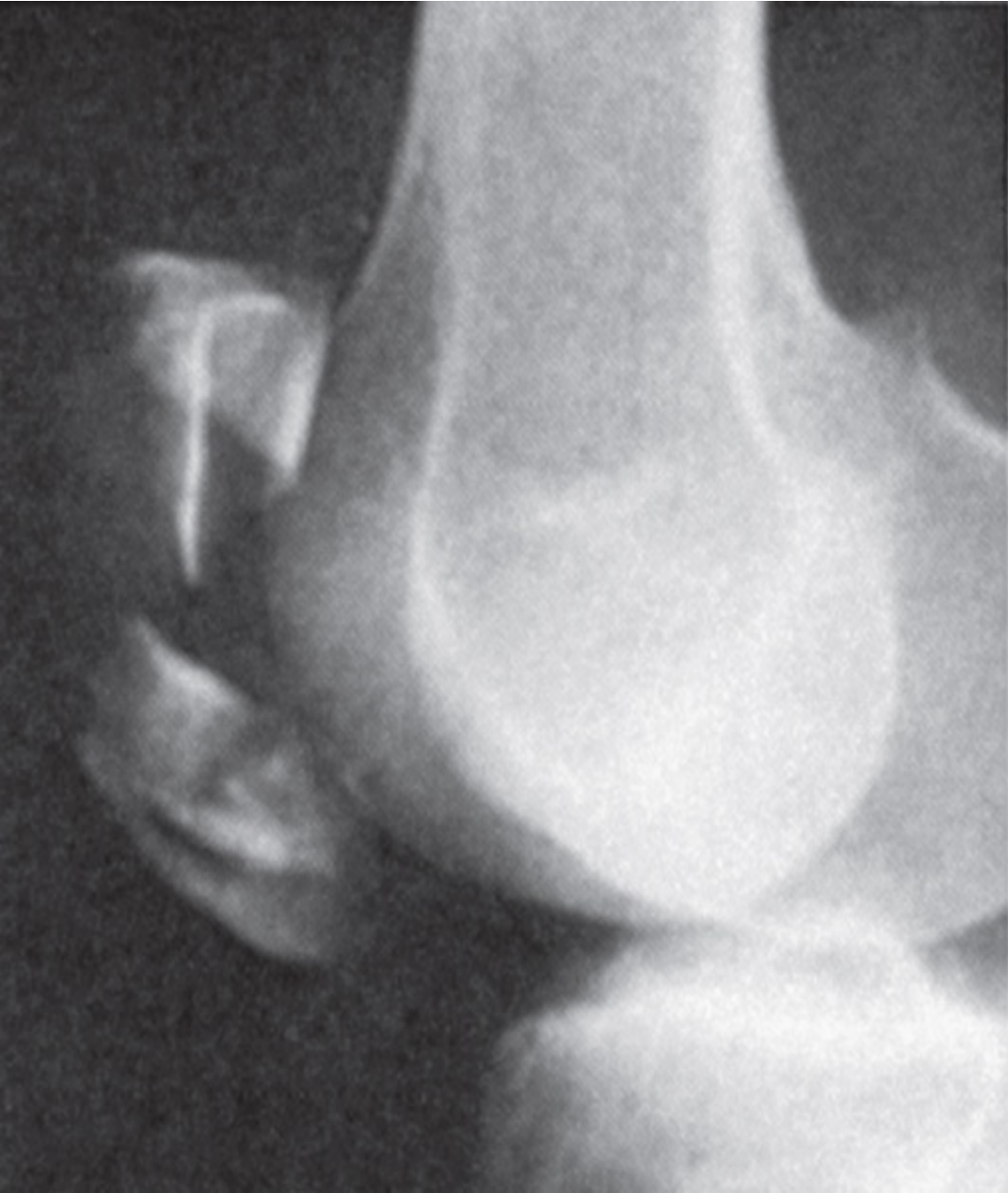
**2.Flexion and extension exercises** are practiced each day.

**3.Brace is worn until active extension of the knee is regained**



32.4 Fractured patella (a,b) Straightforward transverse fractures can be treated by *tension-band wiring*: the fragments are transfixed with K-wires and tightened by looping a malleable wire around the protruding ends of the K-wires.





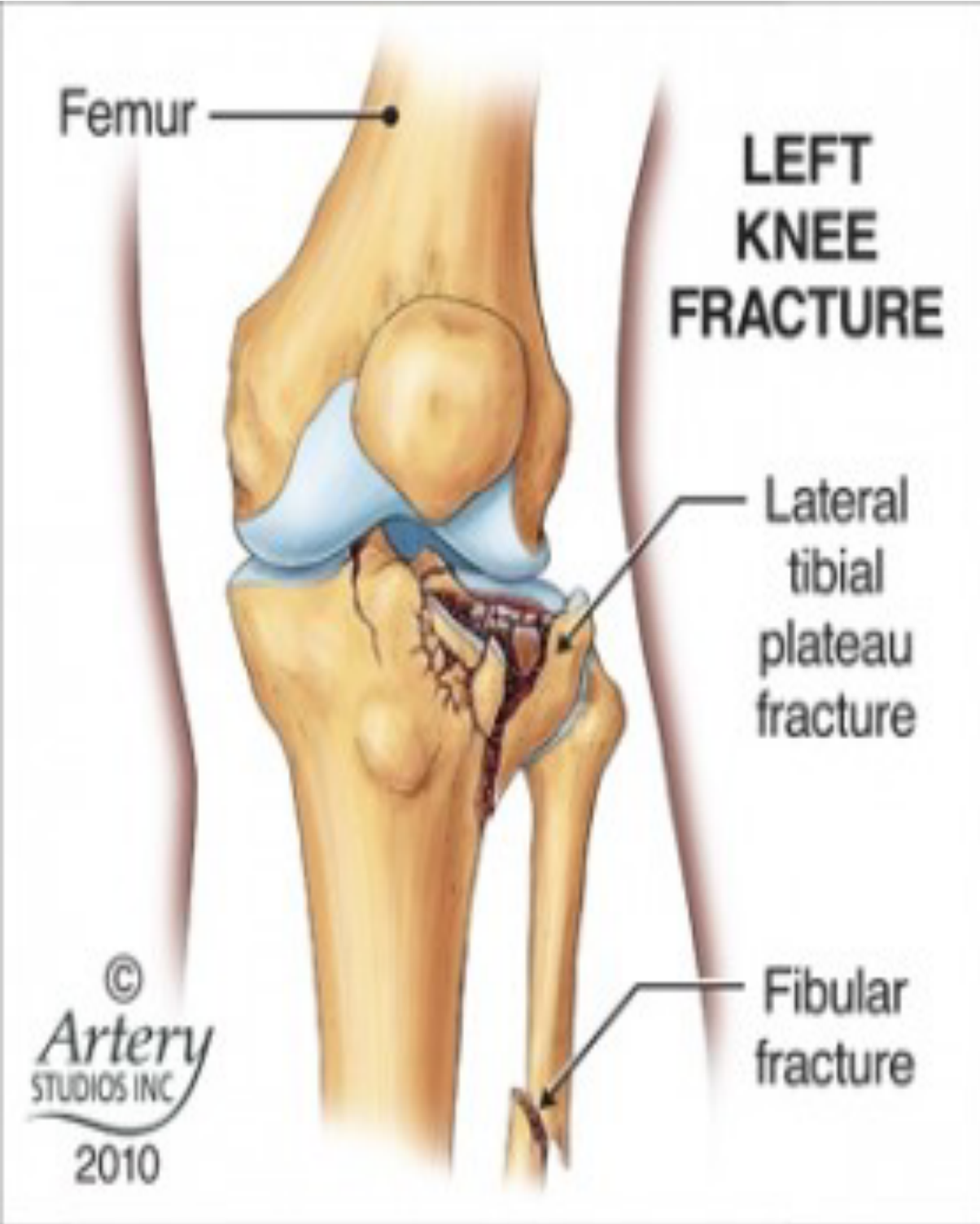
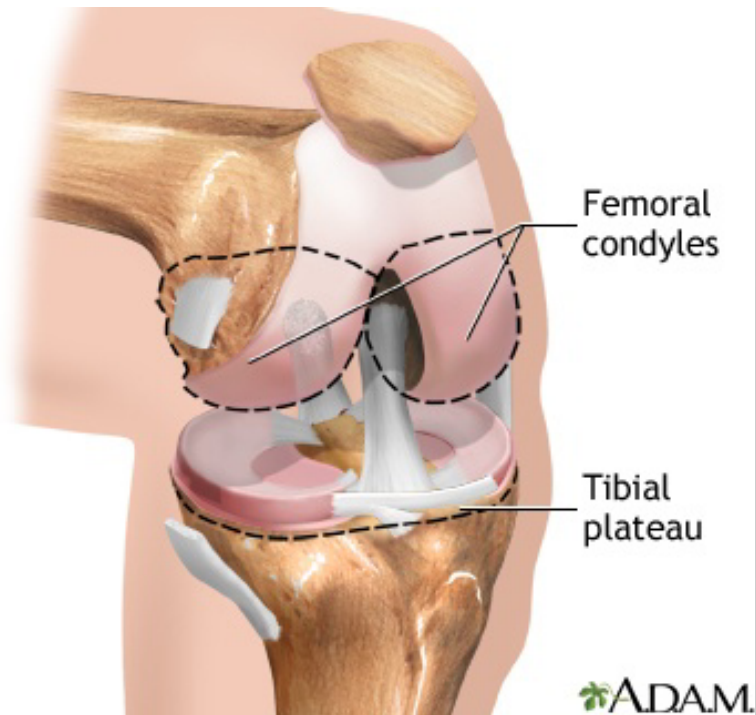
32.4 Fractured patella (c) For displaced comminuted fractures some surgeons would preserve as many useful fragments as possible, but often total patellectomy is preferable.



# Tibial Plateau Fractures

Fractures of the top surface of the tibia

- Caused by **strong bending force** (varus or valgus) combined with **axial load** , e.g.:
  1. A car striking a pedestrian on the side of knee ( **bumper fracture** )
  2. Fall from a height in which the knee is forced into valgus or varus
- One or both tibial condyles are crushed or split by the opposing femoral condyle
- a pure valgus force is more likely to rupture the ligaments



- The fracture pattern and degree of displacement depend on:
  1. the **type and direction of force**
  2. the **quality of the bone** at the upper end of the tibia.
- A useful classification is that of **Schatzker's**

# Schatzker's classification

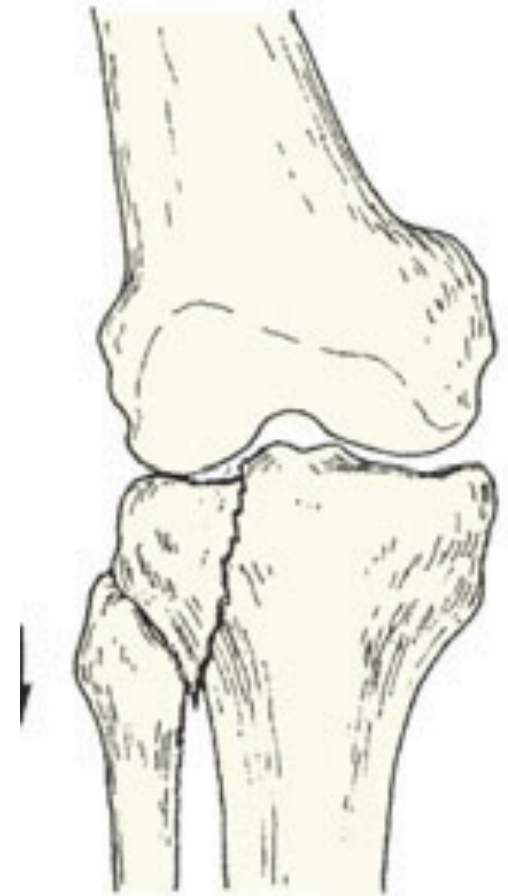
<b>Schatzker I</b>	<b>Lateral split</b>
<b>Schatzker II</b>	<b>Split with depression</b>
<b>Schatzker III</b>	<b>Pure lateral depression</b>
<b>Schatzker IV</b>	<b>Pure medial depression</b>
<b>Schatzker V</b>	<b>Bicondylar</b>
<b>Schatzker VI</b>	<b>Split extends to metadiaphysis</b>

# Classification of Tibial Plateau Fractures

## **Type 1 – a vertical split of the lateral condyle**

This is a fracture through dense bone, usually in younger people.

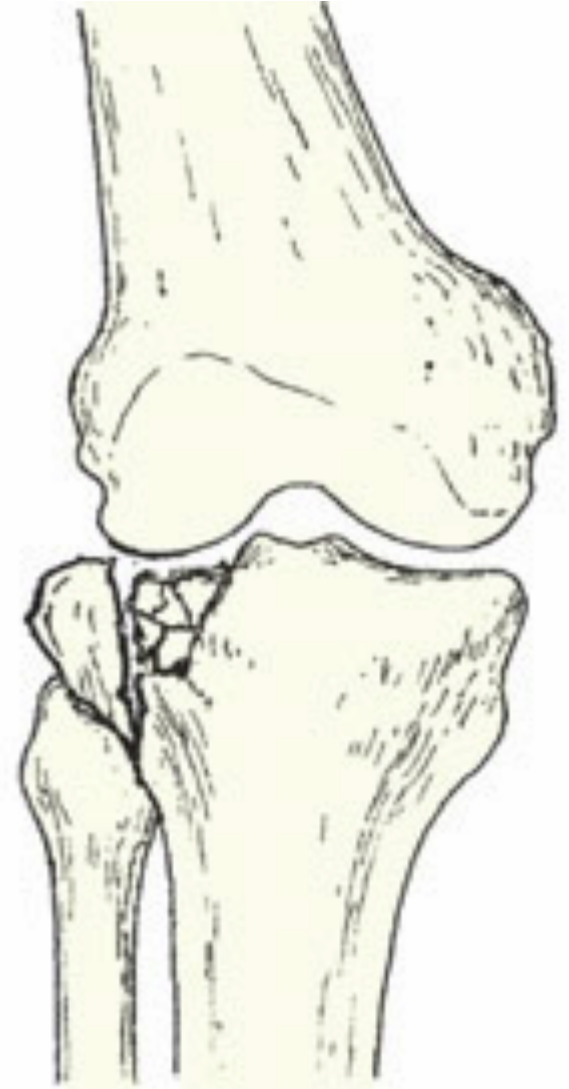
It may be virtually undisplaced, or the condylar fragment may be pushed inferiorly and tilted.



# Classification of Tibial Plateau Fractures

**Type 2 – a vertical split of the lateral condyle combined with depression of an adjacent loadbearing part of the condyle.**

The wedge fragment, which varies in size, is displaced laterally; the joint is widened and, if the fracture is not reduced, may later develop a valgus deformity.

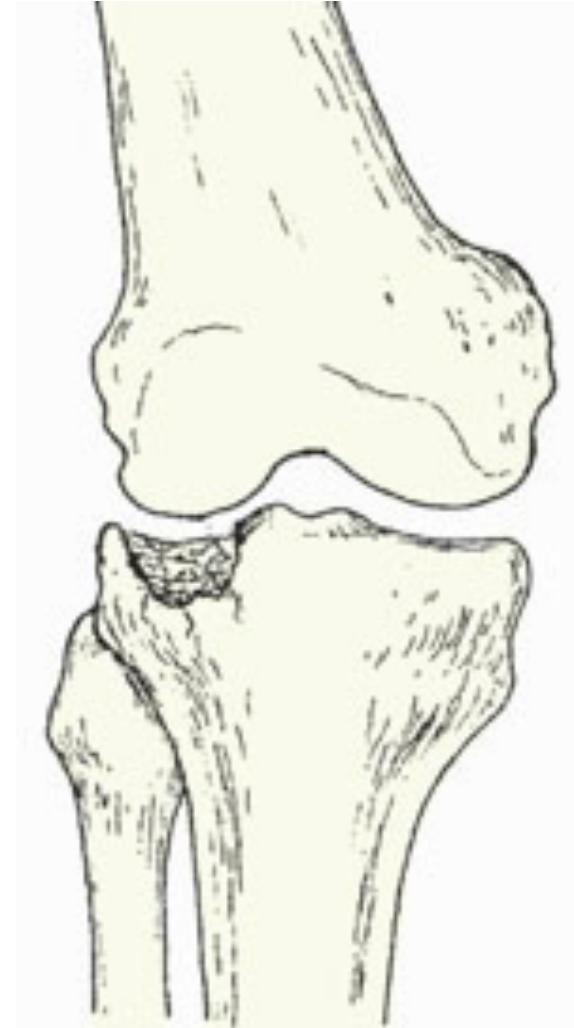


# Classification of Tibial Plateau Fractures

## **Type 3 – depression of the articular surface with an intact condylar rim**

Unlike type 2, the split to the edge of the plateau is absent.

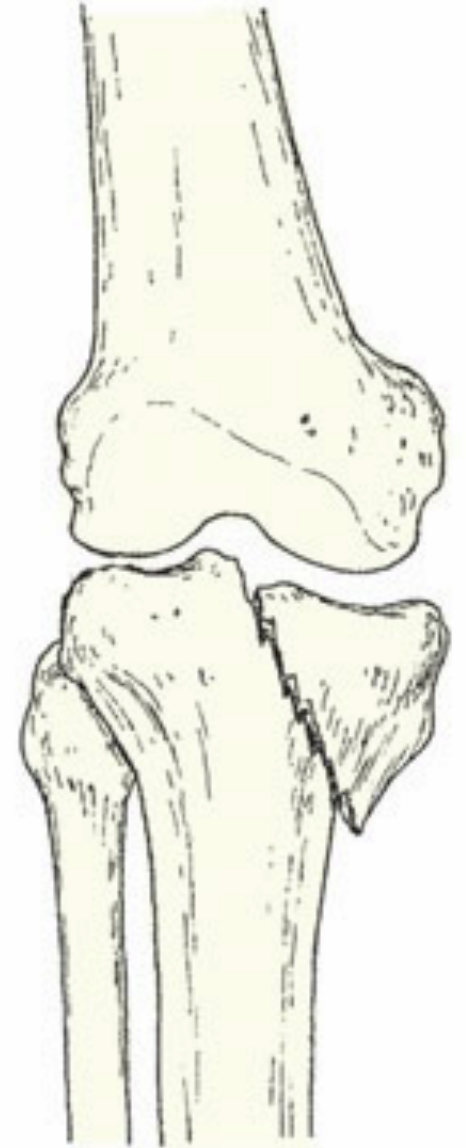
The depressed fragments may be wedged firmly into the subchondral bone. The joint is usually stable and may tolerate early movement.



# Classification of Tibial Plateau Fractures

## **Type 4 – fracture of the medial tibial condyle**

The momentary varus angulation may be severe enough to cause a rupture of the lateral collateral ligament and a traction injury of the peroneal nerve.

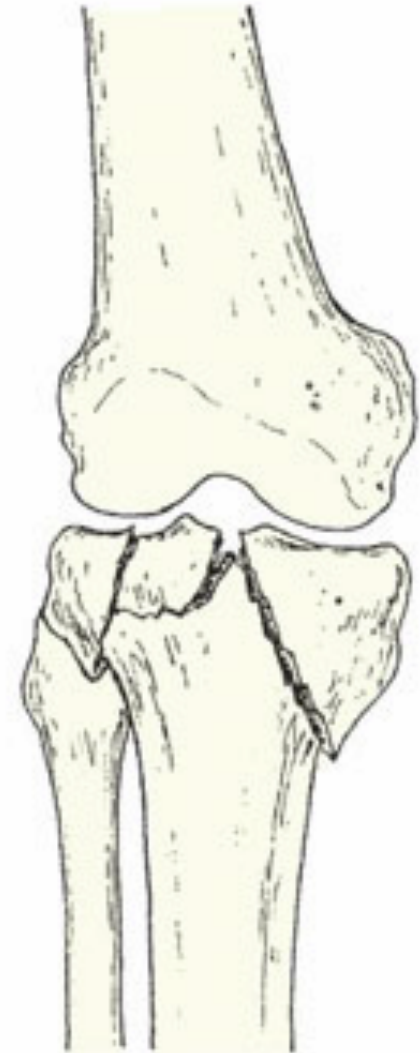




# Classification of Tibial Plateau Fractures

## **Type 5 – fracture of both condyles**

Both condyles are split but there is a column of the metaphysis wedged in between that remains in continuity with the tibial shaft.

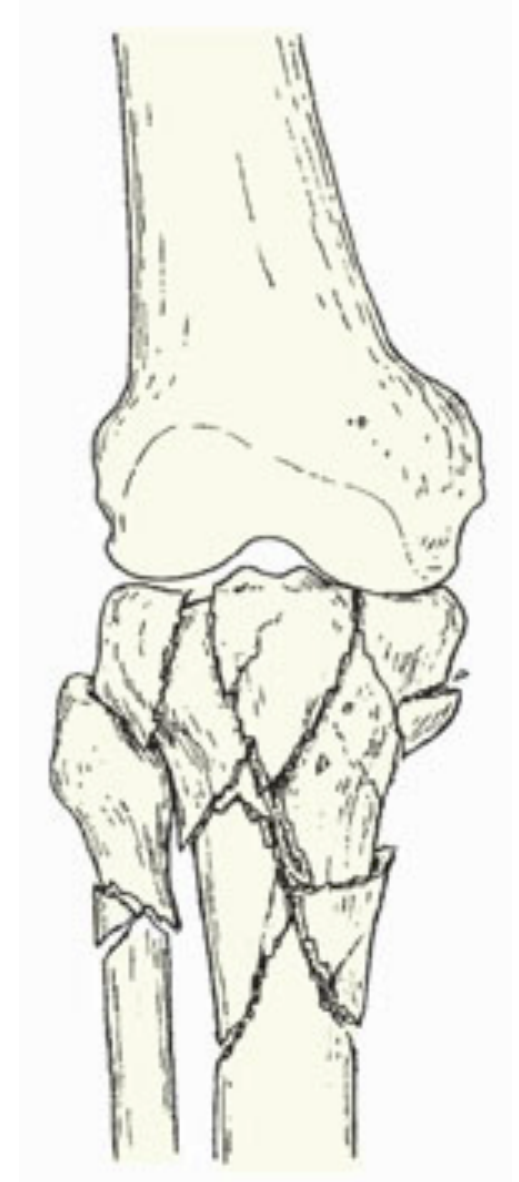


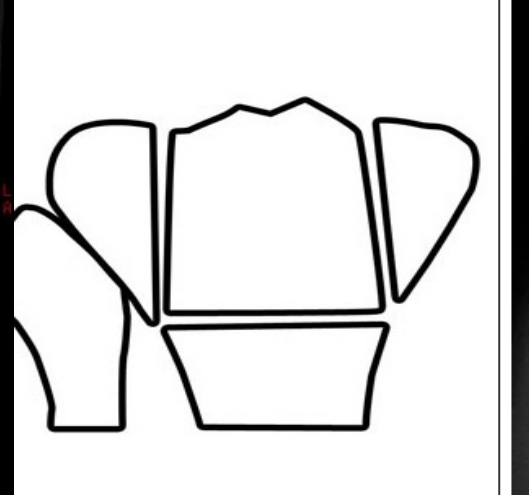
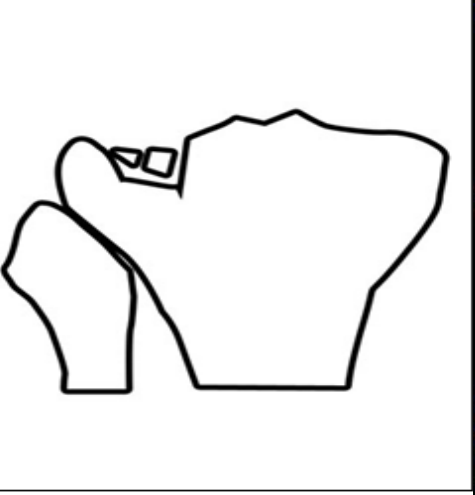
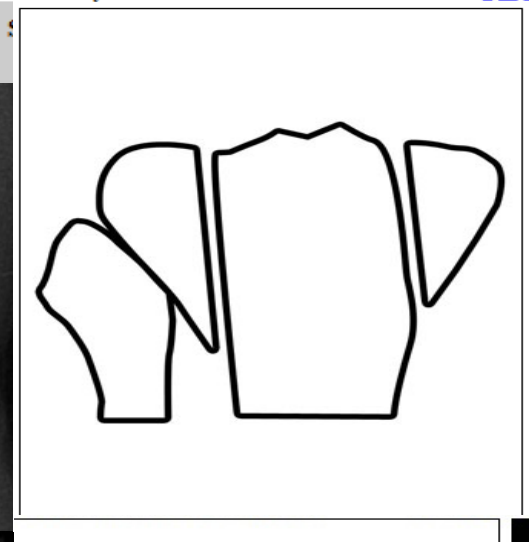
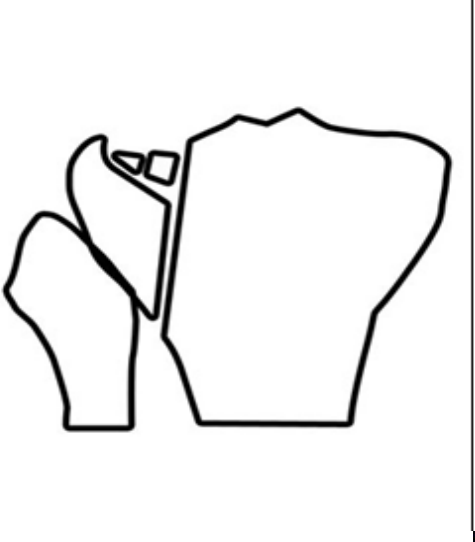
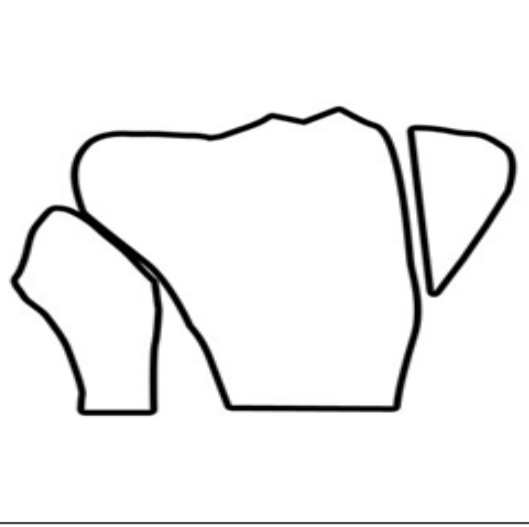
# Classification of Tibial Plateau Fractures

## **Type 6 – combined condylar and subcondylar fractures**

This is a high-energy injury that may result in severe comminution.

Unlike type 5 fractures, the tibial shaft is effectively disconnected from the tibial condyles.





# Clinical Features

- Patient is nearly always an adult
- **Swollen joint**
- **Doughy** feel of a haemarthrosis
- **Diffuse tenderness** on the side of the fracture and also on the opposite side if a ligament is injured
- Major vascular injury is associated with severe fractures, may represent a knee dislocation that has reduced
- **Neurovascular examination is important**
- Traction injury of the peroneal or tibial nerves is not uncommon and it is important to establish whether this is present at the time of admission and before operation.

# Investigation

- **X-rays:**

Multiple views (AP, lateral and oblique) and often CT scan are needed to show the true extent of the fracture (comminution or plateau depression)

This provides information on :

1. the **location** of the main fracture lines
2. the **site and size of the portion of condyle** that is depressed
3. the **position of major parts** of articular surface that have been displaced.





type3



type6

- It is important **not to miss a posterior condylar component** in high-energy fractures because this may require a separate posteromedial or posterolateral exposure for internal fixation.
- With a crushed lateral condyle the medial ligament is often intact, but with a crushed medial condyle the lateral ligament is often torn.

# Treatment

- **FUNCTION IS MORE IMPORTANT THAN ANATOMICAL REDUCTION, because these are intra-articular fractures !!!**



# Treatment

- **Undisplaced and minimally displaced fractures of the lateral condyle (type 1) :**

Treated conservatively

Haemarthrosis is aspirated if the skin is threatened

Compression bandage applied

Knee movements encouraged

when acute pain and swelling subsided (usually within 1 week)

hinged cast-brace is fitted

Usually heals by 8-9 weeks

➤ **If there is displacement**

**open reduction and internal fixation with a lag screw**

**Fractures of medial condyle (type 4):**

**Open reduction and fixation** with a buttress plate and screws. Associated lateral ligament damage will need repair

# Treatment

- **Markedly displaced and/or comminuted fractures of the lateral condyle (type 2 and 3):**

- Open reduction and internal fixation
- Bone grafts maybe needed to support reduction
- Fixation is usually with lag screws and buttress plate.

- **Bicondylar fractures ( type 5 and 6) :**

- These are usually high energy injuries.
- Best reduced and stabilized surgically
- A combination of screw fixation and circular external fixation  good stabilization and low risk of wound complication

# Treatment

- **Osteoporotic condylar fractures:**
  - Elderly can be treated as mentioned earlier, but if the fracture pattern permits a total knee replacement it may offer a more proper solution

# Complications

- **Compartment syndrome:**

- **Joint stiffness:**

Start movement early to avoid

- **Deformity:**

Residual valgus or varus deformity is common

Can be compatible with good function

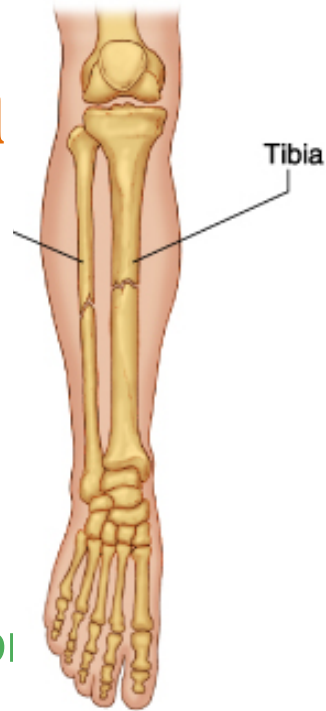
- **Osteoarthritis:**

Likely to develop after 5-10 years if :

1. Marked depression of the plateau
2. Deformity of the knee
3. Ligamentous instability

# Fractures of Tibia and Fibula

- **Twisting force** [?] spiral fracture of both bones at different levels
- **Angulatory force** [?] short oblique fracture usually with butterfly fracture
- **Tibia is more commonly fractured** because of its subcutaneous position
- more commonly sustains an open fracture than any other bone
- **High energy fracture**: A direct injury may crush or split the skin over the fracture , often from a motorcycle accident
- **Low energy fracture**: an indirect injury , causing **spiral or oblique fracture**, one of the bone fragments may pierce the skin from within



# Clinical Features

- Bruising
- Severe swelling
- Crushing of skin
- Open wound
- Weak or absent pulses
- Loss of sensation and inability to move the toes
- **COMPARTMENT SYNDROME !!**
- Deformity

# Investigation

- **X-Ray**

Must see the entire **length** of tibia and fibula, as well as, the **knee and ankle** joints

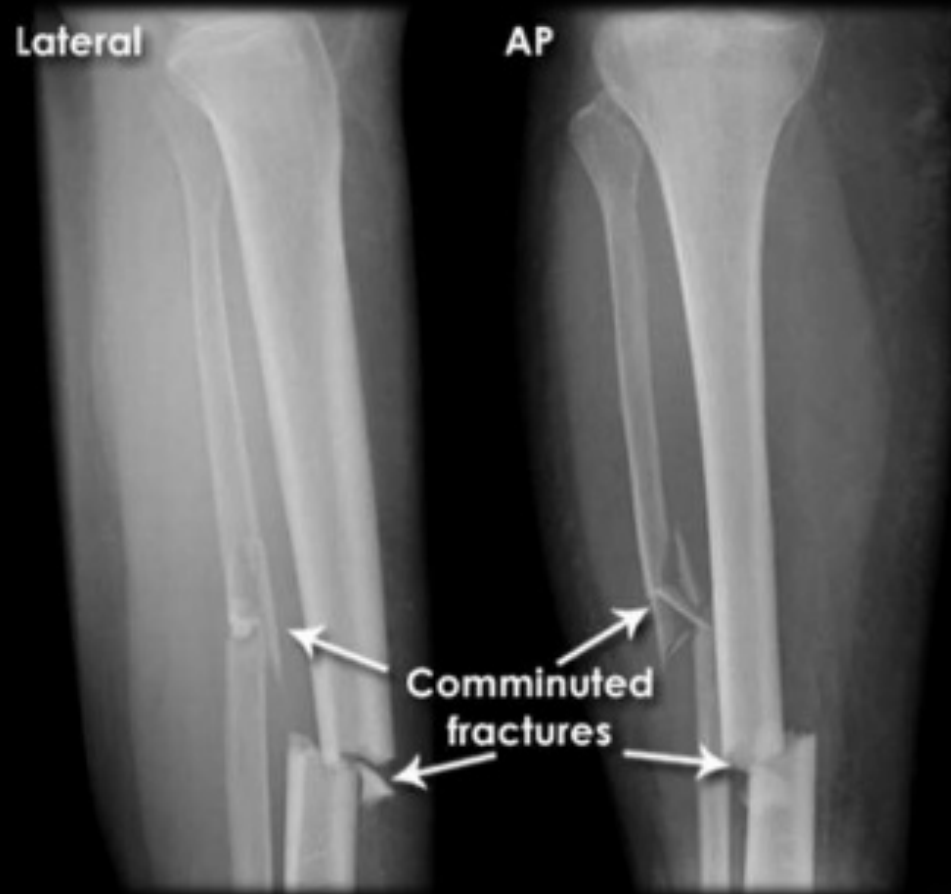
The **type** of fracture, its **level** and the degree of **angulation** and **displacement** are recorded

- **Rotational** deformity can be gauged by comparing the width of the tibio-fibular interspace above and below the fracture





- **Comminuted fractures of the tibial and fibular shafts with medial displacement and posterior angulation**
- **X-rays of the distal end of the bones (not shown) did not reveal further injury**



# Treatment

The behavior of these injuries – and therefore the choice of treatment – depends on the following factors:

1. The state of the soft tissues
2. The severity of the bone injury
3. Stability of the fracture
4. Degree of contamination

## ***1. The state of the soft tissues :***

- The risk of complications and the progress to fracture healing are directly related to the **amount and type of soft-tissue damage.**

## Gustilo Classification of Open Fractures<sup>6</sup>

Type	Description
I	Clean wound <1 cm in length
II	Clean wound >1 cm in length without extensive soft-tissue damage, flaps, or avulsions
IIIA	Adequate soft-tissue coverage despite extensive soft-tissue damage, flaps, or high-energy trauma irrespective of the wound size
IIIB	Inadequate soft-tissue coverage with periosteal stripping, often associated with massive contamination
IIIC	Arterial injury requiring repair

## 2. *The severity of the bone injury*

- **High-energy fractures** are more damaging and take longer to heal; this is regardless of whether the fracture is open or closed. Usually caused by direct trauma and tend to be open (**Gustilo III A–C**), **transverse or comminuted**.
- **Low-energy breaks** are typically closed or **Gustilo I or II**, and **spiral**.

### **3. *Stability of the fracture***

- Will it displace if weight-bearing is allowed?
- Severely comminuted fractures are the least stable and the most likely to need mechanical fixation.

### **4. Degree of contamination**

In open fractures this is an important additional variable.

- **The main objectives are:**

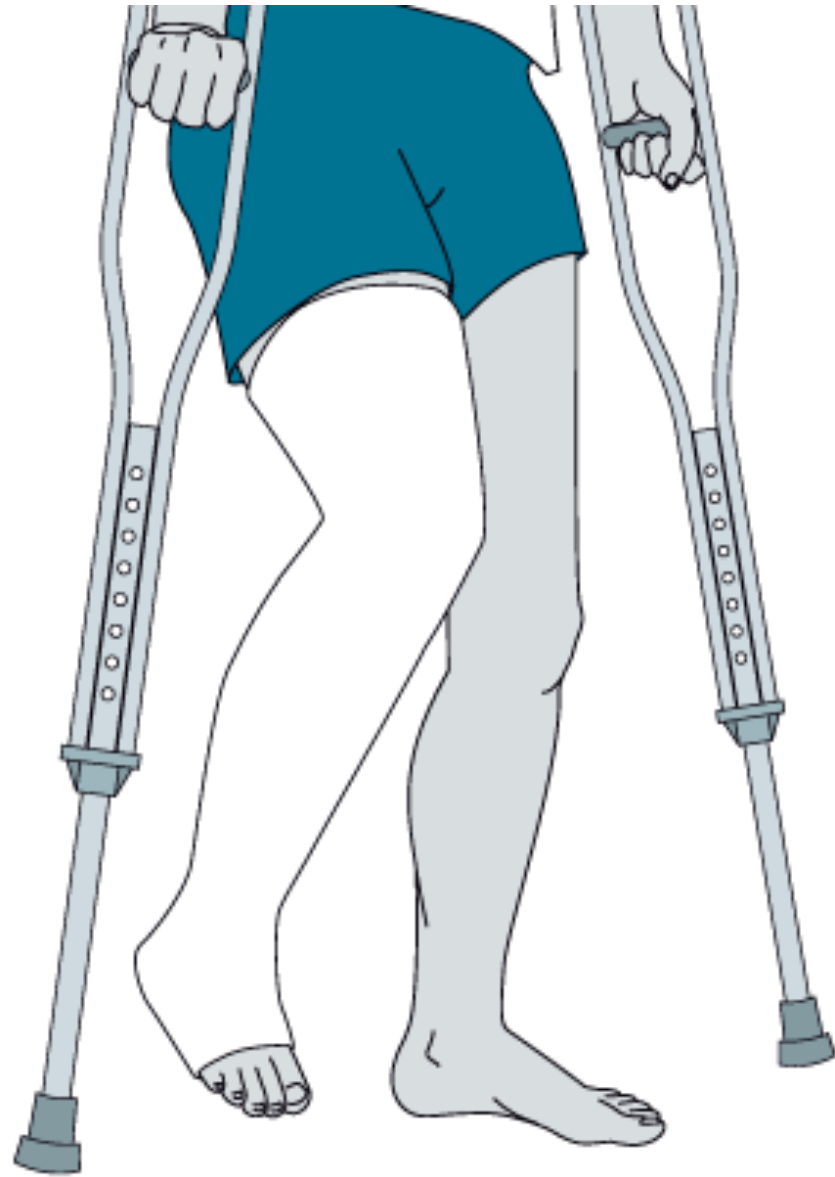
1. To limit soft-tissue damage and preserve (or restore, in the case of open fractures) skin cover.
2. To prevent – or at least recognize – a compartment syndrome.
3. To obtain and hold fracture alignment.
4. To start early weight-bearing
5. To start joint movement as soon as possible.

# Treatment

- **Low energy fractures:**

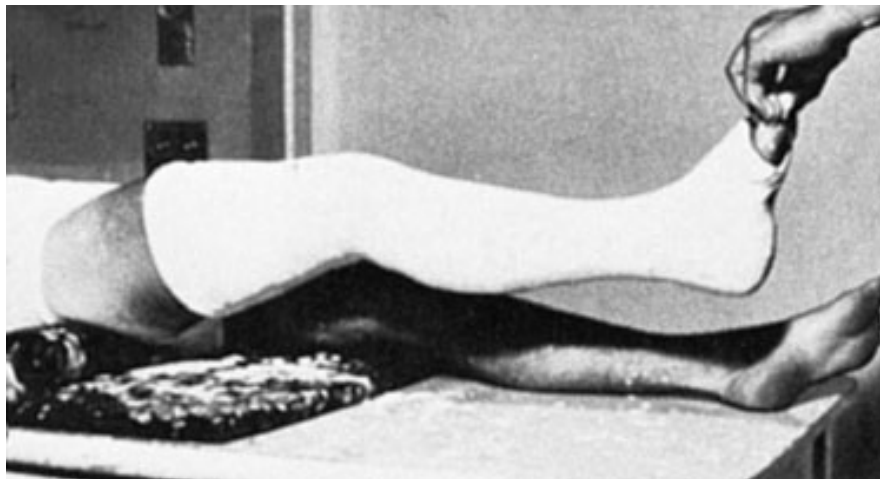
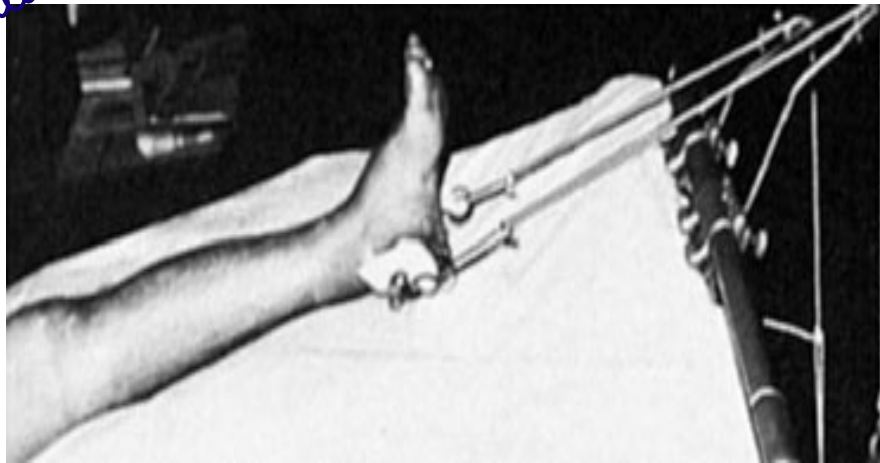
- If the fracture is ***undisplaced or minimally displaced*** ? a **full-length cast** from upper thigh to metatarsal necks is applied with the **knee slightly flexed and the ankle at a right angle**. The fracture must be axially stable to permit weight-bearing through the cast
- ***A displaced fracture*** needs reduction under general anaesthesia with x-ray control before cast application. After cast application and stabilization of fracture weight-bearing is applied
- Needs 8 weeks to unite in children, seldom under 18 weeks in adults





32.9 Fractured tibia and fibula – closed treatment (a) Skeletal traction is used to reduce any overlap, and also as a provisional treatment when skin viability is doubtful. (b) After 10–14 days, a long-leg plaster cast is applied. This method is generally more suited to low-energy fractures where the initial displacement is slight and the soft tissues are well preserved. (c) X-rays showing the position before and after fracture union.

*Traction to prevent overlap*



# Treatment

- **High-energy fracture:**

1. The most important consideration initially is the viability of the damaged soft tissue and underlying bone.

Tissue around the fracture should be disturbed as little as possible, and open operations should be avoided unless there is already an open wound

the risk of compartment syndrome is maximum in first 48 hours

**2. External fixation for stabilization**, intramedullary nailing is an alternative, but may be difficult

# Treatment

- **Open fractures:**

Because of risk of deep infection and chronic osteomyelitis :

- 1. Antibiotics, analgesia , antitetanus (3As)**

(cephalosporin with an aminoglycoside to cover both gram positive and negative bacteria, metronidazole is added if there is soil contamination)

- 2. Debridement( in operating theater, with plastic surgeon so that wound extensions don't compromise skin flaps for bone cover, exposed bone is preferably covered within 5 days)**

- 3. Stabilization(external fixation is favored for the more severe injury)**

- 4. Soft-tissue cover**

- 5. Rehabilitation**

# Complications

**Early :**

## **1- Vascular injury :**

Fracture of proximal half of the tibia may damage the **popliteal artery**. This is an emergency requiring **angiograms, exploration and repair**

## **2- Compartment syndrome:**

Tibial fractures (both open and closed) and intramedullary nailing are the commonest causes of compartment syndrome in leg. Decompression by open **fasciotomy**

## **3- Infection:**

Open fractures are always at risk even if small perforation. Debridement should be carried out before wound is closed

# Complications

**Late:**

## **1-Malunion:**

Slight shortening (up to 1.5 cm). Angulation should be prevented at all stages. The normal ankle compensate more readily for a valgus deformity than for a varus one; however, anything more than  $7^{\circ}$  in either plane is unacceptable

Malunion nearer the ends of the tibia is more likely to lead to early osteoarthritis

Deformity if marked should be corrected by tibial osteotomy

## **2-Delayed union and non-union:**

Occurs in high-energy fractures, and fractures associated with bone loss or deep infection. Bone grafting may solve some 'slow' unions; in others, a different mode of fixation is needed

# Complications

## **3-Joint stiffness:**

Prolonged cast immobilization causes stiffness of ankle and foot, may persist for 12 months or longer in spite of active exercises. Can be avoided by changing to a functional brace as soon as it is safe to do so, usually 4-6 weeks

**4-Complex regional pain syndrome** (algodystrophy): is a **chronic** (lasting greater than six months) pain condition , and is believed to be caused by damage to, or malfunction of, the peripheral and central **nervous** systems.

Common with distal-third fractures

Exercises should be encouraged throughout the period of treatment