PRE & POST-OPERATIVE RADIOLOGICAL ASSESSMENT IN TOTAL KNEE REPLACEMENT

Dr. Divya Rani K
2nd Year Resident
Dept. of Radiology

PRE-OPERATIVE ASSESSMENT

RADIOGRAPHS

- Radiographs are used for assessment and templating of the knee prior to surgery.

- The recommended radiographs for the evaluation of a painful knee are
  - AP 45 degree weightbearing
  - Orthoroentgenogram or Scanogram
  - Recumbent lateral 30 degree flexion
  - sky-line (Merchant view with the knee flexed 45 degrees)

AP Radiograph of the knee

- The AP view should be obtained with the patient in a standing position.

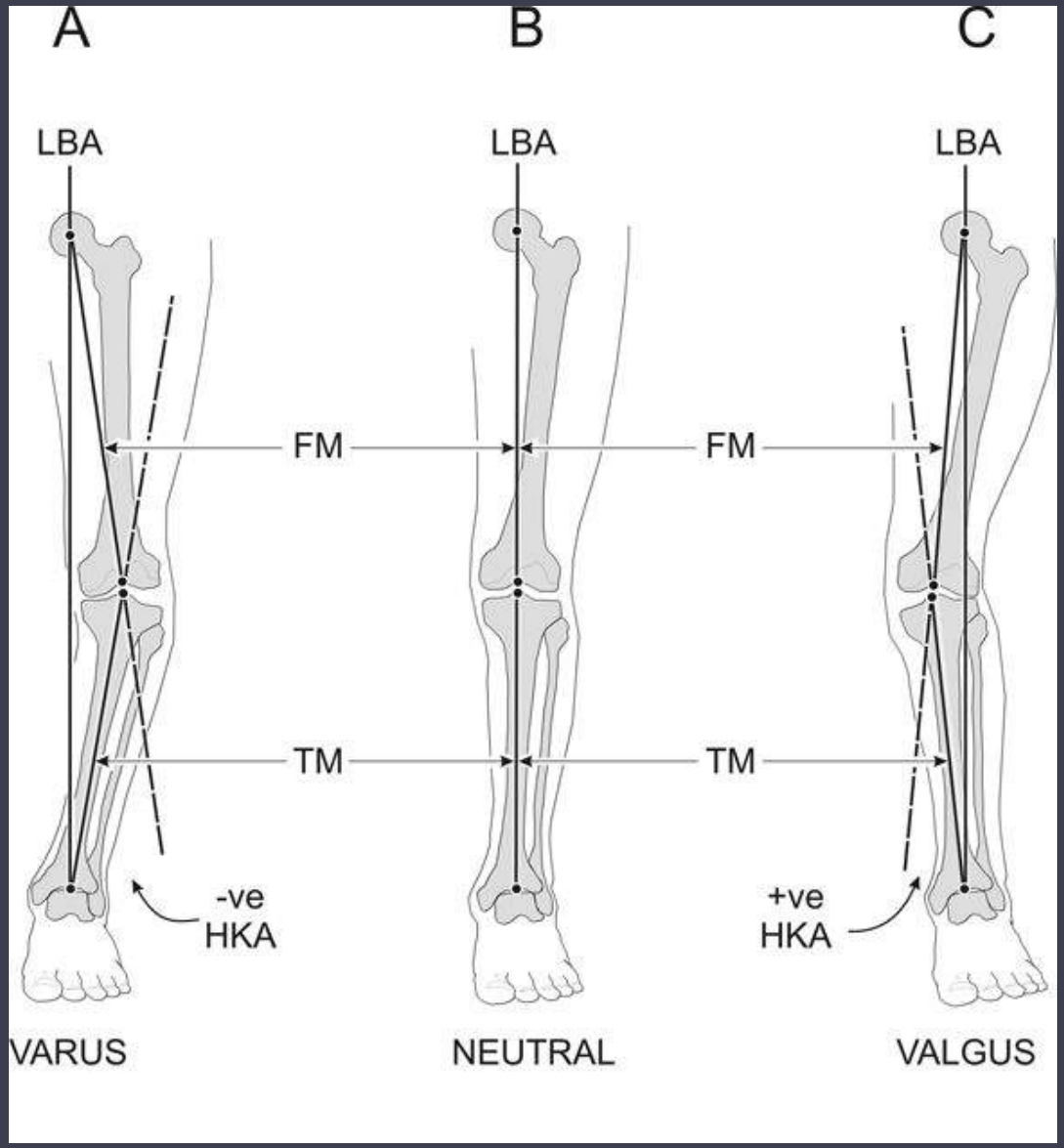
- Anterior posterior views allows determination of
  - Medial and lateral joint spacing
  - Articular surfaces of the medial and lateral joint compartments
  - Femorotibial alignment

Advanced Osteoarthritis

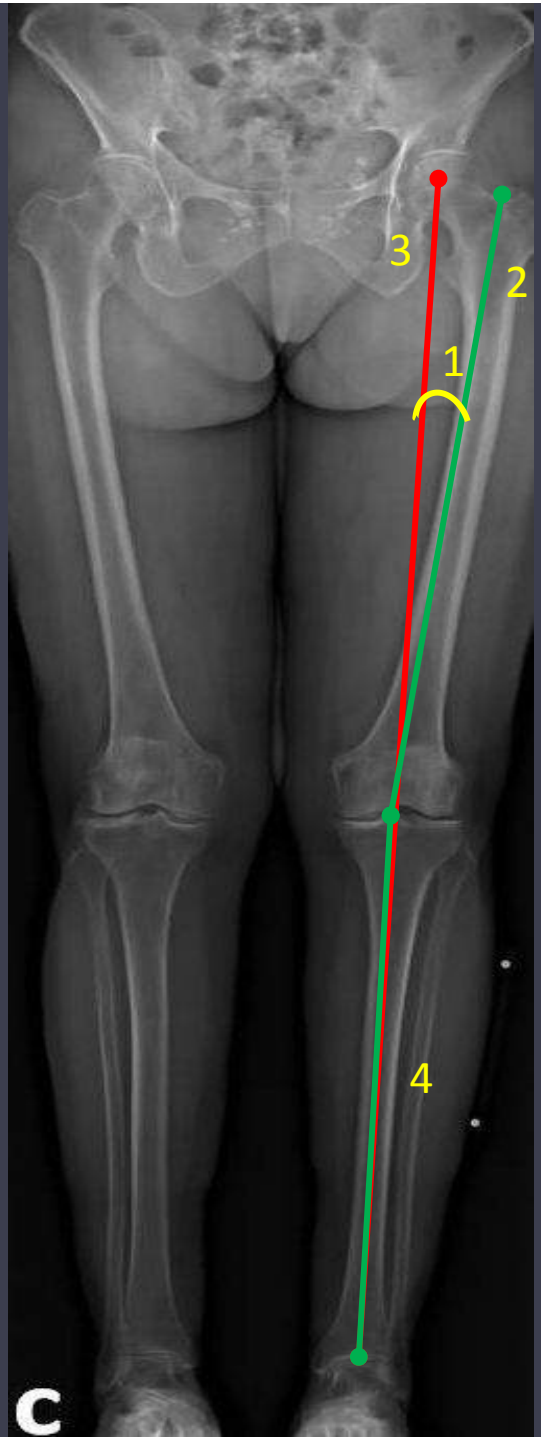
Post traumatic Osteoarthritis

Standing orthoroentgenogram (52-inch casette three joint view) or Scanogram

- Standing AP view of the lower extremities taken from hips to ankles.
- It is used in preoperative assessment of overall alignment (mechanical axis) of the lower extremity. The knee is normally in 7 degree of valgus alignment on AP view.
- It is also used to evaluate anatomic leg length and calculate leg-length discrepancies.



- A. Varus alignment: knee center is lateral to the LBA (HKA is negative)
- B. Neutral alignment: knee center is located on the LBA (HKA = 0°); femoral and tibial mechanical axes are colinear.
- C. Valgus alignment: knee center is medial to the LBA (HKA is positive).



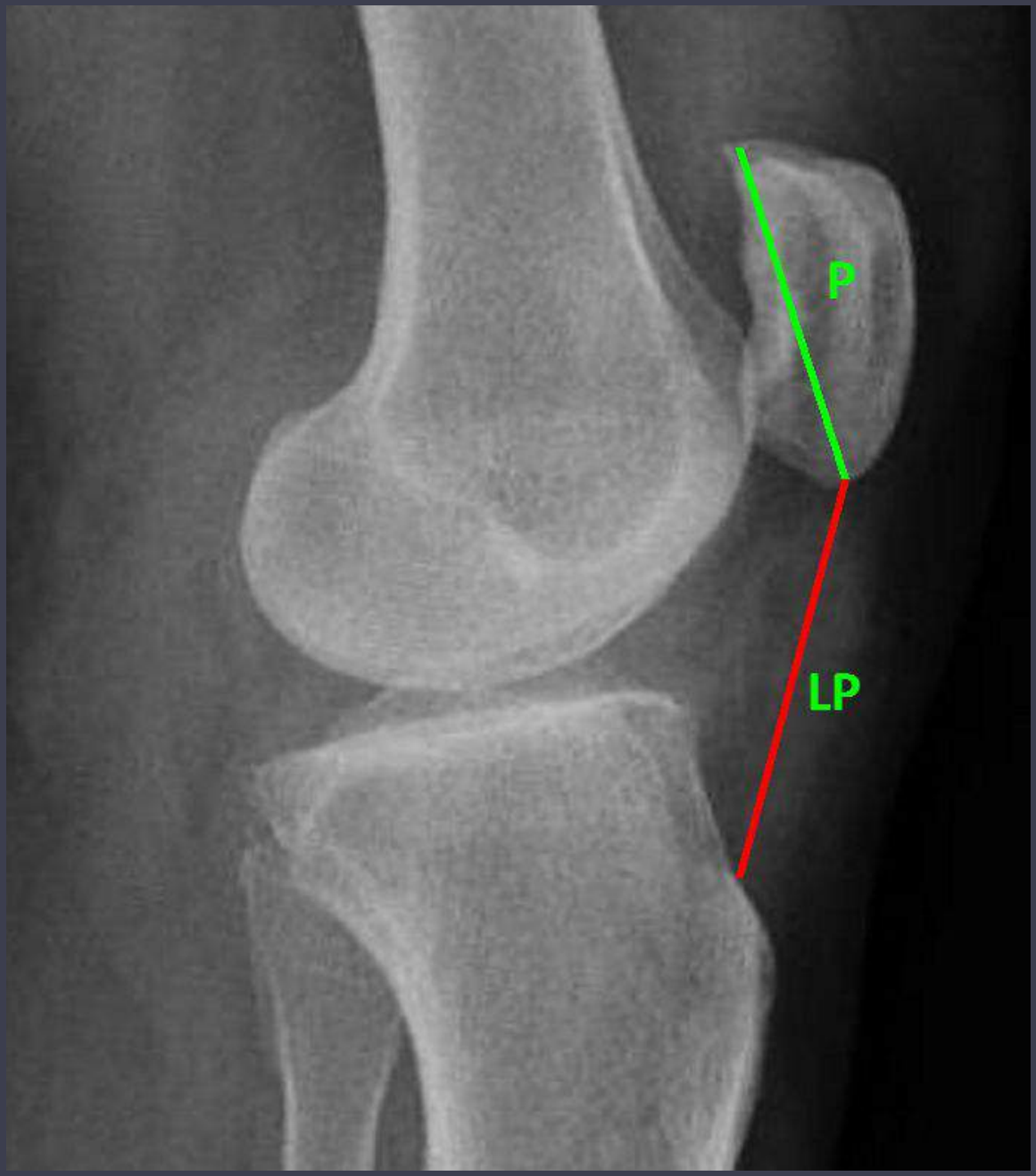
(1) Angle between anatomical (2) and mechanical (3) axes of femur

(4) Mechanical axis of tibia

Lateral radiograph of the knee

- Patellar height should be assessed on this view using Insall-Salvati ratio. The Insall-Salvati is the ratio of the patellar tendon length (LT) to the length of the patella (LP). The values above 1.2 is considered as “Patella Alta”, while the values belove 0.8 is considered as “Patella baja”.

- Suprapatellar and posterior regions must be evaluated in terms of detecting the loose bodies.


P
LP

Patella alta

Patella baja

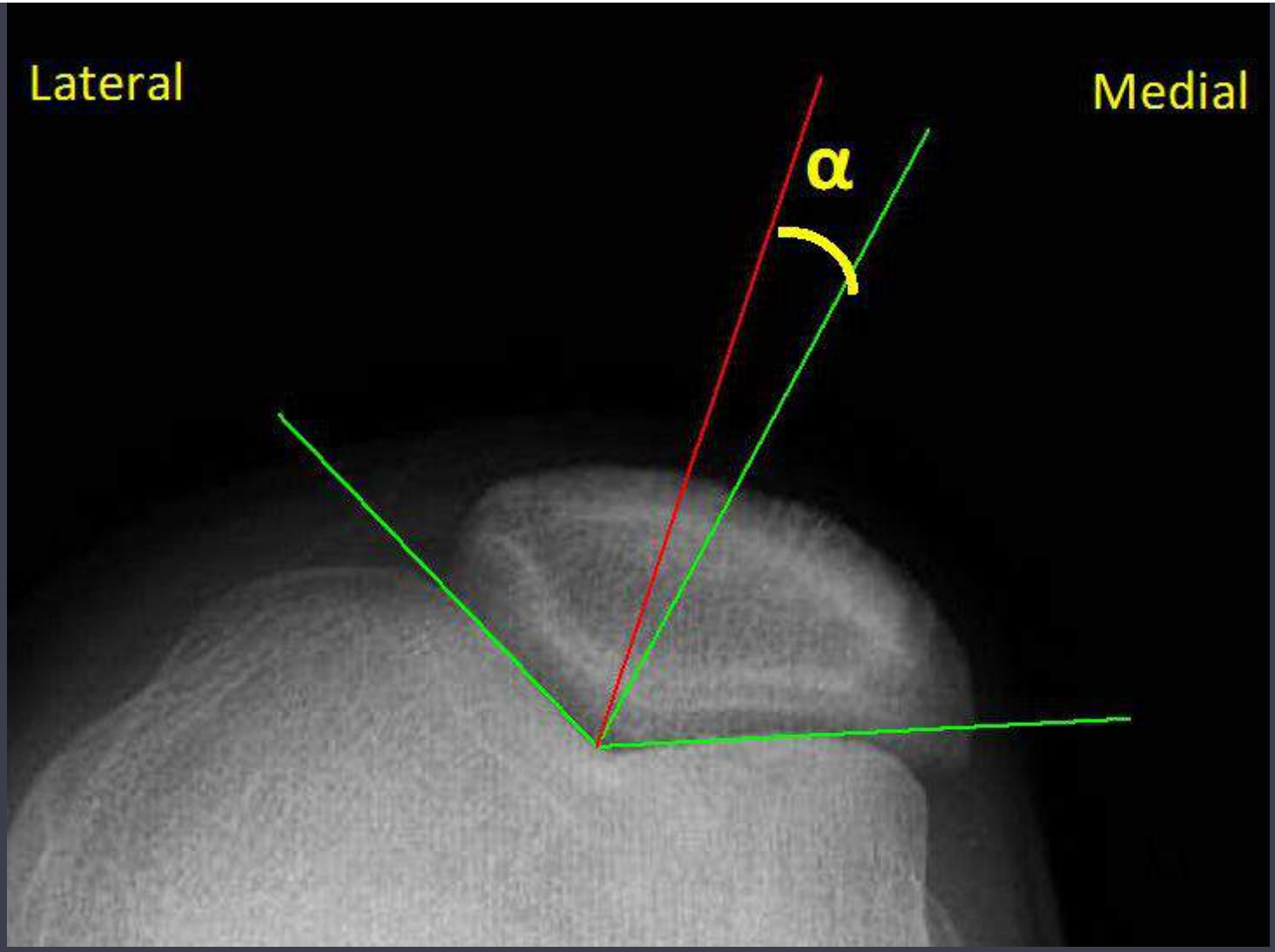
- The lateral view may also allow size selection of the femoral component.

Proper size of the femoral component is assessed via evaluation of the pre-operative lateral radiographs.

Merchant view

- Merchant view helps to assess the patellofemoral alignment, trochlear grove and articular surfaces. Preoperatively patellar subluxation seen on this view alerts the surgeon for lateral release of the patella during TKR.

- Subluxation can be assessed by measuring the congruence angle. Congruence angle demonstrates the relationship of apex of patella with the trochlear groove's bisector. Two lines are drawn to measure the congruence angle. First line is the bisector line of femoral sulcus angle and it establishes a zero reference line. Second line is drawn from the apex of the sulcus angle to the lowest point of the patellar articular ridge.



The congruence angle (α) lower than 16° to lateral or medial direction is considered as normal.

If congruence angle is lateral to the reference line this means the angle is positive while angles medial to the reference lines are considered as negative.

MRI

- MRI is used to asses the Meniscal and Ligament integrity.
- The recommended sequences are
  - T1 weighted Fat supressed spoiled gradient-echo technique
  - T2 weighted fast spin-echo technique

- MRI helps in defining the avascular lesions of the knee, determining the extent of lesion and integrity of the overlying cartilage.

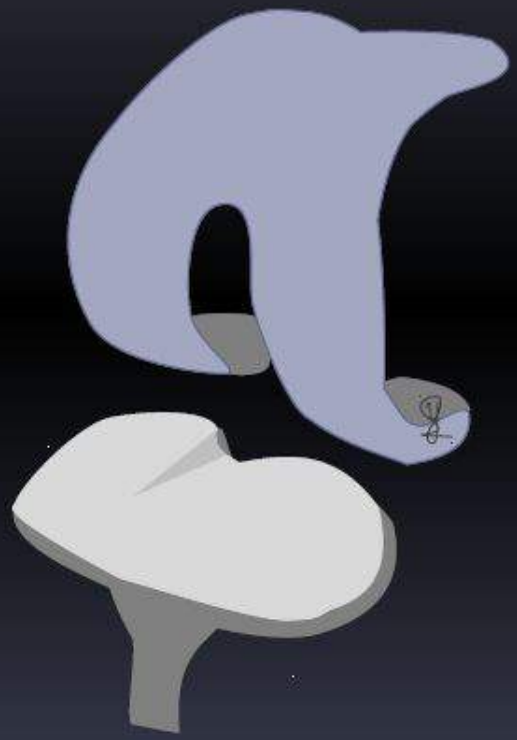
POST-OPERATIVE ASSESSMENT

Knee Prosthesis Design

- Prosthesis may be
  - Unicompartmental
  - Replace all three compartments - Total knee arthroplasty
- May be constrained, partially constrained or non constrained
- Materials
  - Metal alloys – Cobalt Chromium or Titanium
  - Ultrahigh molecular weight polyethylene
  - Polymethylmethacrylate cement
    - Used for fixation of components to bone

Non-Constrained Prosthesis

- Also know as
  - Cruciate retaining prosthesis
  - Posterior cruciate ligament (PCL)-Sparing prosthesis
- Most common type
- Femoral and tibial components are not linked
  - Patient's ligaments, tendons and muscles help maintain stability
- Grove in posterior aspect of tibial component to accommodate PCL



Radiographs
Non-Constrained Prosthesis

Semi-Constrained Prosthesis

- Sacrifice the PCL
- More stable than a non-constrained prosthesis
- Femoral and Tibial components are linked
    - Central box like hole between condyles of femoral component
    - Tibial component has central anterior polyethylene tibial spine
    - Tibial spine inserts into the hole
    - Transverse posterior cam in femoral component
        - Prevents posterior subluxation of tibia

Radiographs
Semi-Constrained Prosthesis

Walls (arrow) of central box-like hole in femoral component allows for distinction between semi-constrained and non-constrained prostheses on radiographs

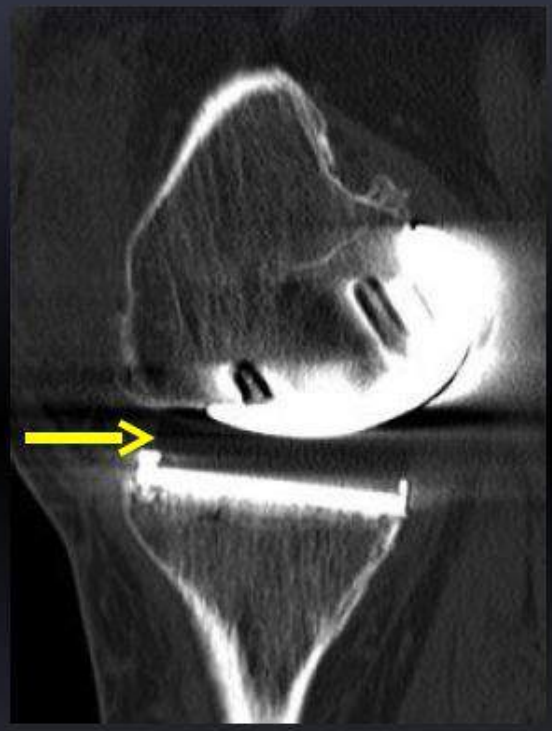
Constrained Prosthesis

- Femoral and tibial components linked
  - Hinged mechanism
- Usually as revision arthroplasty
- In elderly with highly unstable knees
- With tumor resection surgery
- Higher amount of mechanical stress on components
- Shorter life than less constrained prosthesis

Unicompartment Arthroplasty

- Resurfacing of one compartment
- Usually for isolated medial compartment disease
- ACL and PCL preserved
- Lack of ACL is a relative contraindication
- Maybe fixed or mobile

Unicompartment Arthroplasty



- CT images of unicompartment prosthesis
- Note lucent polyethylene spacer (arrows)

Unicompartment Arthroplasty

- Patellofemoral arthroplasty
  - May be considered in patients with trochlear dysplasia or patellofemoral malalignment
  - May need revision to TKA with progression of femorotibial osteoarthrosis

Radiographic Evaluation

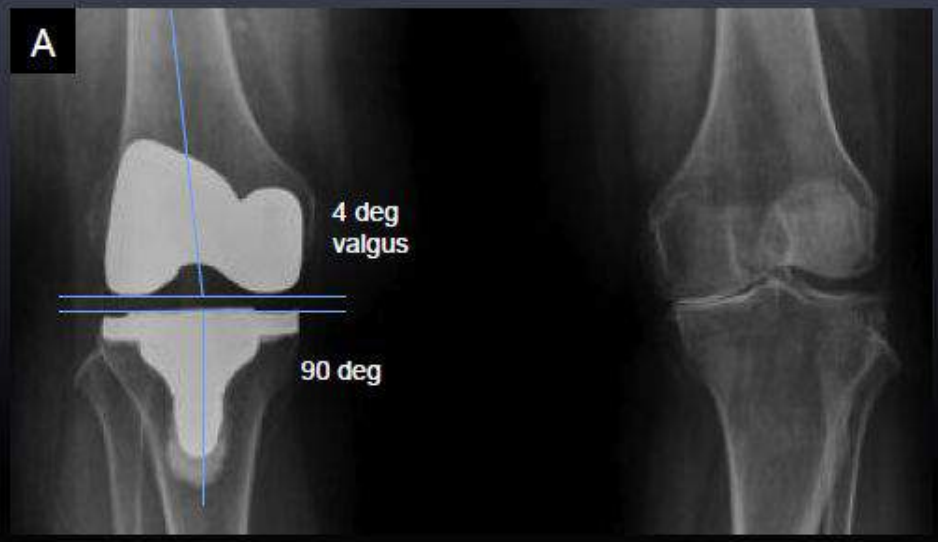
- Radiography most cost effective and common method of follow up
- Baseline
  - Immediate post operative portable
  - AP and lateral views
- Follow up studies
  - May be yearly
  - Standing AP views of both knees
  - Lateral of post operative knee
  - Merchant view
  - Include entire components on AP and lateral views

- Mechanical Axis on three joint view
  - Line drawn from center of femoral head to center of tibiotalar joint
  - Line should pass through center of knee prosthesis

Alignment

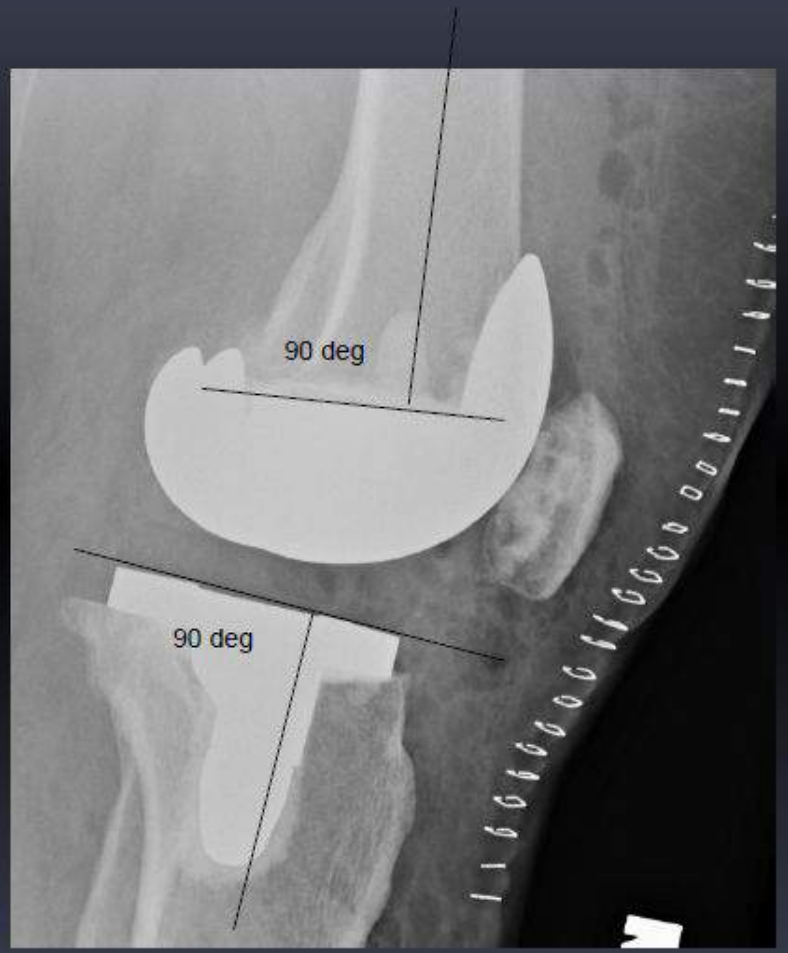
- AP view
  - A: Both knees should be at same level on weight bearing radiographs
  - B: Joint spaces at different levels

    Femorotibial joint space should be uniform medially and laterally
    - May depend on position
  - Femoral component normal = 7 ± 3 deg in valgus to long axis of femur (A)
  - Tibial tray normal = 90 ± 3 deg to long axis of tibia (A)



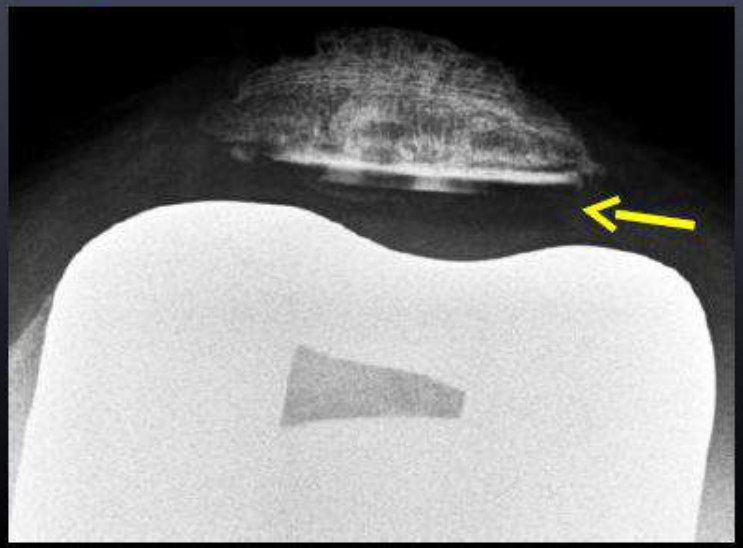
Alignment

- Lateral View
  - Horizontal portion of femoral component is 90 ± 3 deg to femoral long axis
  - Tibial tray perpendicular to long axis of tibia or up to 5 deg posterior tilt



Patellar Component

- Merchant View
  - Patellar component (arrows) centered over trochlea
  - Metal backed high density polyethylene in this case

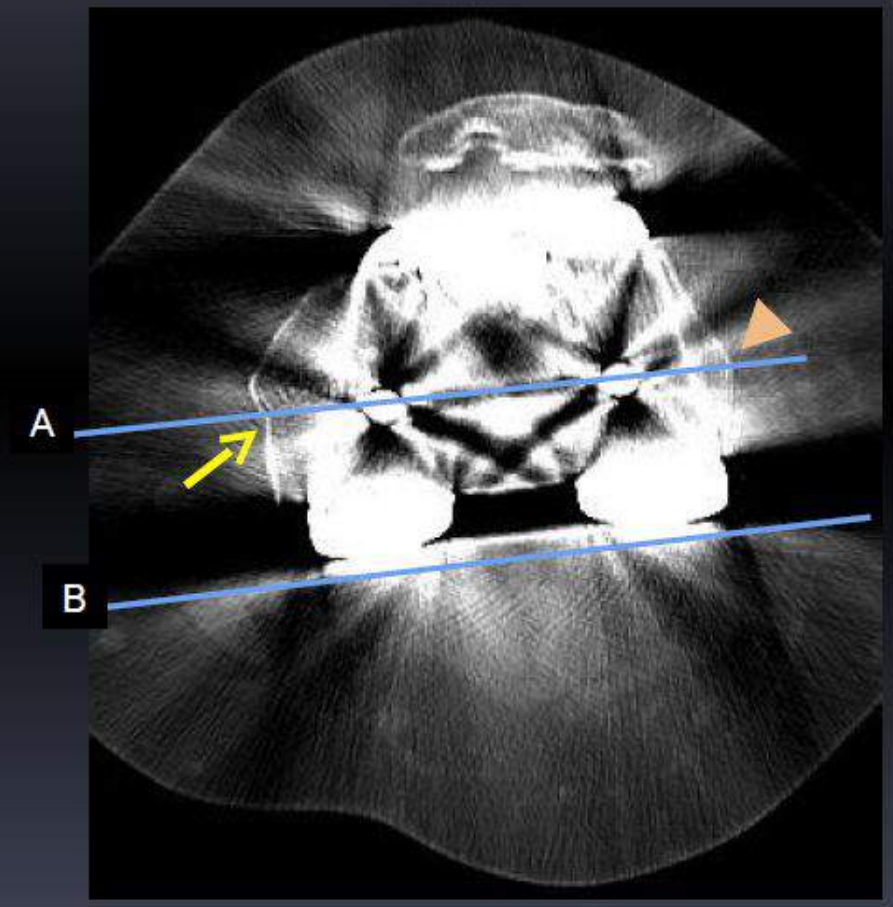


Rotational Malalignment

- CT more accurate
- May be indicated in patients with chronic pain after TKA
- Usually associated with internal rotation of components
  - More commonly the tibial component
  - Leads to patellar dislocation, subluxation or tilt
- Results in wear of components and failure
- Patients have anterior knee pain
- CT - Axial images obtained with knee in extension

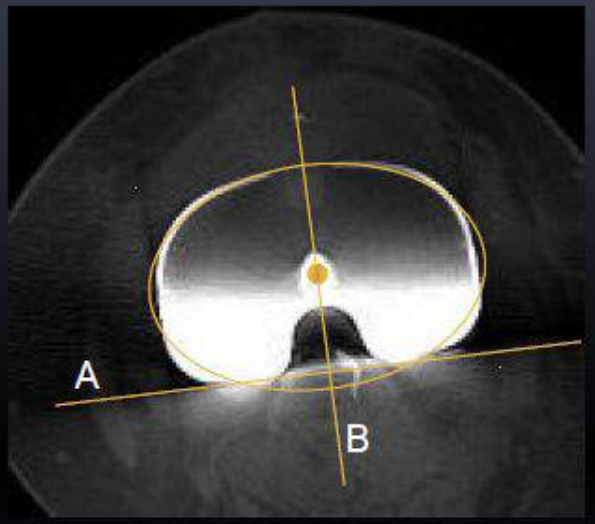
Rotational Malalignment

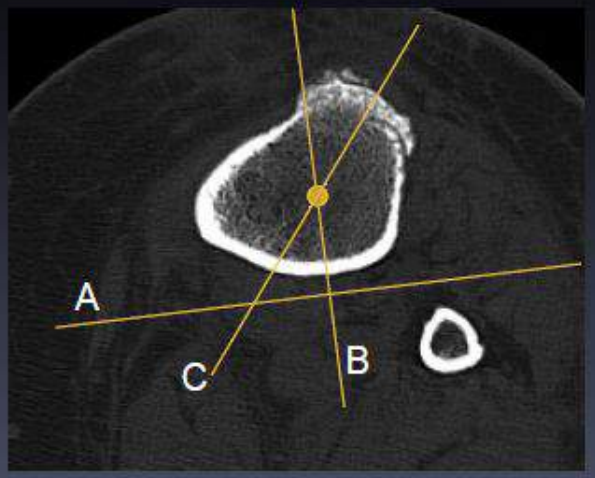
- Femoral component rotation
  - A: Line from medial sulcus (arrow) of medial epicondyle to lateral epicondylar prominence (arrowhead)
  - B: Line along posterior aspect of femoral condyles
  - Posterior condylar angle = Angle between lines A and B
- Normal posterior condylar angle
  - Females = 0.3 ± 1.2 deg internal rotation
  - Males = 3.5 ± 1.2 deg internal rotation



Rotational Malalignment

- Tibial component rotation
  - Center of tibial plateau determined = center of best fit ellipse around tibial component
  - Line A = along posterior aspect of tibial tray
  - Line B (perpendicular to Line A) = tibial component axis
  - Transpose center of tibial plateau to axial image through tibial tubercle
  - Transpose line B to image through tubercle
  - Line C = Line from transposed center to tibial tubercle = Tibial tubercle axis
  - Angle between line B and C is the degree of rotation
  - Normal angle = 18 deg internal rotation





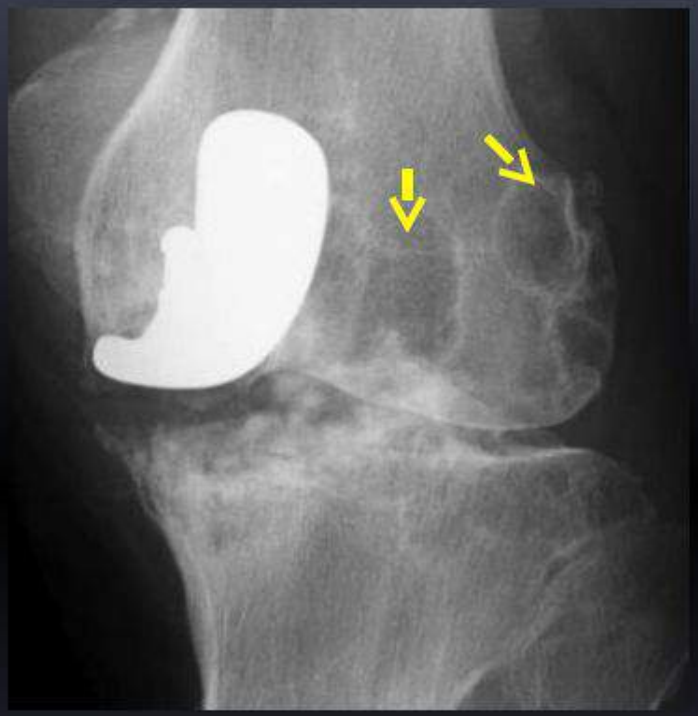
Complications

- Polyethylene wear
- Aseptic Loosening
- Osteolysis due to particle disease
- Instability
- Patellar maltracking
- Infection
- Fractures
- Heterotopic Ossification
- Malalignment
- Dislocation
- Chronic Regional Pain Syndrome

Polyethylene Wear

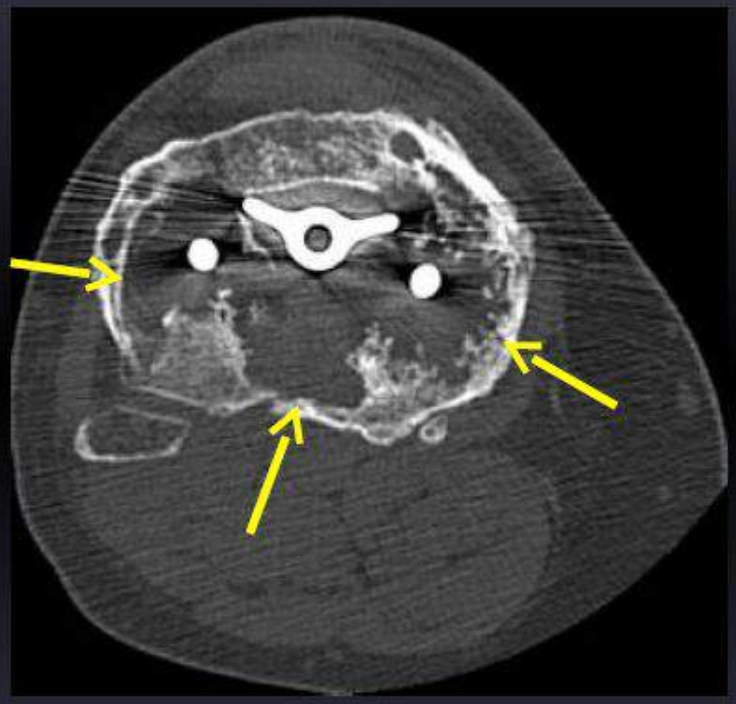
- Most prevalent cause of eventual prosthesis failure
- Wear of liner creates debris and stimulates foreign body reaction
- Leads to synovitis and osteolysis
- With progressive wear asymmetric joint space narrowing
- Eventual metal on metal contact
- Note fragmented tibial component and subsidence (arrow) resulting from polyethylene wear in this patient

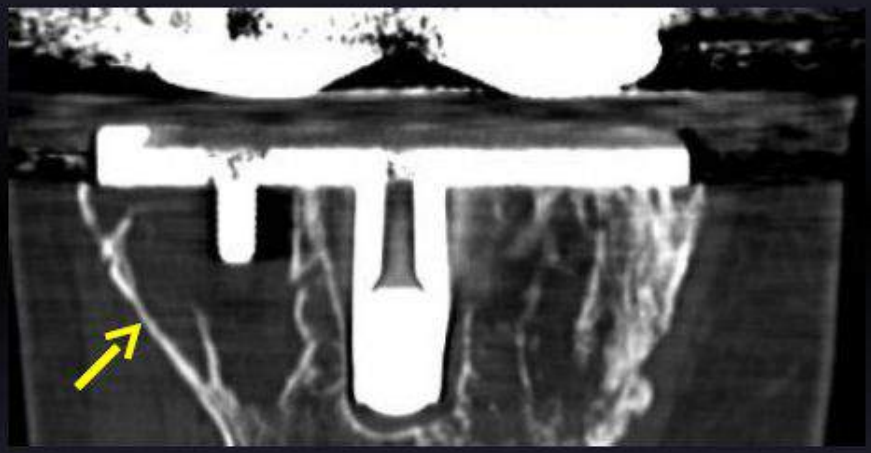
Osteolysis



- Response to small particle debris from the implant, especially polyethylene liner
- Multinucleated giant cells and macrophages create a granulomatous reaction
- Results in osteolysis (arrows)
- AKA – Particle disease
- Arthrocentesis and laboratory studies may help exclude infection

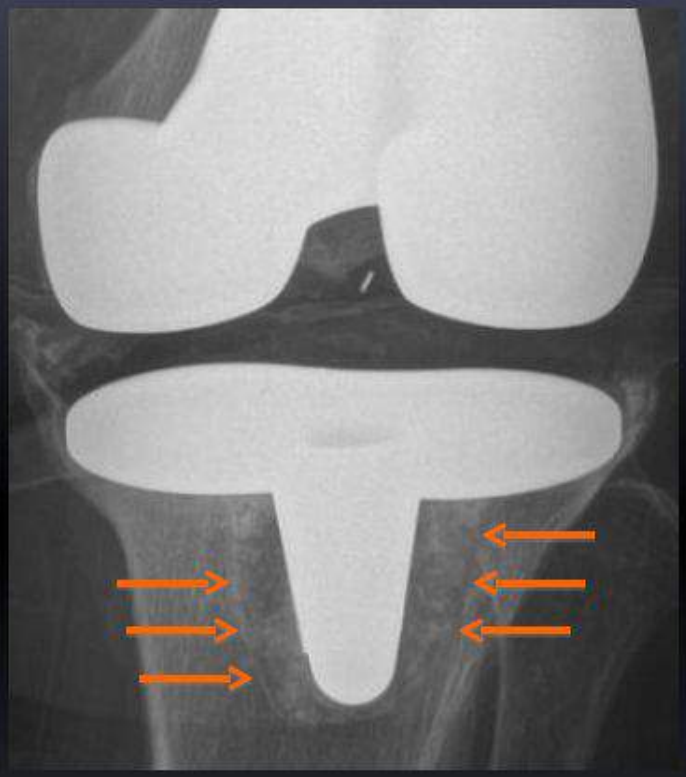
Particle Disease





- CT images showing areas of osteolysis in the proximal tibia around the tibial component (arrow)

Aseptic Loosening

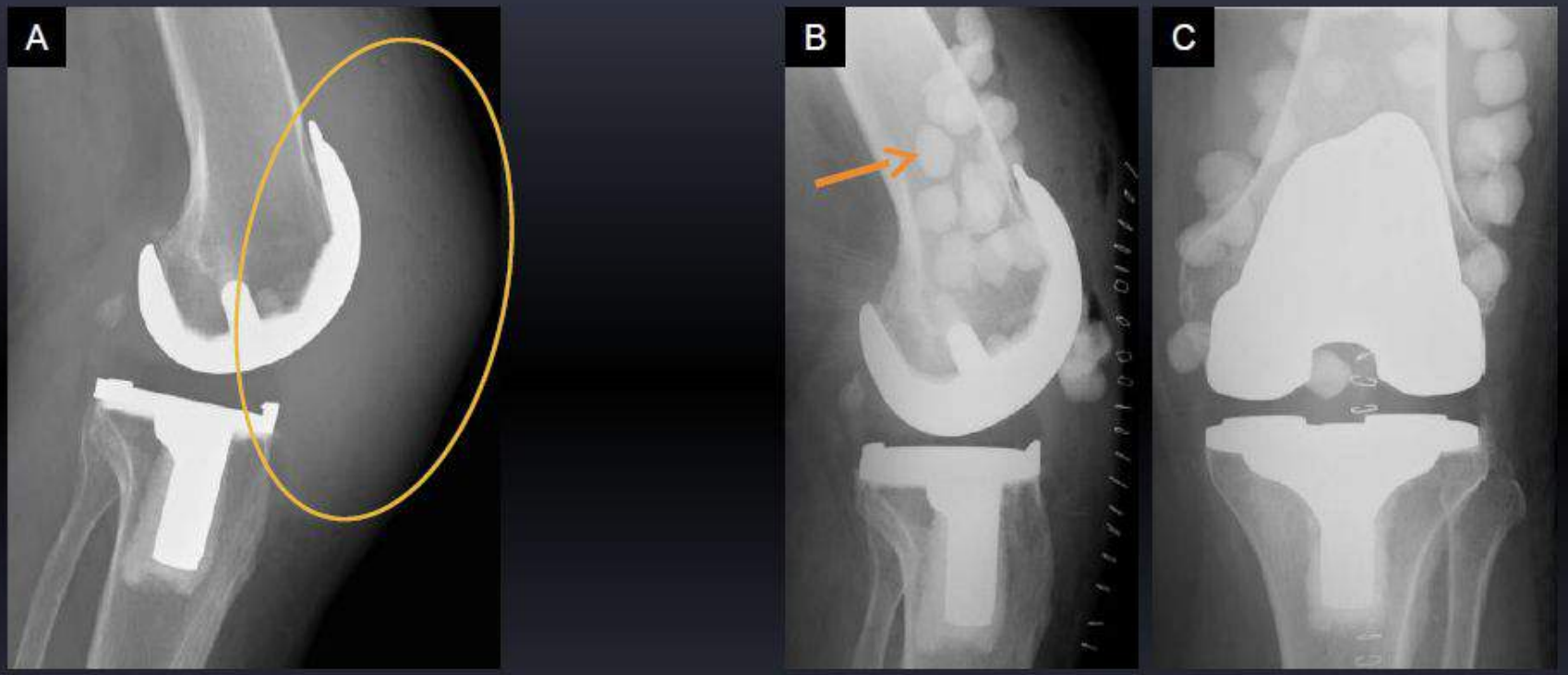


- Failure of bonding between prosthesis and bone without infection
- Progressive widening of lucent region around prosthesis (arrows) greater than 2mm is abnormal
- Uniform lucency less than 2mm may occur within 1-2 years of TKA and remains stable
- Need to exclude infection
- Progresses to subsidence (arrowhead) or migration of components

Infection

- Patients may present with
  - Soft tissue swelling
  - Erythema
  - Pain
  - Joint effusion
- Radiographic findings
  - Periprosthetic lucency similar to loosening but irregular
  - May appear similar to osteolysis of particle disease
  - Possible effusion
  - Periosteal change
- MRI with STIR imaging or ultrasound may help in detecting an abscess around an infected TKA
- Note focal lucent region around femoral component (arrow) due to infection in this patient

Infection

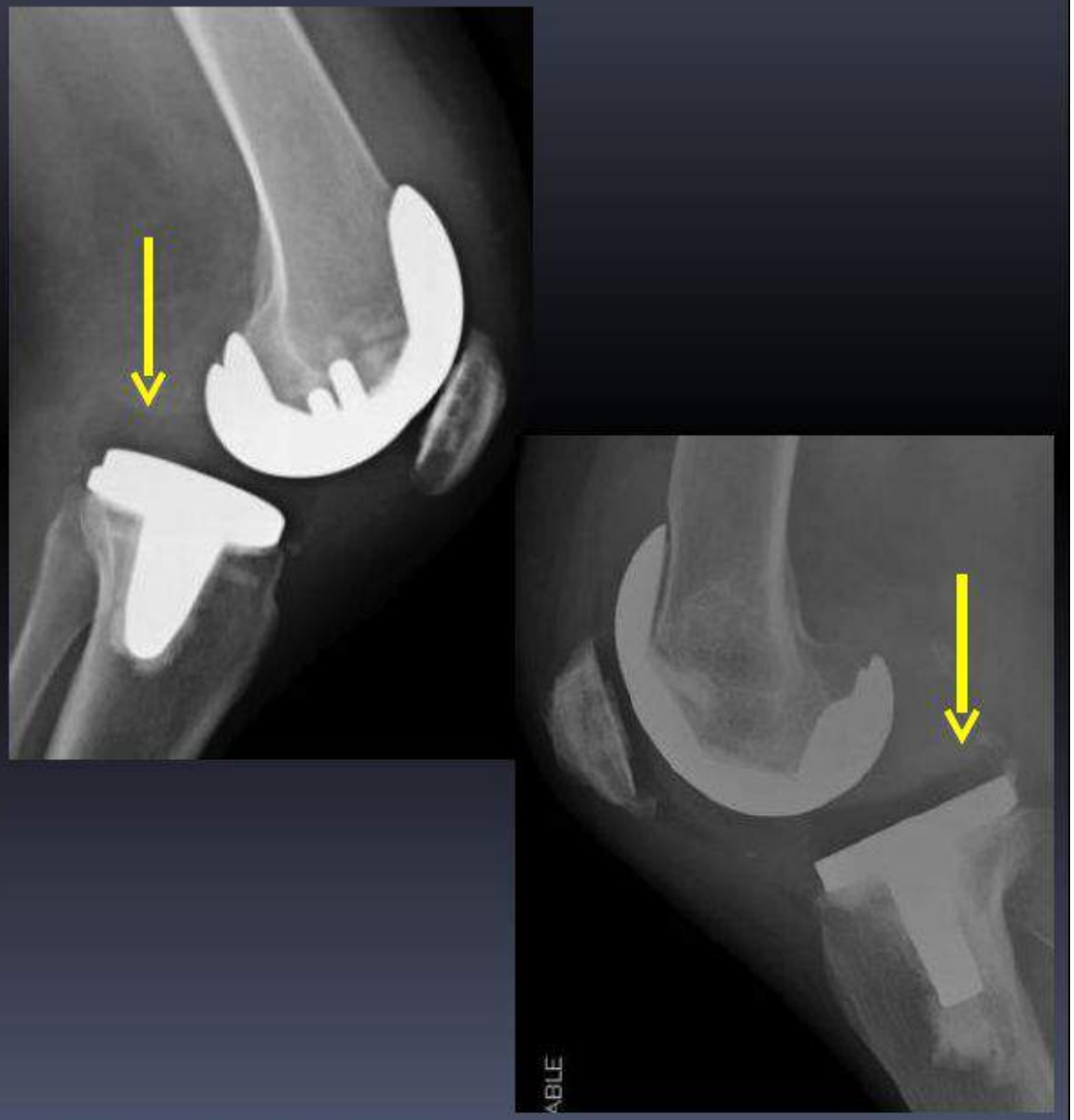


A: Note anterior soft tissue swelling and small pockets of gas (oval) in a patient who had patellar dislocation due to quadriceps tendon rupture. Patella was resected.

B-C: Antibiotic laden beads (arrow) placed after debridement

Instability

- Causes
  - Malalignment of prosthesis
  - Incompetent ligaments
  - Extensor mechanism failure
  - Incorrect choice of prosthesis
  - Surgical error
- Subluxation or dislocation
  - Note posterior subluxation of tibia (arrows) in two different patients with non constrained TKA due to incompetent PCL

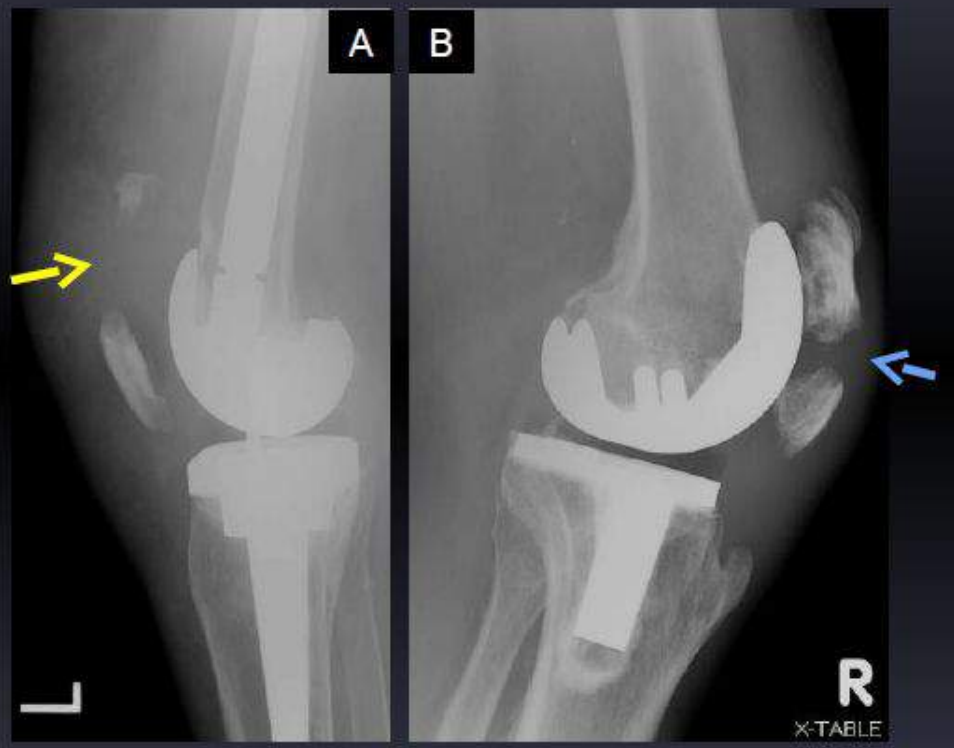


Patellar Dislocation

- Causes of patellofemoral dysfunction
  - Malalignment of components
  - Ruptured quadriceps or patellar tendons
  - Patellar fracture
  - Osteonecrosis of patella
  - Component failure
- Metal backed patellar components have higher failure rates than polyethylene backed components
- Patellar dislocation (arrow) in patient with incompetent extensor mechanism

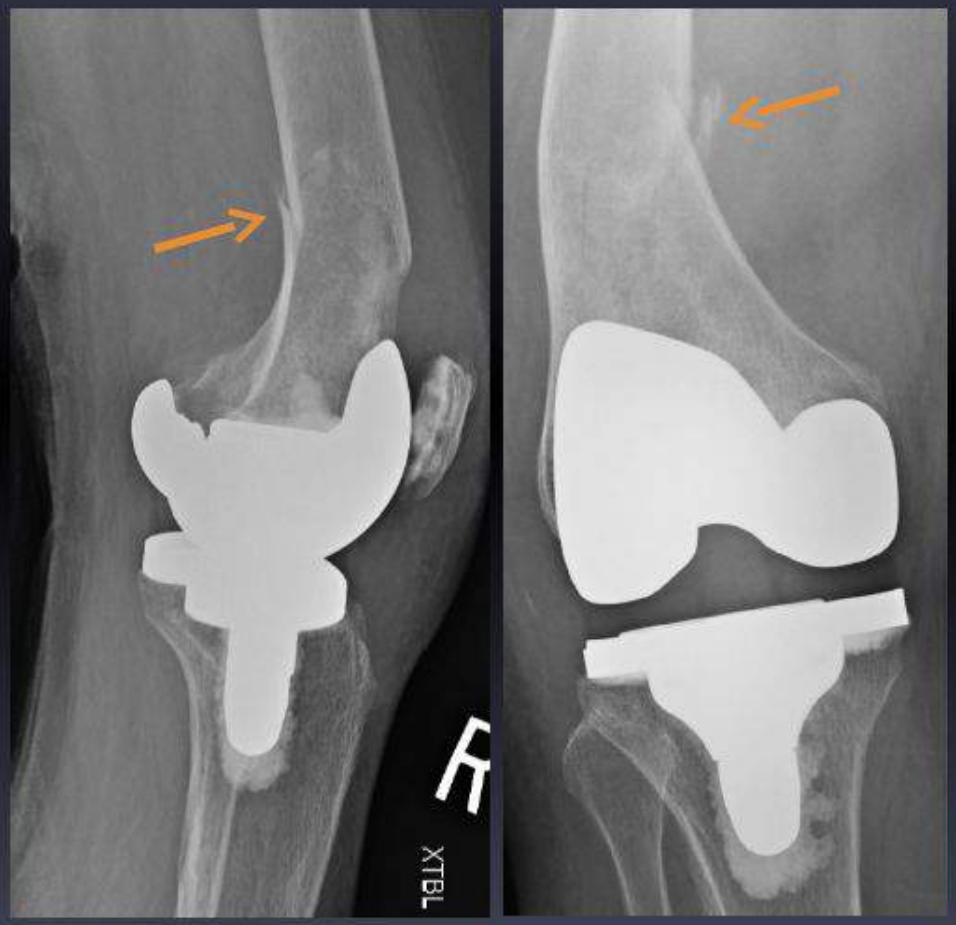
Extensor Mechanism Failure

- A: Avulsion of superior pole of patella and proximal migration due to quadriceps tendon (arrow) injury
- Ultrasound is useful in quickly assessing integrity of the quadriceps tendon
- B: Patellar fracture (arrow)



Fracture

- Causes of fractures include
  - Osteopenia
  - Weakened bone due to osteolysis
  - Elderly patients with increased risk of fall
  - Stresses due to malalignment of prosthesis
  - Long stem prosthesis cause greater stress on bone and increase risk of insufficiency fractures
- Fractures of Femur > Patella > Tibia
- Note femoral fracture proximal to the prosthesis in this patient



Heterotopic Ossification

- Common post operative change
- Often along anterior aspect in the quadriceps tendon or muscles
- May cause pain or snapping
- Note islands of ossification (arrows) along the quadriceps tendon in this patient who also has a femoral fracture

Arthrodesis

- When all types of knee prosthesis fail patients may go on to arthrodesis

Summary

- Number of knee arthroplasties being performed each year is increasing
- Newer prostheses are being designed to improve function and survival rates of implants
- Important for radiologists to understand the design and radiologic appearance of most commonly used prostheses to be able to detect complications at an early stage
- Use of various imaging modalities, arthrocentesis and arthrography may be of benefit in making an early and accurate diagnosis

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Thank You