

# Periprosthetic joint infection (knee)

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## Anatomy & Pathophysiology

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### BONY ANATOMY

- The bones of the knee are the distal femur, the proximal tibia, and the patella [1].
- The medial femoral condyle is larger and projects farther posteriorly and distally than the lateral condyle [4].
- The lateral femoral condyle projects farther anteriorly and is wider in the medial-lateral direction than the medial femoral condyle [4].
- The tibial articular surface slopes 7° to 10° in the sagittal plane [4].
- The medial tibial plateau is larger than the lateral plateau and is concave in its frontal and sagittal planes [4].
- The lateral tibial plateau is smaller and more circular than the medial plateau, concave in the frontal plane and convex in the sagittal plane [4].
- The patella is the largest sesamoid bone in the body, averaging 2.5 cm in thickness [4].
- The patellar articular surface contains a vertical, central ridge that separates the broader lateral facet from the medial facet, and a smaller, more medial facet called the odd facet [4].
- The posterior slope of the tibia is a mean of 10.7° in the medial plateau and 7.2° in the lateral plateau [9].
- The fibular head is located a mean of 1.5 cm distal to the joint line, with a range of 6 to 32 mm [9].

### LIGAMENTS

- The anterior cruciate ligament (ACL) prevents anterior translation and rotation of the tibia on the femur [1].
- The posterior cruciate ligament (PCL) prevents posterior subluxation of the tibia on the femur [1].
- The medial collateral ligament stabilizes the knee to valgus stresses [1].
- The lateral collateral ligament is the main stabilizer against varus stress [1].
- The ACL is composed of 90% type I collagen and 10% type III collagen [4].
- The mean length of the ACL is 33 mm and the mean midsubstance width is 11 mm [4].

- The femoral attachment of the ACL is a semicircular area on the posteromedial aspect of the lateral femoral condyle [4].
- The tibial attachment of the ACL is a broad, irregular, oval-shaped area slightly medial and anterior to the midline between the tibial spinous processes [4].
- The PCL is the largest of the intra-articular ligaments, with an average length of 38 mm and a mean diameter at the midpoint of 13 mm [17].
- The PCL has two distinct bundles: an anterolateral (AL) bundle comprising 85% of the cross-sectional area and a posteromedial (PM) bundle [17].
- The PCL inserts onto a midline depression on the tibia, 10 to 15 mm below the level of the tibial plateaus [17].
- The meniscomfemoral ligaments connect the posterior horn of the lateral meniscus to the intercondylar notch and are thought to be secondary restraints to posterior translation [17].
- The anteromedial bundle of the ACL is tight in knee flexion and the posterolateral bundle is tight in knee extension [9].
- The posterolateral bundle of the ACL is responsible for preventing the pivot-shift phenomenon [9].
- The anterolateral bundle of the PCL is stronger and stiffer than the posteromedial bundle and is tight in knee flexion [9].

## MENISCI

- The menisci are C-shaped fibrocartilaginous disks that provide shock absorption, increase joint congruency, enhance stability, and aid in synovial fluid distribution [1].
- The medial meniscus is firmly attached to the joint capsule along its entire peripheral edge [1].
- The lateral meniscus is attached to the anterior and posterior capsule but has a region posterolaterally where it is not firmly attached [1].
- The medial meniscus has less mobility than the lateral meniscus and is more susceptible to tearing when trapped between the femoral condyle and tibial plateau [1].
- The lateral meniscus is larger than the medial meniscus and carries a greater share of the lateral compartment pressure [1].
- The menisci consist of type I collagen fibers arranged obliquely, radially, and vertically [9].
- Vascular supply to the menisci is derived from the geniculate arteries, which penetrate into 20% to 30% of the peripheral medial meniscus and 10% to 25% of the peripheral lateral meniscus [9].

## VASCULAR AND NERVE ANATOMY

- The blood supply to the knee is formed from an anastomosis around the knee derived from the descending geniculate artery, superior and inferior geniculate arteries, middle geniculate artery, and anterior tibial recurrent arteries [4].
- The middle geniculate artery supplies both the anterior and posterior cruciate ligaments [4].

- The knee is innervated by branches of the femoral nerve (L2, L3, L4), obturator nerve (L2, L3, L4), and sciatic nerve (L4, L5, S1, S2) [4].
- The posterior articular branch of the tibial nerve is the largest nerve providing innervation of the intra-articular knee [4].
- The popliteus artery travels through the adductor hiatus, where it is relatively immobile, and distally through the fibrous arch deep to the soleus muscle [14].
- The common peroneal nerve travels along the posterior edge of the biceps femoris and continues distally around the fibular neck [14].

## KINEMATICS

- The knee is a hinge joint that incorporates both gliding and rolling, which are essential to its kinematics [5].
- The “screw-home” mechanism involves the tibia externally rotating 5 degrees in the final 15 degrees of extension [5].
- The greatest range of motion occurs in the sagittal plane, approximately 160° [21].
- Knee rotation ranges from 45° in external rotation to 30° in internal rotation [21].
- In the frontal plane, the range of motion in both abduction and adduction reaches a maximum of 10° [21].
- During walking, knee range of motion reaches approximately 70° in the sagittal plane, 15° in the frontal plane, and 10° in the transverse plane [21].
- The normal instant center of the knee joint follows a semicircular path related to the tibiofemoral surface and ligaments crossing the joint [21].
- Rupture of the cruciate ligaments or disruption of the tibiofemoral surface causes a major change in the path of the instant center, leading to articular dysfunction [21].
- In full extension, the knee slightly hyperextends with slight tibial external rotation while collateral and cruciate ligaments are tightened to lock the knee [22].
- The popliteus muscle initiates flexion by pulling the lateral femoral condyle backward while the medial femoral condyle slides forward, resulting in tibial internal rotation [22].

## SYNOVIAL ANATOMY

- Embryologically, the knee joint forms from three synovial compartments that normally fuse into a single synovial cavity [16].
- The important synovial plicae of the knee represent unresolved remnants of these partitions and are classified as suprapatellar, infrapatellar, medial patellar, and lateral patellar plicae [16].
- The medial patellar plica is the most common plica to be of clinical significance, with an incidence reported to range from 10% to more than 50% in normal knees [16].
- A pathologic medial patellar plica makes firm contact with the underlying femoral condyle at 30 to 40 degrees of flexion [16].
- In some patients, a median septum separates the posterior aspect of the knee into two compartments, with the posterior cruciate ligament projecting anteriorly in the septum [19].

# Investigations

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## PLAIN RADIOGRAPHY

- Plain radiographs are appropriate initial imaging studies for most knee conditions, allowing assessment of traumatic injury, arthritis, patellofemoral alignment, osteochondral injury, bone neoplasm, and surgical implants [3].
- Standard knee imaging includes anterior-posterior (AP), lateral, and axial views (skyline, sunrise, sunset) [27].
- Supine AP knee radiographs do not adequately estimate joint space width needed to estimate the degree of osteoarthritis progression [27].
- A 45° standing flexion view was introduced to better evaluate joint space because plain frontal radiographs may not accurately display actual joint space due to cartilage wear patterns, meniscal integrity, or tibial slope variances [27].
- The fixed flexion view (FFV) is a technique with improved reproducibility for evaluating joint space, involving a 10° caudal irradiation angle and specific limb positioning [27].
- The Lyon Schuss view (LSV) uses fluoroscopic adjustment of the irradiation angle relative to the medial tibial plateau, which is more accurate for measuring actual joint space width but involves higher radiation exposure and more complex positioning [27].
- Goniometer readings of long limb alignment or measured on a fixed flexion view correlate well with angles measured on long limb radiographs, providing an alternative if long limb radiographs are not available [27].
- Radiographs are the standard for initial evaluation of knee pain, including weight-bearing AP and lateral views, a 45-degree flexion PA view, sunrise view, extension and flexion lateral views, and standing full-length AP radiograph [23].
- The Kellgren-Lawrence (KL) classification grades osteoarthritis severity from 0 to 4 based on AP knee radiographs, using features such as osteophytes, joint space narrowing, subchondral sclerosis, and bone shape alterations [23].
- Knee arthroplasty is recommended when KL Grade 4 findings are present [23].
- Radiographic studies help confirm the clinical diagnosis of a joint disorder determined using history and physical examination [3].

## COMPUTED TOMOGRAPHY (CT)

- CT provides enhanced bone detail through three-dimensional imaging with ionizing radiation [3].
- CT imaging in axial, sagittal, and coronal planes helps visualize fracture lines, displacement, osteolytic lesions around joint arthroplasty, and cortical disruption in cases of infection or neoplasia [3].
- Three-dimensional CT reconstructions assist in preoperative planning for complex intra-articular fractures, multiplanar osteotomy for limb malalignment, and reconstitution of bone loss in joint arthroplasty [3].
- Axial plane CT imaging of the knee helps assess the rotational alignment of components in total knee arthroplasty in cases of patellar maltracking [3].

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## CQ HAND + UPPER LIMB

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- Three-dimensional CT with remodeling is used for preoperative planning for reconstruction associated with dysplasia, post-trauma planning, and complex total knee arthroplasty planning [23].

## MAGNETIC RESONANCE IMAGING (MRI)

- MRI is the most useful study for differentiating osteonecrosis from other conditions such as osteochondritis dissecans, transient osteoporosis, bone bruises, or occult fractures [29].
- A serpentine lesion within a well-demarcated border is a specific finding on MRI for osteonecrosis [29].
- Bone edema on MRI is a common feature of osteoarthritis, osteonecrosis, cartilage injury, and transient regional osteoporosis [29].
- MRI may identify the degree of articular cartilage injury, including chondrosis and full-thickness cartilage loss, as well as associated bone marrow edema and location [3].
- MRI can identify patterns of meniscal injury by location, pattern (horizontal, longitudinal, radial, complex), and displacement [3].
- MRI may suggest cruciate ligament injury through the presence of edema, intra-articular fluid, disruption of ligament fibers, and atypical ligament contour [3].
- MRI is used to assess the continuity of the quadriceps or patellar tendon [3].
- MRI may be used to assess the margin of resection for a neoplasm, identify vascular malformation, or define the location of nerves or vessels relative to popliteal cysts [3].
- MRI is grossly overused in the arthritic patient population and is not indicated if the joint space is significantly narrowed on radiograph [23].
- MRI is indicated when osteonecrosis is suspected in the arthritic patient population [23].
- A systematic review quantified the diagnostic accuracy of MRI for detection of meniscal injury and ACL tear [20].
- Compositional MRI techniques, including T1ρ, T2\*, dGEMRIC, and gagCEST, are used for early recognition of cartilage degeneration [20].

## NUCLEAR MEDICINE

- Nuclear medicine involves labeled radionuclide injection followed by delayed imaging of gamma radiation, where areas of increased concentration appear bright or “hot” [3].
- Nuclear medicine provides a nonspecific study that indicates the presence of an abnormality but does not define its etiology [3].
- Increased radionuclide activity in bone may be a normal postoperative finding for up to 6 to 12 months after fracture repair or arthroplasty [3].
- Technetium-99 (Tc-99) is a radionuclide that may help identify infection, neoplasia, occult fracture, bone healing, active phases of heterotopic ossification, implant loosening, or failure of osseointegration [3].
- Gallium-67 (Ga-67) is a radionuclide that may help differentiate between aseptic and septic prosthetic loosening, requiring 24 to 72 hours for a complete study [3].

## GENERAL ASSESSMENT

- Assessment of the knee joint must combine physical examination with radiographic (including full-length alignment views) and MRI findings [30].
- Radiographic evaluations are essential when diagnosing osteochondritis dissecans (OCD) lesions of the knee, though important aspects may be better seen with MRI [26].
- Physical examination along with radiographic or advanced imaging findings must be used concomitantly to determine the source of symptoms and appropriate surgical intervention [7].

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