KARNATAKA RADIOLOGY EDUCATION PROGRAM

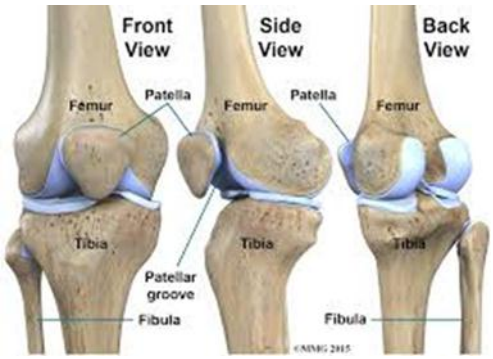
Anatomy and Applied Radiology

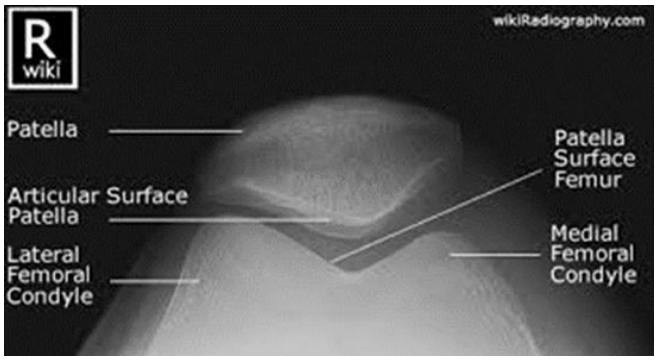
1. KNEE JOINT

The knee is the largest joint in the body, connecting the thigh bone to the shin bone. It has many parts, including bones, cartilage, ligaments, tendons, and a joint capsule.

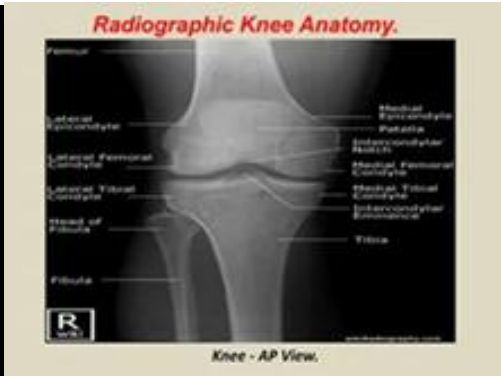
Bones

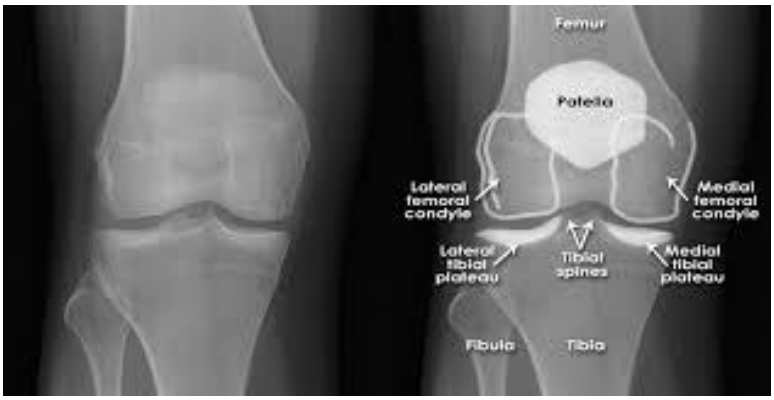
Femur: The thigh bone that connects the hip to the knee
Tibia: The shin bone that connects the knee to the ankle
Patella: The kneecap, a thick, triangular bone that sits in front of the knee
Fibula: A shorter, thinner bone that runs parallel to the tibia on the outside .





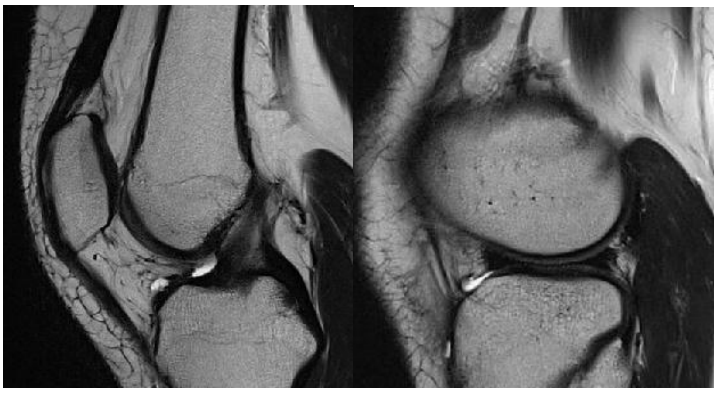
Diagramatic representation **X –Ray – Skyline view**




Femur
Patella
Lateral femoral condyle
Medial femoral condyle
Lateral tibial plateau
Tibial spines
Medial tibial plateau
Fibula
Tibia

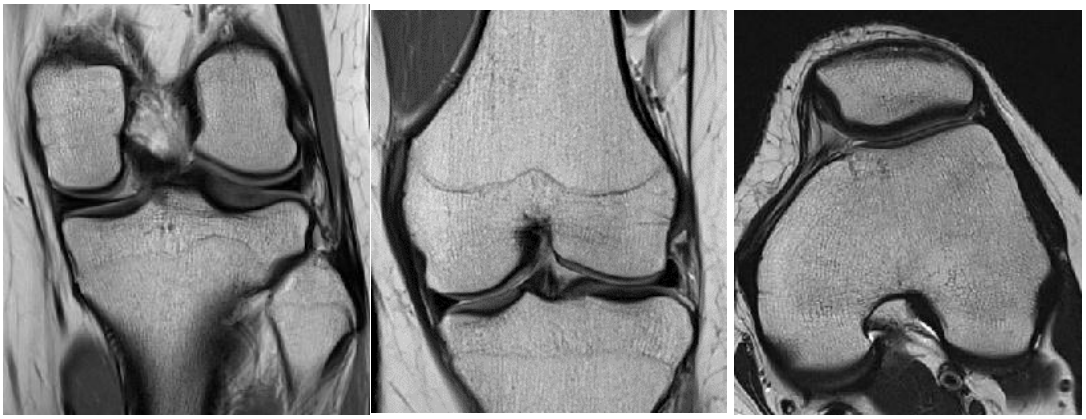
CT

MRI T2



MR FAT SAT

MR PD



Cartilage

Articular cartilage

A smooth, elastic material that covers the ends of the bones, allowing them to glide against each other

ARTICULATING SURFACES

The thigh bone (femur), the shin bone (tibia) and the kneecap (patella) articulate through tibio-femoral and patella-femoral joints.

These three bones are covered in articular cartilage which is an extremely hard, smooth substance designed to decrease the friction forces.

The medial and lateral condyles of the femur articulate with the tibia to form tibiofemoral joint. Similarly, the anterior and distal part of the femur articulate with the patella to form patellofemoral joint.

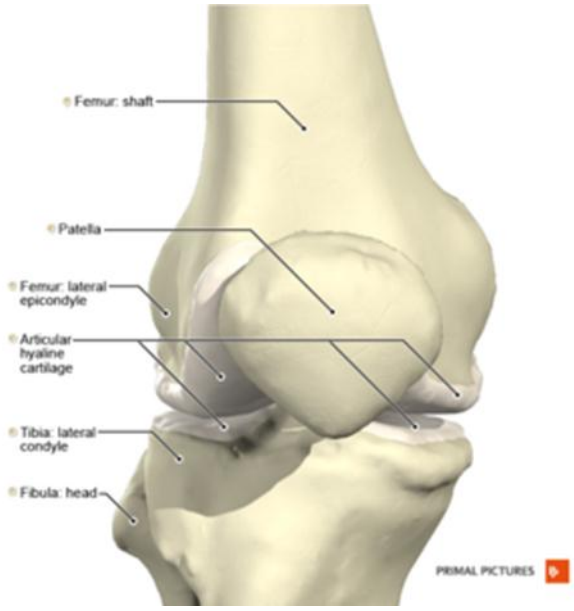
The tibiofemoral joint is the weight bearing joint of the knee. The patella lies in an indentation of the femur known as the intercondylar groove

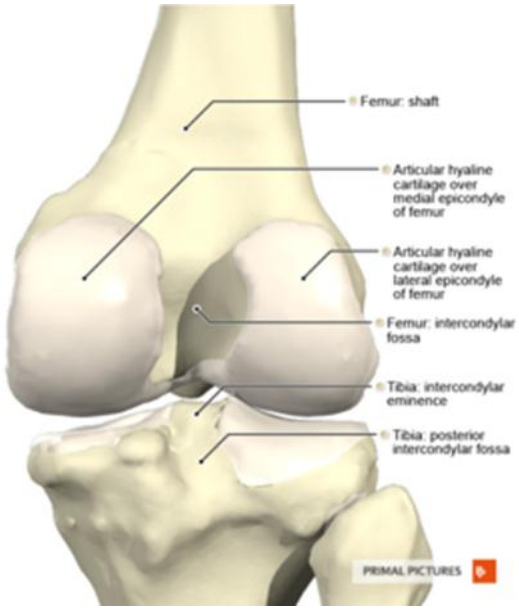
The smaller fibula runs alongside the tibia and is attached via the superior tibiofibular joint is not directly involved in the knee joint, but provides a surface for important muscles and ligaments to attach to.

The distal aspect of the femur forms the proximal articulating surface for the knee, which is composed of 2 large condyles. The medial and the lateral. These two condyles are separated inferiorly by the intercondylar notch although they are connected anteriorly by a small shallow groove which is known as either the femoral sulcus or the patella groove or patella surface. This engages the patella in early flexion.

The tibia also has 2 asymmetrical condyles (medial and lateral) of which are relatively flat, These are also known as the tibial plateau. The medial tibial plateau is much longer than the lateral anteroposteriorly, and the diameter of the proximal tibia is much greater than the shaft posteriorly which is sloped at approximately 7 to 10o to facilitate flexion of the femoral condyles on the tibia.

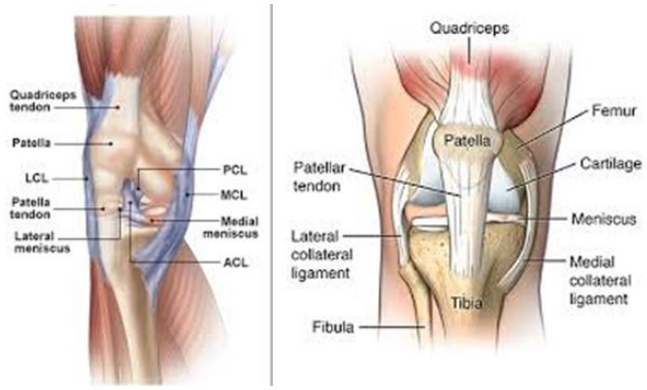
The two tibial condyles are separated by the intercondylar tubercles, these are two bony spines which are roughened and their role lies within knee extension. They become lodged in the intercondylar notch of the femur, adding to the stability of the joint. Overall the tibiofemoral joint is a relatively unstable joint as the plateaus are slightly convex anteriorly and posteriorly. This emphasizes the importance of the other structures of the knee such as the menisci.

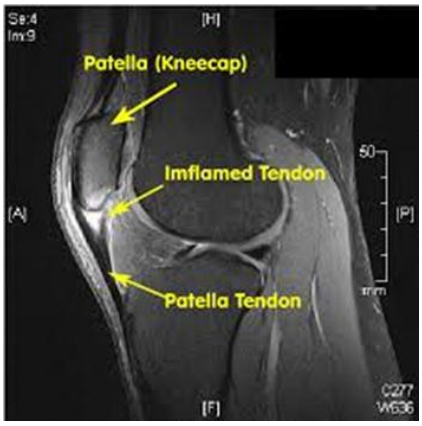




Tendons

Patellar tendon: Connects the kneecap to the tibia
Quadriceps tendon: Attaches to the patella





Meniscus

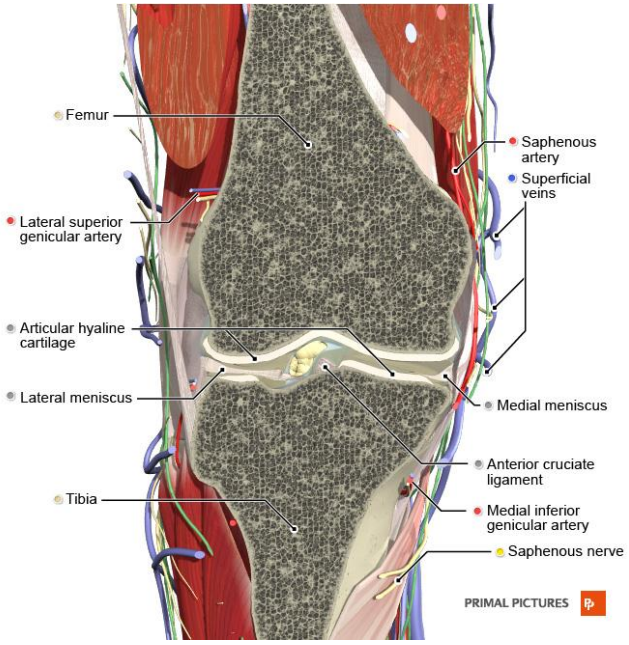
Two crescent-shaped pads of cartilage between the tibia and femur that reduce friction and distribute weight

There are two menisci in the space between the femoral and tibial condyles. They are crescent-shaped lamellae, each with anterior and posterior horn, and are triangular in cross-section. The surface of each meniscus is concave superiorly, providing a congruous surface to the femoral condyles and is flat inferiorly to accompany the relatively flat tibial plateau.

The horns of the medial meniscus are further apart and meniscus appears 'C' shaped, than those of the lateral one where meniscus appears more 'O' shaped. This is due to the increased size of the medial meniscus, which unfortunately leaves a large exposed area that in turn can be prone to injury.

The arrangement of the fibres in the menisci allows for axial loads to be dispersed radially decreasing the wear on the hyaline articular cartilage. This is essential as the compressive loads through the knee can reach 1-2 times body weight during gait and stair climbing and an astonishing 3-4 times body weight during running. The menisci are connected with the tibia by coronary ligaments.

The medial meniscus is much less mobile during joint motion than the lateral meniscus owing in large part to its firm attachment to the knee joint capsule and medial collateral ligament (MCL). On the lateral side, the meniscus is less firmly attached to the joint capsule and has no attachment to the lateral collateral ligament (LCL). In fact, the posterior horn of the lateral meniscus is separated entirely from the posterolateral aspect of the joint capsule by the tendon of the popliteus muscle as it descends from the lateral epicondyle of the femur.




a
b
c
d
e
a
b

Ligaments & Joint Capsule

The joint capsule has thick and fibrous layer superficially and thinner layers deeper. This alongside the capsule ligaments enhances she stability of the knee. As with all of the structures that from the knee they are under most tension and therefore more stable in an extended (closed packed) position in comparison to the laxity present in a flexed position (open packed). Inside this capsule is a specialized membrane known as the synovial membrane which provides nourishment to all the surrounding structures.

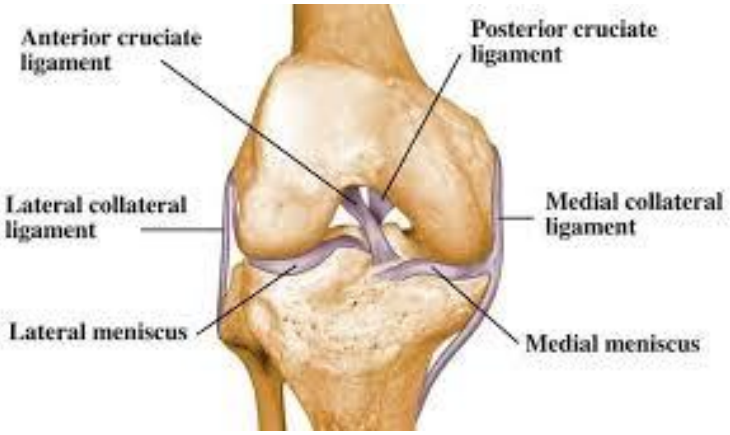
The synovial membrane produces synovial fluid which lubricates the knee joint. Other structures include the infrapatellar fat pad and bursa which function as cushions to exterior forces on the knee. The synovial fluid which lubricates the knee joint is pushed anteriorly when the knee is in extension, posteriorly when the knee is flexed and in the semi flexed knee the fluid is under the least tension therefore being the most comfortable position if there is a joint effusion.

The ligaments of the knee maintain the stability of the knee. Each ligament has a particular function in helping to maintain optimal knee stability.

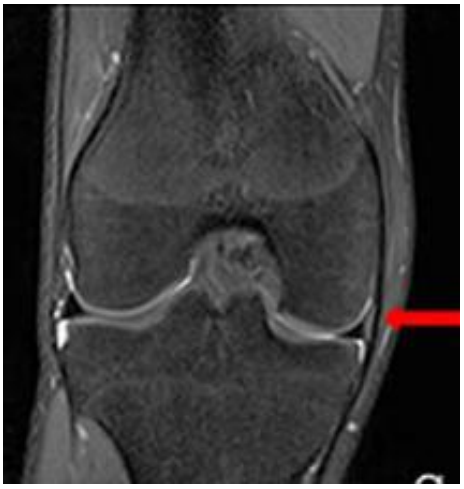
COLLATERAL LIGAMENTS

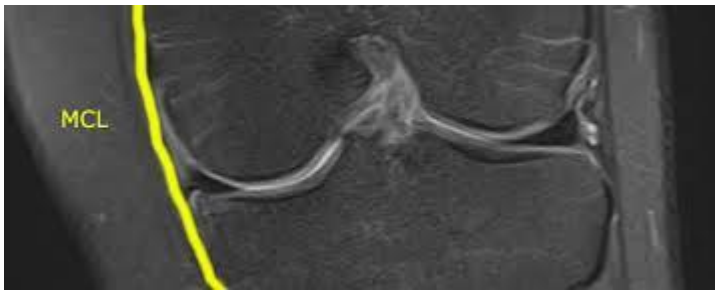
Medial Collateral Ligament (MCL) - This ligament can be divided into two sets of fibres - the superficial and the deep fibres. The general location of this band runs from the medial epicondyle of the femur to the medial condyle and the superior part of the medial surface of the tibia. The superficial fibres originates from medial femoral condyle and attaches to the medial aspect of the proximal tibia distally to the pes anserinus. The deep fibres are continuous to the joint capsule and originates from the inferior aspect of the medial femoral condyle, and inserts to the proximal aspect of the medial tibial plateau. In the middle of the ligament the deep fibres are attached to the medial meniscus. The MCL primarily resists forces acting from the outer surface of the knee, valgus forces, but also resists the lateral rotation of the tibia on the femur. The MCL is able to resist a valgus stress more effectively in the closed pack position (extension) due to the laxity of the ligament in the open packed position (flexed). The MCL does have another role in restraining anterior translation of the tibia on the femur. Therefore when someone has an MCL injury the protection of the anterior cruciate ligament needs to be considered.

Lateral Collateral Ligament (LCL) – a cord like ligament that begins on the lateral epicondyle of the femur and joins with the tendon of the biceps femoris (hamstring muscle) to form the conjoined tendon. This ligament is different to the MCL and is considered to be an extracapsular ligament. Its main role is resisting varus forces on the knee, and similarly to the MCL is most effective in full extension. another similarity of the MCL and the LCL is the ability of the LCL to also resist lateral rotation of the tibia on the femur.



Lateral collateral ligament[MRI]



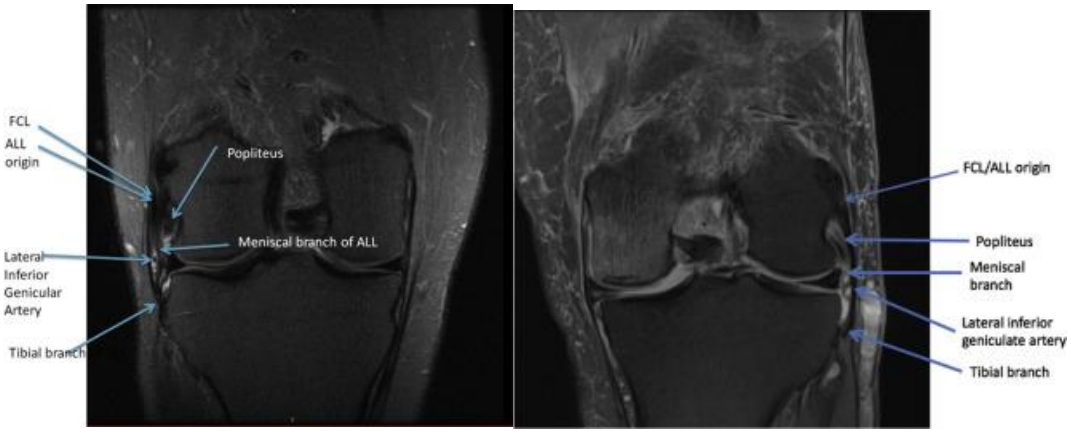


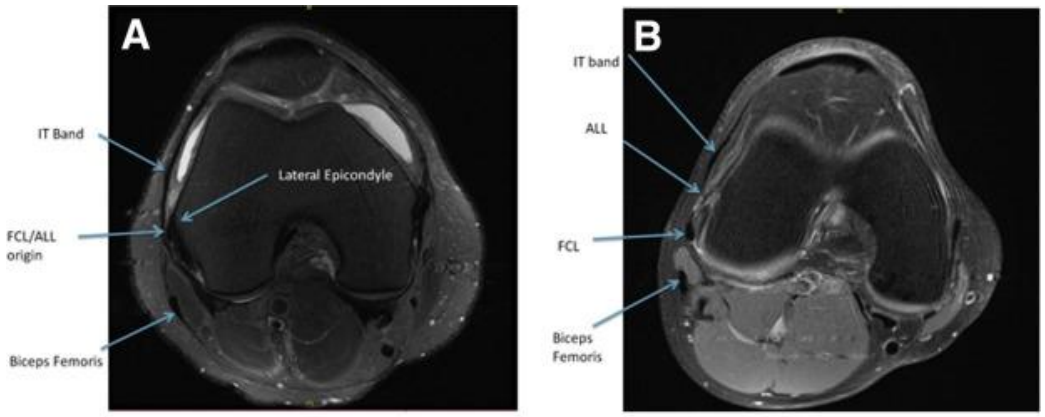
Key points about a normal collateral ligament on MRI:

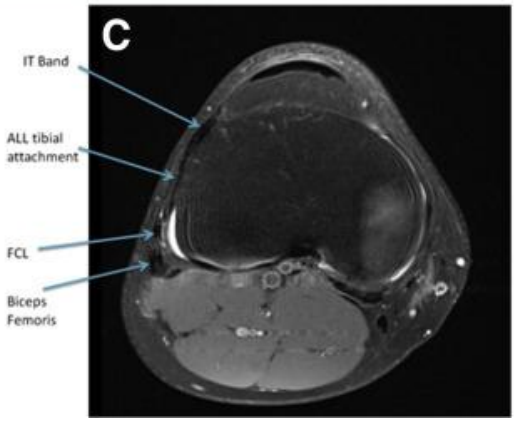
Appearance: A low-signal intensity band on the MRI image, indicating healthy ligament tissue.
Best view: Coronal plane provides the best visualization of the collateral ligaments.
Important factors to check: Continuity of the ligament, no areas of increased signal intensity (edema), and normal alignment.

ANTEROLATERAL LIGAMENT

origin: prominence of the lateral femoral epicondyle, slightly anterior to the origin of the lateral collateral ligament.
proximal ALL fibers connect with LCL
insertion: anterolateral aspect of the proximal tibia (between Gerdy's tubercle and the tip of the fibular head), with firm attachments to the lateral meniscus







CRUTIATE LIGAMENTS

Anterior Cruciate Ligament (ACL) –

The ACL is an important structure in the knee for resisting anterior translation of the tibia on the femur. This ligament is a very well known ligament due to the high injury rate of athletes, which has resulted in a lot of research being done in the field of the ACL. The cruciate ligaments are so called because they form a cross in the middle of the knee joint. The ACL runs from anterolateral aspect of the medial intercondylar tibal spine superolateral and posteriorly to the posteromedial aspect of the lateral femoral condyle. The ACL twists medially as it travels proximally.

There are thought to be 2 bundles of fibres that form the ACL - the anteromedial bundle (AMB) and the posterolateral bundle (PLB). The ACL is responsible for resisting anterior sheering forces on the knee. Depending on the position of the knee, will depend on which bundle of the ACL fibres will be taut. So when the knee close to full extension the PLB will be taut and resisting the force, but as the knee moves into a flexed position the PLB become lax and the AMB becomes taut taking over the role of resisting the anterior sheering forces. At approximately 30o of the flexion neither of the bundles of the ligament are taut leading to the most anterior translation available at this range.

It is most commonly injured in twisting movements. The ACL is also an accessory ligament in resisting rotary forces medially and laterally as well as valgus and varus forces. The PLB of the ACL is theorised to be most effective at providing rotary stability of the knee. In addition to this the AMB is under most tension at approximately 10-15o of knee flexion with medial rotation.

Key points about a normal ACL on MRI:

Appearance: A clear, thin, straight band of fibers with low signal intensity.
Plane of view: Best visualized on sagittal images, with coronal and axial views used for additional confirmation.
Bundles: The ACL is composed of two distinct bundles: the anteromedial bundle (AM) and the posterolateral bundle (PL).
Important consideration:If the ACL is torn, the MRI will show discontinuity in the ligament fibers, increased signal intensity within the ligament, and potential signs of bone bruising around the joint.

Posterior Cruciate Ligament (PCL) –

This ligament runs from the posterior surface of the tibia between the two posterior horns of the menisci it then runs superiorly and anteriorly and attaches to the lateral aspect of the medial femoral condyle. The PCL is much shorted and less oblique with a much larger cross-sectional area in comparison to the ACL. As the PCL blends with the posterior capsule as it crosses to the tibial attachment. Factors such as the size, shape and location possibly contribute to the increased strength of the PCL in comparison to the ACL and is much less frequently injured. The PCL similarly has 2 bundles of fibres the posteromedial (PMB) and the anterolateral bundle (ALB). When the knee is in near full extension the ALB which is much larger and stronger are lax and the PMB are taut whereas in 80-90o of flexion the PMB are lax and the ALB are taut. The PCL is more adept for resisting posterior translation / sheering forces in the knee when it is flexed despite there being the most posterior translation available at 75-90o flexion. The secondary stabilisers at this point in the range are ineffective and relay upon the PCL. The PCL also plays an important role in resisting rotation and valgus / varus forces on the knee. The PCL best resists medial tibial rotation at 90o flexion rather than extension but is not very good at resisting lateral tibial rotation. If the PCL becomes damaged the popliteus muscle plays an important role in stabilising the knee from posterior sheering forces. In the PCL deficient person hamstring contraction can destabilise the knee joint alongside a gastrocnemius contractions (at angles greater than 40o knee flexion), whereas quadriceps contractions degrees the strain on the PCL between angles of 20 and 60o flexion.

Key points about a normal PCL on MRI:

Low signal intensity: This is the most important feature, meaning the PCL will appear dark compared to surrounding tissues on most MRI sequences.

Clear definition: The ligament should have distinct borders and a consistent thickness throughout its course.

Arcuate shape:When viewed in the sagittal plane, the PCL will curve slightly, forming an arc-like appearance.

Coronal plane view:While sagittal images are usually preferred for evaluating the PCL, coronal views can also be helpful to assess the ligament's attachments and potential injury patterns.

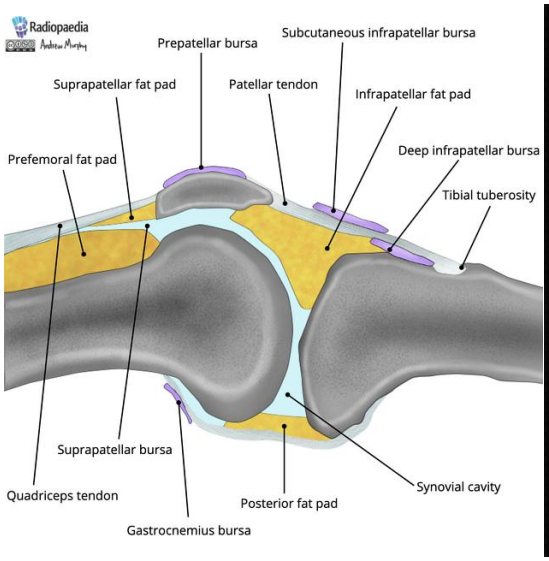
Joint capsule

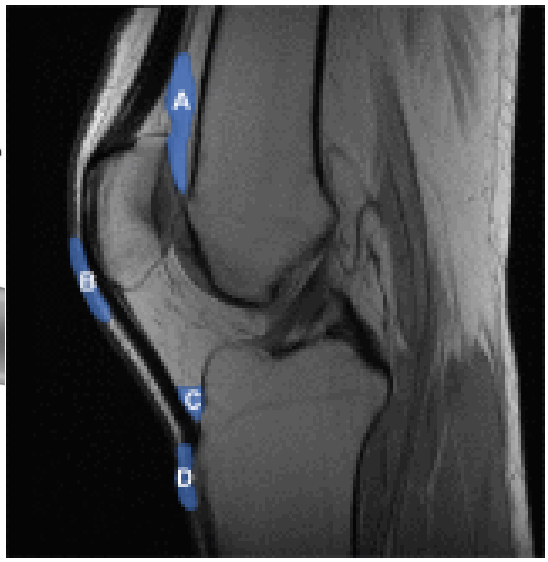
A membrane bag that surrounds the knee joint, filled with synovial fluid that lubricates and nourishes the joint

Bursae

A bursa is synovial fluid filled sac, found between moving structures in a joint – with the aim of reducing wear and tear on those structures. There are four main bursae found in the knee joint.

- **Suprapatellar bursa - A**
- **Prepatellar bursa - B**
- **Infrapatellar bursa – C ,D**
- **Semimembranosus bursa**





Muscles

Quadriceps

Location: Front of the thigh

Function: Straightens the knee

Muscles: Rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius

Tendon: Attaches the quadriceps to the patella

Hamstrings

Location: Back of the thigh

Function: Bends the knee

Other muscles

Gastrocnemius: Flexes the knee and plantarflexes the foot

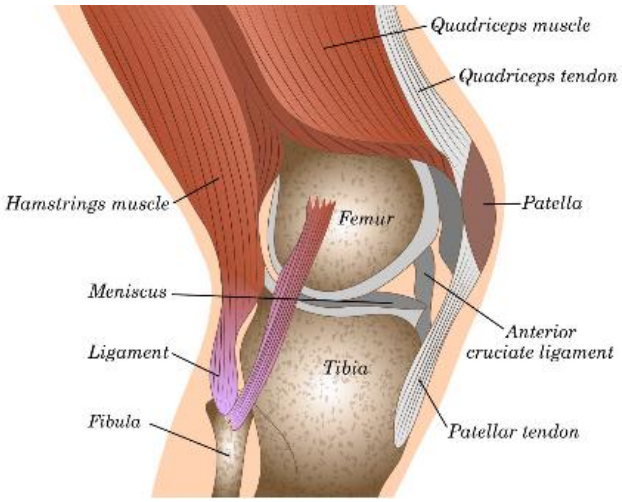
Gracilis: Flexes and medially rotates the knee

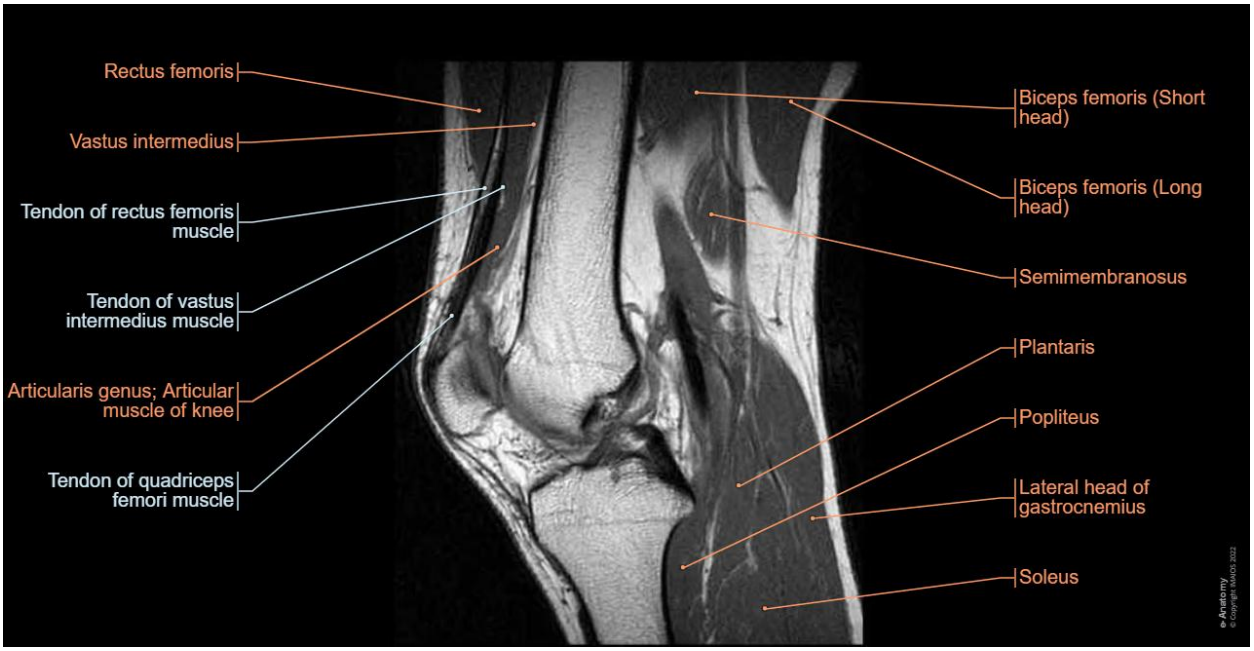
Popliteus: Unlocks and flexes the knee

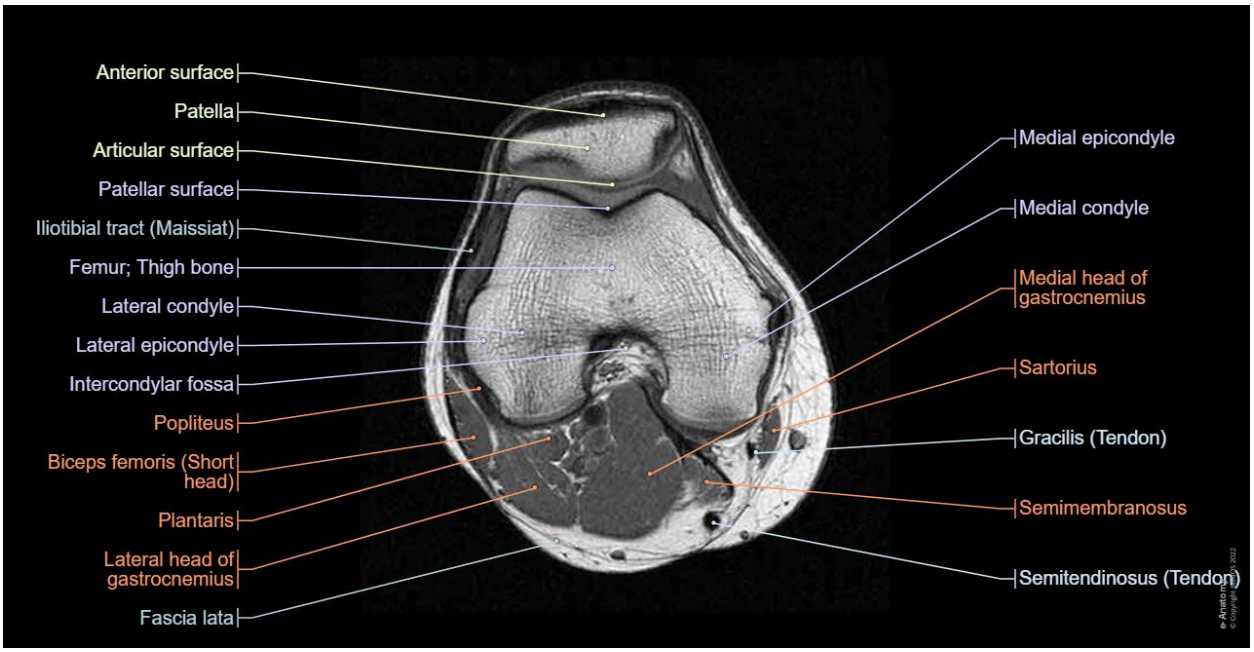
Semimembranosus: Flexes the knee

Biceps femoris: Flexes the knee

Articularis genus: Flexes the knee







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