

Anatomy of the Lower Extremity: Knee Joint

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Besides the shoulder joint, the knee joint is one of the most complex capsuloligamentous structure systems of the human body. Hardly any other joint has as many different stabilizing ligaments and simultaneously such a great degree of movement. Most of all, medical students should be familiar with the functional anatomy since even slight disorders, e.g. in the gliding movements of the menisci, can lead to severe movement impairments and pain. After the hip, the knee is the second most frequent location for the implantation of total endoprostheses.



Anatomy of the Knee Joint

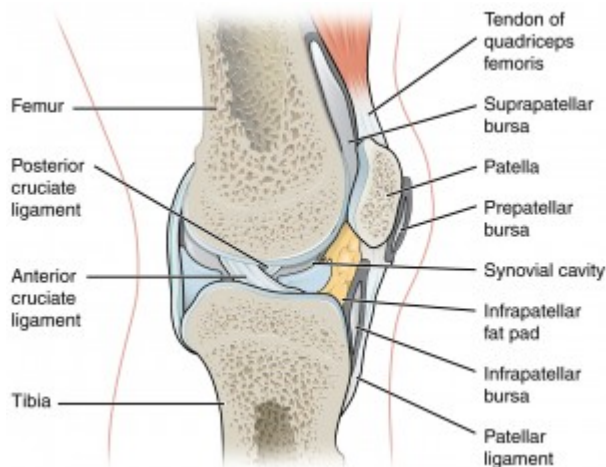


Image: Synovial Joints. By Phil Schatz, License: [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)

The knee is a complex joint made up of 3 articulations: the medial and lateral femorotibial joints and the patellofemoral joint. It is not a simple hinge joint because it has 6° of motion: flexion/extension, internal/external rotation, varus/valgus, compression/distraction, anterior/posterior translation, and medial/lateral translation. The normal range of knee movement is 10° extension to 130° flexion.

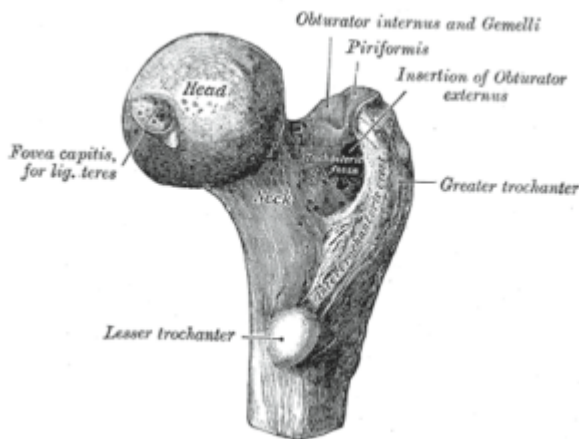


Image: Head of the femur. By Henry Vandyke Carter and Henry Gray: "Gray's Anatomy" (1918), License: [Public Domain](https://publicdomain.org/)

Femur

Medial and lateral condyles form the **distal** femur. Anteriorly, they are separated by the **intercondylar notch**. Posteriorly, they are separated by the **intercondylar fossa**. On the medial epicondyle, the **adductor tubercle** is the insertion point of the **adductor magnus muscle**. Both condyles are covered with hyaline articular cartilage. The **trochlea** is the surface that articulates with the patella.

Tibia

The proximal tibia is made up of the medial and lateral condyles. **Gerdy's tubercle** (iliotibial band insertion) is located on the lateral epicondyle. The **tibial tuberosity** or **tibial tubercle**, located anteriorly, is the point of insertion for the patellar tendon.

The **tibial plateau** is the tibial portion of the femorotibial joint. The articular surface is

divided into a medial and a lateral facet. The facets have an oval shape. The medial facet is concave in both sagittal and coronal planes. The lateral facet is concave in the coronal plane and convex in the sagittal plane, and this is because as the knee flexes, the lateral femoral condyle slides posteriorly on the tibia, meaning the tibia rotates externally with knee flexion.

The **intercondylar eminence** separates the medial and lateral tibial facets. This area is not covered with articular cartilage. The medial and lateral tibial intercondylar tubercles lie within the eminence.

Patella

The **patella** is the largest sesamoid bone in the body. The proximal base is wider than the distal apex. It serves as a pulley for knee extension by reducing the movement arm and thereby decreasing the force needed for knee extension.

The retropatellar joint surface articulates with the femur. It is divided into a wide lateral and narrow medial facet. The lateral facet is concave and the medial facet can either be concave or convex.

Joint Capsule of the Knee

The joint capsule of the knee joint is wide and covers all involved osseous structures. It consists of the following layers: the **synovial membrane** and the **fibrous membrane**.

Synovial membrane

The **synovial membrane** inserts close to the **bone-cartilage border of the femur** and forms the **suprapatellar recess**. Tibial insertion points are located on the bone-cartilage border medially, laterally, and ventrally of the tibial plateau. From the medial and lateral facets, it runs ventrally and revolves around the intercondylar area. The cruciate ligaments are located in this region and are covered by the synovial membrane.

Fibrous membrane

In contrast to the complex course of the synovial membrane, the **fibrous membrane** inserts in almost all areas of the knee joint. The few exceptions are the tibial plateau, the intercondylar area, and the lateral condyles.

At the tibial plateau, the membrane inserts distally at the edge of the plateau. In the intercondylar area, the membrane is bridged from the dorsal direction instead of the ventral. From the insertion line at the lateral condyles, the membrane runs at the outer and superior edges of the bases of the meniscus, and, from the caudal direction, it runs to the outer and lower edges so that the menisci are directly inside of the fibrous membrane.

Parapatellar recess

This recess is very small and is not always present. It is formed between the lateral femoral bone-cartilage border and the lateral surfaces of the patella.

Subpopliteal recess

The subpopliteal bursa communicates with the articular cavity and is referred to as the **subpopliteal recess**.

The capsular bulging between the heads of the gastrocnemius muscle and the femoral condyles is referred to as **recessus subtendinea gastrocnemii** or the pole caps.

Suprapatellar recess

The largest recess of the knee joint is formed by the joint capsule that lies ventrocranial to the patella and contains a superficial and a deep sheet. The deep sheet inserts at the proximal area of the patellar surface and runs cranially to turn back caudally above the base of the patella. Then, it is fixed at the base of the patella as the superficial sheet. This recess is located underneath the tendon of the rectus femoris muscle. This means that the 2 sheets of the recess glide against each other during contraction and stretching of the muscle.

Meniscus

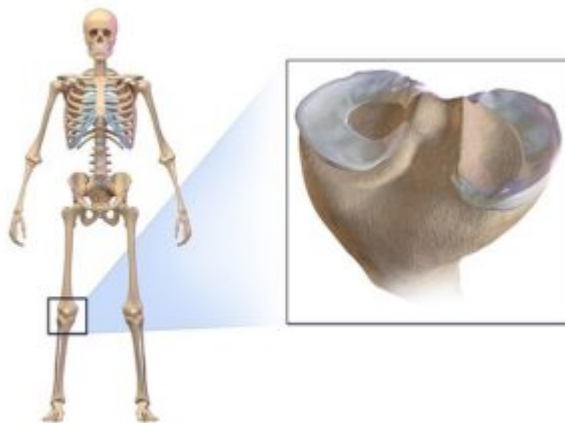


Image: Meniscus of the knee. By Andrewmeyerson, License: [CC BY-SA 4.0](#)

Histology and vascular supply

Menisci are C-shaped fibrocartilaginous wedges that are thick on the outside and thin on the inside. Their primary purpose is shock absorption. They are made of **type I collagenous fibers** and elastic fibers. They consist of 3 layers with each layer having its specific structure:

Meniscus-Layer	Histological meniscus structure
1st meniscus layer	Thin fibril network
2nd meniscus layer	Lattice-like bundles of lamellar fibers
3rd meniscus layer	Circular bundles of fibrils

Both the lateral and medial menisci have their respective anterior and posterior horns, an inner section in the articular cavity, and a base.

The anterior horns of the menisci are anchored by the **patellomeniscal ligaments** and are connected to each other by the **transverse ligament of the knee**. The inner 2/3 of the menisci are supplied via diffusion of the synovial fluid.

The base of each meniscus is supplied by blood vessels that originate from the fibrous membrane. A special feature of the medial meniscus is that additional vessels radiate into it via the **posterior medial collateral ligament**. Anterior and posterior horns are vascularized via the **meniscotibial ligament**.

Ligamentous fixation of the medial meniscus

The **medial meniscus** is C-shaped and is fixed to the bone by several ligaments. The anterior horn is connected to the **anterior intercondylar area** via the **anterior meniscotibial ligament**, while the posterior horn is connected to the **posterior intercondylar area** by the **posterior meniscotibial ligament**. The posterior medial collateral ligament communicates with the dorsomedial area of the meniscus and the **semimembranosus muscle** is fixed at the posterior horn of the meniscus.

Ligamentous fixation of the lateral meniscus

The ring-shaped **lateral meniscus** is fixed at the tibial plateau by the **anterior and posterior meniscotibial ligaments**. The posterior meniscofemoral ligament runs from the posterior horn of the meniscus to the inside of the medial condyle, parallel to the posterior cruciate ligament. Also, the **popliteus muscle** is connected to the posterior horn.

Functional Anatomy: Movement Behavior of the Menisci

During knee flexion, the menisci are pulled dorsally by the femoral condyles. The semimembranosus muscle (medial) and the popliteus muscle (lateral) synergize this gliding motion with their direct connection.

During extension, the femoral condyles push the menisci ventrally on the tibial plateau. The extent of the movement of the lateral meniscus is significantly greater than that of its medial counterpart.

During rotation, the menisci follow the movement of the femoral condyles. During internal rotation, the medial meniscus moves anteriorly and the lateral meniscus moves posteriorly on the tibia.

Ligaments of the Knee Joint

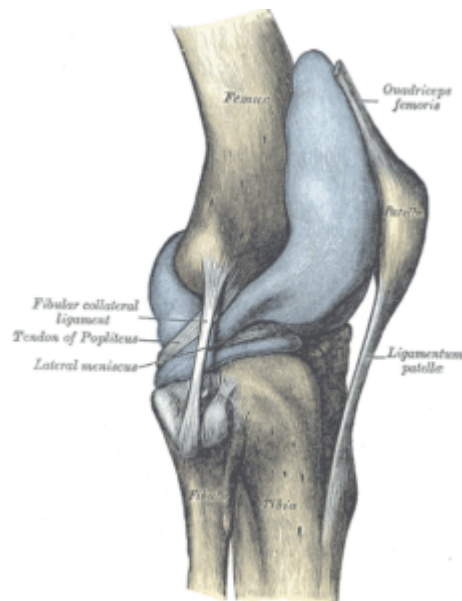


Image: More details

Capsule of right knee-joint (distended). Lateral aspect. By Henry Vandyke Carter and Henry Gray: "Gray's Anatomy" (1918), License: [Public Domain](#)

Anterior cruciate ligament

The **ACL** originates from the **dorsal, inner lateral femoral condyle** and inserts at the roof of the **intercondylar fossa**. It has 2 fiber bundles: the **anteromedial** and the **posterolateral bundle**.

The ACL stabilizes the knee joint preventing excess anterior translation of the tibia on the femur. It also limits the extension and rotation of the joint.

Posterior cruciate ligament

The **PCL** originates from the inner surface of the **medial femoral condyle** and inserts at the **posterior intercondylar area of the tibia**. The PCL also has 2 fiber bundles: the **anterolateral** and the **posteromedial** bundle.

The PCL prevents excess posterior translation of the tibia. It also limits the extension and internal rotation of the knee joint.

Lateral/fibular collateral ligament

The **lateral collateral ligament**, also referred to as the **fibular collateral ligament**, originates from the **lateral femoral epicondyle** and inserts at the **head of the fibula**. This ligament stabilizes the knee joint against **varus stress**.

Medial collateral ligament

The **medial collateral ligament**, also referred to as the **tibial collateral ligament**, originates from the **medial femoral epicondyle** and inserts at the **medial condyle of the tibia**. It stabilizes the knee joint against **valgus stress**.

Patellar tendon

The **patellar tendon** runs from the **apex of the patella** to the **tibial tuberosity** and is the continuation of the quadriceps tendon. The **superficial infrapatellar bursa** lies between the ligament, the tibia, and the infrapatellar fat pad.

Innervation of the knee joint

Nerve Branch	Innervated Region
Obturator nerve (articular and posterior rami)	<ul style="list-style-type: none">• Complete knee
Tibial nerve (articular rami)	<ul style="list-style-type: none">• Medial knee region• Mediocaudal knee region• Dorsal capsule-ligament apparatus
Common peroneal nerve (articular rami)	<ul style="list-style-type: none">• Ventrolateral knee region• Dorsolateral knee region
Femoral nerve (articular rami)	<ul style="list-style-type: none">• Periosteum of the patella• Ventral capsule-ligament apparatus• Medial capsule-ligament apparatus• Lateral capsule-ligament apparatus
Saphenous nerve (articular ramus)	<ul style="list-style-type: none">• Medial capsule region (small area)

Clinical Knee

Cruciate ligament rupture

Cruciate ligament rupture describes the partial or complete rupture of the anterior, posterior, or both cruciate ligaments. Usually, the rupture occurs from direct trauma to the knee or pivoting/buckling injury to the knee during sports resulting in anterior or posterior translational instability. Surgical reconstruction is the treatment of choice.

Dislocation of the patella

The patella usually dislocates laterally, and it can occur due to trauma or ligament laxity. Recurrent dislocation can result in patellofemoral arthritis. Common surgical treatments include medial patellofemoral ligament reconstruction and tibial tubercle osteotomy.



Image: A Baker's cyst (popliteal cyst) is located behind the knee and is a swelling of the popliteal bursa. In this image, the Baker's cyst is the yellowish tissue and was discovered during routine dissection. By Dr. Frank Scali, License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

Baker's cyst

Baker's cysts are common cysts that occur in the popliteal area. In cases of mild swelling, patients hardly notice any symptoms. If the accumulation of fluid increases due to continuous incorrect loading, sensitive structures can be compressed and cause either pain and impairment of movement or both. Baker's cyst can be treated conservatively or with surgery. However, it has a high rate of recurrence.

Meniscal injuries

There are 3 forms of meniscal injuries: degeneration, impingement, and tear. All 3 forms can occur in isolation or in combination with each other.

Degeneration

The degeneration of the meniscus or its fibrils occurs due to the incorrect loading and unloading of the knee joint, causing pathological changes in vascularization. If the blood and nutrient supply to the tissue is insufficient, it decays and cannot regenerate. The degeneration of the meniscus due to loss of vascularization is irreversible.

Impingement

Impingement occurs when the gliding behavior of the meniscus is impaired or absent, and the meniscus is tucked between osseous structures during movements. Extension lock is the most frequent form of meniscus impingement and is most often caused by a rupture of a part of the meniscus.

Tear

Tears can be classified based on their direction or location. **Bucket handle tear** is a special form of meniscus tear that develops longitudinally and can expand into the ventral direction resulting in a hole in the meniscus. The inner part, the so-called bucket handle, can dislocate and can additionally be tucked between bones at flexion or extension. If the meniscus injury progresses, removal of the damaged structure is often the only solution and involves surgery (meniscectomy).

Classification of Rupture	Form of Rupture
According to direction	<ul style="list-style-type: none">• Longitudinal tear• Horizontal tear• Radial tear
According to location	<ul style="list-style-type: none">• Labral tear of the anterior horn• Labral tear of the posterior horn
According to a special form	<ul style="list-style-type: none">• Bucket handle tear



Image: Knee with Osgood-Schlatter, MRI lateral view. By MBq, License: [Copyrighted Free Use](#)

Osgood-Schlatter disease

Osgood-Schlatter disease or simply **Schlatter's syndrome** is aseptic bone necrosis in the area of the tuberosity of the tibia, which often affects teenage boys and children between the ages of 10 and 16. Patients experience severe pain, especially during climbing stairs or quick torsional movements, which are highly functional loads for the knee joint.

References

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