Knee joint - structure, movements, biomechanics

The knee joint

The knee joint is a hinge type synovial joint, which mainly allows for flexion and extension (and a small degree of medial and lateral rotation).

It is formed by 2 articulations between the patella, femur and tibia (also known as the tibiofemoral and patellofemoral)

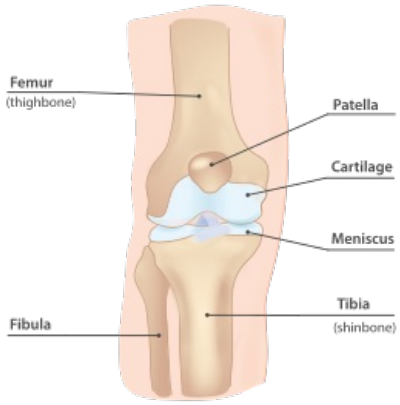
Structure of the knee joint

Articulating Surfaces

The knee joint consists of two articulations – tibiofemoral and patellofemoral.

The joint surfaces are lined with hyaline cartilage and are enclosed within a single joint cavity.

- Tibiofemoral – medial and lateral condyles of the femur articulate with the tibial condyles. It is the weight-bearing component of the knee joint.
- Patellofemoral – anterior aspect of the distal femur articulates with the patella. It allows the tendon of the quadriceps femoris (knee extensor) to be inserted directly over the knee – increasing the efficiency of the muscle.



Knee basic structure

As the patella is both formed and resides within the quadriceps femoris tendon, it provides a fulcrum to increase power of the knee extensor and serves as a stabilizing structure that reduces frictional forces placed on femoral condyles.

Menisci

The medial and lateral menisci are fibrocartilage structures in the knee that serve two functions:

- To deepen the articular surface of the tibia, thus increasing stability of the joint.
- To act as shock absorbers by increasing surface area to further dissipate forces.

In addition to the intercondylar attachment, the medial meniscus is fixed to the tibial collateral ligament and the joint capsule. Damage to the tibial collateral ligament usually results in a medial meniscal tear.

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 bursae found in the knee joint:

- Suprapatellar bursa – an extension of the synovial cavity of the knee, located between the quadriceps femoris and the femur.
- Prepatellar bursa – found between the apex of the patella and the skin.
- Infrapatellar bursa – split into deep and superficial. The deep bursa lies between the tibia and the patella ligament. The superficial lies between the patella ligament and the skin.
- Semimembranosus bursa – located posteriorly in the knee joint, between the semimembranosus muscle and the medial head of the gastrocnemius.

Ligaments

The major ligaments in the knee joint are:

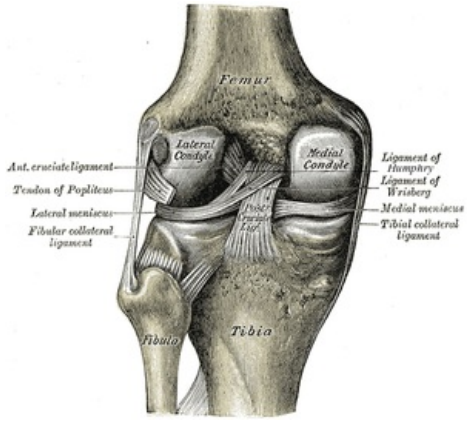
1. Patellar ligament – a continuation of the quadriceps femoris tendon distal to the patella. It attaches to the tibial tuberosity.
2. Collateral ligaments – two strap-like ligaments (medial and lateral). They act to stabilize the hinge motion of the knee, preventing excessive medial or lateral movement
    1. Tibial (medial) collateral ligament – It attaches to the medial epicondyle of the femur proximally, distally it attaches to the medial condyle of the tibia.
    2. Fibular (lateral) collateral ligament – It attaches to the lateral epicondyle of the femur proximally, distally it attaches to a depression on the lateral surface of the fibular head.

3. Cruciate Ligaments – these two ligaments connect the femur and the tibia. In doing so, they cross each other, hence the term ‘cruciate’ (Latin for like a cross)
    1. Anterior cruciate ligament (ACL)– Proximally attaches to the medial side of the lateral condyle, distally attaches to the medial intercondylar region of the tibia, where it blends in with the medial meniscus (prevents anterior dislocation of the tibia onto the femur).
        1. Hyperextension of the knee joint can cause a tear in the ACL
    2. Posterior cruciate ligament (PCL)– Proximally attaches to the lateral side of the medial condyle, distally attaches to the lateral intercondylar region of the tibia (prevents posterior dislocation of the tibia onto the femur)

Neurovascular Supply

The blood supply to the knee joint is through the genicular anastomosis around the knee, which are supplied by the genicular branches of the femoral and popliteal arteries.

The nerve supply is by the nerves which supply the muscles which cross the joint. These are the femoral, tibial and common fibular nerves.



Left knee-joint from behind, showing interior ligaments including the meniscofemoral ligaments Humphry and Wrisberg.

Movement of the knee joint

- Extension: Produced by the quadriceps femoris,
- Flexion: Produced by the hamstrings, gracilis, sartorius and popliteus.
- Lateral rotation: Produced by the biceps femoris.
- Medial rotation: Produced by five muscles; semimembranosus, semitendinosus, gracilis, sartorius and popliteus.

note: Lateral and medial rotation can only occur when the knee is flexed (if the knee is not flexed, the medial/lateral rotation occurs at the hip joint).

Knee biomechanics

The knee is the largest joint of the human body, comprising four bones and a complex structure of soft tissues. These bones make up a double-joint structure – the tibio-femoral joint and the patello-femoral joint.

The analysis of motion applied to a joint requires the use of both kinematics and kinetics data. Kinematics describes motion without reference to the causes of motion, while kinetics studies the relationship between the motion and its causes from both a static and dynamic point of view.

The knee joint has biomechanical roles in allowing gait, flexing and rotating yet remaining stable during the activities of daily life, and transmitting forces across it. Geometrical, anatomical and structural considerations allow the knee joint to accomplish these biomechanical roles.

The point of biomechanics:

- If the knee joint has developed normally, the limb is straight. In this case the mechanical axis of the leg runs through the center of the femoral head, the center of the knee joint, and, when extended, also through the center of the calcaneus.

Types of malalignments:

1. When the mechanical axis is displaced laterally (1), that is, it runs through the lateral femoral condyle (4) or the head of the fibula (5), the condition is known as genu valgum or “knock-knee” (B). In this case the medial collateral ligament (6) will be over-stretched and there is excessive stress on the lateral meniscus (7), the cartilage-covered articular surface of the lateral femoral condyle (4), and the lateral condyle of the tibia (8). The joint space is larger on the medial than on the lateral side. In genu valgum we have increased terminal rotation. In a case of knock-knees the medial surfaces of the legs near the knee joints touch, while the medial malleoli elsewhere have no contact.
2. When the mechanical axis (1) runs through the medial femoral condyle (9) or medial to it, the condition is known as genu varum (C) or “bow leggedness.” The lateral collateral ligament (10) is overstretched and there is increased wear and tear on the medial meniscus (11) and on the cartilage covering of the articular surfaces. In the region of the knee joint the legs cannot be made to touch. In genu varum the legs cannot be completely extended, so terminal rotation cannot occur.

Sources:

[1] Salvador's notes

[2]Jones, O. (2019). *The Knee Joint - Articulations - Movements - Injuries - TeachMeAnatomy*.

Biomechanics of the knee joint

1. https://docs.google.com/document/d/1F8O8zD6wyYiH1_yw4I53OA0i3bGora7480X37hW-SQw/edit

2. https://teachmeanatomy.info/lower-limb/joints/knee-joint/ Jones, O. (2019). *The Knee Joint - Articulations - Movements - Injuries - TeachMeAnatomy*.