

Anatomy and Biomechanics of the Knee

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Movement of the knee joint can be classified as having six degrees of freedom—three translations: anterior/posterior, medial/lateral, and inferior/superior and three rotations: flexion/extension, internal/external, and abduction/adduction.

The movements of the knee joint are determined by the shape of the articulating surfaces of the tibia and femur and the orientation of the four major ligaments of the knee joint: the anterior and posterior cruciate ligaments and the medial and lateral collateral ligaments as a four bar linkage system .

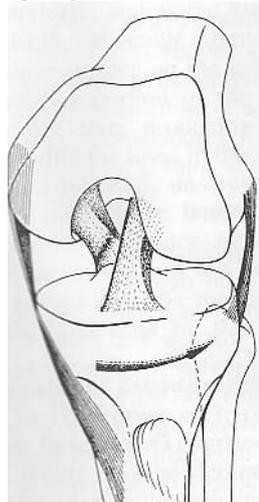


Figure 1: The ligaments of the knee (arrow shows direction of “screw home mechanism” – see below)



Figure 2: Saggital MRI scan showing the anterior (small arrow) and posterior cruciate ligaments (large arrow)

Knee flexion/extension involves a combination of rolling and sliding called “femoral roll back” which is an ingenious way of allowing increased ranges of flexion. Because

of asymmetry between the lateral and medial femoral condyles the lateral condyle it rolls a greater distance than the medial condyle during 20 degrees of knee flexion. This causes coupled external rotation of the tibia which has been described as the “screw-home mechanism” of the knee which locks the knee into extension (see figure 1). The anterior cruciate ligament drives this screw home mechanism and absence of this control is the basis of the pivot shift test of an ACL deficient knee.

The primary function of the medial collateral ligament is to restrain valgus movement of the knee joint with its secondary function being control of external rotation. The lateral collateral ligament restrains against varus rotation as well as resisting internal rotation.

The primary function of the anterior cruciate ligament (ACL) is to resist anterior displacement of the tibia on the femur when the knee is flexed and control the screw home mechanism of the tibia in terminal extension of the knee. A secondary function of the ACL is to resist varus or valgus rotation of the tibia, especially in the absence of the collateral ligaments. The ACL also resists internal rotation of the tibia.

The main function of the posterior cruciate ligament (PCL) is to allow femoral rollback in flexion and resist posterior translation of the tibia relative to the femur.

The menisci are intra-articular crescentic structures made of elastofibrocartilage. They are important for reducing contact stresses on the articular cartilage, shock absorption, circulation of synovial fluid and joint stability. The medial meniscus is tethered to the deep part of the medial collateral ligament and so is more prone to injury than the lateral meniscus which is more mobile. The lateral meniscus is smaller than the medial and is sometimes discoid in shape.

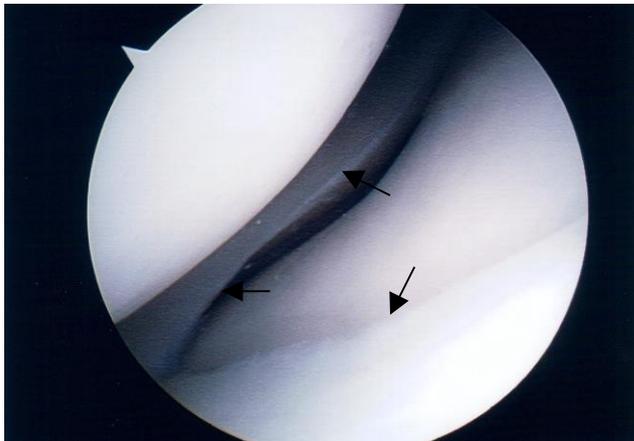


Figure 3: A normal medial meniscus seen at arthroscopy.

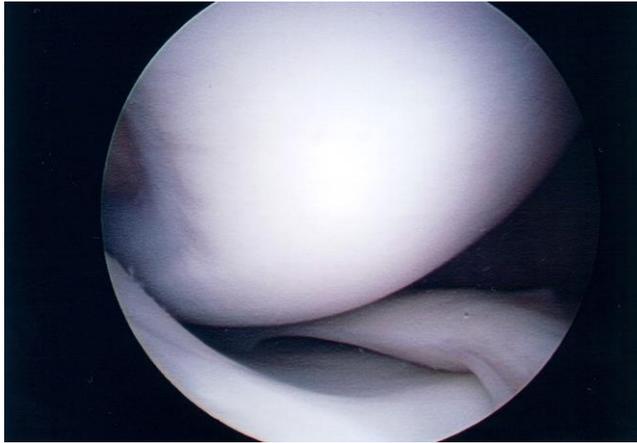


Figure 4: A normal smaller lateral meniscus.

The movement of the patellofemoral joint can be characterized as gliding and sliding. During flexion of the knee the patella moves distally on the femur. This movement is governed by its attachments to the quadriceps tendon, ligamentum patellae and the anterior aspects of the femoral condyles. The muscles and ligaments of the patellofemoral joint are responsible for producing extension of the knee. The patella acts as a pulley in transmitting the force developed by the quadriceps muscles to the femur and the patellar ligament. It also increases the mechanical advantage of the quadriceps muscle relative to the instant center of rotation of the knee.

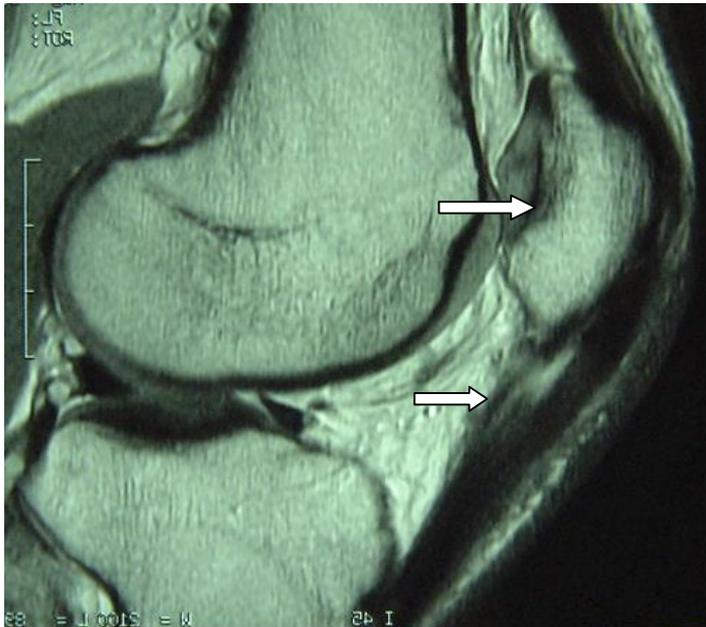


Figure 5: The patellofemoral joint as seen on a sagittal MRI scan (arrows mark the patella and patella tendon)

The mechanical axis of the lower limb is an imaginary line through which the weight of the body passes. It runs from the centre of the hip to the centre of the ankle through the middle of the knee. This is altered in the presence of deformity and must be reconstituted at surgery (see figure 4). This allows normalisation of gait and protects the prosthesis from eccentric loading and early failure.



Figure 4: A long leg view demonstrating abnormal mechanical axes with the line of body weight passing through the medial side of the knee in a footballer. This predisposes the patient to medial joint damage and wear.