

Partial meniscectomy

Anatomy & Pathophysiology

MENISCAL ANATOMY

- The menisci are C-shaped fibrocartilaginous disks in the knee that provide shock absorption, increase congruency between joint surfaces, enhance joint stability, and aid in the distribution of synovial fluid [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 there is 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 than the medial meniscus carries for the medial compartment [1].
- The medial meniscus has a semicircular shape, which covers approximately 50% to 60% of the medial tibial plateau in adulthood [13].
- The posterior horn of the medial meniscus averages 11 mm in the anterior-posterior dimension, whereas the anterior horn is narrower [13].
- The anterior horn of the medial meniscus attaches to the tibia anterior to the anterior cruciate ligament near the intercondylar fossa [13].
- The posterior root of the medial meniscus attaches in the posterior intercondylar fossa between the lateral meniscus and posterior cruciate ligament [13].
- The menisiofemoral ligaments are variably present structures which connect the posterior horn of the lateral meniscus to the medial femoral condyle [13].
- The ligament of Humphrey crosses anterior to the posterior cruciate ligament, and the ligament of Wrisberg crosses posteriorly [13].
- The lateral meniscus has a more circular C-shape with symmetric sizes of the anterior and posterior horns [13].
- The lateral meniscus anterior root attaches anterior to the intercondylar eminence and just lateral to the anterior cruciate ligament insertion site on the tibia [13].

- The lateral meniscus posterior root attaches posterior to the lateral tibial spine just anterior to the medial meniscus posterior root [13].
- The popliteomeniscal fascicles extend from the lateral meniscus to the posterior capsule to create the popliteal hiatus [13].
- The less continuous attachment of the lateral meniscus to the capsule allows for greater meniscal mobility [13].
- Mean lateral meniscus excursion is 11.2 mm versus a mean medial meniscus excursion of 5.1 mm occurring from knee extension to flexion [13].
- The menisci are wedge-shaped fibrocartilaginous structures situated between the femoral condyles and tibial plateau [13].
- The macrostructure of the meniscus is divided into its tibial attachments at the anterior and posterior roots, the curved anterior and posterior horns, and the meniscal body at its midportion [13].
- The transverse, or intermeniscal, ligament connects the anterior horns of the medial and lateral menisci [13].
- The meniscotibial (coronary) ligament stabilizes the medial meniscus through its attachment from the inferior aspect of the posterior horn to the tibia [13].
- The medial meniscus is firmly attached to the deep medial collateral ligament and joint capsule, limiting its mobility [13].
- The menisci are crescent-shaped, fibrocartilaginous structures with a triangular cross section [17].
- The menisci consist of type I collagen fibers arranged obliquely, radially, and vertically [17].
- The medial meniscus is crescent-shaped and attaches more anterior and posterior [17].
- The lateral meniscus has a circular shape and covers a larger proportion of the tibial plateau [17].
- The lateral meniscus anterior attachment is adjacent to the tibial insertion of the anterior cruciate ligament [17].

MENISCAL VASCULARITY AND ZONES

- Menisci have three zones that can be discerned based on vasculature and extracellular matrix composition [13].
- These zones are commonly described as white-white (ww), red-white (rw), and red-red (rr) zones [13].
- The inner one-third of the meniscus is avascular and called the white-white zone [13].
- The middle zone is called the red-white zone because it has limited vasculature [13].
- The back one-third is called the red-red zone because it is the most vascularized tissue region that has access to blood supply through vessels arising from the geniculate arteries [13].
- 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 [17].

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 [3].
- The lateral femoral condyle projects farther anteriorly and is wider in the medial-lateral direction than is the medial femoral condyle [3].
- The tibial articular surface slopes 7° to 10° in the sagittal plane [3].
- The medial tibial plateau is larger than the lateral plateau and is concave in its frontal and sagittal planes [3].
- The lateral tibial plateau is smaller and more circular than the medial plateau, concave in the frontal plane, and convex in the sagittal plane [3].
- The patella is the largest sesamoid bone in the body and averages 2.5 cm in thickness [3].
- The patella has the thickest articular surface in the body, approximately 5 mm in the midportion and 2 mm on the sides [3].
- The posterior slope of the tibia is a mean of 10.7° in the medial plateau and 7.2° in the lateral plateau [17].
- The medial compartment has a large surface area and contains the convex femoral condyle and concave tibial plateau [17].
- The lateral compartment has a smaller surface area than the medial compartment and contains the convex femoral condyle and convex lateral plateau in the sagittal plane [17].

LIGAMENTOUS ANATOMY

- The anterior cruciate ligament (ACL) travels from the medial border of the lateral femoral condyle to its insertion site anterolateral to the medial tibial spine [1].
- The 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 has superficial and deep portions which stabilize the knee to valgus stresses [1].
- The lateral collateral or fibular collateral ligament runs from the lateral femoral condyle to the head of the fibula and is the main stabilizer against varus stress [1].
- The ACL is composed of 90% type I collagen and 10% type III collagen [3].
- The mean length of the ACL is 33 mm; the mean midsubstance width is 11 mm [3].
- The femoral attachment of the ACL is a semicircular area (20 mm long and 10 mm wide) on the posteromedial aspect of the lateral femoral condyle [3].
- The tibial attachment of the ACL is a broad, irregular, oval-shaped area (30 mm long and 10 mm wide) slightly medial and anterior to the midline and between the medial and lateral tibial spinous processes [3].
- The ACL consists of anteromedial and posterolateral functional bundles [7].
- The anteromedial bundle is tighter in knee flexion, but the posterolateral bundle is tighter in extension [7].

CQ HAND + UPPER LIMB

- The native ACL inserts on the tibia just anterior to the posterior part of the anterior horn of the lateral meniscus [7].
- The center of the ACL femoral footprint is 43% of the distance from the proximal to distal articular cartilage margin [7].
- The center of the anteromedial bundle is 29.5% of the proximal to distal distance of the lateral femoral intercondylar notch [7].
- The center of the posterolateral bundle is 50% of the proximal to distal distance of the lateral femoral intercondylar notch [7].
- The posterior edge of the ACL is 2.5 mm from the posterior articular cartilage border [7].
- The ACL is an intra-articular ligament, but technically extrasynovial as it is surrounded by synovium [15].
- The ACL has a variable length (22 to 41 mm) and width (7 to 12 mm), although it is consistently narrowest in the midsubstance [15].
- The femoral origin of the ACL is on the posteromedial edge of the lateral femoral condyle, posterior to the lateral intercondylar ridge [15].
- The tibial footprint of the ACL is on the tibial plateau, in the anterior intercondylar fossa, between the medial and lateral tibial spines [15].
- The tibial insertion of the ACL is 120% larger than the femoral insertion [15].
- The PCL has a mean length of 38 mm and a mean width of 13 mm [17].
- The PCL has a broad, crescent-shaped femoral attachment on the anterolateral medial femoral condyle with a mean length of 30 mm and mean width of 5 mm [17].
- The tibial insertion of the PCL onto the posterior central sulcus is 10 to 15 mm distal to the joint line of the knee [17].
- The anterolateral bundle of the PCL is tight in knee flexion, while the posteromedial bundle is tight in knee extension [17].

VASCULAR AND NERVE ANATOMY

- The blood supply to the knee is formed from an anastomosis around the knee derived from the descending geniculate artery, medial and lateral superior geniculate arteries, medial and lateral inferior geniculate arteries, middle geniculate artery, and anterior tibial recurrent arteries [3].
- The middle geniculate artery supplies both the anterior and posterior cruciate ligaments [3].
- 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) [3].
- The largest nerve providing innervation of the intra-articular knee is the posterior articular branch of the tibial nerve [3].
- The posterior articular branch of the tibial nerve supplies the infrapatellar fat pad, the synovial covering over the cruciate ligaments, and the periphery of the meniscus [3].
- Nerves to the cruciate ligaments contain vasomotor and pain fibers as well as mechanoreceptors that may be involved in proprioception [3].

PATHOPHYSIOLOGY OF MENISCECTOMY

- If the menisci are not present, the convex femoral condyles articulate with the relatively flat tibial plateaus, and the joint surfaces are not congruent [1].
- Absence of menisci decreases the surface area of contact and increases the pressure on the articular cartilage of the tibia and femur, which may lead to rapid deterioration of the joint surface [1].
- The menisci help with load transmission and bear one-third to one-half body weight [18].
- Removal of the menisci increases contact stresses, with up to four times the load transfer to bone [18].
- The posterior horn of the medial meniscus serves as a chock block on the tibial plateau [12].
- Absence of the posterior horn increases instability in both anterior cruciate ligament and posterior cruciate ligament deficient knees [12].

Investigations

PHYSICAL EXAMINATION

- The physical examination of a knee injury begins with observation of the patient's gait [1].
- The uninjured knee is examined as a basis of comparison with the injured knee [1].
- Swelling or effusion is noted during the physical examination [1].
- A small effusion causes obliteration of the recesses on the medial and lateral aspects of the patellar tendon [1].
- With a larger effusion, diffuse swelling is present in the region of the suprapatellar pouch [1].
- A fluid wave can be palpated on the sides of the patella in the presence of effusion [1].
- Active and then passive range of motion is tested carefully during the physical examination [1].
- The knee is palpated to define areas of localized tenderness [1].
- The joint lines are located at the level of the inferior pole of the patella when the knee is flexed to 90 degrees [1].
- Medial joint line tenderness along the course of the MCL is typical at the location of a tear [9].
- Laxity to valgus stresses is assessed by the amount of medial joint space opening that occurs at 30 degrees of flexion [9].
- Zero opening to valgus stress is considered normal [9].
- Medial joint space opening of 1–4 mm indicates a grade I MCL injury [9].
- Medial joint space opening of 5–9 mm indicates a grade II MCL injury [9].
- Medial joint space opening of 10–15 mm indicates a complete or grade III MCL injury [9].
- Grade I and II MCL injuries typically have a firm end point to valgus stress [9].
- A grade III MCL injury tends to have a soft end point to valgus stress [9].

- The integrity of the LCL is assessed by placing a varus stress with the knee in full extension and 30 degrees of flexion [30].
- The average baseline for varus opening is 7 degrees [30].
- Exam findings with an isolated LCL injury include varus laxity at 30 degrees of flexion and no instability in full extension [30].
- The dial test is performed by externally rotating each tibia and noting the angle subtended between the thigh and the foot [30].
- The dial test is performed at 30 and 90 degrees of flexion [30].
- A significant difference in the dial test is an angle 5 degrees or greater than the contralateral leg [30].
- Greater external rotation at 30 degrees on the dial test confirms injury to the posterolateral capsule alone [30].
- Greater external rotation at 90 degrees on the dial test confirms an isolated PCL injury [30].
- Greater rotation at both 30 and 90 degrees compared to the uninjured leg on the dial test confirms injury to both posterolateral structures [30].
- The reverse pivot shift test involves starting with the knee flexed to 90 degrees, extending the knee while loading it axially with a valgus stress and holding the foot in external rotation [30].
- A palpable shift is noted during the reverse pivot shift test as the tibia reduces from its posteriorly subluxed position as the knee is extended [30].
- The external rotation recurvatum test is performed with the patient supine and the hip and knee fully extended [30].
- In the external rotation recurvatum test, the leg is lifted off the bed by the toes [30].
- Hyperextension, varus instability, and external rotation of the tibial tubercle occur with adequate quadriceps relaxation in a patient with posterolateral instability during the external rotation recurvatum test [30].
- The posterolateral drawer test is performed with the tibia in internal rotation, neutral, and externally rotated positions [30].
- With posterolateral injury, the magnitude of the posterior drawer displacement is greatest with external tibial rotation [30].
- An examination under anesthesia can be valuable when physical examination is unreliable because of the patient guarding the knee [9].
- Diagnostic arthroscopy can be used to evaluate for coexisting pathology [9].
- Examination under anesthesia and diagnostic arthroscopy have largely been replaced by MRI [9].

RADIOGRAPHY

- Plain radiographs are appropriate initial imaging studies for most knee conditions [21].
- Plain radiographs allow the assessment of traumatic injury, arthritis, patellofemoral alignment, osteochondral injury, bone neoplasm, and surgical implants [21].

- Imaging studies should include at least two perpendicular views: AP and lateral [21].
- Weight-bearing AP (extension) views are used to assess cartilage loss from the distal femur and tibial plateau [21].
- Weight-bearing PA (Rosenberg; flexion) views are used to assess cartilage loss from the posterior femur and tibial plateau [21].
- Patellofemoral views are used to assess patellofemoral alignment, patellar and trochlear morphology, osteochondral injury, and patellofemoral arthritis [21].
- A notch view is used to assess posterior femoral cartilage, notch width, and osteophytes [21].
- Non-weight-bearing radiographs may identify acute injury without the risk of fracture displacement in trauma cases [21].
- Radiographs should be inspected for acute fracture, lateral capsular avulsion (Segond fracture), loose bodies, Pellegrini-Stieda lesion (MCL calcification), and evidence of patellar dislocation [9].
- Stress radiographs should be obtained in patients prior to skeletal maturity to rule out an epiphyseal fracture [9].
- Radiographs can underestimate isolated chondral lesions [25].
- Radiographs may demonstrate joint space narrowing, osteophytes, sclerosis, and cysts in articular cartilage injury [25].
- Weight-bearing AP and lateral views and an axial view of the patellofemoral joint should be reviewed for articular cartilage injury [25].
- The ability to detect subtle narrowing or an isolated chondral defect on the flexion surface may be improved with a semiflexed PA view [25].
- Long leg alignment views are used to determine the mechanical axis [25].
- If the mechanical axis traverses the involved compartment, realignment may need to be considered as an initial procedure or as an adjunct to a cartilage restorative procedure [25].
- Radiographs are still the standard for initial evaluation of knee arthritis [29].
- Images for knee arthritis evaluation should include weight-bearing AP and lateral views [29].
- Images for knee arthritis evaluation should include a view of the weight-bearing knee flexed at 45-degree angle, imaged posterior to anterior [29].
- Images for knee arthritis evaluation should include a sunrise view (Merchant view) [29].
- Images for knee arthritis evaluation should include extension and flexion lateral views [29].
- Images for knee arthritis evaluation should include a standing full-length AP radiograph from hip joint to ankle joint [29].
- Standing full-length AP radiographs are used to evaluate limb alignment and knee deformity [29].
- Standing full-length AP radiographs are used to identify femoral and/or tibial bone deformity [29].
- The KL rating grades extent of OA based on review of AP knee radiograph [29].
- Primary features used for KL rating include osteophytes, joint space narrowing, subchondral sclerosis with or without subchondral cysts, and altered shape of periarticular bones [29].

- KL Grade 0 indicates normal knee features with no OA [29].
- KL Grade 1 indicates OA possibly present [29].
- KL Grade 2 indicates OA present with minimal severity [29].
- KL Grade 3 indicates OA present with moderate severity [29].
- KL Grade 4 indicates OA present with severe severity [29].
- Knee arthroplasty is recommended when Grade 4 findings are present [29].
- With chronic posterolateral instability, degenerative changes of the lateral compartment are often noted on radiographs [30].
- Lateral joint space narrowing with osteophytes and subchondral sclerosis can be seen with chronic posterolateral instability [30].
- Stress radiographs can help to better quantify the amount of varus angulation present [30].

MAGNETIC RESONANCE IMAGING

- MRI is useful for confirming MCL injury and identifying the site of injury [9].
- MRI is useful to detect the presence of meniscal and other injuries to the knee [9].
- Relative indications for an MRI include an uncertain ACL status despite multiple examinations [9].
- Relative indications for an MRI include evaluation of a suspected meniscal tear [9].
- Relative indications for an MRI include preoperative evaluation for a planned MCL reconstruction or repair [9].
- MRI should be obtained as a useful adjunct to help diagnose posterolateral corner injuries [30].
- MRI is often a useful adjunct for diagnosing posterolateral corner and LCL injuries in the severely injured knee [30].
- MRI findings can refocus the examination to the posterolateral structures when injury is obscured by pain and guarding [30].
- Patterns of meniscal injury can be identified by location (anterior, midbody, posterior, peripheral, articular), pattern (horizontal, longitudinal, radial, complex), and displacement [21].
- MRI may identify the degree of articular cartilage injury (chondrosis, full-thickness cartilage loss) [21].
- MRI may identify the presence of associated bone marrow edema in articular cartilage injury [21].
- MRI may identify the location of articular cartilage injury (medial condyle, lateral condyle, trochlea, patella; anterior, posterior) [21].
- MRI can be used to evaluate articular cartilage morphology [25].
- MRI is grossly overused in the arthritic patient population [29].
- If the joint space is significantly narrowed on radiograph, then MRI is not indicated [29].
- MRI is used when osteonecrosis is suspected [29].
- A systematic review quantifies the accuracy of MRI for detection of meniscal injury and ACL tear [27].

- A systematic review of asymptomatic meniscal pathology in athletes describes isolated meniscal pathology (including intrasubstance meniscal signal) in 31% and frank meniscal tear in 3.9% [27].

COMPUTED TOMOGRAPHY

- Three-dimensional CT with remodeling is used for preoperative planning for reconstruction associated with dysplasia [29].
- Three-dimensional CT with remodeling is used for post-trauma planning [29].
- Three-dimensional CT with remodeling is used for complex total knee arthroplasty (TKA) planning [29].
- Three-dimensional reconstructions may help with preoperative planning for complex intra-articular fractures [21].
- Three-dimensional reconstructions may help with multiplanar osteotomy for limb malalignment [21].
- Three-dimensional reconstructions may help with reconstitution of bone loss in joint arthroplasty [21].
- Axial plane imaging of the hip and knee can help assess the rotational alignment of components of a total knee arthroplasty in cases of patellar maltracking [21].

NUCLEAR MEDICINE

- Nuclear medicine provides a nonspecific study that does not define the etiology of an abnormality but rather the presence of an abnormality that may correlate with a clinical concern [21].
- Increased radionuclide activity in bone may be a normal postoperative finding for up to 6 to 12 months after a fracture repair or arthroplasty [21].
- Technetium-99 (Tc-99) may help identify infection, neoplasia, occult fracture, bone healing, active phases of heterotopic ossification, implant loosening, or failure of osseointegration [21].
- Gallium-67 (Ga-67) may help differentiate between aseptic and septic prosthetic loosening [21].
- 24 to 72 hours are needed for a complete Gallium-67 study [21].

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