CQ HAND + UPPER LIMB
SPECIALIST ORTHOPAEDIC SURGEON

EVIDENCE SUMMARY

Distal femoral osteotomy

Anatomy & Pathophysiology

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 the medial femoral condyle [3].
- The sulcus terminalis is a small ridge on the lateral femoral condyle just distal to the intercondylar notch that separates the patellofemoral and tibiofemoral articular surfaces [3].
- The trochlear groove separates the femoral condyles anteriorly and constitutes the patellofemoral articulation [3].
- The intercondylar notch is of variable width and is the site of attachment of the cruciate ligaments [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 medial and lateral tibial plateaus are separated by the intercondylar eminence and its medial and lateral spinous processes [3].
- The tibial tuberosity is the site of attachment of the patellar tendon and is typically located in the midline anteriorly but may be slightly lateral [3].
- Gerdy's tubercle is the insertion site of the iliotibial band and is located 2 to 3 cm lateral to the tibial tubercle on the proximal tibia [3].
- The proximal fibula articulates with a facet of the lateral cortex of the tibia and is not part of the knee articulation [3].
- The patella is the largest sesamoid bone in the body and averages 2.5 cm in thickness [3].

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- The patella has the thickest articular surface in the body, approximately 5 mm in the midportion and 2 mm on the sides [3].
- The patellar articular surface contains a vertical, central ridge that separates the broader lateral facet from the medial facet, and a smaller, more medial facet called the odd facet [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 fibular head is located a mean of 1.5 cm distal to the joint line, with a range of 6 to 32 mm below the joint line [17].
- The medial epicondyle is the most anterior and distal osseous prominence of the distal femur [3].
- The adductor tubercle is proximal and posterior to the medial epicondyle [3].
- The gastrocnemius tubercle is slightly distal and posterior to the adductor tubercle [3].
- The MCL originates on the femoral sulcus approximately 3.2 cm proximal and 4.8 cm posterior to the articular surface of the femur at the knee [17].
- The lateral trochlear facet resists lateral subluxation of the patella [17].
- The PCL inserts on the anteromedial wall of the intercondylar notch and the ACL inserts on the posterolateral wall [17].

LIGAMENTS

- 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 PCL runs from the lateral aspect of the medial femoral condyle to the posterior aspect of the tibia, just below the joint line [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 [1].
- The lateral collateral ligament is the main stabilizer against varus stress [1].
- The popliteofibular ligament is present in 90% of knees and runs from the tendon of the popliteus muscle to the styloid on the posterior fibular head [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 and 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 is an intra-articular ligament but technically extrasynovial as it is surrounded by synovium [15].

- The ACL has a variable length of 22 to 41 mm and width of 7 to 12 mm, 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 mean width of 13 mm [17].
- The femoral attachment of the PCL is a broad, crescent-shaped area 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 anteromedial bundle of the ACL is tight in knee flexion and the posterolateral bundle is tight in knee extension [17].
- The posterolateral bundle of the ACL is responsible for preventing the pivot-shift phenomenon and stabilizes against anterior translation with 30° of knee flexion [17].
- The anteromedial bundle of the ACL increases anterior tibial translation at 60° and 90° of knee flexion [17].
- The anterolateral bundle of the PCL is stronger and stiffer than the posteromedial bundle and is tight in knee flexion [17].
- The posteromedial bundle of the PCL is tight in knee extension [17].
- The ACL is typically subjected to peak loads of 170 N during walking and up to 500 N with running [18].
- The ultimate strength of the ACL in young patients is about 1750 N [18].
- The ACL fails by serial tearing at 10% to 15% elongation [18].
- Sectioning the PCL increases contact pressures in the medial compartment and the patellofemoral joint [18].

MENISCI

- The menisci are C-shaped fibrocartilaginous disks in the knee that provide shock absorption, allow for increased congruency between joint surfaces, enhance joint stability, and aid in 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 ACL near the intercondylar fossa [13].
- The posterior root of the medial meniscus attaches in the posterior intercondylar fossa between the lateral meniscus and PCL [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 ACL 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 meniscofemoral ligaments connect the posterior horn of the lateral meniscus to the medial femoral condyle [13].
- The ligament of Humphrey crosses anterior to the PCL and the ligament of Wrisberg crosses posteriorly [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].
- Menisci have three zones based on vasculature and extracellular matrix composition: white-white (ww), red-white (rw), and red-red (rr) [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 with access to blood supply through vessels arising from the geniculate arteries [13].
- Menisci are crescent-shaped, fibrocartilaginous structures with a triangular cross section [17].
- Menisci consist of type I collagen fibers arranged obliquely, radially, and vertically [17].
- 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].
- Menisci help with load transmission and bear one-third to one-half body weight [18].

- Removal of menisci increases contact stresses up to four times the load transfer to bone [18].

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 inferior geniculate arteries pass deep to their respective collateral ligaments [3].
- The blood supply of the patella is derived from the geniculate artery complex with some contribution from the anterior tibial recurrent artery and primarily exists in the middle to inferior portions of the patella [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].
- The infrapatellar branch of the saphenous nerve arises proximal to the knee joint medially and crosses distal to the patella to innervate the skin over the region of the anterior knee and proximal tibia [3].
- The popliteal artery is near the PCL, and the distance increases with knee flexion [17].

KINEMATICS AND JOINT FORCES

- The knee is a hinge joint that also incorporates both gliding and rolling, which are essential to its kinematics [4].
- The “screw-home” mechanism involves the tibia externally rotating 5 degrees in the final 15 degrees of extension [4].
- Knee joint surface loads are three times body weight during level walking and up to four times body weight with stair walking [18].
- The quadriceps produces maximum anterior force on the tibia at 0 to 60 degrees of knee flexion [18].
- The patella aids in knee extension by increasing the lever arm and stress distribution [18].
- The patella bears half the body weight with normal walking and seven times the body weight with squatting and jogging [18].
- In descending stairs, compressive force in the patellofemoral joint reaches two to three times body weight [18].
- The mechanical axis of the lower extremity runs from the center of the femoral head to the center of the ankle and normally passes just medial to the medial tibial spine [18].

- The mechanical axis of the lower extremity is in 3 degrees of valgus angulation from the vertical axis [18].
- The anatomic axis of the femur is in 6 degrees of valgus angulation from the mechanical axis and 9 degrees versus the vertical axis [18].
- The anatomic axis of the tibia is in 2 to 3 degrees of varus angulation from the mechanical axis [18].

Investigations

PLAIN RADIOGRAPHY

- Plain radiographs are appropriate initial imaging studies for most knee conditions because they 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 (tilt/subluxation), 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].
- 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 may identify subchondral sclerosis, joint space narrowing, subchondral cysts, osteophytes, and joint subluxation in osteoarthritis [21].
- Radiographs can underestimate isolated chondral lesions but may demonstrate joint space narrowing, osteophytes, sclerosis, and cysts [25].
- Weight-bearing AP and lateral views and an axial view of the patellofemoral joint should be reviewed for articular cartilage evaluation [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 (varus knees with medial compartment lesions or valgus knees with lateral compartment lesions), 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, a view of the weight-bearing knee flexed at 45-degree angle imaged posterior to anterior, a sunrise view (Merchant view), extension and flexion lateral views, and a standing full-length AP radiograph [29].
- A standing full-length AP radiograph from hip joint to ankle joint is used to evaluate limb alignment and knee deformity [29].
- A standing full-length AP radiograph is used to identify femoral and/or tibial bone deformity (developmental or traumatic) [29].
- The Kellgren-Lawrence (KL) rating grades extent of osteoarthritis based on review of AP knee radiograph [29].
- Primary features used for KL rating include osteophytes (periarticular and tibial spine), 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 osteoarthritis [29].
- KL Grade 1 indicates osteoarthritis possibly present [29].
- KL Grade 2 indicates osteoarthritis present with minimal severity [29].
- KL Grade 3 indicates osteoarthritis present with moderate severity [29].
- KL Grade 4 indicates osteoarthritis present with severe severity [29].
- Knee arthroplasty is recommended when KL Grade 4 findings are present [29].
- With chronic posterolateral instability, degenerative changes of the lateral compartment are often noted on radiographs, including lateral joint space narrowing with osteophytes and subchondral sclerosis [30].
- Stress radiographs can help to better quantify the amount of varus angulation present in posterolateral knee injuries [30].

COMPUTED TOMOGRAPHY

- Computed tomography provides a three-dimensional study with ionizing radiation that provides enhanced bone detail [21].
- Imaging in the axial, sagittal, and coronal planes may help visualize fracture lines and displacement, osteolytic lesions around joint arthroplasty, and cortical disruption in cases of infection or neoplasia [21].
- Three-dimensional CT reconstructions may help with preoperative planning for multiplanar osteotomy for limb malalignment [21].
- Three-dimensional CT with remodeling is used for preoperative planning for reconstruction associated with dysplasia, post-trauma planning, and complex total knee arthroplasty planning [29].

MAGNETIC RESONANCE IMAGING

- MRI may help assess overall limb alignment and further delineate intra-articular and extra-articular soft tissues, including cartilage, menisci, ligaments, tendons, muscles, and nerve and vascular structures [21].
- Increasing strength of the magnetic field (measured in Tesla units) increases the resolution of MRI images [21].

- An injected contrast agent (intravenous or intra-articular) may help delineate specific tissues of interest on MRI [21].
- MRI may identify the degree of articular cartilage injury (chondrosis, full-thickness cartilage loss), the presence of associated bone marrow edema, and the location (medial condyle, lateral condyle, trochlea, patella; anterior, posterior) [21].
- MRI can be used to evaluate articular cartilage morphology [25].
- 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 in the context of MCL injury [9].
- Relative indications for an MRI in MCL injury include an uncertain ACL status despite multiple examinations, evaluation of a suspected meniscal tear, or preoperative evaluation for a planned MCL reconstruction or repair [9].
- 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 posterolateral injury may have gone unnoticed during initial evaluation [30].
- MRI is grossly overused in the arthritic patient population [29].
- If the joint space is significantly narrowed on radiograph, then MRI is not indicated for knee arthritis [29].
- MRI is used when osteonecrosis is suspected in knee arthritis [29].
- A systematic review quantified the accuracy of MRI for detection of meniscal injury and ACL tear [27].
- Compositional MRI techniques (T1ρ, T2*, dGEMRIC, gagCEST) are used for early recognition of cartilage degeneration [27].

PHYSICAL EXAMINATION

- The physical examination begins with observation of the patient's gait [1].
- The uninjured knee is examined as a basis of comparison with the injured knee [1].
- Any swelling or effusion should be noted during physical examination [1].
- A small effusion will cause 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 with a larger effusion [1].
- Active and then passive range of motion is tested carefully [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].
- Laxity to valgus stresses is assessed by the amount of medial joint space opening that occurs at 30 degrees of flexion [9].

- The knee is stressed at 30 degrees of flexion for MCL evaluation because with the knee in full extension the posterior capsule and PCL will stabilize the knee to valgus stress [9].
- Zero opening is considered normal for MCL valgus stress testing [9].
- 1–4 mm of medial joint space opening indicates a grade I MCL injury [9].
- 5–9 mm of medial joint space opening indicates a grade II MCL injury [9].
- 10–15 mm of medial joint space opening 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 should include varus laxity at 30 degrees of flexion and no instability in full extension [30].
- The dial test is the most useful test to evaluate for posterolateral instability [30].
- The dial test is performed at 30 and 90 degrees of flexion with a significant difference being an angle 5 degrees or greater than the contralateral leg [30].
- Injury to the posterolateral capsule alone is confirmed with greater external rotation at 30 degrees on the dial test [30].
- An isolated PCL injury is confirmed with greater external rotation at 90 degrees on the dial test [30].
- Injury to both posterolateral capsule and PCL is confirmed when there is greater rotation at 30 and 90 degrees compared to the uninjured leg on the dial test [30].
- A careful neurovascular examination should be performed for LCL and/or posterolateral corner injury as the incidence of neurovascular injury, particularly peroneal nerve injury, has been reported in 12–29% of posterolateral knee injuries [30].
- Patients commonly present with a history of a precipitating traumatic event or previous surgery for articular cartilage defects [25].
- An effusion, motion deficits, or limb malalignment may be observed in patients with articular cartilage defects [25].
- Knee stability should be compared with the normal side in patients with articular cartilage defects [25].
- Physical examination along with radiographic or advanced imaging findings must be used concomitantly to determine the source of each patient's symptoms and to determine appropriate surgical intervention when nonsurgical measures have failed [8].

References

[1] A Lange Medical Book Current Diagnosis Treatment In Orthopedics Fifth Edition. **3Sports Medicine** > **Image KNEE INJURIES**.

[3] Aaos Comprehensive Orthopaedic Review 3. Anatomy and Biomechanics of the Knee > I. Anatomy.

[4] Miller S Review Of Orthopaedics. SECTION 1 KNEE > ANATOMY (FIG. 4.1).

[8] Orthopaedic Knowledge Update 13 Ebook Without Multimedia. Knee Arthroscopy and Preservation, Knee Reconstruction > Introduction.

[9] A Lange Medical Book Current Diagnosis Treatment In Orthopedics Fifth Edition. **3Sports Medicine** > **1. Medial Collateral Ligament Injuries**.

[13] Orthopaedic Basic Science Fifth Edition Print Ebook. Biology and Mechanics of the Skeletal Extracellular Matrix > Gross Anatomy.

[15] Rockwood And Green S Fractures In Adults. 59: Patellar Fractures and Dislocations and Extensor Mechanism Injuries > Anterior Cruciate Ligament Anatomy.

[17] Aaos Comprehensive Orthopaedic Review 3. Radiographic Evaluation and Surgical Anatomy of the Knee > II. Surgical Anatomy of the Knee.

[18] Miller S Review Of Orthopaedics. ARTHRODESIS PERSON > Kinetics.

[21] Aaos Comprehensive Orthopaedic Review 3. Radiographic Evaluation and Surgical Anatomy of the Knee > I. Radiographic Evaluation.

[25] Aaos Comprehensive Orthopaedic Review 3. Articular Cartilage Injury and Treatment > IV. Full-Thickness Outerbridge Grade IV Defects.

[27] Orthopaedic Knowledge Update 13 Ebook Without Multimedia. Knee Arthroscopy and Preservation, Knee Reconstruction > Annotated References.

[29] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > SECTION 11 KNEE ARTHRITIS ASSESSMENT.

[30] A Lange Medical Book Current Diagnosis Treatment In Orthopedics Fifth Edition. **3Sports Medicine** > **2. Lateral Collateral Ligament Injuries**.

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