

Knee arthroscopy

Overview

- Performing arthroscopy for the treatment of early-stage osteoarthritis of the knee may help delay the need for knee arthroplasty, but proper patient selection is imperative [2].
- Arthroscopic débridement allows assessment of the joint and affords the ability to débride the meniscus, loose articular cartilage, and synovium [2].
- Arthroscopic débridement allows the removal of any loose bodies [2].
- Arthroscopic débridement enables visualization of the entire joint and may aid in future decision making regarding osteotomy, unicompartmental knee arthroplasty, or total knee arthroplasty [2].
- Various arthroscopic techniques are described, including lavage and débridement, chondroplasty (laser, radiofrequency), abrasion arthroplasty, and subchondral penetrating procedures (drilling, microfracture) [2].
- Arthroscopic indications include mild to moderate arthritis with minimal malalignment and mechanical symptoms consistent with a loose body, meniscus tear, synovitis, or painful osteophytes [2].
- A history of increased pain of acute onset, specific twisting mechanism, and mechanical symptoms is associated with a good prognosis for arthroscopic treatment of degenerative arthritis [2].
- A history of pending litigation/work injury and chronic symptoms is associated with a poor prognosis for arthroscopic treatment of degenerative arthritis [2].
- A recent effusion on physical examination is associated with a good prognosis for arthroscopic treatment of degenerative arthritis [2].
- Varus/valgus alignment and ligamentous instability on physical examination are associated with a poor prognosis for arthroscopic treatment of degenerative arthritis [2].
- Radiographic findings of loose bodies and normal mechanical alignment are associated with a good prognosis for arthroscopic treatment of degenerative arthritis [2].
- Radiographic findings of complete loss of joint space, chondrocalcinosis, and varus/valgus alignment are associated with a poor prognosis for arthroscopic treatment of degenerative arthritis [2].
- Surgical findings of isolated chondral flap/fracture, isolated unicompartmental disease, and meniscal tears are associated with a good prognosis for arthroscopic treatment of degenerative arthritis [2].

- Surgical findings of diffuse disease, degenerative meniscal tears, and severe chondromalacia are associated with a poor prognosis for arthroscopic treatment of degenerative arthritis [2].
- Arthroscopic procedures are contraindicated in the knee with advanced arthritis, especially when varus or valgus malalignment is present [2].
- The literature lacks well-designed studies to evaluate the efficacy of arthroscopic procedures for the arthritic knee [2].
- Some studies have demonstrated improvement in short-term outcomes with arthroscopic treatment of the arthritic knee [2].
- Most studies demonstrate equivalent outcomes to nonsurgical treatment at mid to long-term follow-up for arthroscopic treatment of the arthritic knee [2].
- Arthroscopic lavage and débridement of the arthritic knee is controversial but effective when properly indicated [2].
- Indications for arthroscopic lavage and débridement are limited to specific mechanical symptoms caused by loose bone, cartilage flaps or particles, meniscal tears, or synovial impingement [2].
- During arthroscopic lavage and débridement, the knee is irrigated and débridement of loose cartilage, meniscus, and/or synovium is performed through the arthroscope [2].
- Irrigation during arthroscopic lavage dilutes the joint fluid, which reduces the concentration of degradative enzymes [2].
- Removal of loose cartilage, meniscus, and/or synovium during arthroscopic lavage reduces mechanical symptoms and removes a source of irritation to the synovial tissue [2].
- In chondroplasty, diseased cartilage is removed or stabilized using a shaver, laser, or radiofrequency probe [2].
- The potential for thermal damage when using a laser or radiofrequency probe has resulted in decreased use of these techniques for chondroplasty [2].
- In abrasion arthroplasty, an arthroscopic shaver is used to débride cartilage defects and penetrate the subchondral bone plate to cause bleeding [2].
- The goal of abrasion arthroplasty is formation of a blood clot, which undergoes metaplasia to become fibrocartilage [2].
- The process of fibrocartilage formation after abrasion arthroplasty is estimated to take 8 weeks [2].
- Fibrocartilage is primarily composed of type I collagen as opposed to the type II collagen of normal hyaline cartilage [2].
- In subchondral drilling or microfracture, cartilage defects are débrided to a stable rim, and the resulting exposed subchondral bone is penetrated with a small drill or awl [2].
- The goal of subchondral drilling or microfracture is to create bleeding bone, which produces a blood clot and subsequent fibrocartilage [2].
- The biomechanical and physiologic differences between fibrocartilage and hyaline cartilage are concerning for lasting effectiveness of subchondral drilling or microfracture [2].

- Some studies have demonstrated by 2 years post-op that the fibrocartilage cap is significantly degraded or no longer present [2].

Anatomy & Pathophysiology

BONY ANATOMY

- The knee joint consists of the distal femur, proximal tibia, and patella [6].
- The medial femoral condyle is larger and projects farther posteriorly and distally than the lateral femoral condyle [13].
- The lateral femoral condyle projects farther anteriorly and is wider in the medial-lateral direction than the medial femoral condyle [13].
- 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 [13].
- The trochlear groove separates the femoral condyles anteriorly and constitutes the patellofemoral articulation [13].
- The intercondylar notch is of variable width and is the site of attachment of the cruciate ligaments [13].
- The tibial articular surface slopes 7° to 10° in the sagittal plane [13].
- The medial tibial plateau is larger than the lateral plateau and is concave in its frontal and sagittal planes [13].
- The lateral tibial plateau is smaller and more circular than the medial plateau, concave in the frontal plane and convex in the sagittal plane [13].
- The medial and lateral tibial plateaus are separated by the intercondylar eminence and its medial and lateral spinous processes [13].
- 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 [13].
- 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 [13].
- The proximal fibula articulates with a facet of the lateral cortex of the tibia and is not part of the knee articulation [13].
- The patella is the largest sesamoid bone in the body and averages 2.5 cm in thickness [13].
- The patella has the thickest articular surface in the body, approximately 5 mm in the midportion and 2 mm on the sides [13].
- 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 [13].
- The posterior slope of the tibial plateau is a mean of 10.7° in the medial plateau and 7.2° in the lateral plateau [16].

- 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 [16].
- 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 [16].
- The adductor tubercle is a prominence on the medial condyle proximal to the MCL origin and is the site of insertion of the adductor magnus muscle [16].
- The lateral femoral condyle has a broader mean anterior-posterior dimension than the medial femoral condyle, allowing internal rotation of the distal femur with knee extension [16].
- The lateral trochlear facet resists lateral subluxation of the patella [16].
- The sulcus terminalis is a transverse ridge extending from the oblique facets of the femoral trochlea that is deeper on the lateral condyle than on the medial condyle [16].
- The PCL inserts on the anteromedial wall of the intercondylar notch and the ACL inserts on the posterolateral wall [16].
- The patella has three facets: lateral, medial, and odd [16].
- The odd facet is a small facet on the distal medial patella that articulates in deep flexion of the knee [16].
- In Wiberg classification Type I patellar morphology, medial and lateral facets are equal in size [16].
- In Wiberg classification Type II patellar morphology, which is the most common, the medial facet is smaller and one half the size of the lateral facet [16].
- In Wiberg classification Type III patellar morphology, the medial facet is so far medial that the central ridge is barely noticeable [16].

LIGAMENT ANATOMY

- The ACL travels from the medial border of the lateral femoral condyle to its insertion site anterolateral to the medial tibial spine [6].
- The ACL prevents anterior translation and rotation of the tibia on the femur [6].
- The PCL prevents posterior subluxation of the tibia on the femur [6].
- The PCL runs from the lateral aspect of the medial femoral condyle to the posterior aspect of the tibia, just below the joint line [6].
- The medial collateral ligament has superficial and deep portions which stabilize the knee to valgus stresses [6].
- 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 [6].
- The lateral collateral ligament is part of the posterolateral “complex” or “corner” of the knee that also resists external rotation [6].
- The popliteofibular ligament, present in 90% of knees, runs from the tendon of the popliteus muscle to the styloid on the posterior fibular head [6].
- The ACL is composed of 90% type I collagen and 10% type III collagen [13].

- The mean length of the ACL is 33 mm and the mean midsubstance width is 11 mm [13].
- 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 [13].
- 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 [13].
- The ACL has two bundles named according to their tibial insertions: the anteromedial bundle and the posterolateral bundle [14].
- The anteromedial bundle of the ACL originates proximal to the bifurcate ridge and is tight in flexion [14].
- The posterolateral bundle of the ACL originates distal to the bifurcate ridge and is tight in extension [14].
- The ACL length is 30 mm and diameter is 11 mm [14].
- The PCL has two distinct bundles defined by their insertion on the femur: an anterolateral (AL) bundle and a posteromedial (PM) bundle [23].
- The AL bundle of the PCL is larger and comprises 85% of the PCL's cross-sectional area [23].
- The PCL femoral footprint is a broad, semicircular attachment on the AL aspect of the medial femoral condyle, adjacent to the articular surface [23].
- In the coronal plane, the PCL femoral attachment is typically between 12 and 4 o'clock in the right knee, and between 12 and 8 o'clock in the left knee [23].
- The insertion of the two PCL bundles is separated by a medial bifurcate ridge [23].
- The PCL inserts onto a midline depression on the tibia, 10 to 15 mm below the level of the medial and lateral tibial plateaus [23].
- The PCL tibial fossa is trapezoidal in shape [23].
- The AL bundle of the PCL occupies the superolateral aspect of the tibial footprint, with the PM bundle occupying the inferomedial aspect of the intercondylar fossa [23].
- The mean length of the PCL is 38 mm and the mean width is 13 mm [16].
- 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 [16].
- The PCL tibial insertion onto the posterior central sulcus is 10 to 15 mm distal to the joint line of the knee [16].
- The AL bundle of the PCL is stronger and stiffer than the PM bundle and is tight in knee flexion [16].
- The PM bundle of the PCL is tight in knee extension [16].
- The ACL anteromedial bundle is tight in knee flexion and the posterolateral bundle is tight in knee extension [16].
- The posterolateral bundle of the ACL is responsible for preventing the pivot-shift phenomenon and stabilizes against anterior translation with 30° of knee flexion [16].
- The anteromedial bundle of the ACL increases anterior tibial translation at 60° and 90° of knee flexion [16].

- The primary function of the ACL anteromedial bundle is to resist anterior tibial translation in knee flexion [14].
- The secondary function of the ACL anteromedial bundle is to resist varus translation in knee extension [14].
- The primary function of the ACL posterolateral bundle is to resist rotatory loads in knee extension [14].
- The secondary function of the ACL posterolateral bundle is to resist varus translation in knee extension [14].
- The primary function of the PCL (AL and PM bundles codominant) is to resist posterior tibial translation at all degrees of knee flexion [14].
- The secondary function of the PCL is to resist tibial internal and external rotation beyond 90 degrees of knee flexion and to resist varus translation [14].
- The primary function of the superficial MCL proximal division is to resist valgus tibial translation [14].
- The secondary function of the superficial MCL proximal division is to resist tibial external rotation [14].
- The primary function of the superficial MCL distal division is to resist tibial external rotation in knee extension [14].
- The secondary function of the superficial MCL distal division is to resist tibial internal rotation [14].
- The primary function of the deep MCL is to resist valgus translation [14].
- The secondary function of the deep MCL is to resist tibial internal and external rotation [14].
- The primary function of the posterior oblique ligament is to resist tibial internal rotation, especially in knee extension [14].
- The secondary function of the posterior oblique ligament is to resist tibial external rotation [14].
- The primary function of the lateral collateral ligament is to resist varus tibial translation [14].
- The secondary function of the lateral collateral ligament is to resist tibial external rotation, especially at 30 degrees of knee flexion [14].
- The primary function of the popliteus tendon is to resist tibial external rotation, especially in knee flexion [14].
- The secondary function of the popliteus tendon is to resist varus tibial translation [14].
- The primary function of the popliteofibular ligament is to resist tibial external rotation, especially in knee flexion [14].
- The secondary function of the popliteofibular ligament is to resist posterior tibial displacement [14].
- The primary function of the oblique popliteal ligament is to resist knee hyperextension [14].
- The secondary function of the oblique popliteal ligament is to resist varus tibial translation [14].
- The ACL primary function is to resist anterior translation of the tibia relative to the femur [20].
- The ACL secondary function is to resist varus/valgus stresses in full extension [20].
- The PCL primary function is to resist posterior translation of the tibia relative to the femur [20].
- The PCL secondary function is to resist tibial external rotation [20].

- The MCL resists valgus stress [20].
- The posteromedial corner (PMC) resists valgus stress [20].
- The fibular collateral ligament (FCL) resists varus stress [20].
- The posterolateral corner (PLC) resists posterior translation, external rotation, and varus angulation of the tibia [20].
- The PLC is made up of the FCL, the iliotibial band, the popliteofibular ligament, the biceps femoris, and the popliteus tendon [20].
- The PCL is extrasynovial and projects anteriorly in a median septum that separates the posterior aspect of the knee into two compartments [24].
- The middle genicular artery courses anteriorly in the posterior septum to nourish the tissues of the intercondylar notch of the femur [24].
- The PCL is the largest of the intra-articular ligaments, with an average length of 38 mm and a mean diameter at the midpoint of 13 mm [23].
- The PCL cross-sectional area is approximately 120% to 150% greater than that of the ACL [23].
- The PCL is most narrow in its midsubstance, fanning out at both the femoral origin and the tibial insertion [23].
- Meniscomfemoral ligaments are present in at least one form in 93% of knees [23].
- The meniscomfemoral ligaments lie anterior (ligament of Humphrey) and posterior (ligament of Wrisberg) to the PCL [23].
- The meniscomfemoral ligaments connect the posterior horn of the lateral meniscus to the intercondylar notch [23].
- The meniscomfemoral ligaments contribute a mean of 17.2% to the PCL footprint and cross-sectional area [23].
- The meniscomfemoral ligaments are thought to be secondary restraints to posterior translation and act to stabilize the posterior horn of the lateral meniscus [23].
- A single meniscomfemoral ligament is present in 93% of the population, and both ligaments are present in 70% [16].
- The ligament of Humphrey is the anterior meniscomfemoral ligament and the ligament of Wrisberg is the posterior meniscomfemoral ligament [16].
- The meniscomfemoral ligaments insert into the substance of the PCL and the medial femoral condyle [16].
- The meniscomfemoral ligaments originate from the posterior horn of the lateral meniscus [16].
- The popliteus tendon originates on the posterocentral tibia and inserts anterior and distal to the LCL on the lateral femoral epicondyle [16].
- The popliteus tendon has an intra-articular course through the popliteal hiatus [16].
- The lateral meniscus mobility is 10 mm and the medial meniscus mobility is 5 mm [16].
- The posterior joint capsule originates at the proximal margin of the posterior femoral condyles and attaches below the tibial plateau [23].

- The posterior joint capsule is continuous medially with the superficial MCL and the posterior oblique ligament (POL) [23].
- There is commonly a variably sized defect in the posteromedial joint capsule between the medial head of the gastrocnemius and the direct attachment of the semimembranosus, which is likely the cause of Baker's cysts [23].
- The semimembranosus has multiple extensions to the posterior aspect of the knee, including proximal posterior capsular arms, distal tibial expansions, and contributions to the oblique popliteal ligament [23].
- The oblique popliteal ligament is a distinct thickening of the capsule arising medially as a confluence of a semimembranosus expansion and an arm of the POL [23].
- The oblique popliteal ligament is usually 48 mm long and widens from 9.5 mm medially to 16.4 mm at its lateral attachment [23].
- The oblique popliteal ligament attaches to both the fabella and the posterior tibia just lateral to the PCL [23].
- The oblique popliteal ligament did not attach to the lateral femoral condyle in any of the 20 knees dissected by LaPrade et al. [23].
- The posterior capsule is strengthened by an expansion from the medial aspect of the popliteus that attaches to the posteromedial joint capsule [23].
- The medial knee has three layers: Layer I (deep fascia overlying vastus medialis tendon, sartorius tendon, and MCL), Layer II (superficial MCL; sartorius, gracilis, and semitendinosus tendons; and posterior oblique ligament), and Layer III (joint capsule, deep MCL, and coronary ligaments) [16].

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 [6].
- The medial and lateral menisci provide a concave surface with which the convex femoral condyles can articulate [6].
- Without menisci, the convex femoral condyles articulate with the relatively flat tibial plateaus, decreasing surface area of contact and increasing pressure on the articular cartilage [6].
- The medial meniscus is firmly attached to the joint capsule along its entire peripheral edge [6].
- The lateral meniscus is attached to the anterior and posterior capsule, but there is a region posterolaterally where it is not firmly attached [6].
- The medial meniscus has less mobility than

Clinical Presentation

HISTORY AND PHYSICAL EXAMINATION

- A detailed history for knee pain must include onset, quality, duration, tempo, location of symptoms, modifying factors, ability to bear weight, and history of trauma [33].
- Physical examination of the knee includes inspection, palpation, gait assessment, range of motion testing, stability testing, neurovascular assessment, hip examination, and special tests for specific pathologies [33].
- Inspection of the knee can reveal skin abnormalities, evidence of trauma, malalignment, and swelling [33].
- Palpation of the knee focuses on points of tenderness to identify focal pathologies such as joint line tenderness, patellar tendon tenderness, or pes anserine bursa tenderness [33].
- Palpation of peripatellar tissue can reveal the presence of effusion and/or synovitis [33].
- Knee alignment (varus, valgus, or neutral) should be assessed in both supine and standing positions because weight-bearing may dynamically change alignment [33].
- Range of motion testing distinguishes between active and passive motion, noting flexion contractures, hyperextension, and blocks to motion that may be pain-related or mechanical [33].
- When active and passive ranges of motion differ, the clinician must differentiate between pain-related, mechanical, or neuromuscular causes [33].
- Hip range of motion should be examined because intra-articular hip pathology can present as referred knee pain [33].
- Basic varus and valgus stability testing is performed at 0° and 30° of flexion, with testing at 30° best isolating the MCL and LCL [33].
- The Lachman test involves flexing the knee to 30°, holding the femur firmly, and translating the tibia anteriorly; a positive test is indicated by no firm end point and significant translation [33].
- The posterior drawer test involves flexing the knee to 90° with the patient supine, stabilizing the distal tibia, and translating the tibia posteriorly; a positive test is indicated by no firm end point and significant translation [33].
- The J-sign test involves bringing the knee from full extension into flexion; a positive test is a visible patellar shift from lateral to medial in a J-shaped path [33].
- The McMurray test for lateral meniscus tears involves flexing the knee, internally rotating the tibia, extending the knee, and applying pressure to the lateral joint line; a positive test is pain or click [33].
- The McMurray test for medial meniscus tears involves flexing the knee, externally rotating the tibia, extending the knee, and applying pressure to the medial joint line; a positive test is pain or click [33].
- The dial test for posterolateral corner deficiency involves externally rotating both tibiae with the patient prone and knee flexed to 30°; a positive test is greater than 10° difference from the contralateral side [33].
- The dial test for combined posterolateral corner and PCL deficiency involves externally rotating both tibiae with the patient prone and knee flexed to 90°; a positive test is greater than 10° difference from the contralateral side [33].

- Patients with knee arthroscopy indications typically present with complaints of knee swelling, locking, catching, or sudden giving way [5].
- Physical examination for patients with mechanical symptoms often reveals an effusion, joint line tenderness, and positive meniscal signs including pain or palpable click with McMurray's test [5].
- Pain with Thessaly's test or Apley's test, or pain while performing a deep squat, are positive meniscal signs observed on physical examination [5].
- Catching or locking, instability in the coronal and/or sagittal plane, or an effusion can signal the presence of a mechanical pathology warranting surgical treatment [46].
- The lumbar spine and hips should be examined because pathology in these locations can present as referred pain to the knee [46].
- Lower extremities should be examined for evidence of muscular atrophy or weakness, with particular attention to hip abductor and quadriceps strength [46].
- Distal sensation and vascular perfusion (peripheral pulses) should be assessed in all patients, and any abnormalities should be documented [46].
- A history of pain that develops immediately after surgery and persists without a pain-free interval, along with pain at rest and weight bearing, suggests an inflammatory and/or neurogenic source of pain [52].
- Pain during weight-bearing activity or knee motion is consistent with a mechanical source of pain [52].
- Pain described as burning or numbness that is nonfocal on examination and improves with analgesics or neuropathic pain medications supports the diagnosis of neurogenic pain [52].
- A history of pain and effusion that occurs after activity and is relieved with rest is consistent with flexion instability [52].
- Flexion instability caused by intact but attenuated soft-tissue constraints can be detected on physical examination by varus and valgus stress testing, with laxity typically more evident in flexion than full extension [52].
- Complete dislocation of a posterior cruciate-substituting knee presents with gross instability in flexion on physical examination [52].
- Patients with symptomatic osteoarthritis who do not have temporary relief from an intra-articular injection should be evaluated for other pathology external to the knee joint [46].

IMAGING

- Plain radiographs are appropriate initial imaging studies for most knee conditions because they allow assessment of traumatic injury, arthritis, patellofemoral alignment, osteochondral injury, bone neoplasm, and surgical implants [4].
- Orthogonal radiographic views should include at least two perpendicular views: AP and lateral [4].
- Weight-bearing AP (extension) views are used to assess cartilage loss from the distal femur and tibial plateau [4].
- Weight-bearing PA (Rosenberg; flexion) views are used to assess cartilage loss from the posterior femur and tibial plateau [4].

- Patellofemoral views are used to assess patellofemoral alignment, patellar and trochlear morphology, osteochondral injury, and patellofemoral arthritis [4].
- The notch view is used to assess posterior femoral cartilage, notch width, and osteophytes [4].
- Non-weight-bearing radiographs may identify acute traumatic injury without the risk of fracture displacement [4].
- Radiography may identify subchondral sclerosis, joint space narrowing, subchondral cysts, osteophytes, and joint subluxation in osteoarthritis [4].
- Radiography may identify joint space loss and peripheral bone erosion in inflammatory arthropathy [4].
- Subchondral radiolucency is a radiographic finding for osteochondral defects, most common in the medial femoral condyle [4].
- Linear radiolucency or radiodensity is a radiographic finding for stress fractures, most common in the proximal medial tibia [4].
- Osteonecrosis presents on radiography as a mixed sclerotic pattern with a subchondral, epiphyseal, or metaphyseal location [4].
- Patellofemoral disease may present on radiography with malalignment, osteophytes, cysts, and joint space loss [4].
- MRI may identify the degree of articular cartilage injury, including chondrosis and full-thickness cartilage loss [4].
- MRI may identify the presence of associated bone marrow edema and the location of cartilage injury [4].
- MRI patterns of meniscal injury can be identified by location, pattern (horizontal, longitudinal, radial, complex), and displacement [4].
- MRI may identify edema, intra-articular fluid, disruption of ligament fibers, and atypical ligament contour to suggest cruciate ligament injury [4].
- MRI may identify edema, avulsion, or discontinuity for extra-articular ligaments such as the MCL or LCL [4].
- MRI may be used to assess the continuity of the quadriceps or patellar tendon [4].
- Baseline weight-bearing radiographs of the knee should be obtained in all patients with symptomatic osteoarthritis [46].
- A standing PA view obtained with the patient's knee in 45° of flexion is often preferred over the standard standing AP view for evaluating osteoarthritis [46].
- The 45° flexion PA view allows better evaluation of the posterior femoral condyles and earlier detection of subtle joint-space loss than the AP view [46].
- Additional radiographs for knee osteoarthritis evaluation should include a lateral view of the affected side and a Merchant or sunrise view of the patellofemoral joint [46].
- Radiographs obtained during initial examination for ligament injury can rule out physeal or other fractures about the knee [43].

- Radiographs may demonstrate abnormalities of alignment, such as an anteriorly translated tibia on a lateral view, that aid in the diagnosis of a ligament injury [43].
- MRI is useful for confirming a suspected diagnosis of ligament injury or when an adequate physical examination is not possible [43].
- Advanced radiographic imaging studies may help assess overall limb alignment and further delineate intra-articular and extra-articular soft tissues [4].
- CT provides enhanced bone detail and may help visualize fracture lines, displacement, osteolytic lesions, and cortical disruption [4].
- Three-dimensional CT reconstructions may help with preoperative planning for complex intra-articular fractures, multiplanar osteotomy, and reconstitution of bone loss in joint arthroplasty [4].
- Axial plane CT imaging of the knee can help assess the rotational alignment of components of a total knee arthroplasty in cases of patellar maltracking [4].
- Nuclear medicine studies provide a nonspecific assessment of the presence of an abnormality that may correlate with a clinical concern but do not define etiology [4].
- Technetium-99 (Tc-99) radionuclide imaging may help identify infection, neoplasia, occult fracture, bone healing, active heterotopic ossification, implant loosening, or failure of osseointegration [4].
- Gallium-67 (Ga-67) radionuclide imaging may help differentiate between aseptic and septic prosthetic loosening [4].
- Wear in total knee arthroplasty can be seen radiographically as asymmetric height of the tibial plateaus, although rotation and flexion can alter projected height making measurements inaccurate [52].
- Loosening in total knee arthroplasty occurs when subsidence or displacement of the component or a complete or progressive radiolucency at the implant and bone interface occurs [52].
- Flexion instability in total knee arthroplasty is associated with paradoxical motion or rolling forward of the femoral implant, which can be seen on flexion lateral radiographs as anterior subluxation of the distal femur on the tibia [52].
- Complete dislocation of a posterior cruciate-substituting knee presents with posterior displacement of the tibia on the femur on lateral radiographs [52].

Investigations

PLAIN RADIOGRAPHY

- Plain radiographs are appropriate initial imaging studies for most knee conditions [4].
- Radiographic studies help confirm the clinical diagnosis of a joint disorder determined using the patient's history and physical examination [4].
- Imaging studies should include at least two perpendicular views: AP and lateral [4].
- Supine AP knee radiographs do not adequately estimate the joint space width needed to estimate the degree of osteoarthritis progression [30].

- A 45° standing flexion view was introduced by Rosenberg et al. to better evaluate joint space [30].
- The fixed flexion view (FFV) has been introduced with improved reproducibility and good evaluation of the joint space [30].
- The Lyon Schuss view (LSV) uses the same posture as the FFV but requires fluoroscopic adjustment of the irradiation angle relative to the medial tibial plateau for more accurate measurement of actual joint space width [30].
- The Lyon Schuss view has a higher radiation exposure dose and is more complex and time-consuming to position than the FFV [30].
- Goniometer readings of long limb alignment or measured on an FFV correlate well with the angle measured on long limb radiographs, providing an alternative if long limb radiographs are not available [30].
- Radiographs may identify subchondral sclerosis, joint space narrowing, subchondral cysts, osteophytes, and joint subluxation in osteoarthritis [4].
- Radiographs may identify joint space loss and peripheral bone erosion in inflammatory arthropathy [4].
- Radiographs may identify subchondral radiolucency in osteochondral defects, most commonly in the medial femoral condyle [4].
- Radiographs may identify linear radiolucency or radiodensity in stress fractures, most commonly in the proximal medial tibia [4].
- Radiographs may identify a mixed sclerotic pattern with a subchondral, epiphyseal, or metaphyseal location in osteonecrosis [4].
- Radiographs may identify malalignment, osteophytes, cysts, and joint space loss in patellofemoral disease [4].
- Lateral capsular avulsion (meniscotibial ligament) is pathognomonic but not essential for ACL injury on radiographs [4].
- Avulsion of the medial femoral epicondyle (Pellegrini-Stieda lesion) may appear within a few weeks of proximal MCL avulsion injury [4].
- The Kellgren-Lawrence classification uses grade I to IV of osteoarthritis severity and is frequently utilized to select the appropriate treatment and timing of intervention [30].
- Knee arthroplasty is recommended when Grade 4 findings are present on radiographs [27].

MAGNETIC RESONANCE IMAGING (MRI)

- 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 [4].
- Increasing strength of the magnetic field (measured in Tesla units) increases the resolution of images [4].
- An injected contrast agent (intravenous or intra-articular) may help delineate specific tissues of interest on MRI [4].
- MRI may suggest cruciate ligament injury through the presence of edema, intra-articular fluid, disruption of ligament fibers, and an atypical ligament contour [4].

- MRI can identify patterns of meniscal injury by location (anterior, midbody, posterior, peripheral, articular), pattern (horizontal, longitudinal, radial, complex), and displacement [4].
- MRI may identify the degree of articular cartilage injury (chondrosis, full-thickness cartilage loss), the presence of associated bone marrow edema, and the location of the injury [4].
- MRI may identify edema, avulsion, or discontinuity for the MCL/LCL or associated posteromedial and posterolateral ligamentous complexes [4].
- MRI may be used to assess the margin of resection for a neoplasm, identify vascular malformation, or define the location of nerves or vessels relative to popliteal cysts [4].
- MRI is the most useful study for differentiating osteonecrosis from other conditions such as osteochondritis dissecans, transient osteoporosis, bone bruises, or occult fractures [32].
- A serpentine lesion within a well-demarcated border is a specific finding on MRI for osteonecrosis [32].
- Bone edema on MRI is a common feature of OA, osteonecrosis, cartilage injury, and transient regional osteoporosis [32].
- MRI is grossly overused in the arthritic patient population [27].
- If the joint space is significantly narrowed on radiograph, MRI is not indicated [27].
- MRI is used when osteonecrosis is suspected [27].
- A systematic review quantified the accuracy of MRI for detection of meniscal injury and ACL tear [10].
- Compositional MRI techniques (T1ρ, T2*, dGEMRIC, gagCEST) are used for early recognition of cartilage degeneration [10].
- MR T1ρ and T2 of the meniscus can be assessed after acute anterior cruciate ligament injuries [10].
- MRI appearance of cartilage repair in the knee has been characterized [10].
- The clinical importance of meniscal tears demonstrated by MRI in osteoarthritis of the knee has been evaluated [10].
- The prevalence of meniscal pathology in asymptomatic athletes includes isolated meniscal pathology (including intrasubstance meniscal signal) in 31% and frank meniscal tear in 3.9% [10].
- Visibility of anterolateral ligament tears in anterior cruciate ligament-deficient knees can be assessed with standard 1.5-Tesla magnetic resonance imaging [3].
- MRI features of the anterolateral ligament of the knee have been described [3].
- MRI appearance of the anterolateral ligament, its association with the Segond fracture, and its historical perspective have been reviewed [3].
- How sensitive and specific 1.5 Tesla MRI is for diagnosing injuries in patients with knee dislocation has been evaluated [9].

COMPUTED TOMOGRAPHY (CT)

- CT is a three-dimensional study performed with ionizing radiation that provides enhanced bone detail [4].
- 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 [4].

- Three-dimensional reconstructions may help with preoperative planning for complex intra-articular fractures, multiplanar osteotomy for limb malalignment, and reconstitution of bone loss in joint arthroplasty [4].
- 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 [4].
- Three-dimensional CT with remodeling is used for preoperative planning for reconstruction associated with dysplasia, post-trauma planning, and complex total knee arthroplasty (TKA) planning [27].
- CT and MRI measurements of tibial tubercle–trochlear groove distances are not equivalent in patients with patellar instability [7].

NUCLEAR MEDICINE

- Nuclear medicine involves labeled radionuclide injection followed by delayed imaging of gamma radiation [4].
- Areas of increased radionuclide concentration appear bright or “hot” on nuclear medicine imaging [4].
- 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 [4].
- Increased radionuclide activity in bone may be a normal postoperative finding for up to 6 to 12 months after a fracture repair or arthroplasty [4].
- Technetium-99 (Tc-99) is a radionuclide that may help identify infection, neoplasia, occult fracture, bone healing, active phases of heterotopic ossification, implant loosening, or failure of osseointegration [4].
- Gallium-67 (Ga-67) is a radionuclide that may help differentiate between aseptic and septic prosthetic loosening [4].
- 24 to 72 hours are needed for a complete Gallium-67 study [4].

GENERAL ASSESSMENT

- Physical examination along with radiographic or advanced imaging findings must be used concomitantly to determine the source of each patient’s symptoms and appropriate surgical intervention [1].
- Assessment of the joint must combine physical examination along with radiographic (including full-length alignment views) and MRI findings [12].
- Radiographic evaluations are essential when diagnosing an OCD lesion of the knee; however, important aspects of the OCD lesions may be better seen with MRI [29].
- Assessing the potential instability of an OCD lesion is key to early treatment [29].

Treatment

INDICATIONS AND PATIENT SELECTION

- Arthroscopic débridement, chondroplasty, loose body removal, microfracture, and partial meniscectomy are acceptable treatments for appropriately indicated patients after failure of nonsurgical care [5].
- Arthroscopic intervention is indicated for alleviation of mechanical symptoms or significant effusion related to meniscal pathology, articular cartilage flaps, or loose bodies in the setting of nonfocal cartilage loss [5].
- Patients presenting with knee swelling, locking, catching, or sudden giving way are typical candidates for arthroscopic intervention for mechanical symptoms [5].
- Physical examination findings supporting arthroscopic intervention include effusion, joint line tenderness, and positive meniscal signs such as pain or palpable click with McMurray's test, pain with Thessaly's test or Apley's test, or pain while performing a deep squat [5].
- Patients must be informed that while alleviation of mechanical symptoms is relatively consistent, they may continue to have pain related to existing chondral wear [5].
- Arthroscopic débridement allows assessment of the joint and affords the ability to débride the meniscus, loose articular cartilage, and synovium, as well as to remove any loose bodies [2].
- Arthroscopy enables visualization of the entire joint and may aid in future decision making regarding osteotomy versus unicompartmental knee arthroplasty versus total knee arthroplasty [2].
- Arthroscopic indications for degenerative arthritis include mild to moderate arthritis with minimal malalignment and mechanical symptoms consistent with a loose body, meniscus tear, synovitis, or painful osteophytes [2].
- Arthroscopic treatment should not be the first-line intervention for patients with osteoarthritis and mechanical symptoms recalcitrant to conservative care [12].
- Good prognostic factors for arthroscopic treatment of degenerative arthritis include increased pain of acute onset, specific twisting mechanism, mechanical symptoms, recent effusion, loose bodies, normal mechanical alignment, isolated chondral flap/fracture, isolated unicompartmental disease, and meniscal tears [2].
- Poor prognostic factors for arthroscopic treatment of degenerative arthritis include pending litigation/work injury, chronic symptoms, varus/valgus alignment, ligamentous instability, complete loss of joint space, chondrocalcinosis, diffuse disease, degenerative meniscal tears, and severe chondromalacia [2].

SURGICAL TECHNIQUES

- The anterolateral portal is established first, located directly adjacent to the lateral patellar tendon edge at the level of the joint line, and primarily serves as a viewing portal [5].
- An anteromedial portal is established under direct visualization, first using a spinal needle to determine appropriate portal position and trajectory [5].

- Most basic arthroscopic procedures can be completed with anterolateral and anteromedial portals, but posteromedial and/or posterolateral portals may be necessary to retrieve loose bodies behind the cruciate ligaments or to treat injuries of the meniscal roots [5].
- Posteromedial and posterolateral portals should be placed under direct arthroscopic visualization using a spinal needle for localization, entering the skin 1 cm proximal to the joint line and just posterior to the medial collateral ligament or lateral collateral ligament, respectively [5].
- Arthroscopic lavage and débridement of the arthritic knee is controversial but effective when properly indicated for specific mechanical symptoms caused by loose bone, cartilage flaps or particles, meniscal tears, or synovial impingement [2].
- The irrigation during lavage dilutes the joint fluid, which reduces the concentration of degradative enzymes [2].
- The removal of loose cartilage, meniscus, and/or synovium reduces mechanical symptoms and removes a source of irritation to the synovial tissue [2].
- Diseased cartilage is removed or stabilized using a shaver, laser, or radiofrequency probe during chondroplasty [2].
- The potential for thermal damage when using a laser or radiofrequency probe has resulted in decreased use of these techniques [2].
- The goal of abrasion arthroplasty is formation of a blood clot, which undergoes metaplasia to become fibrocartilage, a process estimated to take 8 weeks [2].
- Some studies have demonstrated by 2 years post-operatively that the fibrocartilage cap is significantly degraded or no longer present [2].
- Débridement and chondroplasty are currently recommended for symptomatic osteochondral lesions [56].
- Displaced osteochondral fragments can sometimes be replaced and secured with small recessed screws or absorbable pins [56].
- Marrow-stimulating techniques include microfracture, drilling, and abrasion arthroplasty, which involve perforation of the subchondral bone after removal of the “tidemark” cartilage [56].
- Good clinical results in small defects (<2 to 3 cm²) are obtained in 60% to 80% of patients undergoing marrow-stimulating techniques [56].
- Osteochondral autograft transfer (OAT) or mosaicplasty can be used to address medium-sized lesions (2–3 cm²) that include subchondral bone loss [56].
- Lateral trochlea and medial trochlea are acceptable harvest locations for osteochondral autografts [56].
- Osteochondral allograft transplant utilizes cadaveric donor plugs and can be used for larger lesions (≥ 4 cm²), especially with bone loss [56].
- Osteochondral allografts are ideally used within 14 to 28 days of donor death [56].
- Autologous chondrocyte implantation (ACI) is a two-stage process involving biopsy of the patient’s articular cartilage, ex vivo expansion, and subsequent implantation into the defect [56].
- ACI allows for creation of type II collagen-rich hyaline-like cartilage, with minimal type I collagen or fibrocartilage present [56].

- ACI is indicated for medium-sized to larger chondral lesions without bony defects [56].
- Complications related to ACI include chondrocyte overgrowth, periosteal flap hypertrophy, and the morbidity of the second surgical procedure [56].
- Arthroscopic techniques have been used to evaluate, reduce, and fix fractures of the anterior intercondylar eminence of the tibia with percutaneously inserted internal fixation [51].
- Arthroscopy has been advocated to assess the degree of articular surface depression and the adequacy of reduction after tibial plateau fractures [51].
- Fracture patterns appropriate for arthroscopic management are those that can be internally fixed with a cancellous screw and do not require a major reduction or use of a buttress plate [51].

OUTCOMES AND EVIDENCE

- A landmark study by Moseley et al comparing arthroscopic débridement with sham surgery in patients with knee arthritis found no difference in postoperative pain or functional outcomes between groups [5].
- Several subsequent studies assessing outcomes after partial meniscectomy versus physical therapy for patients with knee osteoarthritis and a meniscal tear have demonstrated no significant difference in outcomes between groups [5].
- About 30% of patients randomized to the physical therapy group crossed over and chose to undergo surgery because of continued pain, and good outcomes were achieved in patients who crossed over [5].
- The literature lacks well-designed studies to evaluate the efficacy of arthroscopic procedures for degenerative arthritis, and some studies have demonstrated improvement in short-term outcomes with most demonstrating equivalent outcomes to nonsurgical treatment at mid to long-term follow-up [2].
- Arthroscopic knee débridement may provide relief from mechanical symptoms in carefully selected osteoarthritis patients, but should not be offered as a first-line treatment in lieu of nonsurgical measures [12].
- Patients may continue to have pain because of underlying osteoarthritis, but mechanical symptoms are more reliably improved by arthroscopic débridement [12].
- Condylar lesions undergoing cartilage restoration techniques demonstrate superior outcomes compared with patellofemoral lesions [56].
- Current best available research suggests that for smaller lesions, microfracture, OAT, and ACI have similar recovery periods and functional results [56].
- Improved clinical outcomes following microfracture, OAT, or ACI are seen in well-selected patients, with variable long-term results following microfracture in high-demand patients [56].

Complications

GENERAL COMPLICATION RATES

- Large series published in the late 1980s reported overall complication rates for knee arthroscopy of less than 2% [45].

- More recent reports generally cite overall complication rates for knee arthroscopy of less than 1% [45].
- Four large series with a combined total of 191,584 arthroscopic knee procedures reported complications in 1,175 patients (0.6%) [45].
- Infection and deep vein thrombosis (DVT) or pulmonary embolism (PE) were the most common complications in the four large series of 191,584 arthroscopic knee procedures [45].
- Data from the American Board of Orthopaedic Surgery from 2003 to 2009 showed an overall complication rate of almost 5% for knee arthroscopy [45].
- The complication rate range reported by the American Board of Orthopaedic Surgery from 2003 to 2009 was 2.5% for meniscectomy to 20% for PCL reconstruction [45].
- Infection was the most common complication overall in the American Board of Orthopaedic Surgery data from 2003 to 2009 [45].

NERVE AND VASCULAR COMPLICATIONS

- Saphenous and peroneal nerve injuries are still being reported with arthroscopic repairs [45].
- The frequency of saphenous and peroneal nerve injuries has decreased dramatically with all-inside techniques [45].
- DVT is a concern with long, complicated procedures, particularly in patients who are overweight, have a history of DVT, are taking birth control pills, or have been inactive as a result of injury [45].
- Preoperative ultrasound examination of the lower extremities usually should be done in patients with high-energy knee injuries in whom treatment is delayed for more than 2 weeks [45].
- DVT prophylaxis with at least 81 mg of aspirin twice a day is probably warranted when limited postoperative weight bearing is indicated in patients with high-energy knee injuries and delayed treatment [45].
- The use of a sequential compression device (SCD) may be indicated for high-risk patients [45].

INFECTION AND GRAFT CONTAMINATION

- Careful attention to detail during surgery, including proper sterilization techniques, handling of the graft, and appropriate preparation and draping, can help to prevent postoperative infections [45].
- Molina et al. reported that after a 90-second soak, one of 50 contaminated grafts soaked in chlorhexidine remained positive [45].
- Molina et al. reported that after a 90-second soak, three of 50 contaminated grafts soaked in antibiotic remained positive [45].
- Molina et al. reported that after a 90-second soak, 12 of 50 contaminated grafts soaked in povidone-iodine solution remained positive [45].
- Recent reports have confirmed the efficacy of 4% chlorhexidine for sterilizing contaminated grafts, including laboratory studies that included 495 graft samples [45].
- Bacitracin alone was found effective (97%) for sterilizing contaminated grafts [45].
- A combination of neomycin and polymyxin B was found effective for sterilizing contaminated grafts [45].

- A recommended protocol for a dropped graft involves retrieving it immediately, rinsing with sterile saline, soaking in 4% chlorhexidine gluconate solution for at least 90 seconds (recommended 10 minutes), soaking in neomycin and polymyxin B solution for at least another 90 seconds (recommended 10 minutes), and rinsing thoroughly [45].
- In a survey by Izquierdo et al., 49 surgeons had experienced a total of 57 graft contaminations [45].
- In the Izquierdo et al. survey, 75% of graft contaminations were treated with graft cleansing and proceeding with the reconstruction [45].
- In the Izquierdo et al. survey, 18% of graft contaminations were managed by harvesting a different graft [45].
- In the Izquierdo et al. survey, 7% of graft contaminations were managed by using an allograft [45].
- No reported infections occurred in the Izquierdo et al. survey of 57 graft contaminations [45].
- In the Izquierdo et al. survey, 58% of surgeons with no graft contaminations responded that they would cleanse the graft in a hypothetical scenario [45].
- In the Izquierdo et al. survey, 34% of surgeons with no graft contaminations responded that they would harvest a different graft in a hypothetical scenario [45].
- In the Izquierdo et al. survey, 8% of surgeons with no graft contaminations responded that they would use an allograft in a hypothetical scenario [45].

POSTOPERATIVE INFECTION MANAGEMENT

- Early, thorough arthroscopic irrigation and debridement are indicated when postoperative knee infections occur [45].
- Repeat irrigation and debridement at 48 to 72 hours is indicated if symptoms have not resolved after initial treatment for postoperative knee infection [45].
- Anterior cruciate ligament grafts can be left in place during irrigation and debridement provided that no extensive deterioration of the graft is present at the time of initial irrigation [45].
- Appropriate intravenous antibiotics are generally prescribed for 2 to 3 weeks if susceptible, followed by oral antibiotics to complete a 6-week course of antibiotic treatment for postoperative knee infection [45].
- A recent meta-analysis determined that approximately 85% of grafts could be salvaged with arthroscopic debridement and antibiotic therapy [45].

ARTHROFIBROSIS AND HEALING REACTIONS

- The incidence of arthrofibrosis associated with anterior cruciate ligament reconstruction is increased when meniscal repair is performed [45].
- The incidence of infection associated with anterior cruciate ligament reconstructions is slightly increased when the reconstruction is performed in conjunction with meniscal repair [45].
- Additional exposure, surgical time, and potential for joint contamination during the passing and retrieving of needles are probable reasons for increased infection rates when ACL reconstruction is combined with meniscal repair [45].

- Abnormal healing reactions, arthrofibrosis, complex regional pain syndrome, and failure of graft incorporation fall under the category of surgical limitations [45].
- Chondral or meniscal injuries fall under the category of surgical limitations [45].
- Early surgical intervention for ligamentous injuries before regaining muscular tone and motion is associated with arthrofibrosis [45].
- Surgical procedures such as medial collateral ligament repair on the femoral side and meniscal repair are associated with arthrofibrosis [45].
- Allowing motion and allowing the knee to calm before surgery has been shown to greatly decrease postoperative stiffness and arthrofibrosis [45].

KNEE DISLOCATION SPECIFIC COMPLICATIONS

- Adverse outcomes and complications are common following knee dislocations [49].
- Pain, loss of motion, and recurrent instability occur frequently following knee dislocations [49].
- The most common complications related to the injury of knee dislocation are neurovascular complications [49].
- Infection is a common complication associated with the management of knee dislocation [49].
- Infections following knee dislocation management have a reported rate of 12.5% [49].
- Infections following knee dislocation can result in multiple débridements [49].
- Soft-tissue flap coverage may be required if fistulas form following infection after knee dislocation management [49].
- The reported incidence of heterotopic ossification following knee dislocation management is approximately 25% [49].
- Heterotopic ossification following knee dislocation is more frequently found medially and posteriorly [49].
- PCL reconstruction is one independent risk factor for the development of heterotopic ossification [49].
- The incidence of posttraumatic arthritis in a retrospective long-term follow-up study of 44 multiligament reconstructions was 23% [49].
- A mean of 38% of patients (range, 5% to 71%) require surgical management of arthrofibrosis following knee dislocation [49].
- Iatrogenic neurovascular injury is a concern during surgical reconstruction of knee dislocation due to anatomic distortion and substantial scarring [49].
- Recurrent instability after reconstruction of knee dislocation has a mean incidence of approximately 40% [49].
- Patients with knee dislocation are more common to report anterior-posterior instability rather than medial-lateral instability [49].
- The incidence of pain following knee dislocation injuries has been reported from 25% to 68% [49].
- Factors contributing to pain after knee dislocation can include chronic instability, posttraumatic arthritis, and arthrofibrosis [49].

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