

Multiligament knee injury

Anatomy & Pathophysiology

BONY ANATOMY

- The bones of the knee are the distal femur, the proximal tibia, and the patella [2].
- The medial femoral condyle is larger and projects farther posteriorly and distally than the lateral condyle [6].
- The lateral femoral condyle projects farther anteriorly and is wider in the medial-lateral direction than the medial femoral condyle [6].
- The tibial articular surface slopes 7° to 10° in the sagittal plane [6].
- The posterior slope of the medial tibial plateau averages 10.7° and the lateral plateau averages 7.2° [11].
- The medial tibial plateau is larger than the lateral plateau and is concave in its frontal and sagittal planes [6].
- The lateral tibial plateau is smaller, more circular, concave in the frontal plane, and convex in the sagittal plane [6].
- The patella is the largest sesamoid bone in the body with a mean thickness of 2.5 cm [6, 11].
- The patellar articular surface contains a vertical central ridge separating the broader lateral facet from the medial facet, plus a smaller medial odd facet [6].
- The fibular head is located a mean of 1.5 cm distal to the joint line, with a range of 6 to 32 mm [11].

LIGAMENTS

- The anterior cruciate ligament (ACL) prevents anterior translation and rotation of the tibia on the femur [2].
- The ACL is composed of 90% type I collagen and 10% type III collagen [6, 7, 11].
- The mean length of the ACL is 33 mm and the mean midsubstance width is 11 mm [6, 11].
- The ACL femoral attachment is a semicircular area on the posteromedial aspect of the lateral femoral condyle [6, 7, 11].

- The ACL tibial attachment is a broad, irregular, oval-shaped area between the medial and lateral tibial spinous processes [6, 11].
- The ACL consists of an anteromedial bundle that is tight in flexion and a posterolateral bundle that is tight in extension [7, 8, 11].
- The posterior cruciate ligament (PCL) prevents posterior subluxation of the tibia on the femur [2].
- The PCL is the largest intra-articular ligament with an average length of 38 mm and a mean midsubstance diameter of 13 mm [11, 19].
- The PCL cross-sectional area is approximately 120% to 150% greater than that of the ACL [19].
- The PCL has two bundles: an anterolateral (AL) bundle comprising 85% of the cross-sectional area and a posteromedial (PM) bundle [19].
- The PCL AL bundle is tight in knee flexion, while the PM bundle is tight in knee extension [11].
- The PCL tibial insertion is located 10 to 15 mm distal to the joint line on the posterior tibia [11, 19].
- The medial collateral ligament (MCL) has superficial and deep portions that stabilize the knee against valgus stresses [2].
- The superficial MCL proximal division resists valgus tibial translation, while the distal division resists tibial external rotation in extension [7, 8].
- The lateral collateral ligament (LCL), or fibular collateral ligament, runs from the lateral femoral condyle to the head of the fibula and is the main stabilizer against varus stress [2].
- The LCL resists varus tibial translation and tibial external rotation, especially at 30 degrees of knee flexion [7, 8].
- The popliteofibular ligament is present in 90% of knees and runs from the popliteus tendon to the styloid on the posterior fibular head [2].
- The popliteofibular ligament resists tibial external rotation, especially in knee flexion, and posterior tibial displacement [7, 8].
- The oblique popliteal ligament resists knee hyperextension and varus tibial translation [7, 8].
- The meniscomfemoral ligaments (Humphrey and Wrisberg) are present in 93% of knees and connect the posterior horn of the lateral meniscus to the intercondylar notch [11, 19].
- The anterolateral ligament (ALL) was demonstrated in 100% of 23 human cadaveric knees in a dissection study [29].

MENISCI

- The menisci are C-shaped fibrocartilaginous disks that provide shock absorption, increase joint congruency, enhance stability, and aid in synovial fluid distribution [2].
- The medial meniscus is firmly attached to the joint capsule along its entire peripheral edge [2].
- The lateral meniscus is attached to the anterior and posterior capsule but has a region posterolaterally where it is not firmly attached [2].

- 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 [2].
- The lateral meniscus is larger than the medial meniscus and carries a greater share of the lateral compartment pressure [2].
- The menisci consist of type I collagen fibers arranged obliquely, radially, and vertically [11].
- Vascular supply to the menisci penetrates 20% to 30% of the peripheral medial meniscus and 10% to 25% of the peripheral lateral meniscus [11].

VASCULAR AND NEUROLOGIC ANATOMY

- The blood supply to the knee is formed from an anastomosis including the descending geniculate, superior and inferior geniculate, middle geniculate, and anterior tibial recurrent arteries [6].
- The middle geniculate artery supplies both the anterior and posterior cruciate ligaments [6, 11].
- The popliteal artery travels through the adductor hiatus and distally through the fibrous arch deep to the soleus muscle, where it is relatively immobile [16].
- The common peroneal nerve travels along the posterior edge of the biceps femoris and continues distally around the fibular neck [16].
- The tibial nerve courses distally through the center of the popliteal fossa after branching from the sciatic nerve [16].
- The largest nerve providing innervation of the intra-articular knee is the posterior articular branch of the tibial nerve [6].

KINEMATICS AND BIOMECHANICS

- The knee is a hinge joint that incorporates gliding and rolling, with a “screw-home” mechanism where the tibia externally rotates 5 degrees in the final 15 degrees of extension [7, 8].
- The greatest range of motion occurs in the sagittal plane at approximately 160° [22].
- Knee rotation ranges from 45° in external rotation to 30° in internal rotation [22].
- In the frontal plane, the range of motion in both abduction and adduction reaches a maximum of 10° [22].
- Rupture of the cruciate ligaments or disruption of the tibiofemoral surface causes a major change in the path of the instant center, leading to articular dysfunction [22].
- The crossed four-bar linkage system describes the ACL and PCL as the central pivot and gear, while the menisci provide peripheral force control and braking [23].

PATHOPHYSIOLOGY OF KNEE DISLOCATION

- Knee dislocations represent less than 0.2% of all orthopaedic injuries [16].
- 20% to 50% of knee dislocations spontaneously reduce in the field, leading to underreporting of true incidence [16].
- The four major ligamentous stabilizers of the knee are the ACL, PCL, MCL, and fibular collateral ligament [16].

CQ HAND + UPPER LIMB

- The posterolateral corner (PLC) consists of the FCL, iliotibial band, popliteofibular ligament, biceps femoris, and popliteus tendon [16].
- Associated fractures occur in 57% of knee dislocations, with multiple fractures in 41% and open fractures in 27% [34].
- Damage to cartilage and menisci occurs in at least one-third of patients with traumatic knee dislocation [34].
- Popliteal artery compromise following multiligament knee injury is estimated to occur as high as 50% [34].
- Peroneal nerve palsy complicates knee dislocations at a frequency of approximately 25% [34].
- Recovery of antigravity ankle dorsiflexion strength was observed in 38% of patients with complete peroneal nerve palsy compared to 83% with partial palsy [34].
- High-energy knee dislocations are associated with life-threatening injuries in 27% of patients [34].

Clinical Presentation

- Acute knee dislocation is described as an elusive entity [1].
- Knee dislocations can occur in overweight patients [1].
- Knee dislocations can be associated with vascular injury [1].
- Low-velocity mechanisms can result in knee dislocation [1].

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 [4].
- Imaging studies should include at least two perpendicular views: AP and lateral [4].
- Non-weight-bearing radiographs may identify acute injury without the risk of fracture displacement [4].
- Lateral capsular avulsion (meniscotibial ligament) is pathognomonic but not essential for ACL injury [4].
- Avulsion of the medial femoral epicondyle (Pellegrini-Stieda lesion) may appear within a few weeks of proximal MCL avulsion injury [4].
- Weight-bearing AP and lateral views are standard for initial evaluation [24].
- A view of the weight-bearing knee flexed at 45-degree angle, imaged posterior to anterior, is included in standard imaging [24].
- A standing full-length AP radiograph from hip joint to ankle joint is used to evaluate limb alignment and knee deformity [24].
- Supine AP knee radiographs do not adequately estimate the joint space width [28].

- Plain frontal radiographs of the knee may not accurately display the actual joint space due to different cartilage wear patterns, meniscal integrity, or variances in tibial slopes [28].
- A 45° standing flexion view was introduced to improve evaluation of the joint space [28].
- A fixed flexion view (FFV) technique has been introduced with improved reproducibility and good evaluation of the joint space [28].
- Goniometer readings of long limb alignment or measured on an FFV correlated well with the angle measured on long limb radiographs, providing an alternative imaging source if long limb radiographs are not available [28].

COMPUTED TOMOGRAPHY

- Computed tomography provides enhanced bone detail [4].
- Three-dimensional CT 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].
- Three-dimensional CT with remodeling is used for preoperative planning for reconstruction associated with dysplasia, post-trauma planning, and complex total knee arthroplasty planning [24].

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 [4].
- The presence of edema, intra-articular fluid, disruption of ligament fibers, and an atypical ligament contour may suggest cruciate ligament injury [4].
- Patterns of meniscal injury can be identified 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 [4].
- Edema, avulsion, or discontinuity may be identified for the MCL/LCL or associated posteromedial and posterolateral ligamentous complexes [4].
- MRI may be used to assess the continuity of the quadriceps or patellar tendon [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].
- 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 [4].
- MRI is the most useful study for differentiating osteonecrosis from other conditions [30].
- Serpentine lesions within a well-demarcated border is a specific finding on MRI for osteonecrosis [30].
- Bone edema on MRI is a common feature of OA, osteonecrosis, cartilage injury, and transient regional osteoporosis [30].

- MRI is grossly overused in the arthritic patient population [24].
- If the joint space is significantly narrowed on radiograph, then MRI is not indicated [24].
- MRI is used when osteonecrosis is suspected [24].
- Radiographic evaluations are essential when diagnosing an OCD lesion of the knee and elbow; however, important aspects of the OCD lesions may be better seen with MRI [27].

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 [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; 24 to 72 hours are needed for a complete study [4].

DIAGNOSTIC ACCURACY AND CLINICAL CORRELATION

- A systematic review quantified the accuracy of MRI for detection of meniscal injury and ACL tear [21].
- 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 [9].
- Assessment of the joint must combine physical examination along with radiographic (including full-length alignment views) and MRI findings [31].

Treatment

NON-OPERATIVE MANAGEMENT

- Nonoperative treatment of knee dislocations is indicated when comorbidity or concomitant injury is of sufficient severity to preclude extensive surgery or anesthetic [33].
- Skeletal immaturity is a relative indication for nonoperative treatment of knee dislocations [33].
- Open dislocations are a relative contraindication for nonoperative treatment of knee dislocations [33].
- Dislocations with associated vascular injury are a relative contraindication for nonoperative treatment of knee dislocations [33].
- Irreducible dislocations are a relative contraindication for nonoperative treatment of knee dislocations [33].
- Dislocations with associated compartment syndrome are a relative contraindication for nonoperative treatment of knee dislocations [33].

- Dislocations with subsequent multiligament laxity and joint subluxation are a relative contraindication for nonoperative treatment of knee dislocations [33].
- Life-threatening polytrauma is associated with high-energy mechanism knee dislocations in approximately 27% of cases [33].
- Multiligament knee injury can occur with minimal trauma in obese individuals, referred to as the “ultra-low” energy knee dislocation [33].
- In patients with significant open wounds, implantation of allograft tissue for reconstruction of torn knee ligaments may be too dangerous due to the risk of contamination and potential infection [33].
- The role of surgical reconstruction in skeletally immature and elderly patients with knee dislocations is unknown [33].
- In elderly patients with knee dislocations, comorbidity imposes an obvious risk for surgical intervention [33].
- Technical difficulties in elderly patients with knee dislocations are presented by poor bone quality and the unpredictability of surgical reconstruction of ligamentous injury in those with any degree of preexisting arthritis [33].
- Complex constructs described for reconstruction of multiligament injuries, especially those with several tibial tunnels, significantly increase the chance for growth disturbance in children with open growth plates [33].

OPERATIVE MANAGEMENT: GRAFT SELECTION

- Various combinations of different autografts and allografts, with various reconstruction techniques, are described in the multiligament injury literature [5].
- Attempts to differentiate outcomes between various graft combinations and reconstruction techniques in the multiligament injury literature have become nearly impossible [5].
- Most surgeons are hesitant to add further morbidity by harvesting autograft tissue from the injured knee due to the extreme insult to the joint and its soft tissue envelope at the time of dislocation [5].
- The integrity of autograft tissue may be compromised in the recently traumatized state [5].
- Concerns among surgeons who favor autograft harvest include the mechanical integrity of allograft, its sterility, and its ability to integrate into a foreign host [5].
- The debate over the optimal preparation of allograft tissue continues, with maintenance of structural integrity being weighed against the complete eradication of potential pathogens [5].
- Allograft is unavailable in many countries and centers [5].
- In some places, the cost of procuring allografts may be prohibitive [5].
- For surgeons who employ allograft in the treatment of multiple ligament knee injuries, a specific conversation with the patient outlining its necessity and potential risks is essential [5].
- The issue of autograft versus allograft is likely to be effectively answered only by a multicentered study [5].

POSTOPERATIVE REHABILITATION

- Rehabilitation protocols described in the literature for knee dislocations following surgery vary [32].
- A systematic review by Mook et al. suggested that immobilizing knees after acute surgery for knee dislocation led to increased posterior instability versus a protocol of early mobilization [32].
- A systematic review by Mook et al. found that the trend of increased posterior instability with immobilization was also seen in the incidence of postoperative varus and valgus laxity [32].
- A systematic review by Mook et al. found that within chronic treatment groups, varus laxity was increased with early mobilization [32].
- A systematic review by Mook et al. showed that immobilization after acute surgical treatment of knee dislocations increased the incidence of both flexion loss >10 degrees and extension loss >5 degrees [32].
- A systematic review by Mook et al. found that patients were significantly more likely to have severely abnormal or poor outcomes with prolonged immobilization [32].
- A systematic review by Mook et al. found that patients were significantly less likely to return to work with prolonged immobilization [32].
- Richter et al. compared 6 weeks of immobilization to functional rehabilitation (flexion to 60 degrees allowed after 48 hours) in patients managed both operatively and nonoperatively [32].
- Statistically significant improvements were seen in the Lysholm and Tegner scores, but not the IKDC scores, in patients treated with functional rehabilitation compared to immobilization [32].
- Early results from a prospective randomized study suggest reduced instability and reduced surgical failure rates with the use of a hinged knee external fixation device compared to a hinged knee brace [32].
- A randomized comparison of early versus delayed rehabilitation protocols following acute (<3 weeks) multiligament surgery is subject to the issue of heterogeneity among patterns of injury and repair techniques [32].
- Early motion may be a more favorable option to surgeons who in the past had been hesitant to mobilize acutely repaired tissues, given the more recent popularity of combined early repair and reconstruction [32].

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