Diagnosis and Management of the Multiligament-Injured Knee

Knee dislocations, due to either high- or low-energy trauma, frequently result in the disruption of the anterior and posterior cruciate ligaments in addition to the joint capsule and collateral ligaments. The most serious complications associated with the disruption of multiple knee ligaments and knee dislocations, including injuries to the popliteal artery and common peroneal nerve, are limb threatening. Because of the significant consequences of a missed injury, the clinician must have a high index of suspicion of disruption of multiple knee ligaments with resultant multidirectional instability, based on the available clinical history, the presence of deformity or instability, and any neurovascular deficits present during evaluation.

Despite its severity, the multiligament-injured knee is potentially a challenge to diagnose. Although a prompt and accurate history and physical examination remain the cornerstone of the evaluation to determine the extent of injury and to formulate a thoughtful treatment plan, the clinical examination is not always reliable. Twaddle et al. suggested that in trauma patients with severe knee ligament derangement, clinical examination did not accurately predict the extent or site of soft tissue damage. Similarly, the treatment of multiligament injuries can be difficult. Although nonsurgical management often leads to less acceptable outcomes in patients who are active and athletic, there are individuals with comorbidities (eg, diabetes mellitus, obesity, peripheral vascular disease, closed-head injuries, or significant soft tissue loss) who may be candidates for initial and possibly definitive nonoperative treatment. There is considerable debate concerning the timing of repair and the protocol for postoperative rehabilitation in the surgical candidate. Despite advances in surgical techniques, postoperative stiffness remains a major concern, contributing to the difficulty in managing these injuries.

INCIDENCE AND MECHANISM

Knee dislocation is considered a rare injury, accounting for less than 0.02% of all orthopaedic injuries. Despite several authors who have reported rates of knee dislocation ranging from 0.001% to 0.013% per year, the actual incidence is likely much higher because the knee typically spontaneously reduces after dislocation.

High- and low-energy mechanisms can both lead to knee dislocation and its associated ligamentous disruption. The most common high-energy mechanism is a motor vehicle accident. The injury usually occurs when the anterior aspect of the lower leg contacts the dashboard, forcing the tibia in a posterior direction. High-energy accidents may also produce open fractures, affect both knees, and be associated with other life-threatening injuries.

Knee dislocations can also be caused...
by low-energy mechanisms. Shelbourne et al\textsuperscript{23} reported a series of sports-related, low-velocity knee dislocations associated with football, wrestling, and running. In contrast to anterior cruciate ligament (ACL) injuries, which typically occur via a noncontact mechanism, multiligament injuries typically result from contact or collision that causes knee hyperextension combined with excessive varus or valgus force on the knee. The increased size and strength of athletes in today’s contact sports may lead to higher collision forces that are capable of causing a multiligament knee injury. In addition, spontaneous knee dislocations have been reported to result from trampoline accidents and walking in morbidly obese individuals.\textsuperscript{20,30,39}

**CLINICAL EVALUATION**

A thorough evaluation of knee stability is critical to guide proper treatment of multiligament knee injuries. In addition, an appreciation of the neural and arterial anatomy at the knee is essential, given the incidence of injury to these structures and the potential for serious complications. The clinician should be highly suspicious that a knee dislocation may have occurred if there is deformity, malalignment, or other clinical signs such as massive soft tissue swelling and disproportionate pain. If the capsule is damaged, there may be no true joint effusion; rather, blood may diffuse into the adjacent soft tissues. Low-energy injuries, such as those sustained during sports, may have relatively less soft tissue damage than high-energy trauma and therefore may be overlooked.

The physical examination of an acutely injured knee can be difficult because of pain and subsequent muscle guarding, but it remains the single best indicator of knee patholaxity.

In the nonacute setting, patients may present with ligament injuries that go unrecognized or are mismanaged. Symptoms include persistent pain, feelings of instability, especially during twisting and impact activities, and a mild knee effusion. For all patients undergoing clinical evaluation who have a history suggesting a knee dislocation, plain radiographs must be obtained. In addition, a thorough neurological examination must be performed to document sensory and motor function, as well as a complete vascular examination. Assessment of gait, ligamentous stability, and knee range of motion should also be performed in this setting.

In cases of high-velocity or high-energy trauma, the patient may be unresponsive or sedated and unable to communicate pertinent information. A knee dislocation can be overlooked by focusing on potentially life-threatening head, thorax, and abdominal trauma. Additional factors, such as fractures, open injuries, and soft tissue damage, may also preclude a complete examination. In cases of high-energy dislocation, such as a motor vehicle accident, radiographs of the knee are obtained prior to reduction to evaluate for fracture.

In cases of low-energy trauma, such as those who dislocate the knee on the playing field, immediate reduction should be attempted before performing imaging studies. The extremity is then splinted and the individual is transferred to the emergency room, where radiographs should be obtained to check for associated fractures of the femur and tibia and to confirm a reduced tibiofemoral joint.

Regarding acute injury due to a high- or low-energy mechanism, the extent of injury must be determined. Although the patient often presents with significant pain, swelling, and gross instability, the signs of ligamentous disruption, meniscal tearing, or chondral damage may be unreliable. Magnetic resonance imaging (MRI) can help detect these lesions once the knee is stabilized and evaluation for major arterial or nerve injury is completed. The presence of a furrow between the medial femoral condyle and tibial condyle was first described by Clarke et al\textsuperscript{6} and is an indication for open reduction due to buttonholing of the medial femoral condyle through the medial capsule, with interposition of the medial collateral ligament (MCL) into the joint.\textsuperscript{61}

A thorough examination of the ligamentous structures should be performed on all patients. Although an accurate assessment of the extent of ligamentous injury can be difficult in the acute setting due to pain, hematoma, or associated injuries, an attempt should still be made to examine and document the presence of gross laxity and instability, which indicate disruption of multiple ligaments. A more definitive examination can be performed once pain and swelling are decreased. The examiner should complete a comprehensive evaluation of the integrity of the ACL, posterior cruciate ligament (PCL), posterolateral corner (PLC), MCL, and lateral collateral ligament (LCL).

The ACL is examined by performing the anterior drawer test and the Lachman test, the latter of which is considered to be better.\textsuperscript{29} With these tests, the amount of translation is graded, and in patients with an ACL tear, there may be no firm end point and increased anterior translation when compared to the contralateral side. Although these tests can be easily performed in patients with a chronic injury with minimal pain and swelling, their use in those with acute injuries may be limited. First, under normal circumstances, at 90° of knee flexion, the anteromedial tibia lies approximately 1 cm anterior to the distal femoral condyles. After disruption of both cruciate ligaments, this relationship may be altered, making it difficult to appreciate a true ACL injury via the anterior drawer test due to posterior subluxation of the tibia. Second, in a polytrauma patient or a patient with excessive pain, soft tissue swelling, and associated injuries, it may be difficult to position the knee at 90° of flexion, making it impossible to perform the anterior drawer test.

The usefulness of the pivot shift test to detect anterior knee instability in acute multiligament-injured knees is limited due to the inability to control for hip and leg position, which can alter the results.
of the pivot-shift test. In addition, an associated tear or avulsion of the iliotibial band may not allow the shift to occur as the knee is progressively flexed during testing.

Assessment of the PCL is performed with the posterior drawer test and the posterior sag test. The posterior drawer test is performed by applying a posterior force to the proximal anterior tibia, with the thumbs placed on the joint line to quantify posterior tibial translation. Sekiya et al\(^5\) reported that a grade III (greater than 10 mm of posterior translation) posterior drawer test indicates a combined PCL and PLC injury. In addition, when both the PCL and PLC were injured, Gollehon et al\(^6\) demonstrated that there were large increases in posterior tibial translation and varus rotation at all knee flexion angles. The posterior sag test is performed passively, with the hips and knees at 90° of flexion, to note any posterior translation or sag of the proximal tibia relative to the distal femur.

The MCL and LCL are tested with a valgus and varus stress, respectively, with the knee held at 30° of flexion to isolate the collateral ligaments. Each test is repeated with the knee in full extension. Excessive lateral joint opening with varus stress in full knee extension suggests injury to other structures, including the cruciate ligaments and PLC, in addition to an LCL injury.\(^2\) Likewise, laxity to valgus stress in full knee extension suggests a posteromedial capsular injury and possible concomitant cruciate injury in addition to an MCL injury.

The dial test is used to evaluate the structures that contribute to PLC stability, including the LCL, popliteus tendon, and popliteofibular ligament (FIGURE 1).\(^26\) The test is performed with the knee held at both 30° and 90° of flexion. The patient is positioned either supine or prone, and an external rotation force is applied to the foot as the examiner measures the thigh-foot angle. A difference greater than 10° between legs is considered significant. Increased external rotation at 30° but not at 90° is consistent with an isolated PLC injury, while increased external tibial rotation at both 30° and 90° suggests injury to both the PCL and PLC. An increase solely at 90° of flexion suggests a partial or complete tear of the PCL. The clinician must be aware that an increase in external rotation at both 30° and 90° during the dial test may also signify anteromedial rotatory instability instead of a PLC injury.\(^28\)

### Vascular Injuries

Failure to recognize a vascular injury may lead to serious consequences, including limb amputation. The incidence of popliteal artery injury in association with knee dislocation is reported to be between 4.8% and 65%, and the examiner should be very suspicious of possible arterial injury in high-energy injuries.\(^23,39,41\) The vascular examination begins with inspection of the leg for capillary refill, warmth, and color. The dorsalis pedis and posterior tibial pulses are palpated. The examiner should be aware that a normal physical examination and a palpable pulse do not rule out serious vascular injury.\(^42\) If pulses are absent or abnormal and the knee is grossly dislocated, a reduction should be attempted and the pulses should be re-evaluated. The ankle-brachial index is a noninvasive test that can be performed with a Doppler probe and a blood pressure cuff to supplement the physical examination to detect vascular injury. The ratio between the systolic pressure in the injured extremity and that in the uninjured arm is calculated. Mills et al\(^42\) reported 100% sensitivity, specificity, and positive predictive value of an ankle-brachial index below 0.90 for identifying significant arterial injuries requiring surgical intervention after knee dislocation.

Any concern for vascular injury war-
rants prompt vascular surgery consultation. If pulses are absent and the limb is ischemic, emergent surgical exploration by a vascular surgeon is warranted. The total warm ischemia time is important because lack of perfusion for longer than 6 to 8 hours is associated with greater risk for amputation. In such cases, the orthopaedic surgeon may be required to apply temporary fixation, such as an external fixator, to stabilize the knee joint. Stannard et al demonstrated that selective arteriography is justified in patients with abnormal physical examination findings that are consistent with vascular injury. If no immediate vascular intervention is required, frequent vascular checks and close monitoring are required, even in those with a normal vascular examination. Green and Allen showed popliteal artery disruption to be most common in posterior knee dislocations, occurring in up to 44% of cases (FIGURE 2). Popliteal artery injury has also been reported in ultralow-velocity injuries involving spontaneous dislocation in individuals who were morbidly obese.

NERVE INJURIES

Nerve injury, which is frequently associated with knee dislocation, has an overall incidence of approximately 20%. Most commonly, the peroneal division, rather than the tibial division, of the sciatic nerve is involved. Although several anatomic variables are responsible for this injury pattern, perhaps most significant is the tethered course of the common peroneal nerve, which passes around the proximal fibula. The mechanism of injury is also important; lateral and posterolateral injuries may place increased stretch on the nerve. The examination consists of testing tactile sensation in all nerve distributions of the lower leg and foot. Strength is tested for all muscles innervated by the peroneal and tibial nerves, which produce movements related to ankle dorsiflexion and plantar flexion, foot inversion and eversion, and great-toe extension. Overall, the prognosis for recovery of nerve function lost after a knee dislocation remains poor. Patients with chronic injuries can present with a foot drop and may benefit from an ankle-foot orthosis or a posterior tibial tendon transfer.

IMAGING

Plain radiographs in 2 planes (anteroposterior and lateral) are important to characterize the knee dislocation in terms of the direction of
dislocation and to assess for fractures (eg, Segond fracture, PCL-avulsion fragment, tibial plateau fracture, osteochondral injury) (FIGURE 3). In general, in cases of suspected knee dislocation due to a low-energy mechanism (eg, sports), a reduction should be carried out as soon as possible, because the likelihood of associated fracture is lower. In high-energy situations (eg, motor vehicle accidents), there is a greater chance of associated fracture, and thus radiographs should be performed prior to attempting reduction. However, in all situations, radiographs also must be performed after reduction. MRI is helpful after dislocation to determine which ligaments were involved and to define the injury pattern, although it cannot determine the extent of abnormal translation or rotation of the tibia versus the femur (FIGURE 4). Moreover, MRI can evaluate chondral surfaces, menisci, and other soft tissues. Bui et al retrospectively reviewed MRI in patients after a knee dislocation and reported that 75% of patients had evidence of bone bruising and up to 25% of patients had meniscal tears.

**CLASSIFICATION**

Classification of knee dislocations is primarily based on the direction in which the tibia displaces in relation to the femur. This leads to 5 categories: anterior, posterior, medial, lateral, and rotatory. Anterior knee dislocation is most common, followed by posterior dislocation, while rotatory dislocation is least common. A drawback of this scheme is the difficulty of determining the direction of dislocation if the knee spontaneously reduces before clinical evaluation. Schenck proposed a more anatomic classification scheme that grouped injuries according to the pattern of ligament disruption, helping to guide treatment (TABLE). The benefits of this system include the ability to study outcomes for different injury patterns in the literature and to predict other associated injuries.

**TREATMENT CONSIDERATIONS**

Historically, knee dislocations were treated nonoperatively with immobilization in plaster casts. Frequently, patients who were managed nonsurgically had poor functional outcomes and persistent knee instability. Although several authors previously reported good results with nonsurgical management, most authors recommend surgical stabilization of these injuries. Despite recent trends and advances in surgical techniques, certain patients may benefit from nonoperative treatment. Patients with significant injuries sustained at the time of accident should not be considered for surgery until they are able to participate in a postoperative rehabilitation protocol. If the soft tissues around the knee are significantly damaged or there is concern about adequate postoperative wound healing, surgery should be postponed. Braces can help maintain reduction until surgery is appropriate. In addition, nonsurgical treatment may be appropriate for patients with low functional demands and

**TABLE**

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*Adapted from Schenck.

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**FIGURE 3.**

(A) Sagittal MRI of the knee with disruption of both anterior and posterior cruciate ligaments (arrow). (B) Coronal MRI demonstrating complete tear of lateral collateral ligament from the fibular insertion (arrow). (C) Coronal MRI demonstrating complete medial collateral ligament tear (arrow) and the lateral subluxation of the tibia in relation to the distal end of the femur. Abbreviations: A, anterior; L, lateral; LFC, lateral femoral condyle; M, mediat; MRI, magnetic resonance imaging; P, posterior.
those who are morbidly obese. Finally, some patients may simply wish to pursue nonoperative management.

Numerous authors have reported results of operative and nonoperative treatment of knee dislocations with multiligament injuries. Overall, however, high-quality studies to guide treatment are lacking, and no prospective randomized trials are available to date. In part, this is because knee dislocations are relatively rare except in trauma centers, and because there are wide variations in the classification, surgical approach, timing of surgery, and postoperative rehabilitation of these injuries. Absolute indications for surgery include open fractures, compartment syndrome, vascular injury, and irreducible knee dislocations.

Recently, Levy et al. conducted a systematic review of the literature comparing the utility of operative treatment and nonoperative treatment of multiligament knee injuries. Their report suggested that surgical treatment led to better functional outcomes compared to nonoperative management. There were limitations, however, including a lack of uniform outcome measures among studies, making comparisons difficult. Dedmond and Almekinders performed a meta-analysis to determine the optimal treatment and outcomes after knee dislocation. They evaluated 132 knee dislocations treated surgically and 74 treated nonsurgically, and reported a significantly better Lysholm score in the surgically treated group but no significant between-group difference in postoperative stability. Several authors have demonstrated improved ability to return to sport activities following surgical repair or reconstruction. Overall, in the absence of major contraindications, improved functional outcomes can be expected in most patients who undergo surgical intervention. However, though the outcomes of operatively treated knee dislocations have improved, postoperative stiffness, the ability to return to the preoperative activity level, and persistent pain continue to be significant concerns.

The timing of surgical intervention is usually defined as either acute (earlier than 3 weeks after injury) or delayed. When planning for surgical intervention, there are several factors to consider that may be out of the surgeon’s control. These include the status of the soft tissues, the presence of open fractures or tissue loss, life-threatening injuries, the vascular status of the limb, as well as the degree of knee stability following closed reduction. The major concern with acute management is the potential for postsurgical stiffness and loss of range of motion; however, several authors have reported improved subjective and objective outcome measures after acute repair or reconstruction. Harner et al. reported on 31 knees, 19 of which underwent acute surgical reconstruction. Those treated acutely had higher subjective outcome scores and improved stability compared to those treated in a delayed fashion. Recently, Mook et al. performed a systematic review to determine whether early, late, or staged operative treatment led to better outcomes. Their analysis suggested that delayed surgical intervention could potentially lead to stability equivalent to acute surgical management. Patients managed acutely and those who had staged procedures had a greater likelihood of significant loss of motion that in some cases required additional treatment. No patients in the chronic treatment group required a manipulation for decreased knee range of motion.

Overall, the decision to proceed with acute or delayed reconstruction must be patient-specific and should take all of the various factors into consideration. Even though most authors recommend acute surgical intervention when there are no contraindications, good results have also been obtained with delayed operative management. Patients with significant risks or complicating factors that favor nonsurgical management may be treated with a period of initial bracing, followed by surgical repair or reconstruction at a later date if indicated. In addition, certain injury patterns (ACL/PCL/MCL) may be treated with an initial period of bracing to allow the MCL to heal before proceeding with cruciate reconstruction. The clinician must be aware that arthroscopic reconstruction techniques may cause fluid extravasation into the surrounding soft tissues due to joint capsule disruption, increasing the risk of compartment syndrome. For this reason, a short delay of 1 to 2 weeks may be warranted to allow the capsular injury to heal. It must be emphasized that all injuries must be identified, including those to ligaments, bone, menisci, cartilage, and other soft tissues, before the surgical decision is made. Failure to do so may compromise the final result and lead to the failure of surgical repair or reconstruction.

**SURGICAL TREATMENT**

The goal of surgical treatment for multiligament knee injuries is to provide a functional, stable joint. Anatomic reconstruction is the standard in cases of ACL and PCL disruption, although consideration must be given to collateral ligament injuries that may heal on their own with functional bracing. While the specific details of surgical technique are beyond the scope of this review, general principles of, and information about, operative treatment are essential for all clinicians, therapists,
and caregivers involved in managing the patient. Advances in surgical techniques allow for large portions of knee ligament reconstruction to take place arthroscopically; however, as noted above, the risk of iatrogenic compartment syndrome must be recognized.

An examination under anesthesia prior to surgical incision is essential to define the injury completely. The choice of surgical incisions is based on the pattern of ligamentous injuries, with the most common being injury to the ACL, PCL, and MCL or LCL (FIGURE 5). Arthroscopy is beneficial to evaluate the chondral surfaces, menisci, and joint capsule (FIGURE 6). Associated fractures, patellar or quadriceps tendon ruptures, and nerve injuries can be treated during the surgical procedure.

With both ACL and PCL reconstruction, anatomic reconstruction with graft placement at the footprint of the native ligament is critical. Several types of allograft tissue are frequently used for reconstruction, including an Achilles tendon allograft for PCL reconstruction (FIGURE 7). Despite the drawbacks of possible disease transmission, delayed revascularization, and increased cost, the benefits of allografts include shorter operative time, no donor-site morbidity, smaller and fewer skin incisions, and reductions in postoperative pain and stiffness. If an autograft is chosen, a bone-patellar tendon-bone graft is commonly selected for ACL reconstruction, although hamstring and quadriceps tendons may also be used. Several methods have been described for PCL reconstruction, including inlay versus transtibial tunnel technique, single-bundle versus double-bundle, and varying graft choices as well as fixation methods. We favor quadriceps autografts in most cases. The PCL graft is tensioned with the knee at 90° of flexion, while the ACL graft is tensioned in full extension (FIGURE 8). If MCL reconstruction is indicated, the knee is held at 30° of flexion for graft tensioning. Avulsed collateral ligaments and intrasubstance injuries may be amenable to direct repair.

At the conclusion of the case, if a tourniquet was used, it is let down and distal pulses are confirmed. If any questions arise, Doppler examination is indicated. A dressing is applied and the leg is immobilized in a well-padded, long-leg splint. A drain can be placed to prevent hematoma formation. Once pain is well controlled, the patient is discharged home and a postsurgical rehabilitation protocol is started.

**POSTOPERATIVE REHABILITATION**

Rehabilitation after surgical treatment should protect the reconstructed or repaired ligaments while improving motion and strength. Published protocols have shown good long-term results. Non-weight bearing may be indicated for 6 weeks following surgery, depending on the injury, muscle function, and patient compliance. During the first 3 weeks, a long-leg hinged brace or posterior splint is worn and locked in full extension to protect the repair. Electrical muscle stimulation should be used to enhance quadriceps recruitment. Patellar mobilization is used to prevent patellar entrapment and decreased patellar mobility. Isometric quadriceps exercises are started immediately, because quadriceps weakness is a major concern. Reductions in pain and swelling are also emphasized during this time. Early passive motion is encouraged but initiated based on the injury and patient compliance. By the sixth postoperative week, knee flexion to 90° is desired.

Early partial weight bearing at 25% body weight can be very beneficial for good recovery, but it requires muscle control of the extremity. The time at which partial weight bearing is allowed depends
on the injury and the individual. Once initiated, the amount of weight bearing is gradually increased by 25% body weight per week until the patient is able to bear full weight. Likewise, the amount of knee flexion is increased in a stepwise fashion to protect the PCL repair, with the goal of 120° of flexion by the end of the 12th postoperative week. Weight-bearing exercises are used to rebuild muscle strength. Stationary biking is also utilized during this time to improve strength and range of motion, and proprioceptive exercises are performed.

Weight-bearing exercises are progressed as tolerated and low-resistance quadriceps exercises are employed. Hamstring exercises will strain the PCL and are delayed for 12 weeks. Quadriceps weight-bearing exercises are used until the operative limb shows 70% (or greater) of the strength of the nonoperative side. Activities are gradually increased from the fourth to sixth postoperative month, and a functional brace is provided. The patient is not allowed to return to full activity and sports before 9 months, and only if isokinetic strength testing is within 90% of the contralateral side. The patient must also be without pain, swelling, and significant laxity.10

Postoperative stiffness and loss of knee motion remain a significant concern following knee dislocation.25,66 The rehabilitation protocol emphasizes early protection with immobilization and a gradual return to activities with external hinged bracing. The risks of early, aggressive range of motion are loss of stability and failure of the repaired or reconstructed ligaments. In reality, the clinician must balance these 2 competing factors by frequent examinations. Adjustments to the protocol may be needed, based on the condition of the knee. Fitzpatrick et al23 performed a laboratory study demonstrating decreased forces in the ACL and PCL following placement of an articulated external fixator after multiligament reconstruction. Stannard et al9 advocated hinged external fixator placement after surgery, showing a lower failure rate of the repaired or reconstructed ligaments with aggressive knee range-of-motion rehabilitation.

## CONCLUSION

**Knee dislocations are rare injuries.** However, when they occur, they represent a challenging and complex clinical problem. A thorough knowledge of anatomy and an appreciation of the risk of serious vascular and neurologic injury is required. The physical examination is most important to determine the extent and pattern of injury, as well as to recognize potentially limb-threatening injuries that may require emergent intervention. Although most patients are surgical candidates, the decision to proceed with operative management is patient-dependent and multiple factors must be considered. The goals of rehabilitation are to protect the repair and facilitate functional knee motion and strength.1

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### REFERENCES


