THE MULTIPLE LIGAMENT INJURED KNEE

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Traumatic knee dislocations leading to multiple ligament injury are relatively uncommon but not rare injuries. These injuries demand prompt and appropriate attention; they represent one of the few true orthopedic emergencies because of their potentially limb-threatening nature. Because many of these injuries reduce spontaneously near the time of the injury, the true incidence is unknown but is thought to be relatively low.[24, 31, 38] Out of two million admissions during a 50-year period at the Mayo Clinic, Hoover[15] reported only 14 cases of knee dislocations. At a major level 1 trauma center in New Mexico, only 50 patients with knee dislocations were admitted between 1987 and 1994.[44] At the University of Pittsburgh, 52 patients have been treated for acute and chronic knee dislocations between 1990 and 1997, reflecting a tendency to refer these complex cases to centers familiar with their relative severity.

The ideal management of ligamentous injury in the dislocated knee remains controversial. Because literature is relatively sparse and includes a heterogeneity of injuries, treatment protocols and evaluation methods will vary by specialty and region. Nonoperative management emphasizing immobilization, although possibly leading to a stable knee, is frequently associated with stiffness and dysfunction.[1] Alternatively, more aggressive nonoperative management using early range of motion will restore functional motion at the expense of knee stability.[41] O'Donoghue,[28] Meyers et al[24, 25] and Shields et al[38] were the earliest

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authors to recommend acute repair of all torn ligaments to achieve the best results. Most contemporary reports include recommendations for early ligament repair or reconstruction when necessary.* The focus of this review is on the acute management of the dislocated knee; however, except for the management of vascular injury, the same principles and techniques that apply to the acute injury also generally apply to the chronically unstable knee sustaining a previous dislocation.

DEFINITION

Most dislocations involve tears of the central pivot, including both the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL). Rarely, the PCL[6, 36] or the ACL[2] may remain intact following a knee dislocation. Not uncommonly, one or both collateral ligaments are disrupted with an associated injury to the meniscus, articular cartilage, and posterolateral or posteromedial capsular structures. Often, injury severity is underestimated by the joint position at the time of initial presentation.

CLASSIFICATION

Degree

The dislocation can be partial (i.e., a subluxation), associated with spontaneous reduction, or complete at the time of initial presentation.

Timing

Although somewhat arbitrary, for treatment purposes the authors classify knee dislocations with respect to the time lapsed following the initial dislocation. An acute dislocation is treated within 3 weeks and is the most amenable to primary repair of the torn structures when indicated. A subacute dislocation is treated within 3 weeks to 3 months and is often amenable to a combination of repair and reconstruction of the torn structures. A chronic dislocation is treated beyond 3 months and frequently requires reconstruction of all affected structures.

Direction

The position of the tibia with respect to the femur is the most commonly used classification system (Table 1).[17] The tibia can be displaced anterior, posterior, medial, or lateral relative to the femur. Combinations of these directions also exist with the posterolateral dislocation associated with an irreducible "button-holed" medial femoral condyle

*References 1, 7, 8, 9, 20, 21, 26, 33, 35, 39, 40, 43.

Table 1. CLASSIFICATION SYSTEM ADAPTED FROM KENNEDY[17]

Direction	Mechanism	Injury Pattern
Anterior*	Hyperextension	Posterior capsule → PCL → ACL tears
Posterior†	"Dashboard"	PCL torn
Medial	Varus/rotation	Collaterals, cruciate
Lateral	Valgus Flexion/adduction	Collaterals, cruciate
Rotatory‡	Rotation around PLC	MCL, ACL, PCL

*Most common.
†Second most common.
‡Posterolateral most common.
PLC = posterolateral corner; PCL = posterior cruciate ligament; ACL = anterior cruciate ligament; MCL = medial collateral ligament.
Adapted from Kennedy J: Complete dislocation of the knee joint. J Bone Joint Surg 45A:389–904, 1963; with permission.

through the anteromedial capsule being most common.[30] Kennedy's[17] classification system assumes that both cruciate ligaments are torn; it does not delineate which other structures are disrupted, and does not describe the "hinged knee" in which both cruciates and a collateral ligament are torn, as seen in low velocity injuries with no history of dislocation. These limitations are partially addressed by Schenck[34] whose classification system describes the specific structures involved (Table 2).

MECHANISM

Implicit in Kennedy's[17] classification system is the mechanism of injury (Table 1). Anterior dislocations are believed to occur with extreme hyperextension such as tripping in a hole, and posterior dislocations are believed to most commonly occur as a result of a posteriorly directed blow to the proximal tibia such as in a motor vehicle accident (i.e., "dash-board injury").[33, 38, 41] Medial and lateral dislocations are most likely to occur in high-energy accidents with varus or valgus rotatory moments. Combined dislocations, such as the irreducible posterolateral

Table 2. CLASSIFICATION SYSTEM ADAPTED FROM SCHENK ET AL[34]

Category	Structures Involved
KD I	Anterior dislocation, PCL intact
KD II	ACL/PCL
KD III	ACL/PCL, one collateral torn
KD III M	ACL/PCL/MCL
KD III L	ACL/PCL/MCL
KD IV	ACL/PCL/MCL/LCL

C = Circulatory injury; N = nerve injury.
Adapted from Schenk R, Burke R, Walker D: The dislocated knee: A new classification system. Southern Med J 85:35S1, 1992; with permission.

dislocation, probably involve a flexed non–weight-bearing knee that is suddenly exposed to an abduction and internal rotation moment on the tibia.[30]

ASSOCIATED PATHOLOGY

Vascular Injury

The popliteal artery is tethered at the adductor hiatus proximally and at the soleal arch distally and has little tolerance for skeletal distortion. Popliteal artery injuries occur in approximately one third (10% to 64%) of knee dislocations ranging from intimal injury to complete disruption.[8, 10, 15, 16, 29, 38, 39, 42] Popliteal artery disruption is most common with posterior knee dislocations from the impact of the posterior rim of the tibial plateau. Stretching is more common with anterior dislocations caused by traction at the sites of arterial tethering during hyperextension. Amputation rates up to 86% result if popliteal artery flow is not restored within 6 to 8 hours because of poor collateral circulation about the knee.[10]

Nerve Injury

Injury to the common peroneal nerve is reported between 9% and 49% of knee dislocations and is most commonly seen in the posterolateral and medial dislocations.[38, 40] Often, an interstitial stretch occurs with involvement extending well proximal to the fibula, but occasionally, complete nerve transection occurs. Tibial nerve injuries have also been described.[45] Recovery of nerve function is unpredictable with most series reporting no recovery in more than 50% of injuries.[24, 39–41]

Other Pathology

Open dislocations have been reported by Shields et al[38] in 35% of their patients and by Meyers et al[24] in 19%. These authors observed that posterior and anterior dislocations have a higher frequency of open injuries than dislocations in other directions. In the authors' experience, injury to tendons, including the patellar tendon, biceps femoris, and popliteus, occurs in at least 20% of the patients. Fracture-dislocations are associated with significant joint instability, and soft tissue and neurovascular complications. Although probably underreported, the authors believe concomitant fractures, especially of the tibial plateau, occur in at least 10% to 20% of patients and are generally associated with inferior outcomes. With associated fractures, treatment algorithms must be initiated promptly and address bony stability as well as soft-tissue repair or reconstruction.

EVALUATION AND INITIAL TREATMENT

General Considerations

A high clinical index of suspicion is necessary if the initial examination reveals gross instability of two or more ligaments despite the absence of a frank knee dislocation. A brief history emphasizing the mechanism of injury and a thorough neurovascular examination emphasizing peroneal nerve function and pedal pulses with comparisons to the contralateral limb for symmetry is of the highest priority in the event a knee dislocation is suspected (Fig. 1).

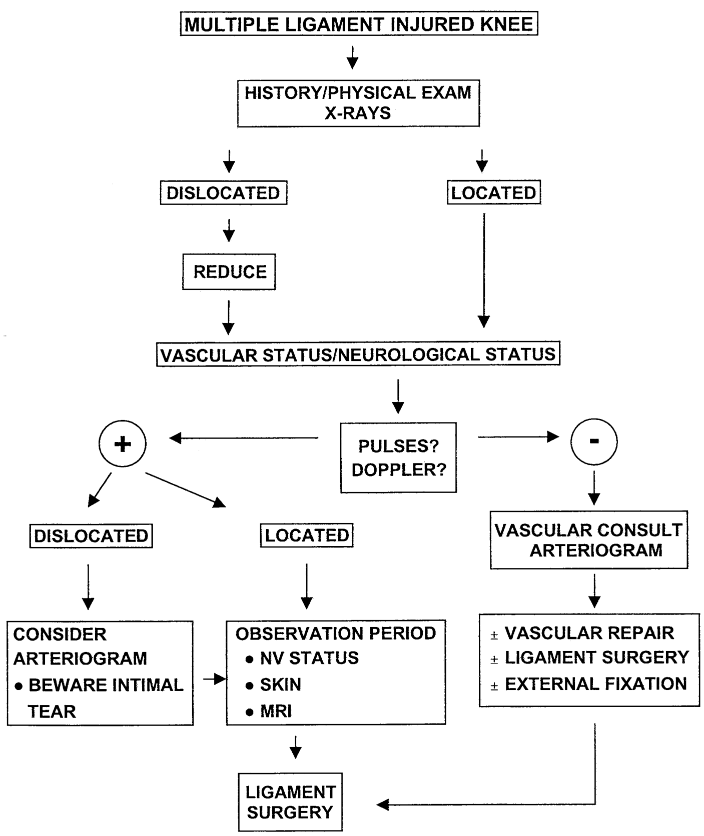

Figure 1. An algorithm for approach to the multiple ligament-injured knee. (*From* Marks PH, Harner, CD: The anterior cruciate ligament in the multiple ligament-injured knee. Clin Sports Med 12:825–838, 1993; with permission.)

Closed Reduction

Acute management involves prompt reduction to reduce potential compression or prolonged stretching of the neurovascular structures. Specific maneuvers including traction-countertraction performed in the emergency department with light intravenous conscious sedation will often reduce an acute knee dislocation (Table 3), but excessive direct force against the popliteal fossa or hyperextension should be avoided to prevent further neurovascular trauma.

Absolute Surgical Indications

Immediate surgical management is indicated most commonly when arterial flow is not restored following reduction or when a patient presents with a "dimple sign" indicating that the medial femoral condyle has irreducibly button-holed through the medial joint capsule potentially causing skin necrosis.[14] Impending or true compartment syndromes and open injuries are additional absolute surgical indications requiring fasciotomy or immediate surgical irrigation and debridement, respectively. Definitive ligament reconstruction is delayed 1 to 3 weeks to allow reduction of swelling, control of the soft tissues, and to reduce the risk of infection. Associated injuries including fractures and extensor tendon ruptures are treated as if they are isolated injuries and thus take precedence over ligament reconstruction.

Management of Vascular Injury

Vascular compromise, including acute compartment syndromes, may be detected upon initial presentation or may develop over the subsequent days following the injury. Assessment of the neurovascular status and routine radiographs are required following prompt reduction to confirm the vascular status, to determine the quality of the reduction, and to rule out associated fractures. If the pedal pulses remain absent or there is evidence of ischemia following reduction, immediate vascular consultation is recommended while the patient is still in the operating room. A "one-shot" arteriogram followed by vessel exploration and repair is performed.[23] Formal arteriography is required, however, to

Table 3. REDUCTION MANEUVER BASED ON DIRECTION OF DISLOCATION

Direction	Maneuver
Anterior	Traction and elevation of distal femur
Posterior	Traction and extension of proximal tibia
Lateral/medial	Traction and appropriate translation
Rotational	Traction and appropriate derotation

determine if an intimal tear is present. A dialogue between the orthopedic and vascular surgeon is necessary so that incisions can be appropriately placed for later ligament reconstruction. Arterial repair typically involves resection of the injured arterial segment and interposition vein grafting. If technically possible, the popliteal vein is also reconstructed in the stable patient to prevent venous insufficiency, venous thrombosis, and possibly, improve arterial patency.[3, 27, 45] Prophylactic fasciotomies are performed following revascularization procedures. Judicious repair of bony avulsions or of torn structures is performed only if encountered as part of the vascular exposure.

Generally, joint stability is maintained with a knee immobilizer or, when necessary, with an external fixator to protect the vascular repair until ligament reconstruction is performed. A request from the vascular surgeon that the knee be held in flexion to reduce repair tension must be weighed against the risk of persistent subluxation of the tibia on the femur. Optimally, the knee should be immobilized in slight flexion pending definitive ligament surgery.

The assumption that vascular compromise is caused by self-limited arterial spasm will expose patients to unnecessary, potentially devastating consequences. Several authors have documented progressive thrombosis caused by intimal injury.[27, 29] Asymmetry of the pedal pulses in the presence of a reduced knee warrants an arteriogram to rule out intimal tears. Strong palpable symmetrical pulses do not rule out arterial or intimal injury. Doppler pressure measurements may not detect intimal damage and many authors recommend an arteriogram in all cases despite the vascular status.[5, 8, 23, 39] Recent literature suggests that serial examination by a vascular surgeon may be sufficient to detect arterial injuries requiring treatment.[42] Kendall et al[16] think that if distal pulses are symmetrical and an ankle brachial index is greater than 0.15, then arteriography is not necessary. Because concomitant popliteal vein injury is likely to occur and patients are often relatively debilitated from the initial injury, the authors routinely use subcutaneous heparin, aspirin, or Lovenox (Rhône-Poulenc Rorer Pharmaceuticals Inc, Collegeville, PA) as prophylaxis against deep vein thrombosis during the window period before definitive treatment is rendered.

Management of Nerve Injury

Sensory and motor function is thoroughly documented. Progressive loss of sensory function suggests impending compartment syndrome or ischemia. Initial treatment of peroneal nerve injuries requires an ankle foot orthosis to prevent the development of a plantar flexion contracture. Nerve function may return up to 1 year, and neurolysis may play a role in expedited return.[25] If there is a neurologic deficit at the time of surgery with an intact nerve, the authors release the anterolateral fascial bands where the common peroneal nerve enters the lateral compartment to prevent postoperative edema from causing nerve compression. Most authors agree that treatment of the intact but damaged nerve warrants at least 3 months of observation to assess for spontaneous recovery.[46] Treatment of the disrupted peroneal nerve includes tagging both ends of the peroneal nerve for later identification and cable grafting. Treatment of residual nerve dysfunction requires late nerve grafting or reconstruction, tendon transfers, or dynamic bracing.

Evaluation of Ligament Injuries

Ligament testing in the acute multiple ligament-injured knee is often limited because of pain and must be performed carefully to avoid inadvertent passive hyperextension or redislocation. Initial evaluation of the PCL requires determination of the normal medial tibial plateau step-off in reference to the medial femoral condyle. Gentle use of the Lachman examination and collateral ligament stability testing in 0 degrees and in 20 to 30 degrees of flexion is usually possible. Assessment of the posterolateral corner with external rotation testing in 30 degrees and in 90 degrees is important, but often difficult because of pain. Magnetic resonance (MR) imaging provides accurate assessment of all of these structures in addition to the status of the menisci, cartilage, extensor mechanism, and potentially identifies fractures and bone bruises. MR imaging is invaluable in the preoperative planning of these difficult cases and permits preoperative counseling to patients and their families regarding expectations and outcomes.

SUBSEQUENT TREATMENT

General Considerations

Treatment goals include the restoration of knee stability, full range of motion, and return of the individual to his or her preinjury level of function. Most authors recommend operative treatment for patients with ligament injuries with the possible exceptions of older, more sedentary individuals and those who are stable following reduction.[7–9, 20, 21, 26, 33, 35, 39–41, 43]

The authors reconstruct or repair all acute combined ligament injuries with Grade III laxity patterns because of the generally poor results following nonoperative treatment. Isolated Grade I and II PCL injuries are generally not reconstructed, and the feeling is that most if not all acute Grade III PCL injuries are associated with a concomitant posterolateral corner injury mandating repair or reconstruction. Acute surgical intervention permits anatomic repair when possible of relatively healthy noncontracted tissue and allows reduction and fixation of bony avulsions. Important considerations include accurately defining the extent of the pathology, surgical timing, repair versus reconstruction, minimizing iatragenic trauma, technical factors, postoperative rehabilitation, and avoiding complications.

Defining the Pathology

Critical evaluation of the findings on MR imaging (Fig. 2) and plain radiographs is instrumental to the preoperative planning of these complex injuries. Plain radiographs will help identify avulsion injuries (i.e., PCL femoral or tibial attachment, lateral collateral ligament [LCL] fibular attachment) and tendon injuries (i.e., patellar tendon avulsion from the tibial tubercle). All sizes of tibial plateau fractures, even if nondisplaced, should be aggressively treated. For chronic cases, a bone scan is helpful to separate pain from instability.

Surgical management begins with an examination under anesthesia to more completely define the ligamentous injuries. The most common injury patterns include the combined injury of the ACL, PCL (posterior cruciate ligament), and MCL (medial collateral ligament), and the combined injury of the ACL, PCL, LCL, and posterolateral corner. Arthroscopy is useful to define pathology not readily appreciated by imaging or physical examination (Fig. 3). Careful attention to the status of the meniscus, articular cartilage, popliteal tendon, capsule, and cruciates is critical to direct appropriate repair or reconstruction of these involved structures.

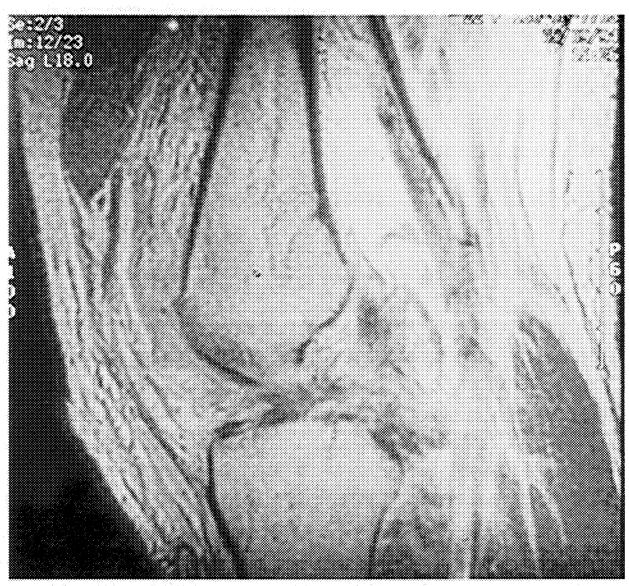

Figure 2. MR image of the knee demonstrating disruption of the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL).

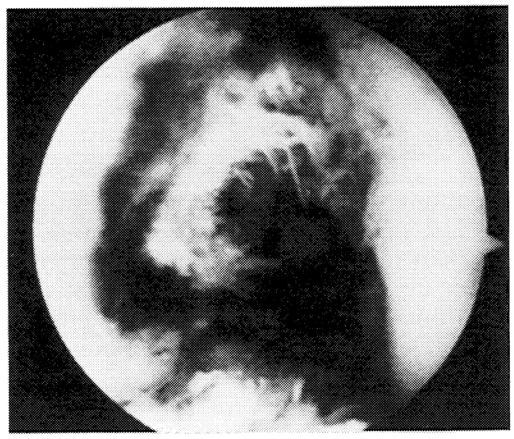

Figure 3. Arthroscopic examination of the dislocated knee demonstrating complete disruption of the ACL and PCL when viewing the intercondylar notch.

Surgical Timing

Delaying surgery for 1 to 2 weeks following the initial injury offers several advantages. It provides a period of vascular monitoring, reduces the risk of postoperative stiffness,[37] prevents excessive scarring of the collateral ligaments and "corners" that may otherwise interfere with their repair, allows a period for restoration of range of motion and quadriceps tone, provides a protection period to reduce swelling and stabilize the soft tissues, and allows capsular healing permitting an arthroscopically-assisted approach to repair or reconstruction. Surgical intervention should not take place until adequate and stable limb profusion exists and there are no comorbidities preventing safe surgical intervention.

Repair Versus Reconstruction

The operating surgeon must be prepared to repair or reconstruct all torn ligaments. MR imaging is particularly useful to predict which structures are repairable and which must be reconstructed. In general, repair is not as strong as reconstruction and modification of postoperative protocols must reflect this difference. Repairs are generally not possible beyond 3 weeks because of scar formation and soft tissue contracture. Repairs are less desirable for midsubstance pathology and are more amenable with "peel-off" or insertional injuries, including bony avulsions. The authors advocate repair of avulsions with or without a fragment of bone using the techniques described by Marshall.[22] The authors have found the use of nonabsorbable suture passed through small drill holes tied over a cortical bridge of bone to be quite effective in performing these repairs. Primary repair of cruciate midsubstance tears has not been successful,[22] and the authors reconstruct all nonbony avulsions of cruciate ligaments. Avulsed ligaments and intrasubstance MCL tears may be directly repaired. Intrasubstance tears of lateral ligaments are generally reconstructed and repaired simultaneously. Peripheral meniscus tears and capsular avulsions are directly repaired. If surgery must be delayed beyond 3 weeks, it may be prudent to wait until full range of motion is established and the patient demonstrates residual laxity leading to functional instability.

Minimizing Iatrogenic Trauma

Arthroscopic versus Open Techniques

Arthroscopy is not always possible in the acute or subacute setting because of capsular venting and inability to maintain joint distension potentially leading to a compartment syndrome. Commonly, most of the procedure can be performed arthroscopically by 2 to 3 weeks following the injury. Occasionally, however, an "arthroscopically assisted" approach is used; various portions of the procedure are performed through a medial-based parapatellar tendon mini-arthrotomy, assisted by the arthroscope for better visualization and magnification in a dry field. If the arthroscope is used, the authors use gravity flow rather than an arthroscopic pump to minimize the extent of fluid extravisation.

Graft Selection

Graft selection will vary by region and surgeon preference. If autografts are chosen, the patellar tendon autograft is commonly used to reconstruct the ACL and the contralateral patellar tendon autograft or ipsilateral hamstring is used to reconstruct the PCL. The authors believe, however, that allografts have major advantages over autografts. Use of allografts eliminates graft site morbidity, decreases dissection time, reduces the number and extent of skin incisions, decreases postoperative pain and stiffness, and decreases tourniquet time.[13] The risk of HIV infected soft tissue allografts is calculated to be 1 : 1,667,700[4] and with modern-day polymerase chain reaction testing, there have been no reports of disease transmission to date. The authors' preference is to use allograft patellar tendon to reconstruct the ACL, allograft Achilles tendon to reconstruct the PCL and LCL, and ipsilateral hamstring tendon to reconstruct the posterolateral corner (Fig. 4).

Technical Factors

Patient Positioning

The patient is positioned supine on the operating table, and a well-padded tourniquet is applied to the upper thigh as high as possible. A

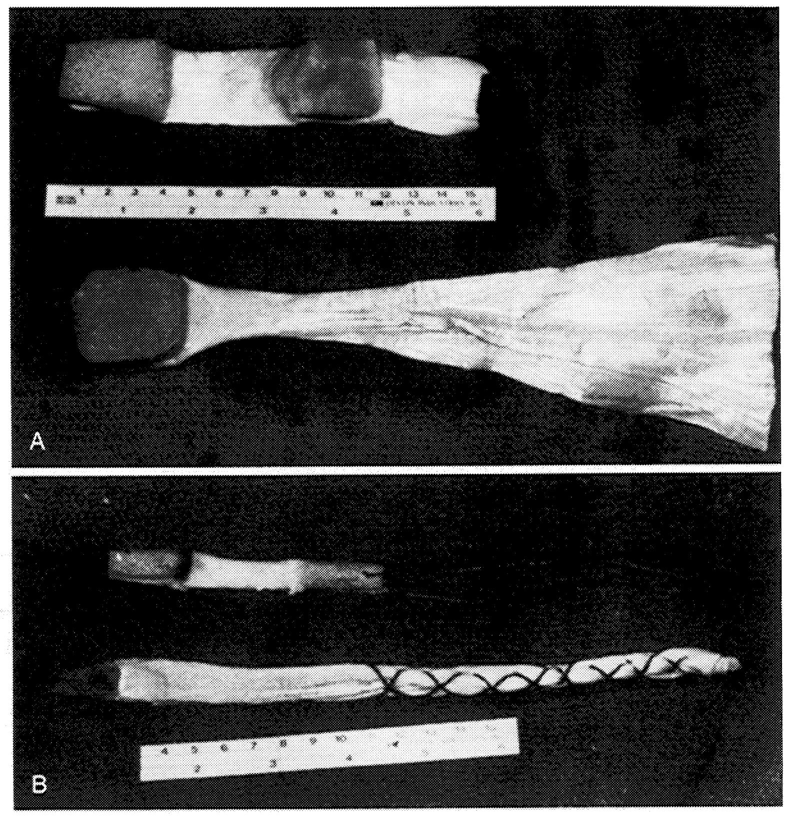

Figure 4. *A,* The allograft material is prepared for use. The bone-patellar tendon-bone allograft is used to reconstruct the ACL *(top).* An Achilles' tendon allograft is used to reconstruct the PCL *(bottom). B,* The final allografts are prepared by sizing them to the tunnel diameter with no. 2-0 nonabsorbable stay sutures placed transversely through the bone plugs, and a no. 5-0 nonabsorbable stay suture tubularizing the tendinous portion of the Achilles' graft to facilitate graft passage.

lateral post situated at the level of the tourniquet is helpful to prevent lateral movement of the leg while held in the flexed position. A sandbag secured to the bed at the level of the midcalf provides a "bump" to rest the foot against during flexion. The tourniquet is generally not inflated unless necessary. Presurgical preparation should provide wide exposure of the entire extremity.

Operative Techniques

General Considerations. Examinationunder anesthesia with special attention to collateral ligament testing will determine where and when to make appropriate incisions. If capsular healing and injury pattern permit, the authors begin and perform much of the procedure arthroscopically through standard inferomedial, inferolateral, and superolateral portals. However, with MCL insufficiency and significant valgus laxity in the acute setting, the authors typically begin with a medial based incision.

Medial Side Injury. If the cruciates and MCL are torn, a medial "hockey stick" incision is made beginning at the level of the vastus medialis and continuing anterior to the medial femoral epicondyle onto the anteromedial tibia to the medial aspect of the patellar tendon. The MCL, capsule, and meniscus are repaired through this incision. The meniscus is repaired by an outside-in technique, using vertically placed No. 2-0 nonabsorbable sutures placed 3 to 5 mm apart. Capsular and MCL avulsions are repaired using suture anchors. Intrasubstance tears of the MCL are repaired primarily using no. 2 nonabsorbable sutures with a modified Kessler type configuration. Through this same incision, a short medial parapatellar arthrotomy allows access to the ACL and PCL for reconstruction and the hamstring tendons can be harvested when necessary.

Lateral Side Injury. If the cruciates and lateral structures are torn, an arthroscopic approach is advocated initially to avoid the need for both medial and lateral incisions, which potentially could cause skin necrosis. The lateral structures are then approached through a 15-cm curvilinear incision beginning midway between the fibular head and Gerdy's tubercle and continued proximally to the lateral femoral epicondyle, paralleling the posterior edge of the iliotibial band (ITB) (Fig. 5). The peroneal nerve is identified proximally, posterior to the biceps tendon, and then dissected distally to the point at which it enters the anterior tibial muscular compartment. Release of the nerve from its fascial bands as it enters the lateral compartment, and gentle neurolysis is performed to release gross hematoma within the nerve when present. The interval between the posterior edge of the ITB and the biceps tendon is developed and the ITB is partially released subperiosteally from Gerdy's tubercle, reflected anteriorly, and held with stay sutures placed along its leading edge. Repair of the ITB with suture anchors placed within Gerdy's tubercle is performed during closure. A vertical incision is made at the posterior border of the LCL taking care to protect or coagulate the inferior geniculate vessel located within the capsular reflection at this level. This window allows visualization of the lateral meniscus and popliteal tendon.

Systematic inspection of the posterolateral corner is performed. Peripheral lateral meniscus tears, capsular avulsions, the biceps femoris tendon, ITB, and components of the arcuate complex are repaired using the same techniques as on the medial side with use of suture anchors where necessary. Avulsions of the LCL and popliteal tendon are directly repaired, but more commonly, interstitial injury of these structures mandates concomitant reconstruction. The LCL is reconstructed using an Achilles' tendon allograft of 7 to 8 mm in width. The LCL can be detached and elevated from its distal insertion and the allograft bone

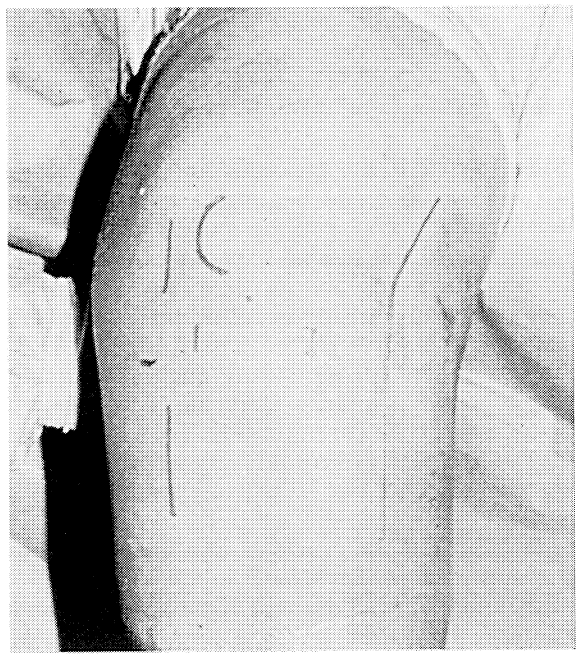

Figure 5. Skin incision for surgical exposure of the lateral collateral ligaments (LCL) and posterolateral corner. An inferiomedial incision is made for the ACL and PCL tibial tunnels, and a superiomedial incision is made for the PCL femoral tunnel.

block fixed vertically into the fibula using an interference screw with the native LCL tensioned and repaired proximally and distally to the graft. Suture anchors are placed into the lateral femoral epicondyle, with passage of the suture arms through the Achilles' tendon and proximal LCL, to reinforce the repair (Fig. 6).

If the popliteus is significantly injured, the popliteofibular ligament is reconstructed using a semitendinosis autograft fixed anatomically on the femur through a 7 mm tunnel using an Endobutton (Acufex, Boston, MA) set outside the medial femoral condyle. The graft is passed deep to the LCL graft toward the posterior and proximal aspect of the fibula, passed anteriorly through a 7-mm tunnel, and sutured to itself and the surrounding soft tissue (Fig. 7).

Cruciate Reconstruction. The principles of ACL and PCL reconstruction are discussed in detail elsewhere, and the order of reconstruction is outlined in Table 4.[11, 12, 21] There are several technical aspects that warrant consideration when performing combined ACL and PCL reconstruction. The femoral and tibial ACL tunnels are placed at the center of the anatomic insertions of the ACL. Because the PCL is absent, the authors use the posterior edge of the anterior horn of the lateral meniscus as a reference to the center of the ACL tibial footprint when a

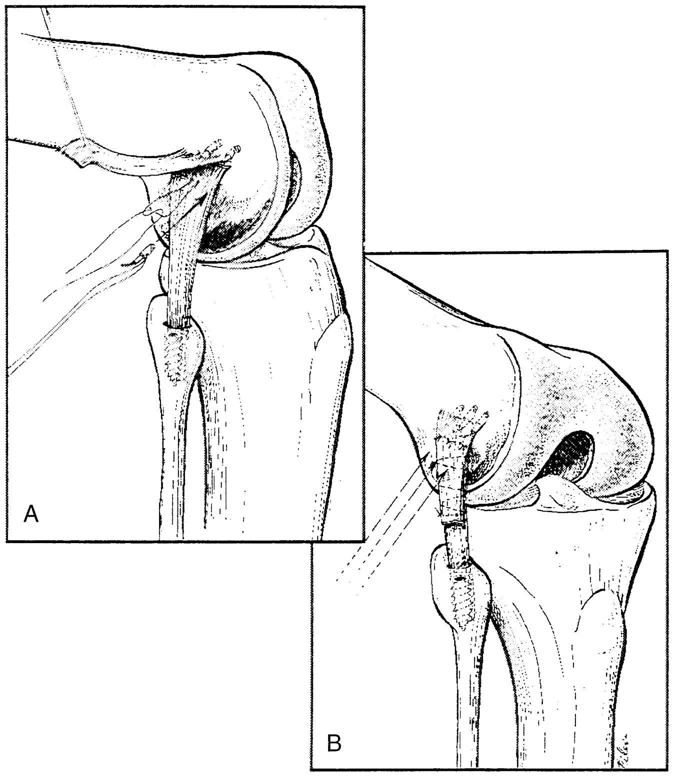

Figure 6. Illustration of LCL reconstruction using an Achilles tendon allograft. *A,* The torn or stretched LCL is detached and elevated from its fibular insertion, and the allograft bone block is fixed in a tunnel the proximal fibula using an interference screw. The tensioned graft is fixed at the lateral epicondyle using multiple suture anchors. *B,* The native LCL is tensioned and sutured to the allograft.

paucity of tibial footprint remains. The guide pin should be directed through the anteromedial tibial cortex to a point just anterior to the over-the-top position with the guide set at 55 degrees to increase the length of the tibial tunnel. The guide itself is passed through the inferomedial portal. The femoral tunnel is placed endoscopically such that a 1- to 2-mm cortical wall remains posteriorly. This is placed at the 10-o'clock position for a right knee and the 2-o'clock position for a left knee.

The goal of PCL reconstruction is to recreate the anterolateral component of the PCL with respect to the position of the anterior femoral component and the lateral tibial component such that normal anatomic tightening occurs in flexion. The PCL tibial tunnel is drilled through the anteromedial tibia entering distal to the ACL tibial tunnel so as to leave a 1-cm cortical bridge with the guide set to about 60 degrees so that it parallels the tibiofibular joint. The pin should exit the posterolateral

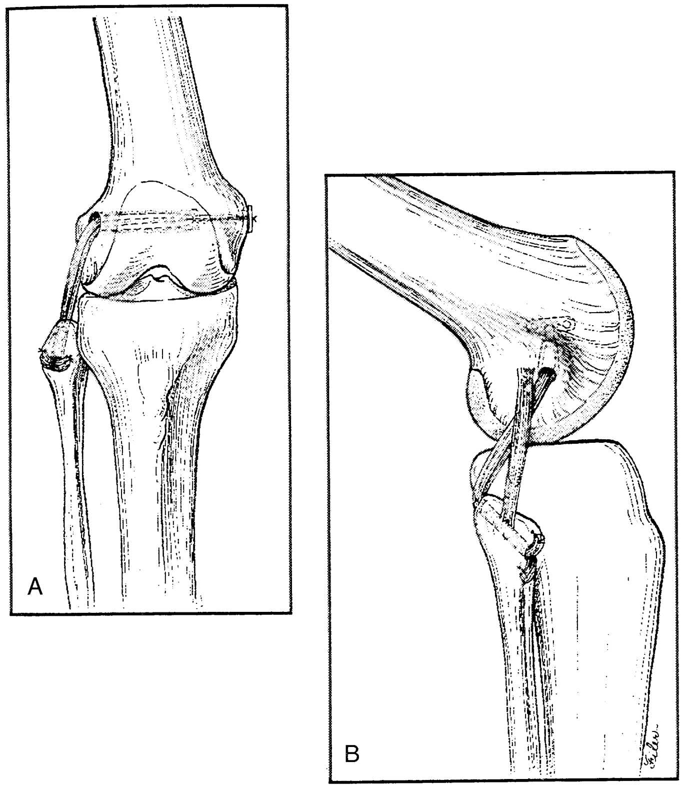

Figure 7. Popliteofibular reconstruction using a looped semitendinosus graft. The graft is fixed into a tunnel extending from the lateral femoral condyle, proximal and medial to the medial femoral condyle, using an Endobutton (Acufex, Boston, MA) set outside the medial femoral condyle. It is then passed deep to the LCL and through the tunnel in the proximal fibula, from posterior to anterior, and sutured to itself and surrounding soft tissues.

aspect of the tibial PCL footprint as confirmed by an intraoperative lateral radiograph (Fig. 8). The guide itself is passed through the inferomedial portal. The authors make liberal use of the 70-degree arthroscope and a well-placed posteromedial portal to prepare and visualize the PCL tibial footprint. The PCL femoral tunnel is placed 8 to 10 mm proximal to the distal articular cartilage at the anterior half of the PCL femoral footprint. With the guide set at approximately 35 degrees, the guide tip is passed through the inferomedial portal, a 2- to 3-cm skin incision is made (if not already present) between the medial facet of the patella and the medial epicondyle.

The bone blocks for the PCL Achilles' tendon allograft and the ACL bone-patellar-tendon-bone allografts are fixed at the femur using interference screws.[18] The medial or lateral repairs are then performed as described earlier. Before final fixation of the collateral repairs/recon-

Table 4. ORDER OF LIGAMENT RECONSTRUCTION

Step 1. Tibial tunnels	
	PCL followed by ACL tunnel
Step 2. Femoral tunnels	
	ACL followed by PCL tunnel
Step 3. Graft passage	
	Pass PCL tendon end first through femoral tunnel exiting tibial tunnel
	Pass ACL through tibial tunnel into femoral tunnel
Step 4. Femoral fixation	
	Fix PCL and then ACL on femur with interference screws
Step 5. Collateral repair	
	Secure extra-articular repairs or reconstructions with internal rotation and valgus force on tibia for posterolateral corner and LCL repairs, respectively
Step 6. PCL tibia fixation	
	Fix PCL graft on tibial at 90 degrees of flexion with reproduction of anteromedial step-off
Step 7. ACL tibia fixation	
	Fix ACL graft on tibial side at full extension

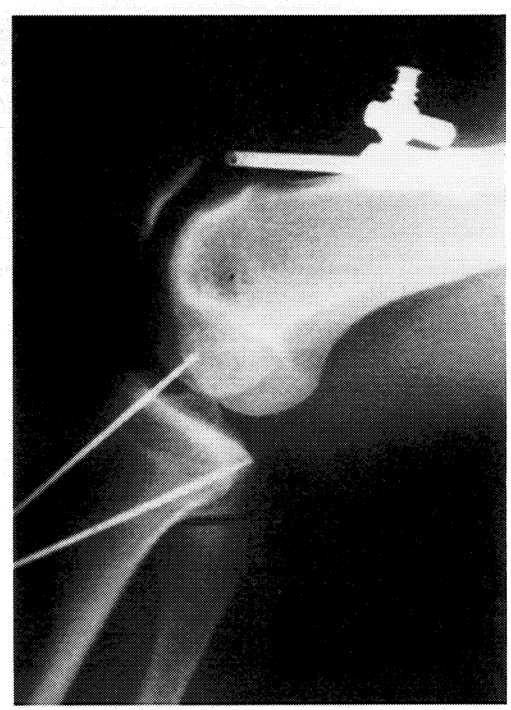

Figure 8. Intraoperative lateral knee radiograph confirming proper placement of ACL and PCL tibial tunnels.

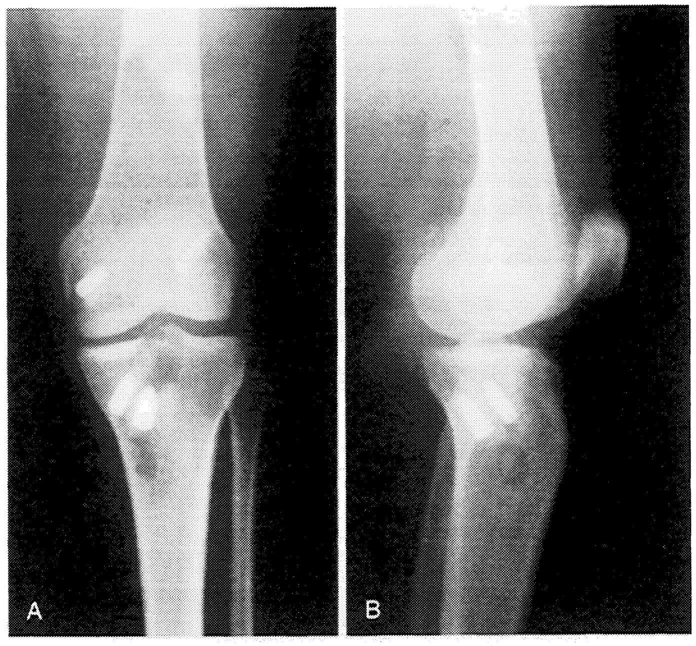

Figure 9. Postoperative radiographs following reconstruction of the ACL and PCL.

struction, the PCL graft is tensioned at 90 degrees of flexion with reproduction of the normal step-off of the medial tibial plateau (about 1 cm). The soft tissue end of the graft is fixed at the tibia using a screw and spiked washer.[32] The ACL graft is then tensioned in extension and fixed at the tibia with an interference screw. Postoperative radiographs confirm proper reduction of the tibia in respect to the femur and verify fixation position (Fig. 9).

Following fixation of the ACL and PCL grafts on the tibia, the remaining extra-articular repairs/reconstruction sutures are tied. The knee is brought through a range of motion from 0 to 90 degrees of flexion. Suction drainage is used for the lateral incision or medial arthrotomy incision. The knee is braced in full extension with a bolster placed beneath the tibia to prevent posterior sagging of the tibia on the femur.

Postoperative Rehabilitation

The first 2 to 4 weeks is considered the period of maximal protection for the reconstruction. The knee is maintained in full extension while patients ambulate non–weightbearing with crutches to protect the collateral repair. Quadriceps isometrics are begun immediately, but active hamstring exercises are avoided for 3 months to avoid posterior translation stress. Passive range of motion is begun within the first week, but performed in the prone position or with support applied to the posterior proximal tibia to prevent posterior subluxation. After the early protection phase, the brace may be unlocked for ambulation and sleeping. After 4 weeks, weightbearing is advanced as tolerated unless a posterolateral repair or reconstruction was performed, in which case ambulation remains partial weight-bearing for a total of 3 months. Not uncommonly, range of motion is slow to return taking up to 6 months for return of full flexion.

Avoiding Complications

Stiffness

In the authors' series, significant loss of motion was uncommon. In general, ACL reconstruction can lead to extension loss, PCL reconstruction to flexion loss, and MCL reconstruction to both flexion and extension loss. Lateral side reconstruction is not thought to lead to postoperative motion loss but may result in residual laxity. Avoiding soft-tissue advancement and tenodesis and opting for anatomic repair and reconstruction is critical to prevent abnormal length-tension relationships from developing. Emphasizing the return of preoperative motion and immobilizing in full extension guarantees full extension following surgery. In our experience, 10% to 20% of acute repairs require manipulation for flexion loss at 8 to 10 weeks postoperatively. Generally, manipulations have been quite effective in restoring flexion.

Neurovascular Injury

Careful preoperative evaluation is critical to document neurovascular status. If the vascular status is ever in question, liberal use of the arteriogram will evaluate and diagnose the spectrum of vascular damage, from intimal tear to complete arterial disruption. An open dialogue with a reliable and competent vascular surgeon will prevent potentially devastating complications caused by ischemia and can help the surgeon plan subsequent surgery for ligament reconstruction.

Residual Laxity

Addressing all pathology at the time of definitive repair/reconstruction will help minimize postoperative laxity. The argument that Grade III MCL tears will go on to heal as in the combined ACL-MCL injury does not apply to knee dislocations. Whenever possible, repair must be performed, especially when collateral ligament disruption is present. Unrecognized posterolateral corner injury is a common site of missed pathology and will lead to laxity in the reconstructed PCL if ignored.

Avoiding soft-tissue advancements and tenodesis and operating early to anatomically repair disrupted structures will help prevent residual laxity.

RESULTS

The authors recently reported their experience with multiple ligament reconstructions performed following obvious or occult knee dislocation and using the principles and techniques described in this review.[19] Since this report on 19 patients, 25 of 30 patients who underwent multiple knee ligament reconstruction using fresh frozen allografts have been completely evaluated. Average follow-up was 36 months (range 24 to 67 months). Fifteen patients had an acute reconstruction (less than 3 weeks) and 10 had a chronic reconstruction. The ACL was reconstructed in 22 and repaired in 3. The PCL was reconstructed in 23 and partially torn in 2. The LCL and or posterolateral corner was reconstructed in 6, repaired in 3, and partially torn in 2. The MCL was repaired in 7 and partially torn in 5.

No patient lost more than 3 degrees of extension and 5 patients lost more than 15 degrees of flexion. Mean flexion loss was 11.2 degrees (SD $\pm$ 7.9 degrees, range, 0 to 33 degrees). No patient had a Lachman test rated above a 1B. Seven patients had a posterior drawer test rated as Grade II and no patients rated as Grade III. The mean corrected anterior translation on KT-1000 testing was 0.1 mm (SD $\pm$ 2.3 mm; range -1 to 7 mm). Using the International Knee Documentation Committee (IKDC) rating for subjective assessment, there were 9 normal, 13 nearly normal, 4 abnormal, and 1 severely abnormal knees. The authors conclude that reconstruction of the multiple ligament injured knee provides satisfactory subjective functional assessment, range of motion and stability, but the ability of patients to return to high demand sports and heavy manual labor is less predictable.

SUMMARY

Knee dislocations are complex cases requiring careful initial management to prevent devastating consequences caused by limb ischemia from vascular injury. Initial treatment includes gentle reduction and neurovascular assessment including an arteriogram and vascular reconstruction when necessary. Evaluation by examination and MR imaging will help define all ligamentous and associated pathology. All combined instabilities are repaired or reconstructed at the time of surgery. Early intervention within 3 weeks is preferred, as acute reconstruction is technically easier and more predictable than chronic reconstruction. Allografts are particularly helpful in these complex and time consuming knee injuries. Postoperative rehabilitation consists of initial immobilization followed by a supervised rehabilitation program emphasizing range of motion and strengthening.

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