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Multiligament Knee Injuries and Their Treatment

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Multiligament knee injuries are rare but potentially devastating. They require expeditious and thorough evaluation and treatment for best outcomes. Management consists of a careful history and physical examination, including a complete assessment of the neurovascular status with ankle-brachial indexes \pm magnetic resonance angiography. Imaging should include plain radiographs, stress radiography as necessary, and possibly computed tomography scans if fracture is suspected. Magnetic resonance imaging is the modality of choice for evaluating the ligaments and soft tissues. Once evaluation is complete, the decision to proceed with surgery versus conservative management is made. We favor surgery in patients who are able to tolerate the procedure, are relatively high functioning, and are not obese. Surgery is performed at 10 to 14 days if repair is possible or it is delayed until at least 4 to 6 weeks from the time of injury if reconstructions are to be performed to minimize the risk of arthrofibrosis. We prefer allografts for our reconstructions rather than autografts to minimize morbidity and operative time. After surgery, patients may be anticoagulated with either aspirin or coumadin. With extensive, focused rehabilitation, patients can return to heavy labor and/or sports beginning at 9 to 12 months postoperatively. Oper Tech Sports Med 18:219-226 © 2010 Elsevier Inc. All rights reserved.

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Although multiligament knee injuries are uncommon, failure to diagnose and treat them appropriately can lead to devastating outcomes. Careful and thorough clinical evaluation is critical as is timely, appropriate treatment. The following is an overview of our approach to these injuries and their treatment.

Diagnosis

History

In our practice, patients are usually referred from other centers rather than seen in the emergency room. Regardless of the manner of presentation, however, a careful and complete history is mandatory. This includes an understanding of the mechanism of injury and the level of energy of the forces involved. A knee dislocation with subsequent reduction should always be considered a multiligament injured knee and should be evaluated as such. Comorbidities, especially a history of diabetes, peripheral neuropathy, or vascular insufficiency, should be elicited during the history. It is also im-

portant to gain a sense of the individual's overall well-being and activity level.

Physical Examination

Multiligament knee injuries are usually the result of high-energy forces; therefore, other injuries should first be ruled out. In the emergency room scenario, this often means a full trauma evaluation is performed under the auspices of the trauma surgery, orthopedic surgery, and emergency departments. During the secondary survey, the limb is inspected for gross deformity and alignment. A subluxated or frankly dislocated knee joint should be relocated promptly. It is important to also consider patellar dislocations in the setting of multiligamentous knee injuries. The skin should be examined for color and integrity. A thorough neurovascular examination is performed, including palpation of the popliteal, dorsalis pedis, and posterior tibial arteries as well as determining whether there are motor or sensory changes. Peroneal nerve injury is not uncommon, especially with lateral injury.¹ In the office setting, we do not routinely perform ankle-brachial indices (ABIs) because most of our patients are seen upon referral and typically have already had an angiogram or magnetic resonance angiography (MRA) performed. There is prospective literature to support the use of ABIs and serial examinations in the initial evaluation period.² However, it should be noted that a recent retrospective study reported

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false-negative rates for ABIs and angiograms of 67% and 40%, respectively.³ Early experience at our institution with MRA has shown that it correlates well with angiography and holds potential to be an important tool for diagnosing arterial lesions.^{1,4} We perform MRA routinely for patients with knee dislocation or bicruciate injury who have not had a vascular imaging study before referral to our facility.

Ligament examination should include testing anterior cruciate ligament (ACL) integrity with the Lachman, anterior drawer, and pivot shift tests although in the acutely injured patient the pivot shift and drawers tests are of limited utility because of restricted motion. It is important to note that in cases of multiligament rupture the tibiofemoral relationship is compromised, which can affect the ability of the examiner to accurately judge translation and rotation as well as varus/valgus stability if injuries exist on both sides of the joint. Furthermore, in the acutely injured knee, significant swelling and pain can limit range of motion, particularly knee flexion.

Posterior cruciate ligament (PCL) examination should include the posterior drawer test at 90° of knee flexion and 45° of hip flexion, the posterior sag test (at approximately 70° of flexion), and the quadriceps active test (though this is usually not possible in the acutely injured knee). In the normal knee, the medial tibial plateau is usually 1 cm anterior to the medial femoral condyle. We devised the following simplified clinical grading system to be used with the posterior drawer test: normal, no loss of tibial offset; grade A, slight loss of tibial offset; grade B, flush with femur; and grade C, the tibia can be translated posterior to the femur. We have found that grade C injuries, according to this system, are usually associated with injury to the posterolateral corner or medial side of the knee.⁵ Medial collateral ligament (MCL) and lateral collateral ligament (LCL) testing should be performed with valgus and varus stressing of the knee, respectively, at 0° and 30° knee flexion.

Posteromedial corner testing can be performed with the anteromedial drawer test. It is also important to examine the posterolateral corner using the external rotatory (dial) test at 30° and 90° with the patient in the prone position. We also rely on the posterolateral spin test to detect posterolateral corner injury. With the knee flexed at 30° or 90° and the patient supine, the step-off of the lateral tibial plateau from the lateral femoral condyle can be palpated with the examiner's thumb and compared with the contralateral side. The virtue of this test, compared with the dial test, is that it avoids error because of rotation of the tibia, ankle, or foot.⁶

Imaging

Imaging should first consist of obtaining a radiographic series of the knee (anteroposterior/lateral/oblique/merchant). Alignment of the knee is carefully examined, and the characteristic radiographic signs of soft-tissue injury are looked for (effusion, Segond fracture, an posterior sag). It is important to always document reduction of the joint because an unstable knee is prone to recurrent subluxation or frank dislocation. Weekly radiographs are indicated to confirm that the reduction is maintained if the patient is treated nonoperatively or before surgery. If the tibia shows interval displacement (usually pos-

teriorly) on radiographs, an external fixator may be applied or an open procedure may be necessary.

Stress testing is a useful adjunct to standard radiographs, both in the office and intraoperatively. Stress radiography may be performed at 30° of flexion for varus and valgus laxity testing. Greater than 5 to 6 mm of widening should prompt suspicion of ligamentous injury; >9 to 10 mm suggests complete rupture. It is important to always consider that both sides of the joint may be affected, and, therefore, widening may be present both medially and laterally. One of us (RFW) also performs TELOS stress radiography (Telos Stress Device; METAX, Kupplungs und Dichtungstechnik GmbH, Marburg, Germany) in the office as warranted. If fracture is suspected, a computed

Figure 1 (A) Coronal magnetic resonance image showing both medial and lateral collateral ligament injuries. (B) Sagittal magnetic resonance image showing bicruciate ligament rupture.

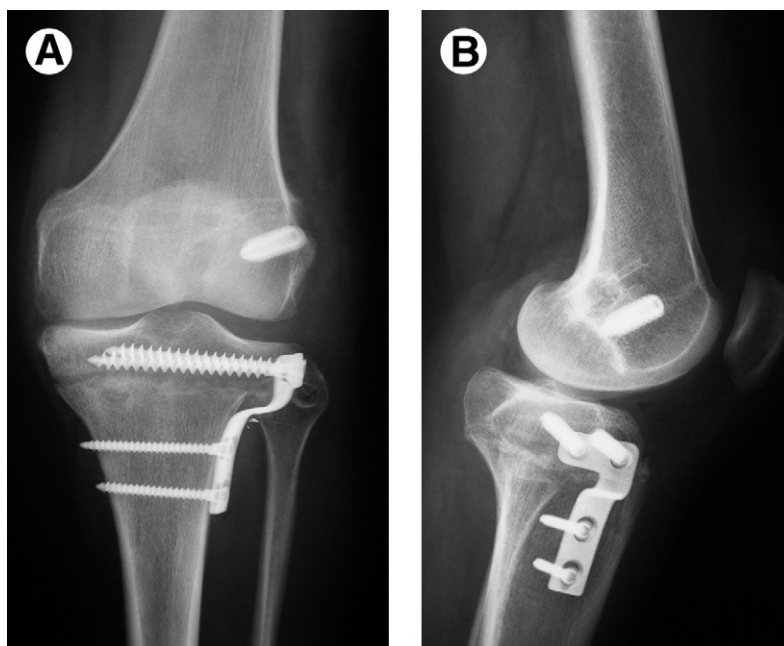


Figure 2 (A) Anteroposterior and (B) lateral radiographs showing closing-wedge high tibial osteotomy performed after failed ACL and posterolateral corner surgery.

tomography scan is recommended. For soft-tissue evaluation, however, MRI is our modality of choice (Fig. 1).

ABIs, angiograms, and MRA are usually performed before the patient has been referred to us. If not, we have the patient undergo MRA. Early data from our institution showed 100% agreement between conventional angiograms and MRA in patients who had both studies performed although numbers were limited.¹ We ensure that every patient we operate on has an imaging study performed preoperatively to document the status of the circulation of the injured extremity.

Patient Selection/Preoperative Planning

We favor surgical treatment for patients with multiple ligament-injured knees. However, not all patients are good candidates for multiligament knee surgery. Relative contraindications to surgery include morbid obesity and advanced age or extremely limited preinjury function. Patients with medical contraindications to surgery are treated conservatively with initial immobilization, bracing, and rehabilitation. For patients who present late with a grossly stable knee, we recommend treating with rehabilitation and subsequent reconstruction if necessary.

Acute Versus Chronic Considerations

Evaluation in the acute scenario should focus on diagnosing and treating injuries that threaten life and limb, such as fractures, neurovascular injuries, and open injuries. In cases in which surgery must be performed acutely (ie, open fractures/injuries with vascular compromise/irreducible dislocations),

other pathologies, such as meniscal or articular cartilage defects, can be definitively addressed at a later date.

For the patient who presents in the chronic scenario, evaluation should focus on a more thorough understanding of the overall status of the joint. Limb alignment, articular cartilage integrity, and the state of the menisci should be investigated. Long-leg radiographs should be obtained. Gait should be examined for evidence of dynamic thrust. Depending on the extent of the pathology, surgery may be staged. For cases of severe deformity, we now favor an opening-wedge biplanar high tibial osteotomy to address both the coronal (varus/valgus) and sagittal planes (tibial slope). If this is done, we prefer to perform the ligament reconstructions at a later time (Fig. 2).

Timing of Surgery

The optimal timing of surgery varies. One of us (RFW) will often perform surgery at approximately 10 days after injury to minimize scar formation and swelling^{7,8} and allow a more anatomic dissection. Thus, if indicated, soft-tissue repair with augmentation can be attempted, with reconstruction as an alternative if the tissue is not amenable to repair. Based on our own experience, and as reported by Shelbourne et al,⁹ soft-tissue avulsions off the fibula that are repaired early can lead to excellent long-term outcomes.

The other author (RGM) generally prefers waiting a minimum of 4 to 6 weeks before surgery to minimize the risk of arthrofibrosis. In most cases, he prefers reconstructions in view of data indicating lower rates of failure for reconstructions versus repairs.¹⁰⁻¹³ According to a recent report from the Mayo Clinic,¹¹ the rate of failure for reconstructions compared with repairs of the fibular collateral ligament/postero-

lateral corner was 6% versus 40%, respectively. This supports the results of an earlier prospective study by Stannard et al¹⁰ who noted a 37% failure rate of repairs versus 9% of reconstructions. A recent systematic review also reported significantly higher rates of knee flexion loss after acute surgery for multiligament knees (performed within 3 weeks of injury) compared with chronic or staged procedures.¹⁴

Ultimately, the timing of surgery will be determined by a number of factors, including the vascular status of the affected extremity, degree of swelling, soft-tissue lesions/condition of skin, and the degree of instability. The decision to attempt repair should be based on the integrity of the soft tissues, the nature of the soft-tissue injury, and the experience of the surgeon.

On occasion, patients are referred to our institution with an external fixator already applied and/or having had a vascular repair performed. For these patients, the external fixator is left on for approximately 5 to 6 weeks before it is removed and rehabilitation is begun. These patients may be stable after removal of the fixator, at which point further surgery is not necessary.

Surgical Techniques

Just before the procedure, a thorough ligament examination under anesthesia is performed, including the pivot shift/reverse pivot shift. We prefer to use a tourniquet during the open portion of the procedure as long as preoperative imaging has ruled out vascular injury.

We perform our ACL and PCL reconstructions arthroscopically and strive for an anatomic reconstruction of both the ACL and PCL footprints. For the ACL reconstruction, we use either a transtibial (RFW) or anteromedial portal approach (RFW and RGM)¹⁵ depending on whether the transtibial method can recreate the femoral footprint. For the PCL, we use a transtibial single-bundle approach that strives to reproduce the anterolateral bundle (ALB). Currently, there is yet no good evidence in the literature showing improved results with double-bundle or tibial inlay, both of which are more technically complex and may remove an excessive amount of bone stock. Tibial inlay is an option, however, in the revision setting.

Whether one first addresses the ACL or the PCL will depend on surgeon preference. One of the authors (RGM) recommends drilling the ACL femoral socket first endoscopically and then positioning the ACL guidewire on the tibia to provide a reference point for the tibial PCL tunnel. The other author (RFW) will often begin with the PCL and then address the ACL. For the PCL portion of the procedure, a posteromedial accessory portal is first established under visualization. With an arthrocare device, the posterior capsule is elevated off the tibia (up to 2.5 cm distally) to ensure the tunnel is low enough for anatomic reconstruction. Then, a combination of shaver and arthrocare devices are used to debride the tibial stump of the PCL via the posteromedial portal, taking care that the instruments are directed anteriorly at all times. For the PCL, we have been using the Acufex system (Smith and Nephew, Andover, MA). The Acufex director PCL Tibial Aimer is placed through the medial portal at a 60° to 65° angle, with a 15-mm offset. The guidewire should aim for



Figure 3 A lateral fluoroscopic image showing appropriate guidewire positioning for the ACL and PCL tibial tunnels.

the posterior half of the PCL facet. To protect the vital structures during guidewire placement and reaming, a curette can be placed directly over the guidewire. Fluoroscopy is used to confirm appropriate ACL and PCL pin positions (Fig. 3). Once the PCL pin is placed, we ream over the tibial PCL guidewire (usually 11 mm). We then ream the ACL tibial tunnel. For the femoral PCL tunnel, we attempt to recreate the anterolateral bundle of the PCL and prefer an outside-in minisubvastus approach. Either an inside-out or outside-in approach may be used as long as the femoral PCL tunnel is created at the center of the ALB, approximately 7 mm away from the articular margin. Once all the tunnels have been reamed, the ACL and PCL grafts are passed through the respective tunnels and fixed on the femoral side but not the tibial side. For the PCL graft, we use a switching stick in the posteromedial portal to act a pulley and facilitate graft passage. Because we typically use Achilles allograft, we prefer passing the grafts with the bone plugs in the femoral tunnels; metallic interference screws are then used to fix to the femur, and bioabsorbable screws are used in the tibial tunnels for the soft-tissue end. We prefer to fix the grafts in the following order: the PCL at 90° of flexion, followed by the ACL in full extension (RGM) or 30° knee flexion (RFW), the posterolateral corner, and lastly the medial collateral ligament.

For the posterolateral corner, a 12- to 18-cm incision is made beginning proximally over the lateral epicondyle and extending distally midway between the fibular head and Gerdy's tubercle, parallel to the posterior aspect of the iliotibial band. The interval lies between the iliotibial band and the biceps femoris. The peroneal nerve is identified and released, usually at the level of the proximal fibula to the peroneal muscles, and kept protected throughout the duration of the case. Epineurial hematoma can cause nerve palsy, and the peroneal nerve must be handled gently throughout. In the acute scenario, direct suture repair of the injured structures may be performed from deep to superficial. For reconstructions, we prefer to use an anatomic method

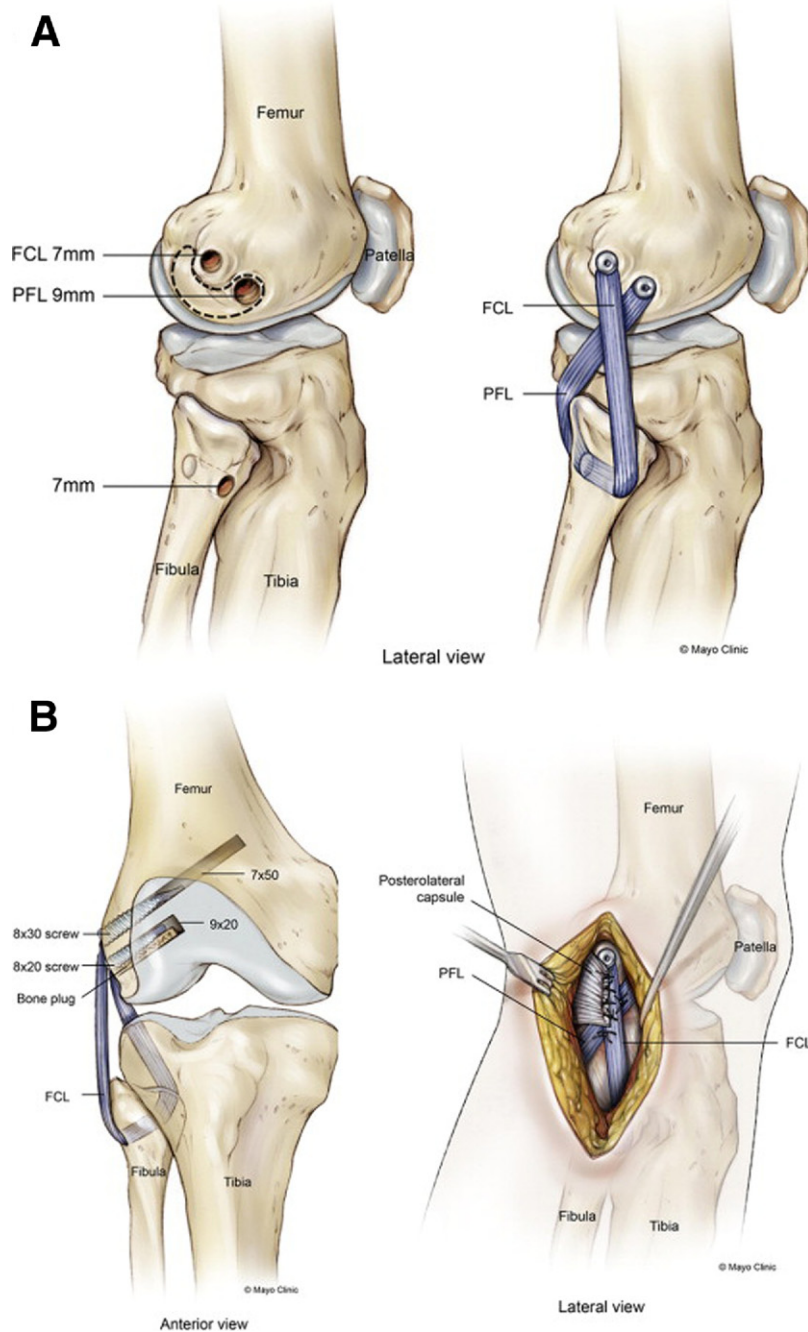


Figure 4 (A) An illustration showing posterolateral reconstruction with a single Achilles tendon allograft. (B) Tunnel placement and graft construct. A graft construct and posterolateral capsular shift. (Reprinted with permission Schechinger SJ et al.¹⁶)

and are employing a fibular-based technique.¹⁶ With this technique, a single Achilles tendon allograft is used to reconstruct the lateral collateral ligament, the popliteus tendon, and the popliteofibular ligament (Fig. 4). Tensioning is performed with the knee in approximately 30° flexion, 10° to 15° of internal rotation, and maximum valgus. This technique also uses a posterolateral capsular shift that is performed after graft fixation is completed.

For the MCL, if arthroscopy confirms 8 to 10 mm or more of valgus opening, we proceed with surgical intervention. Distal avulsions can be addressed by repair with suture anchors; how-

ever, if the ligament is diffusely injured, it must be reconstructed. For reconstructions, we make a small incision, approximately 4-cm long, over the medial epicondyle. Through this incision, subcutaneous dissection can be performed. A guide pin is placed just posterior to the medial epicondyle along its axis and parallel to the joint. The position is then verified with fluoroscopy. We test isometry by wrapping a suture around the pin and fixing the other end of the suture at the insertion point of the superficial MCL on the tibia (at the level of the pes anserinus, slightly posterior) (see Fig. 5). The knee is then taken through a range of motion. The graft has been placed isometri-

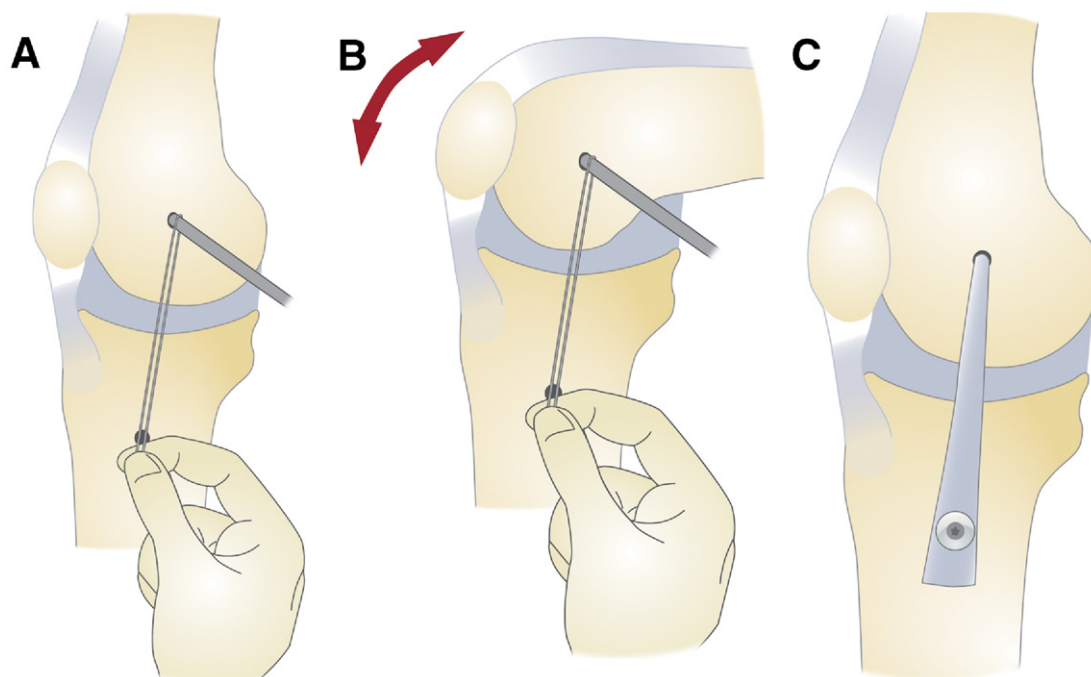


Figure 5 MCL reconstruction with Achilles allograft. (A) Suture wrapped around guide pin and held at the tibial insertion point of the MCL. (B) Suture excursion should be less than 1-2 mm with knee flexion and extension if placed at the isometric point. (C) Final construct, see text for details.

cally if the suture undergoes a maximum excursion of 1 to 2 mm during flexion and extension. Once isometry is confirmed, a 10-mm reamer is used to ream over the guide pin at a depth of approximately 20 mm. We typically use an Achilles allograft for the reconstruction, with the bone plug secured into the femoral tunnel using an interference screw after pretensioning. The tendinous portion of the graft is fixed to the isometric tibial insertion point with a low-profile screw and spiked soft-tissue washer. The graft is fixed at 20° flexion with a varus force. For proximal MCL ruptures without loss of tissue, one of us (RFW) recommends using autogenous semitendinosus tendon for augmentation. With its distal insertion left intact, the tendon is detached proximally and then wrapped about a pin placed at the level of the medial epicondyle. The free limb is then tensioned, and the knee is taken through a range of motion to test for isometry (Fig. 6). Once this is confirmed, the tendon is fixed at the isometric point on the femur with a cancellous screw (usually 6.5 mm, partially threaded, taking care to aim away from any bone tunnels) and ligament washer. Avulsed native MCL is also fixed to its origin with the screw and washer. The free end of the tendon is then fixed distally to the tibia with a staple, and the 2 limbs are approximated with an Orthocord suture (Depuy Orthopaedics, Inc, Warsaw, IN).

Graft Selection

Considering the multiple grafts needed for these types of surgeries, we prefer an allograft for our augmentations/reconstructions. This eliminates donor site morbidity from graft harvesting and decreases surgical time. We have had success with Achilles allografts and tend to use them exclusively. We

have no noted instances of disease transmission from allograft usage at our institution.

Concomitant Injuries

Meniscal lesions are treated either by repair or partial meniscectomy as indicated. In the patient who presents with chronic injuries, articular cartilage repair techniques and/or meniscal transplantation may be performed in staged procedures. In the acute and subacute setting, we do not believe that these injuries should affect timing.

Postoperative Treatment and Rehabilitation

Most patients are admitted for at least 1 night of observation and for pain control. They are monitored for compartment syndrome with serial examinations. All patients receive perioperative intravenous antibiotics, usually Ancef (SmithKline Beechan, Philadelphia, PA), for a 24-hour period. Anticoagulation is tailored according to the type of procedure performed, weight-bearing status, patient history, and comorbidities. We often place patients on aspirin or coumadin for 6 weeks until they are weight bearing. Rehabilitation is progressed slowly. After surgery, patients are made non-weight bearing, with the brace locked in extension during ambulation for 4 to 6 weeks, before they may be advanced. Motion is restricted until at least 4 weeks after surgery. The goal is to obtain approximately

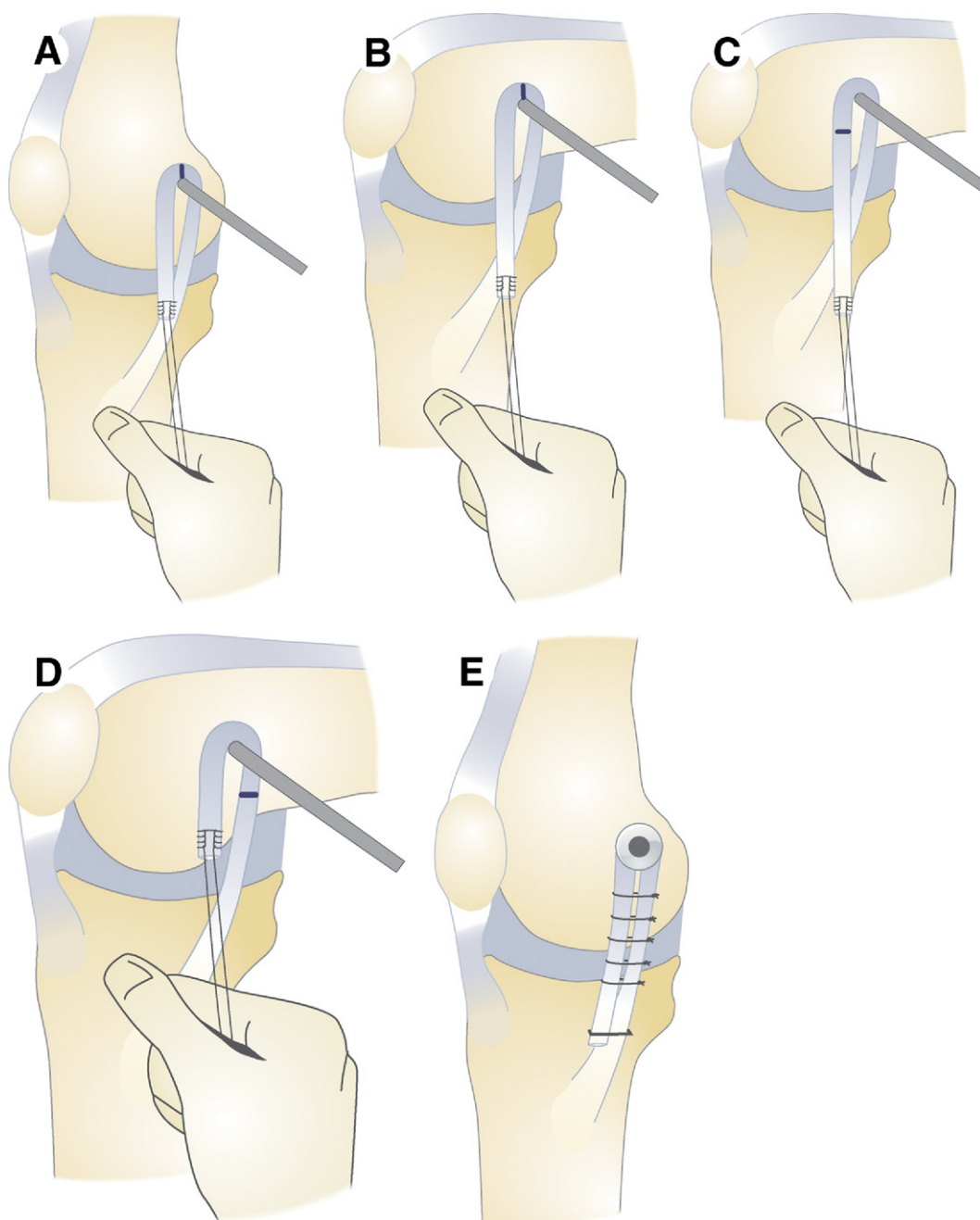


Figure 6 An illustration showing the pin technique for MCL augmentation with autogenous semitendinosus tendon. (A) The semitendinosus tendon detached proximally is looped about a guide pin placed at the medial epicondyle with the knee in extension. The looped tendon is labeled with a marking pen at the 12 o'clock position. (B) The pin has been placed at the isometric point if the tendon undergoes <1 to 2 mm of excursion in either direction with knee flexion. (C) If the tendon is observed to undergo more than 2 mm of excursion in the direction of the free limb with knee flexion (ie, loosens), the pin has been placed too distal and too posterior. (D) If the tendon is observed to undergo more than 2 mm of excursion in the direction of the fixed limb with knee flexion (ie, tightens), the pin has been placed too proximal and too anterior. (E) The final construct showing proximally detached semitendinosus tendon looped about the isometric point and fixed with a cancellous screw and ligament washer proximally. The free limb is fixed distally with a staple through both tendon limbs. The native, proximally avulsed MCL can also be fixed with the screw and washer.

90° of knee flexion by 8 weeks. We do not typically use continuous passive motion (CPM). Active knee flexion involving the hamstrings is restricted for 12 weeks in cases of PCL reconstruction.

Return to Sport/Heavy Labor

To test whether a patient is ready to return to running, we use the step-down test. With the patient on a platform (approx-

imately 8-inches high), they are instructed to step forward and down toward the ground, alternating between the affected and unaffected limbs. If they cannot perform this task without loss of balance or control, we do not recommend they commence running. This test is used to evaluate eccentric quadriceps strength, mechanics, and muscle control. Most patients are allowed to return to sports or heavy labor at 9 to 12 months postoperatively once range of motion, proprioception, and strength are sufficient.

What Have You Changed Over the Years?

One of us (RGM) now uses a commercially available tensioning boot to tension the ACL and PCL grafts during reconstruction.¹⁷ After the knee is cycled to allow for settling of the graft and pretensioning, it is placed in 90° of flexion (for the PCL graft) or 0° (for the ACL graft), and the boot is tensioned to 9 kg. With the graft under tension, fixation is performed with the implant of choice. Previous studies have shown good results with the tensioning boot,^{7,18-20} and we have found it provides for a convenient way to reproducibly tension our grafts and limit graft advancement during fixation, though manual tensioning is also acceptable.

The senior author (RFW) notes his transition to reconstructions or augmentations with repair for posterolateral corner injuries over the last several years. Although earlier treatment usually consisted of repairs alone, based on recent data, it seems clear now that repairs with augmentation or reconstructions provide more reproducible results.^{10,11} Along with an increased recognition of these lesions, this has led to significantly better outcomes for what were typically considered devastating injuries. However, in the senior author's experience, fibular avulsions can heal predictably and do not typically require a reconstruction.

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