Management of Chronic Combined ACL Medial Posteromedial Instability of the Knee

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Abstract: The medial collateral ligament is the most commonly injured ligament in the knee. High-grade medial collateral injuries are associated with injuries to the posteromedial structures of the knee. Chronic medial-sided instability is rare due to the intrinsic capacity of the medial ligamentous structures to heal. However, when combined with anterior cruciate ligament deficiency, significant anterior, valgus, and rotatory laxity of the knee occurs. In this review, we discuss the important biomechanical, clinical, and surgical considerations in the management of chronic combined anterior cruciate ligament, medial, and posteromedial instability of the knee.

Key Words: chronic injured knee, combined medial collateral ligament (MCL) injury, anterior cruciate ligament (ACL) injury, posteromedial instability, multiligament knee injury

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Combined anterior cruciate ligament (ACL), medial collateral ligament (MCL), and posteromedial corner (PMC) injuries have an estimated frequency of 6.7% of all knee ligament injuries.[1] These injuries can be associated with both high-energy and low-energy mechanisms. Medial-sided injuries typically heal with nonoperative treatment, therefore chronic instability is rare. Because knee motion is dynamic and multiaxial, the stabilizing structures must work together to provide stability during activity. Because of the complex interaction of these structures, significant controversies exist in the management of chronic combined ACL medial and posteromedial instability of the knee.

Although it is widely accepted that most acute combined ACL and low-grade medial-sided injuries should be treated nonoperatively first, the literature is unclear regarding treatment of these injuries in the chronic and high-grade setting. Hara et al[2] showed in their cohort study that patients with ACL insufficiency and chronic grade II valgus laxity treated with ACL reconstruction alone had no clinically significant difference in outcomes compared with patients undergoing ACL reconstruction for isolated ACL tears. Other authors recommend reconstruction of the medial structures to reduce stress transfer to the reconstructed ACL, which may lead to late graft failure.[3] In this review, we discuss the relevant anatomy, biomechanics, clinical findings, and management of combine ACL medial posteromedial instability of the knee.

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ANATOMY

Knowledge of the clinically relevant anatomy of the medial aspect of the knee is critical to optimize functional results with surgical treatment. The medial side of the knee is arranged into 3 layers: layer 1 consists of the sartorius and the sartorius fascia; layer 2 is defined by the parallel fibers of the superficial MCL, posterior oblique ligament (POL), and semimembranosus; and layer 3 consists of the deep MCL and the posteromedial aspect of the capsule. The gracilis and semitendinosis are located between layers 1 and 2, whereas the posterior aspect of layer 2 merges with layer 3 to form the PMC.

Laprade et al[4] performed a cadaveric study evaluating the anatomy of the medial aspect of the knee. They noted 3 osseous prominences on the medial aspect of the distal femur: the medial epicondyle, the adductor tubercle, and the gastrocnemius tubercle. The superficial MCL is the largest structure on the medial knee. The femoral attachment is an average of 3.2 mm proximal and 4.8 mm posterior to the medial epicondyle and has an average length of 10 to 12 cm. The majority of the tibial attachment is located proximally within the pes anserine bursa, with the posterior aspect blending more distally with the semimembranosus tendon, an average of 61.2 cm distal to the joint line. The deep MCL extends from the femoral condyle to the meniscus (meniscofemoral) and from the meniscus to the tibia (meniscotibial ligament).

POL is a thickening of the capsular ligament. Its origin lies approximately 8 mm distal and 6 mm posterior to the adductor tubercle (Laprade and colleagues); distally it fans out into 3 different arms: (1) the tibial arm inserts close to the posterior edge of the tibial articular surface; (2) superior (or capsular arm), which is continuous with the posterior capsule and is confluent with the oblique popliteal ligament; and (3) a poorly defined superficial (distal) arm that inserts onto the semimembranosus tendon and the tibia.[5]

BIOMECHANICS

Along with the other ligaments of the knee, the superficial MCL, deep MCL, and POL function together to provide valgus, anterioposterior (AP), and rotational stability to the knee. The superficial MCL is the primary valgus stabilizer of the knee at all flexion angles but especially at 25 degrees of knee flexion. Isolated sectioning of the superficial MCL leads to significantly increased opening to valgus stress at all flexion angles except in full extension.[6] The deep MCL is a secondary valgus stabilizer in all knee flexion angles.

AP translation is primarily controlled by the ACL and posterior cruciate ligament. When the ACL is deficient, the medial-sided ligaments contribute significantly to AP stability.[7] Loss of the superficial MCL leads to increased anterior translation at 90 degrees, whereas loss of the deep

MCL and POL leads to increased anterior translation in all knee flexion angles. Moreover, injury to the deep MCL disrupts the stability of the posterior horn of the medial meniscus and leads to the loss of its function as a secondary stabilizer to anterior translation. The superficial MCL is also an important static stabilizer of external rotation at 90 degrees, whereas the POL functions as an important internal rotation stabilizer, especially in full extension.

The biomechanical interaction between the ACL and medial posteromedial structures is critically important to consider and is a source of controversy. Studies have shown increased forces on an ACL reconstruction graft when MCL deficiency is present and eventual loosening of the healing MCL and ACL graft if an isolated ACL reconstruction is performed.[3,8] Other studies have shown no clinical difference with isolated ACL reconstruction and MCL deficiency in the short term.[2] Further biomechanical and clinical studies are necessary to help determine the best course of treatment.

CLINICAL FINDINGS

In the chronic setting of combined ACL medial posteromedial instability, patients complain of persistent knee instability and pain. They have typically failed 6 weeks of nonoperative treatment of an initial combined ACL-MCL injury. They may have had a second insult to the medial side, which they were not able to heal. Clinical decision making in this setting is determined by their physical examination, radiographic findings, symptoms, and long-term functional goals.

The most sensitive physical examination method to assess the integrity of the ACL is the Lachman test.[9] With the knee flexed 30 degrees, anterior translation of the tibia in relation to the femur is evaluated; grade I tear: < 5 mm; grade II: 5 to 10 mm; grade III: > 10 mm of anterior tibial translation. The anterior drawer test, evaluating anterior tibial translation with the knee flexed 90 degrees is also useful to evaluate the ACL, however, this is not as sensitive as the Lachman test. The pivot-shift phenomenon, when present, is indicative of an ACL-deficient knee. However, this is often difficult to perform in the office setting secondary to patient guarding.

To evaluate the medial structures, a valgus stress is applied to the knee at both 25 degrees of flexion and full extension. Medial joint opening < 5 mm with the knee in 25 degrees of flexion is characteristic of a grade I, isolated superficial MCL injury; medial joint opening between 5 and 10 mm is indicative of a grade II MCL tear, whereas opening > 10 mm is consistent with a grade III MCL rupture. Valgus stress is then applied in full extension. Isolated superficial MCL injury should not have any laxity to valgus stress in full extension. When laxity is present in full extension, any injury to the POL has occurred. Opening between 5 and 10 mm with the knee in full extension is characteristic of a combined ACL and medial-sided injury. Medial joint opening > 10 mm in full extension is consistent with a combined bicruciate ligament and medial-sided injury. In addition to cruciate injury, patellar instability and tearing of the vastus medialis obliquus are associated with laxity in full extension.

IMAGING

Plain radiographs are required to evaluate for the presence of fractures and to assess for tibiofemoral subluxation or dislocation. Initial views should include AP and lateral radiographs. In the chronic setting, presentation is more delayed and the patient can bear weight. A 45-degree posteroanterior flexion view should be obtained to allow for more accurate assessment of the tibiofemoral joint space[10] as well as a patellar axial view to evaluate the patellofemoral joint. A 3-joint standing radiograph (including hip, knee, and ankle) is necessary to evaluate the overall lower extremity alignment.

Magnetic resonance imaging is a sensitive tool for identifying soft-tissue structures in a patient whose physical examination is difficult to assess secondary to guarding. It provides detail for injuries of the menisci, cruciate ligaments, the superficial MCL, POL, posteromedial complex, and semimembranosus tendon. It is also useful for identifying osteochondral injuries and can be helpful in preoperative planning, to identifying the location of the MCL tear and therefore limit the exposure needed intraoperatively (Fig. 1).

NONOPERATIVE TREATMENT

Numerous factors, including the severity, location, time from injury, as well as associated injuries must be considered when formulating a treatment plan. There is no specific algorithm that can be generalized to the entire population; it needs to be individualized based on the

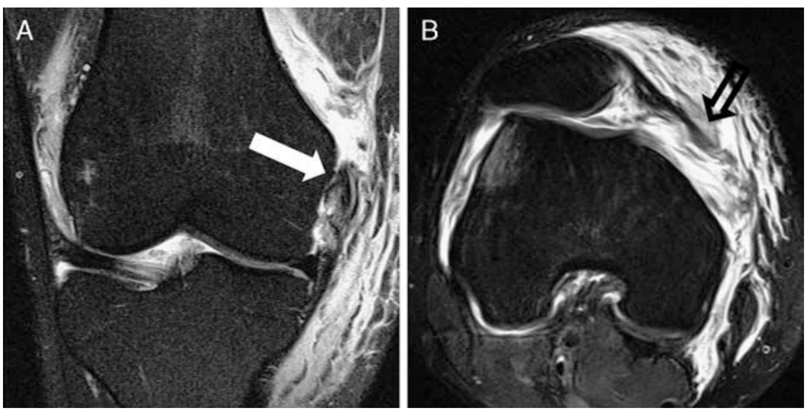

FIGURE 1. Magnetic resonance imaging coronal (A) and axial (B) views of right knee showing complete femoral-sided medial collateral ligament tear (white arrow) with associated medial patellofemoral ligament tear (black open arrow).

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patient's clinical examination, comorbid diseases (if present), occupation, and physical demands. Combined injury to the MCL and ACL represents a completely different entity than an isolated MCL injury. Even though the general consensus is that isolated acute MCL ruptures can be treated nonoperatively, the optimal treatment for a concurrent ACL and MCL injury remains controversial.

In the acute setting, nonoperative treatment of the combined medial-sided injury and an ACL tear is indicated for mid-substance MCL tears, grade I MCL tears, grade II femoral-sided MCL tears in patients who are not professional or competitive athletes, and grade III femoral-sided MCL tears in nonactive individuals. In these scenarios, management of active individuals consists of delayed surgical reconstruction of the ACL, typically 6 weeks postinjury, to allow the MCL to heal. Patients generally present with chronic combined ACL medial posteromedial instability after failed nonoperative treatment or delayed presentation, therefore nonoperative treatment in this setting is only reserved for patients who are low demand or have significant comorbidities that preclude them from having surgery.

OPERATIVE MANAGEMENT

The main surgical options include isolated ACL reconstruction or ACL reconstruction with reconstruction/repair of medial posteromedial ligaments of the knee (Table 1). The optimal surgical management for chronic combined ACL medial posteromedial instability of the knee is controversial. Although biomechanical studies have shown increased stress transferred to ACL grafts when the medial side laxity is not address surgically, this has not been seen clinically in short-term clinical studies. Multiple studies have found no difference clinically between nonoperative and operative treatment during ACL reconstruction of grade II MCL injuries.[11,12] Therefore, isolated ACL reconstruction can be considered for combined ACL and grade II medial instability.

In combined ACL and grade III medial-sided instability, some authors recommend reconstruction/repair of the medial ligaments along with ACL reconstruction. This is because of concerns for increased stress transfer from a high-grade medial-sided injury to an isolated ACL reconstruction graft, which may lead to late graft failure. When good tissue is still present, a femoral or tibial-sided MCL avulsion is best managed with a repair of the MCL to its anatomic origin (femoral) or insertion (tibial). This may be accomplished with a screw and washer. A distalization of the tibial MCL insertion can also be considered if good-quality MCL tissue is present and an avulsion-type injury is not present. MCL reconstruction is performed when there is poor native tissue quality and high-grade combined injuries.

Osteotomies are performed in the setting of chronic medial-sided laxity and valgus malalignment as seen on 3-joint standing x-rays.[13] Excessive valgus malalignment is defined as the weight-bearing line falling lateral to lateral tibial spine into the lateral compartment or >10 degrees of valgus malalignment of the mechanical axis. High tibial osteotomy or distal femoral osteotomies may be performed. Most surgeons avoid varus producing high tibial osteotomies due to concern for joint obliquity. Distal femoral varus osteotomies include lateral opening-wedge or medial closing-wedge osteotomies. We prefer a medial closing-wedge distal femoral osteotomy with a blade plate in patients with chronic medial-sided laxity and valgus malalignment (Fig. 2).

AUTHORS' PREFERRED TECHNIQUE

ACL Reconstruction

We perform an anatomic single-bundle ACL reconstruction. We routinely do not use a tourniquet for an ACL reconstruction. The anterolateral portal is used for visualization: for the diagnostic arthroscopy, meniscal repair/meniscectomy, and visualization of the tibial tunnel during the ACL reconstruction. An anteromedial portal serves as a working portal for meniscal/ACL surgery, as well as for visualization to confirm anatomic location of the femoral ACL tunnel, and drilling of this tunnel. In our experience this portal provides the optimal view of the medial aspect of the lateral femoral condyle. It is important to hyperflex the knee when drilling from the anteromedial portal to avoid damage to the medial femoral condyle. Graft choice is surgeon dependent; in the setting of an isolated ACL reconstruction, our graft preference is to harvest either hamstring, patellar or quadriceps tendon autografts in young patients. However, we do not harvest hamstring autografts in patients with grade II or III MCL injuries due to concern for worsening valgus laxity in these patients. If we plan on simultaneously reconstructing the MCL, allograft tissue is preferred for the MCL reconstruction, as described below. In older patients with less physical demands or individuals who participate in activities that involve less cutting and pivoting maneuvers, we prefer to use allograft tissue for the ACL reconstruction, with the same technique described above.

MCL/PMC Reconstruction

We treat acute complete femoral and tibial-sided avulsions with a screw and washer or anchor fixation. For subacute, symptomatic grade II MCL laxity and isolated

TABLE 1. Summary of Surgical Indications for Medial-sided Injuries of the Knee

Operation	Surgical Indication
Acute repair	Presence of intra-articular ligamentous entrapment
	Bony avulsion
	Associated tibial plateau fracture
	Magnetic resonance imaging finding of complete tibial or femoral-sided avulsion in high-level athletes
Delayed repair	Combined with anterior cruciate ligament reconstruction if the examination under anesthesia shows valgus laxity in full extension with a subacute medial collateral ligament injury
Augmentation	Added to any repair with poor tissue quality
Reconstruction	Symptomatic chronic valgus laxity
Femoral osteotomy	Chronic valgus laxity with valgus lower leg alignment

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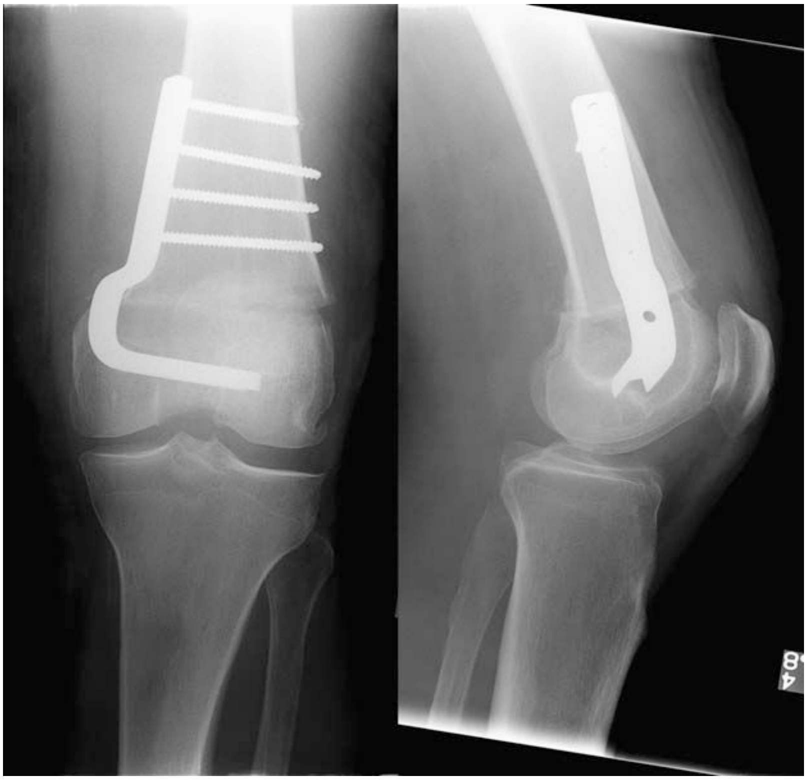

FIGURE 2. Anteroposterior and lateral x-rays of left knee medial closing-wedge distal femoral osteotomy with blade plate for chronic medial-sided laxity and valgus malalignment.

deep MCL involvement, a POL repair/reconstruction is performed using a pants-over-vest technique with nonabsorbable suture. The imbrication is tightened at 30 degrees of knee flexion, but full extension is assured in the operating room before closing the wound. Loss of extension is not uncommon after an imbrication of the POL.

For chronic, more severe MCL injuries or mid-substance tears, we prefer to reconstruct the MCL with a double-bundle technique, using the medial epicondyle as the femoral origin for both bundles, and separate anterior and posterior tunnels as insertion sites on the tibia. We proceed with an imbrication of the POL, as needed. We prefer to use a tibialis anterior or semitendinosis allograft. The allograft is prepared by doubling it over and whip-stitching 3 cm of the looped-over graft, followed by whip-stitching 2 cm of each of the 2 free ends of the tendon in a running baseball fashion. Our reconstruction technique is similar to that described by Borden et al.[14] We palpate the medial epicondyle and make a 2 to 3 cm longitudinal incision centered over it and carry the dissection down, exposing the origin of the superficial MCL on the femur. A 2 mm Kirschner-wire (K-wire) is drilled into the center of the femoral origin from medial to lateral, out the lateral cortex of the femur. Next, we identify the 2 insertion points for the tibial tunnels. Using the same incision that we used to drill the ACL tibial tunnel, dissection is carried down to the sartorius fascia. This is split along the superior border of the gracilis tendon, to expose layer II of the MCL and the attachment of its anterior fibers on the tibia. A path is made using blunt dissection with either a clamp or a finger from the femoral incision, along layer II of the MCL, so that it can be seen exiting out the tibial wound, along the same direction as the MCL fibers.

To ensure isometry of the reconstruction, a suture is looped over the K-wire in the femoral condyle and then passed in the direction of the MCL along the tunneled path made via blunt dissection. Isometry is evaluated by holding the suture at the MCL anterior tibial insertion site and moving the knee through a full range of motion (ROM). The isometric point on the tibia is the location where there is little or no change in length of the suture. At this point, a 2-mm K-wire is then passed from medial to lateral, to the lateral cortex of the tibia. To identify the isometric point for the posterior tibial tunnel, the hamstring tendon are retracted posteromedially and a suture is placed 2 to 2.5 cm posterior to the previously placed K-wire and the knee is taken through a full ROM. The isometric point is identified in a similar manner as the anterior tibial isometric point. A K-wire is drilled from medial to lateral in this location. Next, we proceed with drilling of the tunnels. The femoral tunnel is drilled over the K-wire, with the reamer the same diameter as that of the looped allograft. The tibial tunnels are then drilled, again the same diameter reamer as that of the nonlooped free ends of the graft. If there is a size discrepancy between the 2 free ends, we prefer to use the wider bundle for the anterior tunnel.

Using a beath pin, the looped tendon is passed into the femoral tunnel. The graft is fixed with a bioabsorbable interference screw (usually 25 mm in length). The remainder of the graft is passed through the previously created plane over layer II down to the tibial insertions. The posterior bundle is fixed with a biotenodesis screw, with the knee in 60 degrees of flexion and a gentle internal rotation force.[14] The anterior bundle is then passed in a similar manner and fixed with a biotenodesis screw with the knee in 30 degrees

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of flexion and the leg internally rotated. We use these type of screws so that we do not have to pull the beath pin out of the anterior lateral tibial cortex and risk injury to the deep peroneal nerve, and the anterior tibial artery and vein (Fig. 3). The knee is taken through a full ROM, ensuring adequate tension of both the anterior and posterior bundles. The POL is inspected. If there is any laxity upon palpation, or if laxity persists after a valgus stress is applied to the knee, we proceed with an imbrication of the POL in a pants-over-vest fashion. The wounds are then closed in layered fashion.

When a combined ACL-MCL is performed, we perform our diagnostic arthroscopy, and drill the ACL femoral and tibial tunnels before drilling the MCL tunnels. We place a tunnel dilator through the tibial tunnel to minimize convergence of the MCL tibial tunnels with the ACL tibial tunnel. If this begins to occur, the dilator will limit further drilling of the MCL tunnel and it can be redirected as needed. In those patients who had an ACL reconstruction after nonoperative management of the MCL and mild valgus laxity is present at the time of the ACL reconstruction, Jari and Shelbourne[1] have reported treating the MCL via multiple sharp longitudinal perforations to stimulate further healing. The authors concluded that this technique can tighten the MCL without compromising knee ROM; however, we have no experience with this technique.

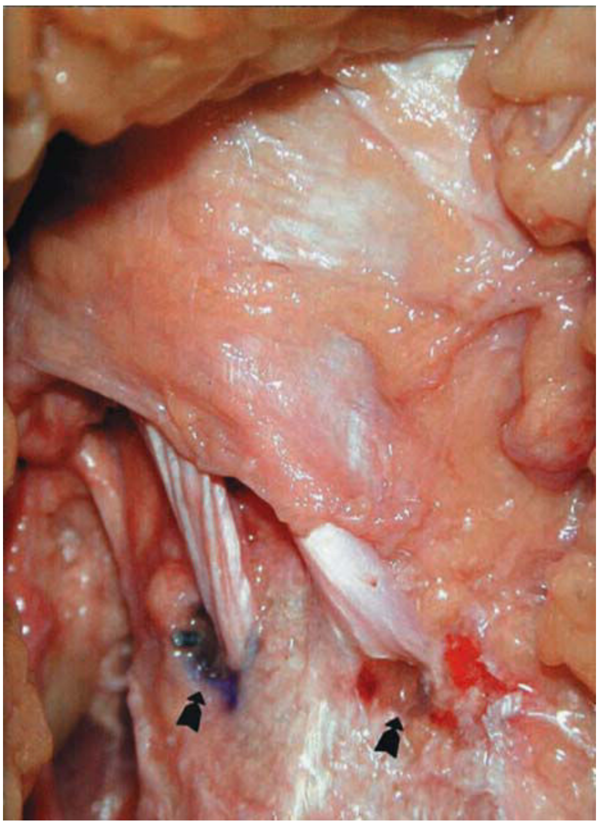

FIGURE 3. Left knee showing anterior (red in online version) and posterior (blue in online version) bundles of double-bundle medial collateral ligament reconstruction secured with absorbable interference screws (arrows). Reprinted with permission from Borden et al.[14]

POSTOPERATIVE MANAGEMENT

Postoperative rehabilitation consists of placing the knee in a hinged knee brace locked in full extension for a maximum of 3 weeks, after which time the brace is unlocked to allow for progressive ROM exercises. Gentle active flexion can be initiated at 2 weeks. The authors' preference is to allow the patient to partial weight bear for 3 weeks with crutches and a brace locked in full extension. Then, weight-bearing is progressed to full by 6 weeks. Crutches are discontinued after the patient is able to bear full weight and closed kinetic-chain strengthening is initiated. Once the patient regains full motor strength, and proprioceptive skills, they are permitted to return to sports and/or strenuous labor, typically after 9 months postoperatively.

CLINICAL STUDIES

Despite the advances in treatment of multiligamentous knee injuries, few clinical studies on chronic combined ACL medial posteromedial instability studies have been published. Zaffagnini et al[12] published their prospective study with minimum of 3-year follow-up comparing isolated ACL reconstruction patients who had no MCL injury versus those with chronic grade II laxity. Although chronic grade II MCL injured patients had significantly greater opening to valgus stress (0.8 mm difference), they found no significant difference in clinical outcome. More recently, Zhang et al[15] published their series of 21 patients who underwent ACL-MCL reconstruction for chronic ACL and grade III MCL injuries. At an average of 3.4-year follow-up, the mean medial side opening was 0.8 mm, KT-1000 side to side difference was 0.8 mm for anterior translation, International Knee Documentation Committee was significantly improved from 45 to 87, and 95% patients had normal or near-normal knee ROM. They concluded that combined reconstruction of ACL and MCL can significantly improve stability and clinical outcomes in the short term for chronic combined ACL-MCL injuries.

To our knowledge, no prospective studies have directly compared MCL repair versus reconstruction in the setting of an ACL tear. Stannard et al[16] retrospectively reviewed their outcomes in 73 dislocated knees with posteromedial injuries. Twenty-five patients had a repair of the PMC; 5 (20%) failed requiring revision. Autograft reconstructions were performed on 27 knees, with 1 (3.7%) failure. Allograft reconstructions were performed on 21 knees, with only 1 (4.8%) failure. There was a significant difference between the failure rate of PMC repairs and reconstructions ($P = 0.042$). The authors concluded that PMC repair is inferior to reconstruction in patients who sustain knee dislocations. Studies have also noted differences in ROM after ACL reconstruction combined with MCL repair, based on location of the MCL tear. Robins et al[17] retrospectively analyzed their results in 20 patients, 13 who had MCL tears at or proximal to the joint line and 7 with tears distal to the joint line. They noted a statistically significant faster return of motion (flexion and extension) in patients with MCL lesions distal to the joint line. The authors also demonstrated 8 degrees more flexion (statistically significant) and 3 degrees more extension (did not reach statistical significance). Furthermore, there was a trend toward more subsequent procedures (extension casting, manipulations, surgical releases) in the cohort with proximal MCL disruptions (8 procedures in 5 patients), versus no additional procedures in the group with distal disruptions, $P = 0.053$.

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CONCLUSIONS

The management of combined chronic ACL medial posteromedial instability is determined by careful history, clinical examination, and radiographic studies. Medial and posteromedial laxity may transfer significant stress to isolated ACL reconstruction grafts and lead to possible late graft failure. Therefore, although lower grade medial side injuries may be treated with isolated ACL reconstruction, chronic grade III injuries may require simultaneous ACL-MCL reconstruction. Further long-term clinical studies are necessary to determine the optimal management.

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