Posteromedial Corner Knee Injuries: Diagnosis, Management, and Outcomes

A Critical Analysis Review

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Abstract

» The posteromedial corner of the knee comprises the superficial medial collateral ligament (MCL), deep MCL, posterior oblique ligament, oblique popliteal ligament, and posterior horn of the medial meniscus. The main medial knee structure is the superficial MCL.

» Injuries to the medial knee are the most common knee ligament injuries. A comprehensive history and physical examination are key to the diagnosis of a posteromedial corner injury. Patients often present with swelling and pain over the medial joint line after an injury involving a valgus and external rotation force. The valgus stress and anteromedial drawer tests can aid the clinician in deciphering whether an isolated medial structure was injured or if a complete posteromedial corner injury is likely.

» Valgus stress radiographs can be utilized to quantify the amount of medial joint gapping. A side-to-side difference in gapping of 3.2 mm is consistent with an isolated superficial MCL tear, and a side-to-side difference of ≥9.8 mm is consistent with a complete posteromedial corner injury. Magnetic resonance imaging is also a useful tool in the detection of medial-sided injuries and has been reported to have an 87% accuracy.

» Although a large number of medial knee injuries can be treated nonoperatively, complete posteromedial corner injuries may require surgical treatment to restore joint stability and biomechanics. There is heterogeneity between techniques with regard to the type of graft, the tibial and femoral tunnel position, and the tensioning protocol. Anatomic techniques have been reported to better restore knee kinematics and function.

Medial-sided knee injuries are among the most common knee ligament injuries encountered by orthopaedic surgeons. These injuries often occur when a valgus stress is applied to the knee along with tibial external rotation. These ligament injuries can occur in isolation or with concomitant meniscal or cruciate ligament injuries, which require prompt identification and evaluation to improve long-term prognosis of the knee[1,2]. Grade-III medial-sided injuries, as defined by LaPrade et al.[3], have been reported to have a concomitant cruciate ligament injury in as many as 78% of cases (47 of 60 patients)[2].

Recently, there has been increasing interest in the posteromedial corner of the knee that has led to better understanding of

the anatomy and its role in knee kinematics. The posteromedial corner of the knee includes 5 major components: the superficial medial collateral ligament (MCL), the deep MCL, the posterior oblique ligament, the oblique popliteal ligament, and the posterior horn of the medial meniscus. Historically, the nomenclature of the medial knee structures has been inconsistent, leading to confusion and controversy[4-6]. In an attempt to standardize the nomenclature and to accurately guide anatomic reconstructions, LaPrade et al.[3,7,8] reported on the quantitative anatomy of the medial structures of the knee and identified each of the structures in relation to reliable anatomic landmarks[9,10].

Assessment of medial knee injuries can be challenging; therefore, in addition to a detailed physical examination, imaging studies are recommended to assist in the diagnosis. The grade of the medial knee injury is based on the number of structures that are torn, and treatment options depend on the location of the tear and presence of concurrent ligament injury. The majority of medial injuries will usually heal without operative intervention[2,11]. However, a subset of patients with grade-III medial knee injuries will develop persistent pain and continued functional rotatory or valgus instability after nonoperative treatment. Identifying patients at risk for poor outcomes following conservative management is important but challenging because of inconsistent reports. There is still controversy in the literature on the treatment of combined posteromedial corner injuries with concomitant cruciate ligament injuries. Some authors have advocated for nonoperative treatment of all medial-sided injuries[2]; however, because of the increased risk of developing persistent anteromedial rotatory instability, leading to increased force on the reconstructed cruciate ligaments, most authors advocate for concurrent operative treatment of medial structures in a knee with injury to multiple ligaments[1,12,13].

This article provides a critical analysis of the current, relevant literature

on the diagnosis and management of posteromedial corner knee injuries and assesses current posteromedial corner reconstruction techniques and outcomes. Current reconstruction techniques for the superficial MCL and posterior oblique ligament have been described in the literature and therefore will be the focus in the anatomic and biomechanical sections.

Quantitative Anatomy of the Posteromedial Corner

The anatomy of the posteromedial corner of the knee is complex, which can render injuries to any combination of structures challenging to treat surgically. The posteromedial corner of the knee comprises the superficial MCL, the deep MCL, the posterior oblique ligament, the oblique popliteal ligament, and the posterior horn of the medial meniscus (Fig. 1). To properly treat an injury to any combination of the structures in the posteromedial corner, it is necessary to understand not only anatomic relationships, but also the biomechanical roles of each structure both individually and as a unit.

The main medial structure is the superficial MCL, which averages 10 to 12 cm in length. The femoral superficial MCL attachment is 3.2 mm proximal and 4.8 mm posterior to the medial epicondyle. The superficial MCL has 2 tibial attachments: the proximal tibial attachment, which is a soft-tissue attachment 1 cm distal to the joint line on the anterior arm of the semimembranosus tendon, and the distal attachment on the tibia, which is located 6 cm distal to the joint line. The deep MCL is a thickening of the medial joint capsule, which is firmly adherent to, but separable from, the superficial MCL. The deep MCL femoral attachment site is approximately 1 cm distal to that of the superficial MCL and courses distally to attach to the medial part of the meniscus, which includes the meniscofemoral and meniscotibial divisions. On the tibia, the deep MCL attaches approximately 3 to 4 mm distal to the joint line[14].

The posterior oblique ligament has 3 fascial attachments at the distal aspect of the semimembranosus tendon[8]. The main arm of the posterior oblique ligament is the central arm, which arises from the main semimembranosus tendon and reinforces the deep MCL and then continues to attach to and blend with the posteromedial joint capsule and medial meniscal junction[8]. The femoral attachment of the central arm of the posterior oblique ligament is located 7.7 mm distal and 2.9 mm anterior to the gastrocnemius tubercle.

The semimembranosus tendon has multiple tibial attachments that provide dynamic stabilization to the posteromedial corner[15,16]. The anterior arm of the semimembranosus attaches to the tibia deep to the proximal attachment of the superficial MCL, and the direct arm attaches posteromedial to the medial tibial crest[8] (Fig. 1).

Diagnosis of Posteromedial Corner Injuries

Biomechanics of the Posteromedial Corner

There is an intricate interplay between the posteromedial structures, and an important load-sharing distribution between the superficial MCL and the posterior oblique ligament has been reported that depends on the knee flexion angle[17]. The proximal superficial MCL is the primary knee valgus stabilizer across all knee flexion angles[8,10,18,19]. The proximal superficial MCL acts as a secondary stabilizer to external and internal rotation depending on the knee flexion angle[9,20]. The distal superficial MCL acts as a primary stabilizer for both external and internal rotation. The posterior oblique ligament and the posteromedial capsule provide primary valgus restraint in extension, and the superficial MCL plays a more dominant role in flexion because of relaxation of the posterior oblique ligament in flexion[9]. Moreover, biomechanical studies have demonstrated the role of the posterior oblique ligament as a primary stabilizer for internal rotation and a secondary stabilizer for valgus
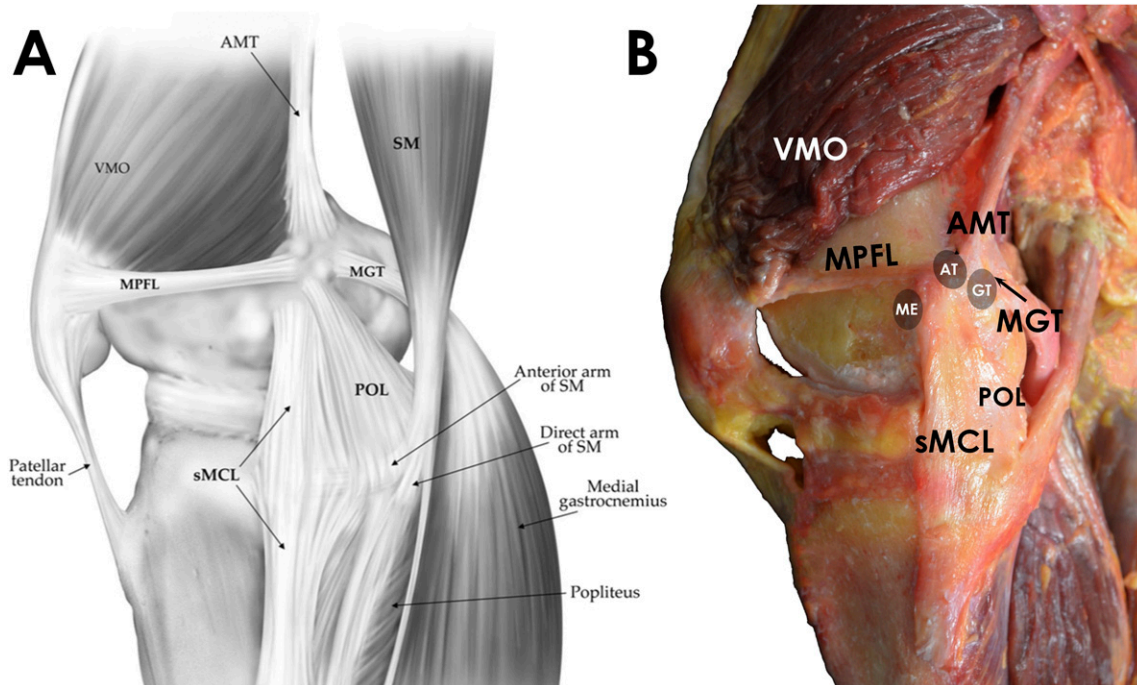
Fig. 1

Figs. 1-A and 1-B The posteromedial corner. AMT = adductor magnus tendon, VMO = vastus medialis obliquus muscle, SM = semimembranosus muscle, MPFL = medial patellofemoral ligament, MGT = medial gastrocnemius tendon, POL = posterior oblique ligament, sMCL = superficial medial collateral ligament, ME = medial epicondyle, AT = adductor tubercle, and GT = gastrocnemius tendon. **Fig. 1-A** Illustration. (Reproduced from: LaPrade RF, Engebretsen AH, Ly TV, Johansen S, Wentorf FA, Engebretsen L. The anatomy of the medial part of the knee. J Bone Joint Surg Am. 2007 Sep;89[9]:2000-10.) **Fig. 1-B** Cadaveric specimen showing soft-tissue attachments of the posteromedial side of the knee.

and external rotation[7,21]. Valgus instability, which is observed in the setting of medial-sided tears, increases the forces on both the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL), increasing the risk of graft failure if the posteromedial corner is not concurrently repaired or reconstructed[19,22].

Patients with a posteromedial corner injury often have pain, valgus instability, and anteromedial rotatory instability. A detailed history and physical examination are important initial steps in the diagnosis and will help to guide further workup of suspected posteromedial injuries.

Physical Examination

A comprehensive examination should be carried out at different knee flexion angles to evaluate the different posteromedial structures. Patients with posteromedial corner injuries have increased laxity with application of a valgus stress.

The degree of valgus gapping is related to the severity of the injury. For isolated superficial MCL tears, the maximum amount of valgus gapping should be observed with the knee in 20° to 30° of flexion. If valgus gapping is observed with the lower limb in full extension, a concurrent injury to the meniscofemoral deep MCL attachment, the posterior oblique ligament, or both structures should be suspected. Furthermore, physical examination findings suggestive of valgus gapping in extension should raise the suspicion for a concomitant ACL injury[21,23].

The anteromedial drawer test is performed with the knee in 80° to 90° of flexion and the foot externally rotated 10° to 15°. The examiner then exerts an anterior and external rotatory force on the foot and the tibia and assesses the amount of anteromedial tibial rotation. The examiner visually assesses the location of tibial rotation to differentiate between anteromedial and

posterolateral tibial rotation with an increase of tibial external rotation via an increased excursion of the tibial tubercle. Additionally, the dial test should be performed at both 30° and 90° of knee flexion[19,21]. A positive dial test, defined by increased anteromedial tibial translation observed as increased excursion of the tibial tubercle from the neutral position when a rotational force is applied to the tibia while the femur is fixed, may be indicative of a medial knee injury[21]. Patients with injuries to the posterolateral corner structures also may present with increased tibial external rotation; hence, pathologic external rotation is not pathognomonic for posteromedial corner injuries. In posteromedial corner injuries, the anteromedial aspect of the tibia subluxates anteriorly on the femur, and in the posterolateral corner injuries, the posterolateral aspect of the tibia subluxates posteriorly on the femur. Biomechanical studies have demonstrated the important role of the
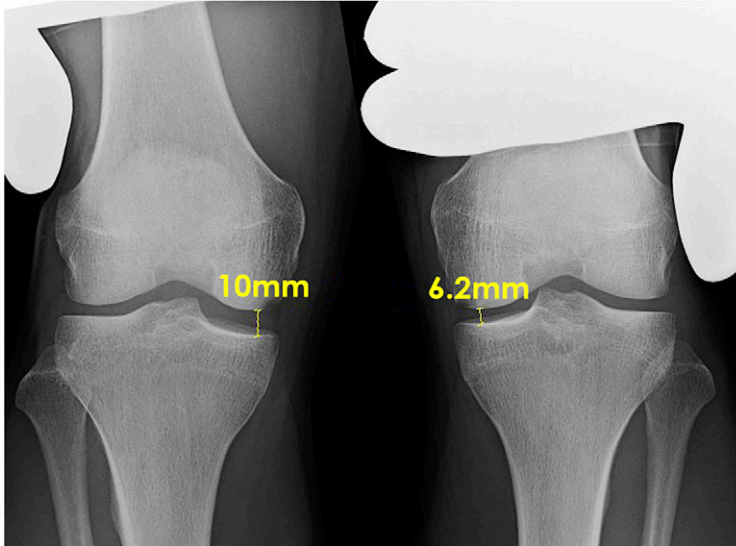
Fig. 2

Valgus stress radiographs of the right and left knees in a patient with a left-sided posteromedial corner injury. A comparison of medial compartment gapping reveals a side-to-side difference of 3.8 mm, indicative of a complete superficial MCL injury.

posterior oblique ligament in controlling internal rotation near full extension. On physical examination, an increased valgus gapping in extension and an increased internal rotation near full extension can be observed in posterior oblique ligament injuries. Complete posterolateral corner injuries will result in increased varus gapping and increased external rotation of the tibia. A 10° to 15° side-to-side difference in rotation is considered pathologic.

Imaging

The 2 primary imaging modalities used for diagnosing posteromedial corner injuries are valgus stress radiographs and magnetic resonance imaging (MRI). Radiographs should be obtained for suspected medial knee injuries; however, these images are often normal following acute injuries. Chronic medial knee injuries may present with heterotopic ossification of the femoral insertion of the MCL, referred to as the

Pellegrini-Stieda calcification[20]. Valgus stress radiographs made with the knee in 20° of flexion are more helpful in making an objective diagnosis. A 3.2-mm side-to-side difference in medial gapping is consistent with a complete superficial MCL injury[24]. Furthermore, biomechanical studies have demonstrated that a complete posteromedial corner injury can result in a side-to-side difference of ≥9.8 mm of medial gapping[24] (Fig. 2). Long-leg, weight-
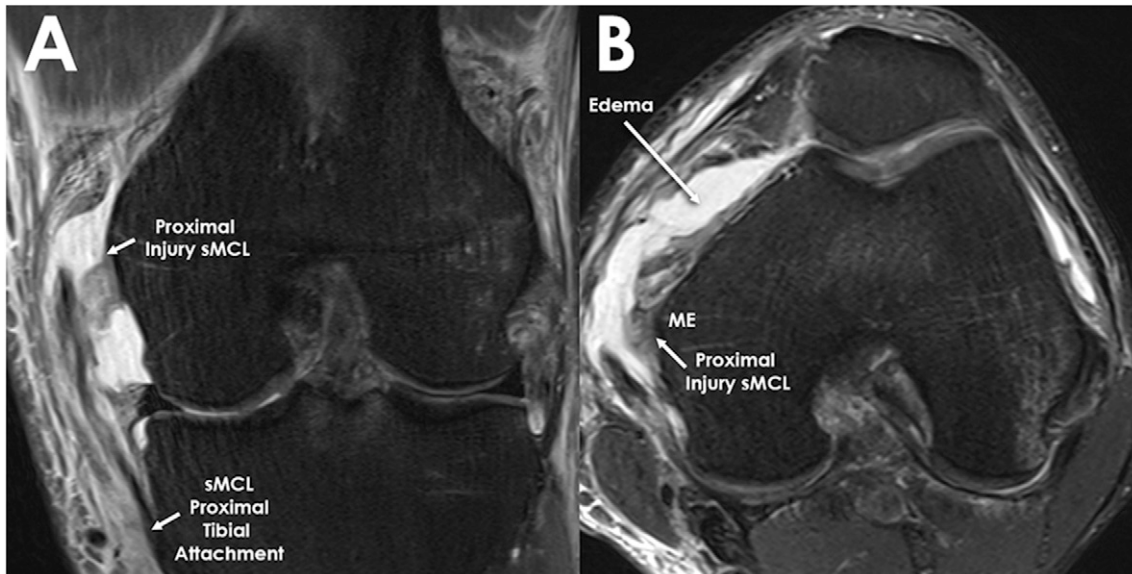

Fig. 3

Coronal cut of an MRI (T2 sequence) demonstrating a proximal tear of the superficial MCL (sMCL) (**Fig. 3-A**) and a tear of the meniscofemoral ligament portion of the deep MCL (**Fig. 3-B**). Of note, osseous edema can be seen on the lateral compartment. ME = medial epicondyle.

bearing, anteroposterior radiographs are important in chronic MCL injuries to assess for valgus alignment.

MRI can also be utilized to identify injured posteromedial corner structures and to identify concomitant injuries. Coronal MRI sequences (Fig. 3) are particularly useful in imaging the medial knee structures and have been reported to have an accuracy of 87%[23]. Also, lateral compartment bone bruises have been described as a secondary sign of medial-sided knee injuries. Lateral compartment bone bruises have been reported to be present in 45% of isolated medial knee injuries[25].

Ultrasound can also be used to visualize the MCL[26,27] and has been reported to be effective in evaluating MCL injuries in 1 small series[28]; however, it has not been demonstrated to be superior to stress radiographs or MRI evaluation of isolated MCL and posteromedial corner injuries.

Classification
The clinical injury classification relies on the amount of medial compartment gapping present with an applied valgus stress during the physical examination. The American Medical Association (AMA) grading scale is frequently utilized to classify the severity of injuries[29]. A grade-I tear presents with localized pain along the medial knee structures and 0 to 5 mm of medial compartment gapping compared with the contralateral, uninjured knee. An isolated grade-II medial knee injury also presents with localized pain along the medial knee structures and demonstrates substantial gapping with a present end point. Finally, a grade-III, or complete, medial knee injury is present when there is no defined end point. Of note, the gap sizes corresponding with grade-I injuries have been reported to be 0 to 5 mm, those for grade-II injuries have been reported to be 6 to 10 mm, and those for grade-III injuries have been reported to be >10 mm compared with the uninjured contralateral knee. However, because of the subjective nature of this test, the accuracy is less than optimal and

depends largely on the experience of the examiner.

A second, more objective, radiographic classification is based on bilateral valgus stress radiographs, made at 20° of knee flexion. As stated before, a 3.2-mm increase in medial gapping compared with the contralateral lower limb is consistent with a complete superficial MCL injury, and a 9.8-mm increase in medial gapping compared with the contralateral lower limb is consistent with combined posteromedial corner injury[24].

Treatment of Grade-III Medial Knee Injuries
Nonoperative Management
Grade-I and II superficial MCL injuries are usually treated nonoperatively. However, the treatment of grade-III injuries is largely dependent on the presence or absence of concomitant ligament tears[19]. Isolated, acute grade-III posteromedial corner injuries are typically managed with nonoperative treatment with bracing for 5 to 7 weeks and physical rehabilitation programs that focus on restoring quadriceps function, enhancing knee range of motion, and controlling edema[30]. Although several different knee rehabilitation protocols have been proposed to treat isolated, acute medial knee injuries, satisfactory outcomes have been reported regardless of protocol disparity[10]. There is no consensus in the current literature on whether a hinged knee brace is necessary to treat grade-III medial knee injuries. Our protocol utilizes a brace during the early phases of rehabilitation and then either continues to use the brace through the ongoing competitive season or discontinues use 8 to 12 weeks after the injury. Injury pattern has been shown to affect outcomes following nonoperative treatment. Proximal MCL injuries have superior outcomes when compared with distal injuries[31]. The poor healing of distal superficial MCL injuries may be due to the poor vascularity in the distal superficial MCL tibial attachment and the tendency of the pes tendons to be

interposed between the attachment and the superficial MCL tissue.

Operative Management
High-grade injuries of the posteromedial corner, specifically injuries with valgus gapping in extension or grade-III meniscotibial MCL tears, have a higher risk of not healing, with a resultant residual valgus and rotational instability[18,32]. Persistent instability increases the load on the cruciate ligament grafts, increasing the risk of reconstruction graft failure. Therefore, in a setting of a multiligament knee injury involving the posteromedial corner, early concurrent augmentation (if the posterior oblique ligament can be repaired) is recommended to facilitate early mobilization and rehabilitation[33]. Allograft tendons can be utilized for the reconstruction in chronic medial-sided injuries involving the posterior oblique ligament in which the posterior oblique ligament cannot be repaired primarily. Allograft tissue is also utilized in patients who have deficient hamstrings because of a previous surgical procedure.

Patients with chronic posteromedial knee injuries who report rotatory and valgus instability would likely require a full posteromedial reconstruction (superficial MCL and posterior oblique ligament). These patients with chronic injury should be evaluated for frontal plane knee alignment, because those with a valgus alignment may require a first-stage osteotomy or a superficial MCL or posteromedial corner reconstruction with a concurrent distal femoral osteotomy. If alignment is not corrected prior to or concurrently with a ligament surgical procedure, the posteromedial corner reconstruction graft has a higher risk of failure.

Anatomic Superficial MCL Augmentation Technique
An anteromedial hockey-stick incision is performed and blunt dissection is carried out over the sartorius fascia. The semitendinosus and gracilis tendons are isolated and an open-ended hamstring tendon stripper is used to detach the

tendons proximally. Care is taken to preserve their distal insertion. The posteromedial aspect of the tibia is identified at this point and 2 double-loaded suture anchors are placed at the distal tibial insertion of the superficial MCL, 6 cm distal to the joint line. The first anchor is placed at the posterior insertion and then is used as a reference for the second anchor, which is placed slightly anterior and proximal. The semitendinosus and gracilis tendons are now sutured to the tibia, along with the remnant superficial MCL, to reconstitute the distal superficial MCL tibial attachment. Once the hamstring grafts are secured distally, proximally, the adductor tubercle is identified using the adductor magnus tendon as a reference. The superficial MCL proximal attachment is 12 mm distal and 8 mm anterior to the adductor tubercle[8]. A sharp dissection is performed on the superficial MCL proximal attachment to define it, and an eyelet pin is placed through its center with an aiming guide. A 35-mm-deep tunnel is reamed using a 7-mm acorn reamer. Both tendon grafts are then passed through deep to the sartorial fascia along the native course of the superficial MCL. A guide-pin is then placed in the femoral reconstruction tunnel and the graft is measured from this point such that 30 mm of graft is whipstitched for later passage into the tunnel. The excess graft length is removed. A passing suture is then pulled through the tunnel to pull the graft into the reconstruction tunnel. The knee is positioned at 20° of flexion in neutral rotation, a gentle varus force for reduction is applied, and the grafts are fixed with a 7 × 23-mm bioabsorbable screw. A spinal needle is used to define the joint line, the last double-loaded suture anchor is inserted 12 mm distal to the joint line, and the sutures are tied to the grafts with the knee positioned at 20° of knee flexion and in neutral rotation to reconstitute the superficial MCL proximal tibial attachment (Fig. 4-A).

In patients with multiligament injuries, the sequence of graft fixation is dependent on the involved ligaments.
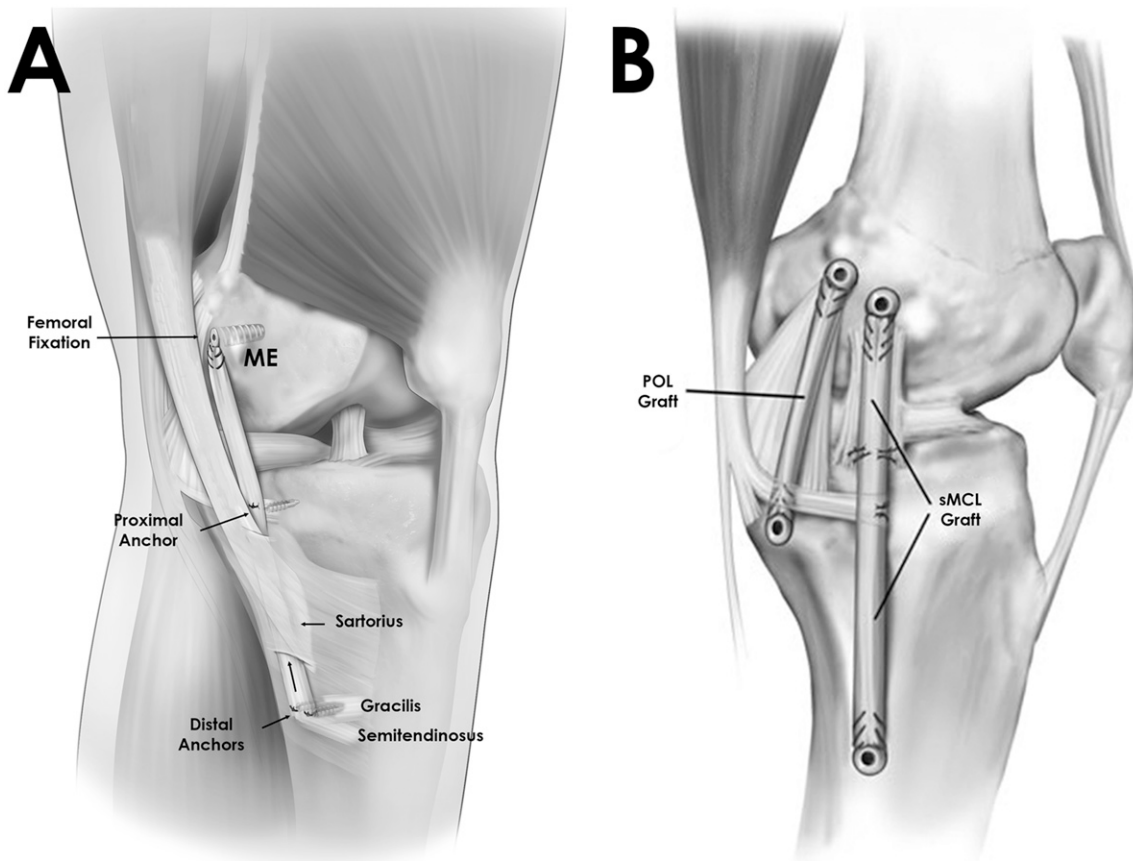
Fig. 4

Figs. 4-A and 4-B Schematic representations of a left knee. **Fig. 4-A** Superficial MCL augmentation technique. ME = medial epicondyle. (Reproduced, with permission, from: Wijdicks CA, Michalski MP, Rasmussen MT, Goldsmith MT, Kennedy NI, Lind M, Engebretsen L, LaPrade RF. Superficial medial collateral ligament anatomic augmented repair versus anatomic reconstruction: an in vitro biomechanical analysis. Am J Sports Med. 2013 Dec;41[12]:2858-66. Epub 2013 Sep 13.) **Fig. 4-B** Full posteromedial corner reconstruction. sMCL = superficial MCL and POL = posterior oblique ligament. (Reproduced, with permission, from: Wijdicks CA, Ewart DT, Nuckley DJ, Johansen S, Engebretsen L, LaPrade RF. Structural properties of the primary medial knee ligaments. Am J Sports Med. 2010 Aug;38[8]:1638-46.)

The senior author performs multiligament reconstructions in the following order: PCL, posterolateral corner, ACL, and, lastly, MCL or posteromedial corner. Concomitant, early anatomic reconstruction of all torn ligaments has been reported to better restore knee joint kinematics while allowing for early rehabilitation[3,14,33-38]. Furthermore, isolated cruciate ligament reconstruction in knees with collateral ligament deficiency has been shown to change joint kinematics[39] and increase graft forces on the ACL and PCL[40,41]. Thus, single-stage reconstruction is advocated in the setting of multiligament injuries.

Anatomic Posteromedial Corner Reconstruction

LaPrade et al. outlined an anatomically based posteromedial corner reconstruction technique that includes reconstruction of the proximal and distal divisions of the superficial MCL and the posterior oblique ligament using 2 separate semitendinosus grafts[3]. For this technique, a 7 × 25-mm closed socket tunnel is reamed at the distal superficial MCL attachment, 6 cm distal to the joint line. When there is a concurrent PCL reconstruction, tunnel convergence can be avoided by aiming the superficial MCL tunnel 30° distally[42,43]. A 7 × 25-mm closed-socket tibial posterior oblique ligament reconstruction tunnel is reamed, aiming toward the Gerdy tubercle[10]. However, when there is a concurrent PCL tunnel, the posterior oblique ligament tunnel should be aimed 15 mm medial to the Gerdy tubercle to avoid tunnel convergence[42].

The distal attachment of the adductor magnus tendon is a reliable landmark for identification of the adductor tubercle and constitutes the "lighthouse" (a critical structure within an anatomical area that gives a surgeon perspective during initial soft-tissue dissection) to the medial side of the knee[44]. The medial epicondyle is located 12.6 mm distal and 8.3 mm anterior to the adductor tubercle. An eyelet passing pin is drilled through the superficial MCL femoral attachment aiming anteriorly and proximally. Prior to reaming the superficial MCL tunnel, an eyelet pin is drilled at the femoral posterior oblique ligament attachment (7.7 mm distal and 2.9 mm anterior to the gastrocnemius tubercle) and parallel to the superficial MCL femoral eyelet pin, ensuring enough bone bridge between the tunnels. A 7-mm reamer used to ream both the superficial MCL and posterior oblique ligament reconstruction tunnels to a depth of 25 mm. When
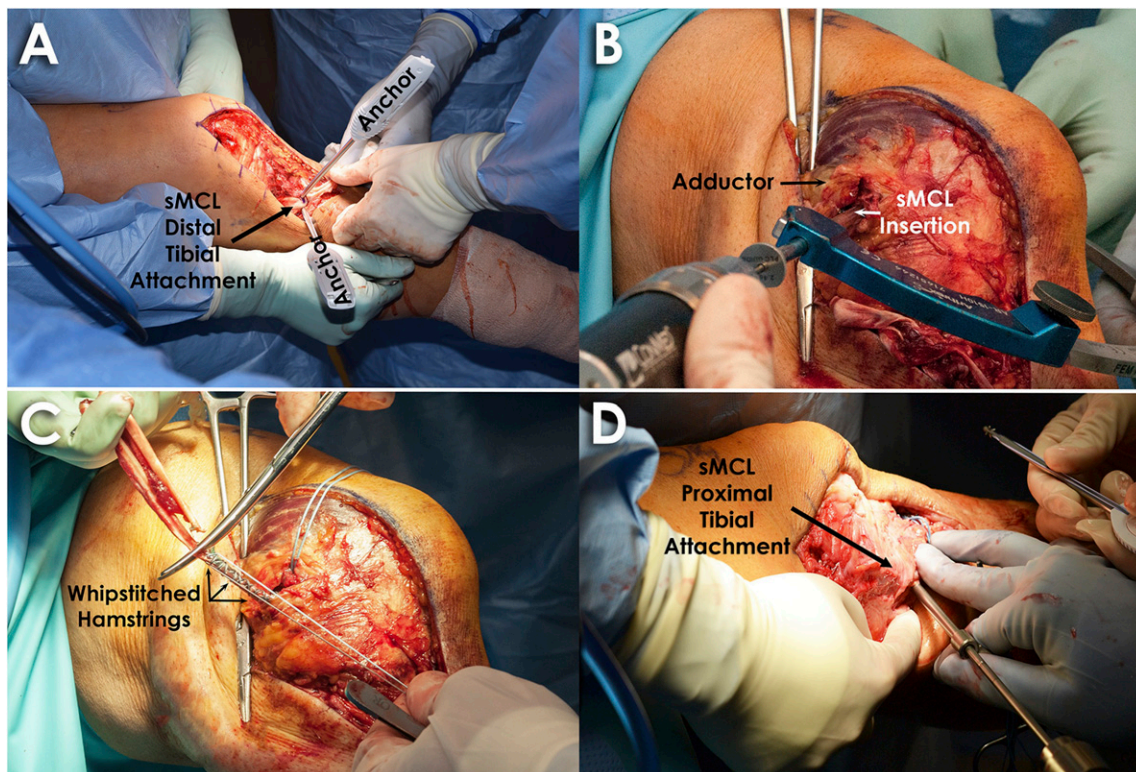

Fig. 5

Figs. 5-A through 5-D Intraoperative photographs of an anatomic posteromedial corner reconstruction. **Fig. 5-A** Two suture anchors are used to secure the distal superficial MCL (sMCL) to its anatomic tibial attachment. **Fig. 5-B** A guide is then used to drill the femoral sMCL insertion tunnel. A surgical tool is placed deep in the adductor tendon to allow the surgeon to identify the sMCL femoral footprint. **Fig. 5-C** The whipstitched hamstring graft is brought into the surgical field and is measured to ensure that there is sufficient length. **Fig. 5-D** The sMCL graft is fixed with the tibia in neutral rotation at 20° of flexion and a slight varus reduction force to ensure that no medial compartment gapping occurs.

the PCL is reconstructed concurrently, the superficial MCL should be aimed 40° proximally and 40° anteriorly and the posterior oblique ligament should be aimed 20° proximally and 20° anteriorly to avoid convergence with PCL tunnels[43].

The posterior oblique ligament graft is tightened first in full extension, followed by the superficial MCL graft, which is fixed with the tibia in neutral rotation, at 20° of flexion and with a slight varus reduction force to ensure that no medial compartment gapping occurs. A suture anchor is placed at the proximal tibial attachment of the superficial MCL, 12.2 mm distal to the medial joint line, and the graft is secured[14,38] (Figs. 4-B and 5-A through 5-D).

Nonanatomic Posteromedial Corner Reconstruction

Several nonanatomic reconstructions for posteromedial corner injuries have been described in recent years[45-48]. All of these involved reconstruction of both the superficial MCL and posterior oblique ligament. Detailed information regarding graft type, fixation technique, and tensioning characteristics can be found in Table I.

Postoperative Management

Early protected range of motion and aggressive rehabilitation to decrease postoperative stiffness should be performed[10,49]. The specific rehabilitation protocol is dependent on concomitant ligament injuries and resulting reconstructions performed along with the posteromedial corner reconstruction. Most commonly, patients who undergo complete posteromedial corner reconstruction will remain partially or non-weight-bearing with crutches and passive range of motion up to 90° of knee motion beginning on postoperative day 1[19,48,50,51], until 6 weeks after the surgical procedure. Most authors recommend a hinged knee brace for the first 6 weeks after the surgical procedure, regardless of weight-bearing status or range-of-motion protocols[10,48,52,53]. Patients typically return to sports and full activity in 6 to 9 months for an isolated posteromedial injury, assuming appropriate progression with respect to strength and completion of functional sport testing[19,51,54].

Clinical Outcomes

LaPrade and Wijdicks[10] reported on 28 patients who underwent anatomic posteromedial corner reconstruction of the MCL and posterior oblique ligament with concurrent cruciate or bicruciate ligament reconstruction. Patients had clinical improvement in mean subjective International Knee Documentation Committee (IKDC) scores from 44 to 76 points postoperatively and all 28 patients had resolution of side-to-side instability at 2-year follow-up. Radiographically, improvements were reported in valgus stress radiographs from 6.3-mm to 1.3-mm side-to-side difference. All patients had <3-mm joint space widening on the valgus stress radiographs[10].

Outcomes following nonanatomic reconstruction of the posteromedial corner have also been described. Kim et al.[55] described a concomitant reconstruction

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TABLE I Current Literature on Surgical Techniques for the Treatment of Posteromedial Corner Injuries

Reference	Graft Type		Fixation Technique		Reason for Nonanatomic	Tensioning Technique
	Autograft	Allograft	Femur	Tibia		
Anatomic						
LaPrade[10] (2012)	2 semitendinosus*	2 semitendinosus*	Interference screw	Interference screw, suture anchor	NA†	Superficial MCL: 20° flexion, neutral rotation, varus stress manual tension; posterior oblique ligament: full extension, manual tension
Nonanatomic						
Dong[45] (2014)		Hamstring tendon and tibialis anterior	Interference screw	Suture	Single femoral tunnel, nonanatomic tibial tunnels	Superficial MCL and posterior oblique ligament: 30° flexion, neutral rotation, varus stress; manual tension
Weimann[46] (2012)	2 semitendinosus		Cortical button	Interference screw	Single femoral tunnel, medial epicondyle femoral attachment	Superficial MCL: full extension; posterior oblique ligament: 45° flexion; manual tension
Preiss[47] (2012)	2 semitendinosus		Interference screw	Interference screw	Single femoral tunnel	Superficial MCL: 30° flexion; posterior oblique ligament: full extension; manual tension
Lind[54] (2009)	Semitendinosus		Interference screw	Interference screw	Pes attachment, single femoral tunnel	Superficial MCL: 10° flexion, neutral rotation; posterior oblique ligament: 60° flexion, neutral rotation; manual tension

*2 semitendinosus autografts or allografts. †NA = not applicable.

TABLE II	Current Literature on Clinical Outcomes After Surgical Treatment of Posteromedial Corner Injuries*					
	Reference					
	LaPrade[9] (2012)	Koga[51] (2012)	Kim[55] (2008)	Lind[54] (2009)	Stannard[52] (2012)	Tardy[50] (2017)
Level of Evidence	IV	IV	IV	IV	IV	IV
No. of patients	28	18	24	50	48	19
Age† *(yr)*	32.4	24	36.3	34	36	36.3
Duration of follow-up† *(mo)*	18	26	52.6	40	43	75
Type of injury			NR			
Acute	8	10		0	27	19
Chronic	20	8		50	21	0
IKDC score† *(points)*		NR	NR	NR		
Preop.	43.5‡				NR	NR
Postop.	76.2‡				37.4 to 42.6	81
Lysholm score† *(points)*	Not reported			NR		
Preop.		81	NR		NR	NR
Postop.		91	91.9		87	89
Valgus stress† *(mm)*				NR	NR	NR
Preop.	6.2‡	6.0‡	7.8‡			
Postop.	1.3‡	1.0‡	1.1‡			

*NR = not reported. †The values are given as the mean. ‡There was a significant difference between scores (p < 0.05).

of the MCL and posterior oblique ligament utilizing semitendinosus autograft with a preserved tibial attachment in 24 patients. Preoperatively, the mean medial joint opening was 7.8 mm on valgus stress radiographs and subsequently <2-mm medial joint space opening in 22 (92%) of 24 patients at the time of follow-up. Lind et al.[54] reported 91% satisfaction in retrospective evaluation of 50 patients who underwent reconstruction of the MCL and posteromedial corner using ipsilateral semitendinosus autograft. Medial stability according to the IKDC score was normal or nearly normal (grade

TABLE III	Recommendations for Care	
Treatment Option	Recommendation	Grade*
Superficial MCL acute repair	In cases of osseous avulsions, immediate repair has been reported to yield good results.	B
Superficial MCL augmentation	Although both augmentation and reconstruction procedures have been reported to produce excellent outcomes with low failure rates, no definitive conclusion has been made on whether to use an augmentation or reconstruction technique.	A
Posteromedial corner reconstruction	High-grade injuries of the posteromedial corner, specifically injuries with valgus gapping in extension or grade-III meniscotibial MCL tears, have a higher risk of not healing, with a resultant residual valgus and rotational instability, and thus should be considered for posteromedial corner reconstruction. Furthermore, patients with chronic posteromedial knee injuries who report rotatory and valgus instability would likely require a full posteromedial reconstruction.	A

*Grade A indicates good evidence (Level-I studies with consistent findings) for or against recommending intervention. Grade B indicates fair evidence (Level-II or III studies with consistent findings) for or against recommending intervention. Grade C indicates conflicting or poor-quality evidence (Level-IV or V studies) not allowing a recommendation for or against intervention. Grade I indicates that there is insufficient evidence to make a recommendation.

A or B) in 98%. Improved outcomes are also reported after surgical treatment of the posteromedial corner in the setting of multiligament injuries[50,52]. However, an early single-stage surgical procedure rather than a delayed surgical procedure yields better clinical outcomes[50]. In addition, reconstruction of the posteromedial corner using either autograft or allograft in patients with a knee dislocation yields superior stability to that of repair[52]. Details of each study included are reported in Table II.

Posteromedial corner reconstructions are not without complications. The most commonly reported complications include deep implant removal, pain, wound infection, joint stiffness, and arthrofibrosis[50,52,55]. Stannard and Bauer reported the prevalence of arthrofibrosis to be 20% in the repair group and 17% in the reconstruction group. Furthermore, posteromedial corner repair was associated with higher failure rates (20%)[52]. Reintervention rates after a posteromedial corner surgical procedure are reported to be as high as 26%[50]. Recommendations for care are displayed in Table III.

Conclusions

Isolated grade-I or II MCL injuries and isolated grade-III superficial MCL tears may be treated nonoperatively. However, in grade-III superficial MCL injuries with concomitant ligament lesions or in the presence of rotational instability (complete posteromedial corner injury), surgical reconstruction is often recommended. Stress radiographs and MRI are valuable in determining the extent of the injury and aiding in the treatment choice. Early protected range of motion and an aggressive postoperative rehabilitation to decrease the prevalence of arthrofibrosis should be performed when possible. Future clinical randomized studies investigating the effects of the different reconstructions and rehabilitation protocols are recommended to define clearer treatment algorithms.

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