# Treatment of MCL Injury in Combined ACL/MCL Injury

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Daniel Whelan, Majid Chowdhry, Michael Hantes, Norimasa Nakamura, and Yasukazu Yonetani

## 34.1 Introduction

Combined injuries of the anterior cruciate ligament (ACL) and medial collateral ligament (MCL) are the most common multi-ligament injuries of the knee [1]. A concomitant injury is present in 78 % of grade III MCL injuries [2], with the ACL being involved in 95 % of cases [2].

The extra-synovial location of the MCL, with its abundant vascular supply, provides it with a much higher healing capacity [3–6]. In most instances, nonoperative management of isolated MCL injuries is sufficient, including injuries in high-performance athletes [7]. However, this does not appear to be the case for combined injuries [8], where chronic anteroposterior, valgus, and rotatory instability can develop [9]. If certain MCL injuries are not addressed at the time of ACL reconstruction, increased stresses on the graft can lead to higher rates of failure [8, 10–13]. The increased laxity of concomitant ACL tears can lead to certain MCL tears healing with lower biomechanical strength [14].

In particular, the treatment of an associated grade III MCL tear is the subject of much debate [6, 12, 15, 16]. In-depth evaluations of injury patterns, biomechanics, and anatomical repair techniques have shown a wider spectrum of medial and posteromedial corner structures that impart valgus and rotational stability to the knee [17–21]. This realization has challenged the traditional conservative management strategies of combined injuries, justifying a more aggressive surgical approach in certain situations [5, 15, 18, 22].

Proponents exist for isolated MCL repair or reconstruction [12, 16, 23] versus more complex MCL and posterior oblique ligament (POL) reconstructions (anatomic and nonanatomic) [18, 24–26]. Many questions still remain about the timing of surgery, as well as the best methods for fixation and graft tensioning [5, 27–30]. These factors remain important areas for basic science and clinical investigation.

D. Whelan (✉) • M. Chowdhry
Department of Orthopaedic Surgery, St Michael's Hospital, Toronto, ON, Canada
e-mail: whrland@smh.ca; db_whelan@hotmail.com; m.chowdhry@doctors.org.uk

M. Hantes
Department of Orthopedic Surgery, University of Thessalia, University Hospital of Larissa, Larissa, Greece
e-mail: hantesmi@otenet.gr

N. Nakamura
Institute for Medical Science in Sports, Osaka Health Science University, Osaka, Japan
e-mail: Norimasa.nakamura@ohsu.ac.jp

Y. Yonetani
Department of Orthopaedic Surgery, Hoshigaoka Medical Center, Hirakata, Japan
e-mail: yonechan-osk@umin.ac.jp


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## 34.2 History and Physical Examination

The common factor of combined injuries is likely to be a combination of valgus, external rotation, and hyperextension [31–33]. Patients either present with pain and swelling (<3 weeks) or instability (>3 weeks). To compensate for medial instability, the patient may walk with a vaulting gait and, if swollen, with a slightly flexed knee [34, 35]. Point tenderness at the level of the proximal tibia could represent an underlying "Stener-like" lesion-guiding management toward primary repair [36]. Proximal tears are more likely to go on to heal themselves. Mid-substance tears can be mistaken for meniscal tears. Lateral meniscal tears, osteochondral fractures of the lateral femoral condyle, or lateral tibial plateau can occur in contrecoup injuries.

The American Medical Association's grading scale is most commonly used to classify the severity of MCL tears (see Table 34.1) [37]. Valgus stress testing applied at 30° of flexion remains the gold standard for assessing isolated MCL tears [38]. To improve the accuracy of clinical gapping [39], LaPrade et al. have quantified damage to individual medial structures to joint space widening seen on stress radiographs (see Table 34.2) [40].

In combined injuries, valgus stress testing at 0° of flexion is more informative [41]. Excessive laxity on valgus stress will indicate injuries to the MCL and secondary stabilizers of the knee [42]. With the anterior drawer, MCL and ACL tears together may result in greater anteroposterior (AP) translation [8, 10]. The Slocum-modified anterior drawer test is a way to identify PMC injuries. An external rotation anterior drawer test, performed in 10–15° of external rotation of the tibia, exposes PMC injuries [43]. External rotation stress is thought to be applied in the following order: PMC, anterior MCL, and ACL. Conversely, intact lateral-sided ligaments will prevent an anterior drawer of the tibia on the femur when performed in 30° of internal rotation even if the MCL and ACL are torn.

The dial test, more commonly used to detect posterolateral corner (PLC) and PCL injuries, can also show increased external rotation at 30 and 90° of flexion with medial-sided injuries [14, 41]. Performing the examination in both the supine and prone position can be used to distinguish the difference between anteromedial and posterolateral tibial rotation, using a combination of visualization and palpation [14].

Laterally displaceable patellae and extensor mechanism damage have been variably reported in

**Table 34.1** American Medical Association's grading scale

| American Medical Association grading scale | | Clinical laxity (mm) [39] | Radiographic widening (in 20° flexion) [40] |
|---|---|---|---|
| Grade I | Localized tenderness but no instability | 3–5 mm | 3.2 mm difference compared to contralateral side |
| Grade II | Localized tenderness and a partial tear of the MCL and POL | 6–10 mm | – |
| Grade III | Complete disruption and instability with valgus stress testing | >10 mm | 9.8 mm difference compared to contralateral side |

**Table 34.2** Average gapping increase compared to normal knee

| Protocol | Medial joint gapping (mm) in 0° knee flexion | Medial joint gapping (mm) in 20° knee flexion |
|---|---|---|
| Intact | 7.±0.7 | 7.4±0.7 |
| Proximal sMCL | 9.4±1.0 | 10.6±1.9 |
| MF | 9.9±1.2 | 12.2±2.0 |
| POL | 12.2±1.5 | 14.1±2.1 |
| Distal sMCL | 13.2±2.6 | 15.3±2.3 |
| MT | 14.1±2.8 | 16.2±2.8 |
| ACL | 15.9±3.9 | 21.2±3.9 |
| PCL | 21.6±4.2 | 27.8±4.7 |

Adapted from Laprade et al. [40]

*sMCL* superficial medial collateral ligament, *MT* meniscotibial, *MF* meniscofemoral, *POL* posterior oblique ligament, *PCL* posterior cruciate ligament, *ACL* anterior cruciate ligament the literature to occur in 9–59 % of combined ligament injuries [44, 45]. While these injuries rarely have been found to cause instability, the literature that examines their relative contribution is poor, and careful examinations should be performed to identify potentially aggravating injuries.

## 34.3 Imaging

Acutely, static widening of the medial joint space on plain radiographs can indicate a medial-sided injury or structure incarceration, e.g., medial capsule or MCL (≥5 mm). The "irreducible" knee dislocation can present this way following posterolateral joint subluxation or vastus medialis entrapment [46, 47]. Valgus stress radiographs can confirm suspicions of medial-sided injury [14, 17]. LaPrade et al. quantified side-to-side differences of 1.7 mm and 3.8 mm at 0° and 20°, respectively, in isolated MCL tears and 6.5 mm and 9.8 mm at 0° and 20°, respectively, in combined MCL and posteromedial corner disruption [40]. Otherwise, an examination under anesthetic can be used to detect rotatory injuries not previously detected by preoperative imaging or examination [42].

Chronically, radiographic changes can provide clues to the pattern of underlying injury. A Pellegrini-Stieda lesion, an ossified posttraumatic avulsion lesion of the MCL from the medial epicondyle of the femur [48], a deep femoral notch sign, peaked tibial spines, or cupula lesions can indicate long-standing MCL and ACL injuries.

MRI without contrast remains the gold standard where the diagnosis of medial-sided knee injuries can be performed with an accuracy of 87 % [49]. Its greatest advantages are in suspected complete MCL tears, suspected ACL tears, persistent clinical instability, and identifying the location of tear where surgery is required [50]. Individual medial-sided structures and the exact location of the injury can be visualized (see Fig. 34.1) [51]. MRI arthrograms enhance the identification of PMC injuries. Kimori et al. found arthrography to be more useful than arthroscopy and clinical examination in detecting tears, but interpretation can be difficult [51–53].

Nakamura et al. (contributing author) developed a new classification for MCL injuries based on the appearance of the superficial medial collateral ligament (sMCL) on MRI: femoral insertion site injury (type I), tibial insertion site injury (type 2), or injury throughout the length of the MCL (type 3) [53]. All five of their type 3 injuries required MCL reconstruction and there were no type 2 injuries. No differences were observed in IKDC sagittal laxity or valgus stability in all injuries.

Ligament discontinuity, subcutaneous edema, internal (ligament) change of signal intensity, and contrecoup bipolar bone bruises have all been associated with MCL tears [54–56]. When the pivot-shift mechanism does not dissipate all the deforming forces of certain high-energy injuries, varus, the internal rotation impaction on the anteriorly subluxated proximal tibia, is thought to lead to central medial femoral condyle and posterior tibial plateau contusion [57, 58].

The recently described "wave sign" indicates a distal tibial avulsion injury (Fig. 34.2a–c) [36]. This is thought to occur because the distal end of the ligament is not tethered to other soft tissue structures locally and takes on a serpiginous appearance when it retracts proximally. Taketomi et al. described three types: an avulsion injury where the distal end of the torn ligament remains under pes anserinus, the so-called "Stener" lesion of the knee where the distal end of the ligament sits outside pes anserinus [59], and MCL incarceration within the joint. They make the argument that potentially all of these types of MCL tears require surgical intervention.

## 34.4 Pathoanatomy and Applied Anatomy Relating to Combined ACL/MCL Injury

LaPrade et al. have extensively described (1) bony landmarks, (2) ligaments, and (3) tendons (adductor magnus, medial head of the gastrocnemius, semimembranosus, and the pes anserinus) of the medial side of the knee [21]. The MCL complex is made of the sMCL, the deep medial collateral ligament (dMCL), and POL (part of PMC) [23]. The other constituent components of


**Fig. 34.1** Coronal images of type I (**a**, **b**) and type III (**c**, **d**) MCL injuries. The superficial fiber, which is depicted as low-signal image on spin echo (**a**, *arrow*) and gradient echo (**b**, *arrow*) images, is interrupted by high-signal image at the femoral attachment site in type I MCL injury. In contrast, interruption of the superficial fiber by high-signal image is observed throughout the length of the fiber in type III MCL injury (Ref. [53])

the PMC are the semimembranosus tendon (and its multiple reflections), the oblique popliteal ligament, posterior horn of the medial meniscus, and medial joint capsule [60]. The sMCL has one femoral and two tibial attachments (proximal and distal). The femoral attachment is located 3.2 mm proximal and 4.8 mm posterior to the medial epicondyle [21]. Many reconstruction techniques incorrectly identify the medial epicondyle as the attachment site of the MCL [15, 26, 61–64]. The tibial insertion is broader, attaching primarily to soft tissues proximally and to bone distally, 60 mm from the joint line [65]. The dMCL is a vertical thickening of the medial joint capsule and consists of the MF (attaching 15.1 mm posterior and distal to the medial epicondyle) and MT ligaments (3.2 mm from medial tibial plateau) [65].

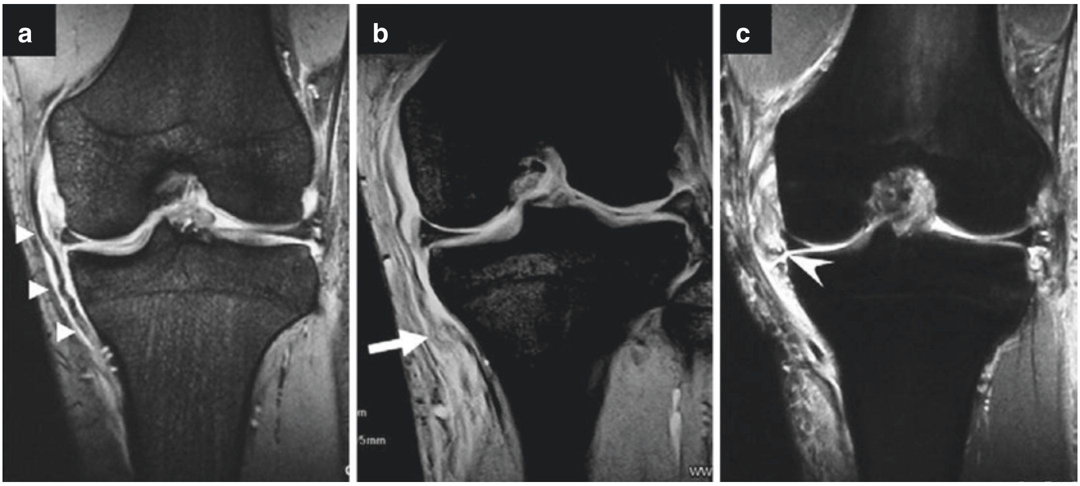


**Fig. 34.2** (**a**) "Wave sign": the waving of the superficial layer (*triangle*). (**b**) The distal end of the superficial MCL (*arrow*). (**c**) The entrapment of the distal end of the superficial layer into the medial knee joint (*arrow head*) (Ref. [36])

The posterior oblique ligament (POL) arises from behind the medial femoral epicondyle, 7.7 mm distal and 6.4 mm posterior to the adductor tubercle [65]. It fans out from its origin with three fascial arms: superficial, central, and capsular [21, 61]. The central arm is the largest, inserting near the margin of the tibial articular surface, the capsular arm reinforces the PM joint capsule, and the superficial arm blends with semimembranosus.

The MCL complex is a primary restraint to direct valgus stress. It also secondarily contributes to external rotation and anteroposterior stability [23]. The sMCL provides the majority of this stability in all degrees of flexion; the dMCL only providing secondary stability. The distal division of the sMCL is a primary stabilizer for external rotation and the POL, the primary stabilizer for internal rotation, highlighting its importance in counteracting AMRI [41].

The PMC provides one third of the restraint to valgus stress in full extension, slackening off in flexion [66]. It has a secondary role in the prevention of posterior translation of the tibia. However, in the context of combined injuries, it has a more important role in the resistance to external rotation. When damage to the PMC is combined with an MCL tear, external rotation is increased by 30° [42]. Failing to address the rotational component of this injury is what is thought to lead to residual laxity and functional compromise and the main source of controversy surrounding repair or reconstruction techniques.

Pes anserinus tendons and semimembranosus have a role in tightening medial structures in external rotation and flexion. In the context of damage to medial structures, utilization of these tendons to reconstruct MCL or POL may compromise the results of surgery inadvertently. Avoiding the harvest of hamstring autograft may be preferable, instead of favoring other graft options in these cases.

## 34.5 Treatment

ACL reconstruction and nonsurgical treatment of grade I and II MCL injuries have outcomes similar to that of isolated ACL injury reconstructions [67, 68]. Based on this, many authors propose protection of the MCL with a knee brace and delaying ACL reconstruction surgery [1, 69, 70]. Usually a period of 6–8 weeks is required for MCL injuries to heal.

The abovementioned approach can be utilized with grade III MCL injuries even among professional athletes with successful results [7]. However, the persistent valgus and/or AMRI of certain MCL tears can compromise ACL reconstructions if the medial side is not addressed [8, 11–13].

Both of these situations of compromised stability can prevent athletes from returning to pivoting sports [1, 2, 17].

### 34.5.1 Nonoperative Management of MCL Injuries

The indications for the nonoperative management of both ACL and grade III MCL tears are rare [71], with very little published on the topic [72, 73]. A higher rate of instability and a lower rate of return to sport make this a less desirable option. A number of studies have evaluated the nonoperative treatment of grade III MCL tears with concurrent reconstruction of the ACL [3, 28–30, 74–76]. Halinen et al. found that nonoperative MCL management regained ROM and quadriceps strength faster [28]. Petersen and Laprell compared early and late ACL reconstruction and reported significantly higher reoperation rates for stiffness and lower Lysholm scores with early ACL reconstruction [30]. Nonoperative management of MCL injuries is not as much of an issue as early ACL reconstruction. The vast majority of surgeons prefer not to operate in the acute phase for this reason [68, 76]. However, these studies also do not confirm superiority of nonoperative MCL management. Although sagittal and valgus stability is generally restored [3, 28–30], regaining ROM can still be an issue [28, 30, 74, 76].

Many authors have recommended a "wait and see" approach [1, 2, 33, 69, 77], bracing patients to resist coronal plain movement while permitting weight bearing and ROM for 6–8 weeks [1, 17, 78, 79]. At the time of ACL reconstruction, radiography can be used for an examination under anesthesia and valgus stress views obtained on the table [53]. Residual valgus instability after ACL reconstruction, illustrated by the medial joint space opening up more than 7–10 mm in 30° of flexion compared to the other side, should be an indication to proceed onto MCL reconstruction [33, 53, 69]. Significant residual instability can also be confirmed with arthroscopic valgus stress testing. Eight to 10 mm of opening of the medial compartment suggests persistent instability.

### 34.5.2 Operative Management of MCL Injuries

#### 34.5.2.1 MCL Repair

Different treatment combinations reflect changing trends in management over time [1, 17–19]. Opinion has shifted from early repair of the MCL and reconstruction of the ACL to delayed reconstruction of both ligaments when needed [1, 27, 33, 77].

Proponents of MCL repair report relatively good correction of valgus laxity with the advantage of avoiding complicated reconstruction options [68, 80–82]. Many reconstruction options are nonanatomic and only address the anterior portion of the superficial MCL [25, 26, 63]. Surgery in the acute phase is facilitated by more pliable tissue and more easily identifiable anatomical structures [25, 26]. The trade-off is a reduction in range of motion and possibly rotatory stability. Postoperative stiffness has proven to be a problem with early surgery, with 19–38 % MUA rates [28, 30, 68, 70, 76, 81–83]. Older rehabilitation protocols have been suggested as a possible cause for these findings.

Doubt has also been cast over the rotational stability of MCL repairs [63]. A recent study by Dong et al. looked at a triangular-vector reconstruction technique versus an anatomic repair technique of the MCL (See Fig. 34.3a–c) [63]. Both treatment methods effectively treated valgus instability, but medial pain and rotational instability were higher in the repair group. Repaired oblique fibers of the middle of the MCL and POL were not able to restore the medial structures to their original level of function [12, 84].

Although MCL repair in the acute phase is not typically offered, severe valgus alignment, large bony avulsions, and sMCL tibial avulsions that get incarcerated in the joint or displaced to the other side of the pes anserine tendons ("Stener-like" lesion of the knee) are all indications for acute MCL repair [33]. Although there is no high-level evidence to support the acute fixation of these lesions, much like the Stener lesion of the thumb, it is unlikely that the distally avulsed end of the sMCL will heal to its anatomic footprint if there is interposition of the sartorius fascia and hamstring tendons [59, 68].

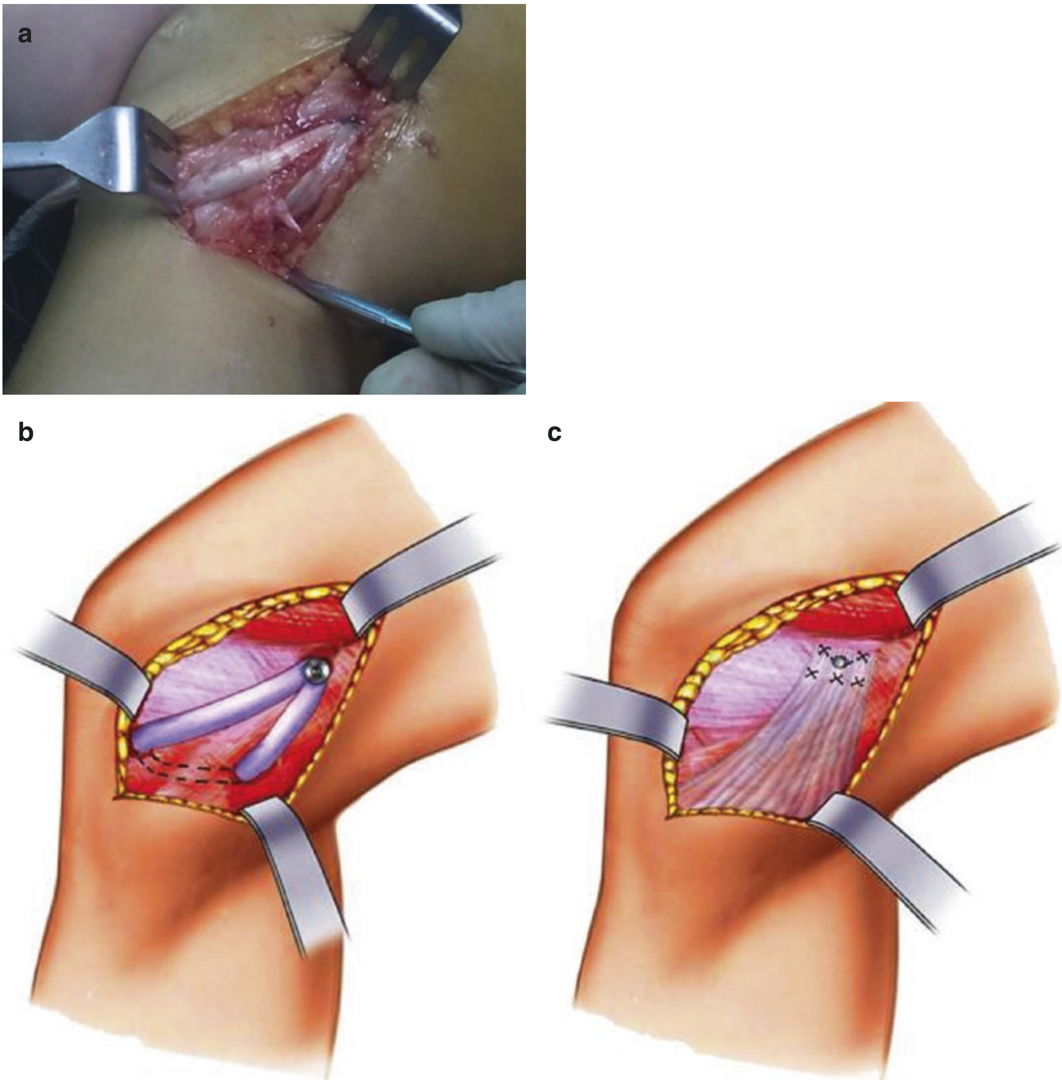


**Fig. 34.3** (**a**) Photograph of triangular reconstruction technique. (**b**) Illustration of same technique. (**c**) Illustration of MCL repair using suture anchors (Ref. [24])

Our preferred approach for repair is through a medial-sided 4 cm incision centered over the medial femoral epicondyle down to the crural fascia. Under fluoroscopic control, the isometric point of the proximal sMCL insertion is found as described by Wijdicks et al. [20]. The injured structures are repaired from the deepest structures outward. A peripheral tear of the medial meniscus is commonly seen (33 %) and repaired with an open technique. An MF ligament tear can be directly repaired using sutures alone or suture anchors. Suture anchor fixation is preferred for MT ligament tears.

For proximal avulsions of the sMCL, its attachment site is found and a 3.2 mm drill is inserted to a depth of approximately 35–40 mm. The MCL is prepared with a modified running locking stitch up each side. A small slit is then made proximally, and a 4.5 mm screw with a soft tissue spiked washer is placed through the slit (see Fig. 34.4) [85]. Sutures from the free end are also tied around the screw. Final tensioning is

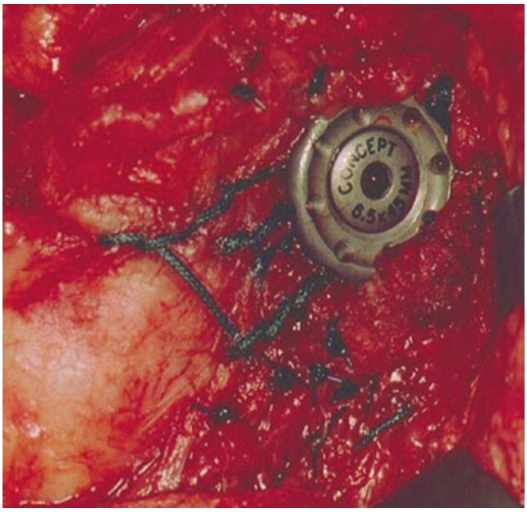


**Fig. 34.4** An MCL repair using the suture post and ligament washer construct [85]

performed with the leg in about 20–30° of flexion and slight varus.

Distal sMCL avulsions can be approached through an anteromedial incision midway between the PM border of the tibia and the tibial tubercle. The sartorius expansion is incised over the top of the pes tendons and the tendons retracted distally. Most distal avulsions occur distal to the level of the pes tendons. The sMCL can be retracted proximally some distance. Two anchors are used to reattach the proximal sMCL 1 cm below the joint line. These sutures are then weaved through the proximal MCL fibers but not tied. Then similar to the proximal MCL attachment, after lock stitching the distal ligament is split and the limbs tied around and secured by a screw and washer construct [86]. Tensioning is performed with the leg in about 20–30° of flexion and slight varus. Once the distal avulsion has been repaired, the leg is placed in full extension and the proximal anchors are sutured securely.

Whelan et al. (senior author) recently showed the biomechanical reliability of a "double row" repair of distal sMCL avulsion injuries (suture-bridge repair technique) [87]. Double row repair, in the shoulder, has shown greater healing and lower re-rupture rates, encouraging its application in the knee [88, 89]. Double-loaded suture anchors are placed at the proximal aspect of the sMCL anatomic insertion on the tibia and passed through the ligament tissue and tied but not cut. "Press fit" suture anchors are then placed at the distal aspect of the sMCL anatomic insertion site on the tibia to secure the retained sutures from the proximal anchors. The proximal sutures are "crossed over" before being secured distally as per standard suture-bridge configuration (see Fig. 34.5a, b).

If required, posteromedial structures can be tightened to improve resistance to AMRI. Two methods have been described by Jackson et al. [90]. The first of these is based on a technique described by Hughston et al. [91]. Laxity is removed by increasing the distance between the origin and insertion of the lax structure. The Lax segments are attached to surrounding intact structures, increasing the distance the ligament or tendon travels, increasing its tension. This is then followed by mattress stitch imbrication of the body of the structure. Alternatively, the posterior medial capsule can be released from the meniscus and re-sutured to it in a more advanced position in a "pants-over-vest" fashion. Both of these procedures are best performed with the patient supine, the hip in external rotation, and the knee positioned in 30° of flexion, internally rotated and under gentle varus stress.

#### 34.5.2.2 MCL Reconstruction

Chronic valgus laxity resulting in symptomatic instability unresponsive to conservative treatment is an indication for MCL reconstruction [17, 69]. Abnormal shear stresses and load patterns in an unstable knee can lead to degenerative change [92]. To avoid this, addressing all injured medial knee structures by restoration of native anatomy and insertion sites are recommended [17–19, 93]. Reconstruction techniques differ in graft choice, fixation method, tensioning method, number of bundles, and the medial structures they aim to reconstruct. No true consensus on the optimal method of reconstruction exists at the current time.

Reconstruction techniques can be split into three categories: anatomic, nonanatomic, and nonanatomic tendon transfer reconstructions [77]. LaPrade et al. described an anatomical reconstruction

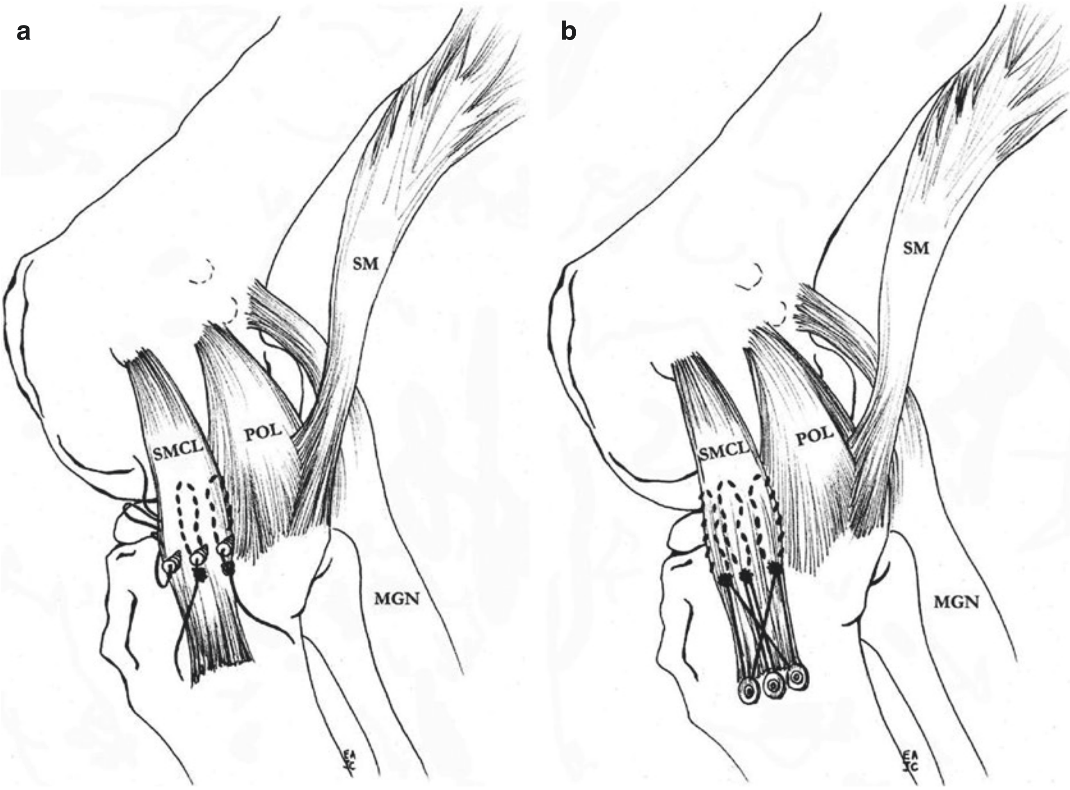


**Fig. 34.5** (**a**) sMCL suture-bridge repair technique. Double-loaded suture anchors are placed at the proximal aspect of the sMCL anatomic insertion on the tibia, and the sutures are passed through the ligament tissue and tied but not cut. (**b**) "Press fit" suture anchors placed at the distal aspect of the sMCL anatomic insertion on the tibia to secure the retained sutures from the proximal anchors. The proximal sutures are "crossed over" before being secured distally as per standard suture-bridge configuration (Ref. [87])

of MCL and POL to their precise, native attachment sites using hamstrings double-bundle autografts (see Fig. 34.6) [18]. Medial joint space gapping was <3 mm in all 24 of their patients. Accurate restoration of anatomic attachment sites, with independent ligament tensioning, may explain these good results. However, the extensive approach and requirement for multiple tunnels add complexity to the operation. Inadvertent disruption of bone tunnels created for other ligament reconstructions can lead to graft failure of either or both ligaments. Concerns have also been raised about stress shielding and altered knee mechanics that results from significantly over-tensioned grafts [94].

Significant heterogeneity exists among nonanatomic reconstruction techniques [12, 16, 26, 63, 95–97]. Single- and quadruple-bundle hamstring autografts appear to perform equally well, with minimal medial joint gapping on valgus stress [16, 26, 95]. Tendo-Achilles (T-A) allograft is also a popular choice of graft, avoiding further compromise of medial stability through the sacrifice of hamstring autografts. Both single- and double-bundle techniques have achieved good resistance to medial gapping [12, 97]. Quadriceps tendon and bone-patella-tendon-bone techniques have also been described [16].

Dong et al.'s nonanatomic triangular-ligament reconstruction with a single-bundle semitendinosus allograft appeared to show superior control of rotatory instability compared to anatomic repair. Their graft was fixed into both ends of an anterior to posterior drilled tibial tunnel [63]. The intervening tendon is fixed at the apex of the construct in a single femoral tunnel at the level of the medial epicondyle of the femur (see Fig. 34.3).

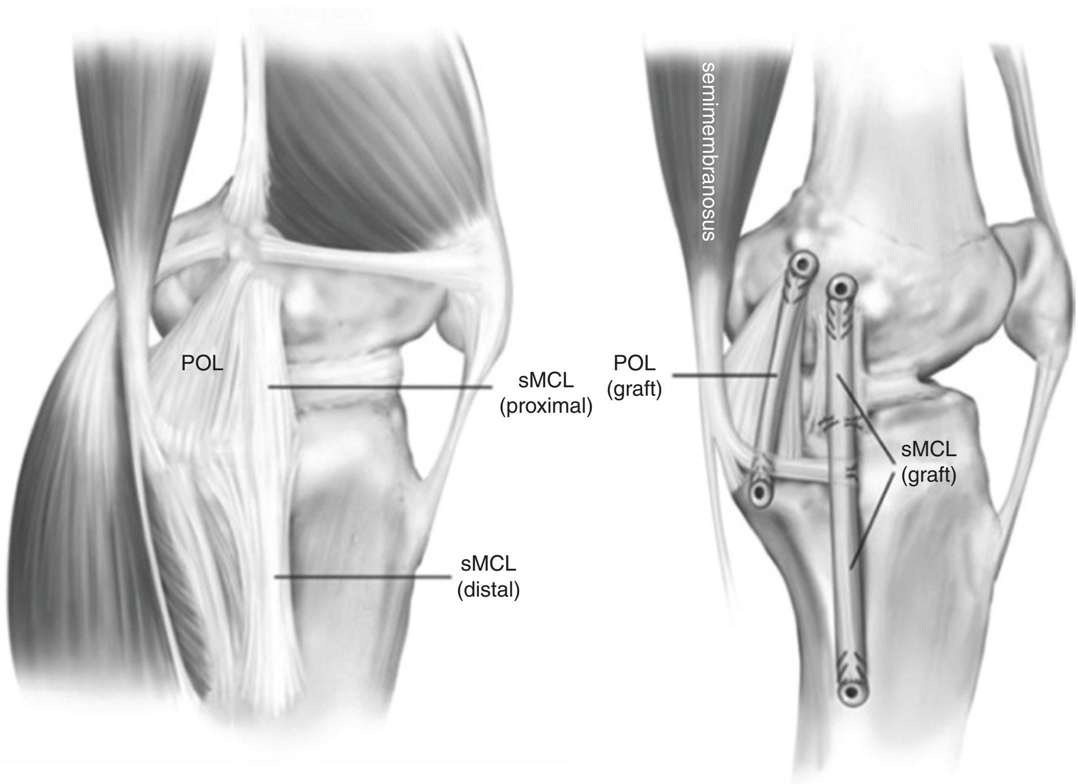


**Fig. 34.6** A diagram of a right knee illustrates the superficial medial collateral ligament (*sMCL*) and posterior oblique ligament (*POL*) reconstruction grafts (Ref. [93])

Allograft, however, is not as readily available in all hospitals making this a potentially expensive option with an inherent risk of disease transmission and biomechanical compromise. Complex reconstruction techniques requiring multiple bone tunnels and points of fixation stand to interfere with tunnels needed for ACL reconstruction [97]. They also may not fully restore the functions of the sMCL and POL. A number of the abovementioned techniques use a single femoral tunnel as representative of the proximal insertion sites of the sMCL and POL, when in fact their insertion site is not the same [20, 24, 26, 64]. The medial epicondyle is often quoted as the site used for assessing isometry [61, 62]. The correct proximal femoral attachment of the sMCL is 3.2 mm proximal and 4.8 mm posterior to the medial epicondyle [20, 21].

Nonanatomic tendon transfer preserves the distal attachment of the hamstrings (see Fig. 34.7). Proximal fixation of the graft usually occurs into a single femoral tunnel in the medial femoral epicondyle, and a posterior limb replicates the POL. Variants of this last feature have been described that either interact with the semimembranosus tendon or fit into a posterior tibial tunnel [15]. This has included suturing the semitendinosus tendon to itself [5] or passing the free end of the graft posterior to anterior through a tibial tunnel [25]. Minimal differences in side-to-side joint space widening under valgus stress have been reported with the majority of these techniques. However, in Lind et al.'s study, 50 % of patients had >3 mm medial widening [25].

In tendon transfer, maintaining the insertion site of the hamstrings anteriorises the position of the reconstructed sMCL. This is thought to be biomechanically inferior [18]. These techniques also use a single femoral insertion point to represent sMCL and POL.

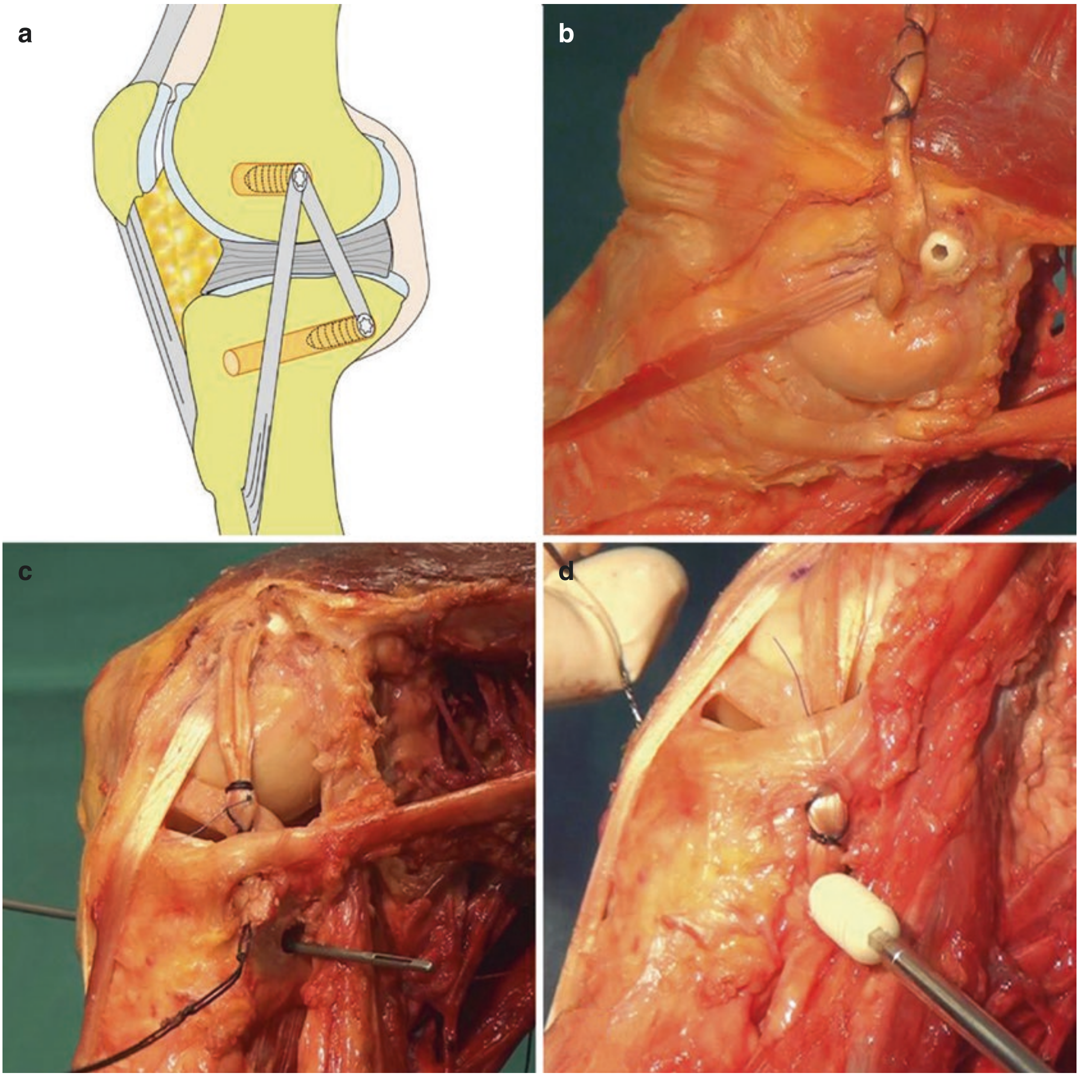


**Fig. 34.7** (**a**) Illustration of Lind's technique. (**b**) The tendon loop is armed in a baseball suture fashion, passed into the tunnel, and fixed with an interference screw. (**c**, **d**) The free end of the graft is passed through the posterior tibial tunnel opening and fixed here with an interference screw [33]

Our preferred technique is tendon transfer using hamstring autografts. The distal insertions of these tendons are left intact, but the tendons are rerouted around a 4.5 mm screw suture post and ligament washer construct at the distal anatomical footprint of the sMCL. The exact location of the distal footprint and proximal insertion point is determined by the technique described by LaPrade et al. [20]. A 25 mm femoral tunnel is created. The graft is cut to the appropriate length and a whipstitch run along the free end of both tendons. Using a beath pin, the sutures from the free end of the graft are passed through the femur at the anatomical insertion site of the sMCL and out through the skin on the lateral side, pulling the graft along with it into the tunnel. The ACL is usually fixed at this stage (often using BTB autograft) in full extension. The MCL is tensioned in 30° with a slight varus moment (slight "figure-of-four" position) and fixed with a biocomposite interference screw. We also then often back the fixation up by tying the sutures over a button on the lateral side of the femur.

If allograft is required or desired for a particular patient, we prefer the nonanatomic reconstruction of the sMCL described by Marx et al. [97]. The three-point sMCL fixation principle described by LaPrade et al. is used for fixation: the proximal isometric insertion site in the femur just proximal and posterior to the medial epicondyle (T-A bone plug with interference screw), the proximal tibia 1.5 cm below the joint line (with suture anchors), and distal to the pes tendons 6 cm distal to the joint line [20, 21]. The proximal suture anchors are tied with the knee in full extension. A suture post and ligament washer construct, as previously described, using a large 3.5-mm bicortical screw and 18-mm spiked washer is used for distal fixation.

#### 34.5.2.3 Graft Tensioning

Correct tensioning of ligaments in reconstruction is dependent on choosing the correct location of ligament insertion, understanding the mechanical properties of the graft, the chosen fixation, and tensioning method [98]. On the basis of Wijdicks et al.'s study, the sMCL is the primary restraint to valgus stress throughout the full range of knee flexion [19]. The distal portion of the sMCL primarily resists external rotation with increasing knee flexion. The ACL is tensioned and fixed first before the medial structures are fixed [99]. Most techniques describe tensioning the sMCL in 30° of flexion and varus [15, 26, 93, 100, 101].

The POL, on the other hand, has been shown to be most important in counteracting valgus stress and internal rotation in full extension [19]. There does not appear to be one consistent trend in the way the POL is tensioned, with variations in position of flexion, internal rotation, and presence or absence of varus stress. Recent recommendations have suggested tensioning in full extension to avoid over-constraint of the posteromedial capsule [12, 93].

### 34.5.3 Postoperative Rehabilitation

In the context of combined injuries, ACL rehabilitation takes precedence over medial-sided repair [78]. The general goal of prehabilitation is to allow sufficient healing of medial structures, restoration of ROM, quadriceps strength, and reduction in swelling before proceeding to an ACL reconstruction within 5–7 weeks after injury [14, 17].

A hinged brace is useful at this stage to control valgus and rotational stress. Weight bearing, ROM, and eccentric quadriceps and hamstrings strengthening exercises are encouraged as early as comfort allows. The ROM achieved on a stationary exercise bike is thought to provide the same stimulus for healing as the use of a constant passive motion machine in animals, accelerating the healing of grade III MCL tears [14]. Side-to-side exercises and activities should be avoided to prevent applying any unnecessary stresses on the collaterals [17].

Our postoperative rehabilitation protocol is performed as described by LaPrade et al. [14]. After surgery, ACL rehabilitation takes precedence over medial-sided repair [78]. ROM exercises are initiated within the "safe zone" determined intraoperatively, the range that does not put excessive strain on the MCL repair or reconstruction. Ideally, we aim for a passive or passive-assisted ROM from 0° to 90° immediately after surgery to minimize the risk of arthrofibrosis. If a bone-tendon-bone (B-T-B) autograft has been used, we do not permit our patients to weight bear for the first 2 weeks. Aggressive patella-femoral mobilization, quadriceps reactivation, straight leg raises in the knee brace, and hip extension and abduction exercises are encouraged immediately after surgery.

After 2–4 weeks range of motion is increased as tolerated with a target of 0–130° by 6 weeks. This rehabilitation is performed with the knee in a hinged brace. Progression to weight bearing as tolerated is likely to be between 2 and 6 weeks postoperatively when a normal gait without immobilizer or crutches has been achieved. It is important for the patient to be able to ambulate without effusions developing as this can affect both ROM and quadriceps strength.

At 6 weeks when good quadriceps control can be demonstrated, the hinged brace is discontinued. Closed chain exercises can be instituted alongside stationary bike usage with light resis-

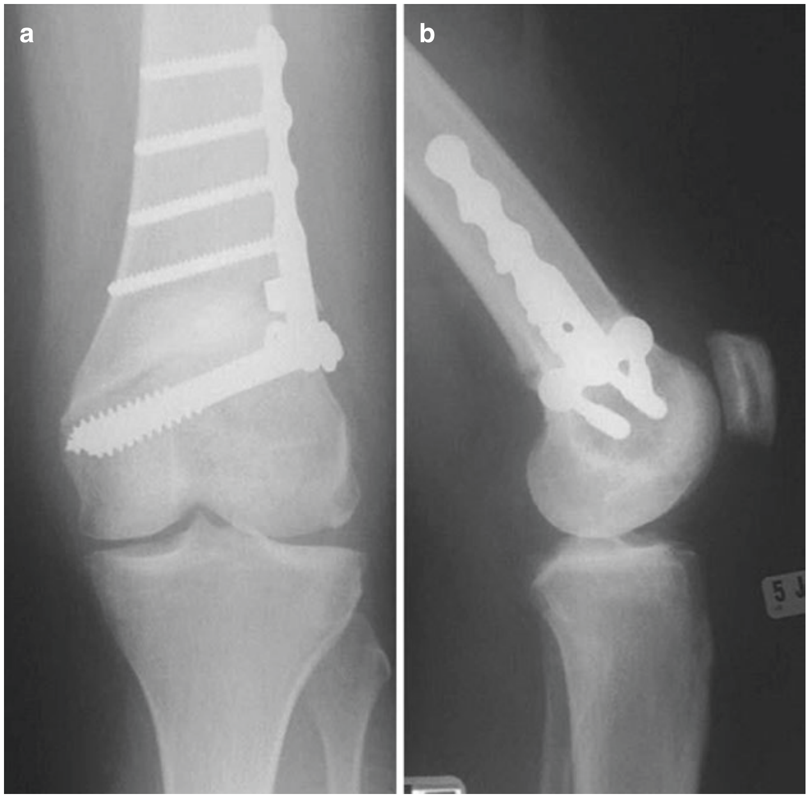


**Fig. 34.8** Distal femoral osteotomy used to correct valgus malalignment, taken 8 months postoperatively (Ref. [109]). (**a**) antero-posterior plain radiograph view of distal femoral osteotomy plating. (**b**) Lateral plain radiograph view of distal femoral osteotomy plating

tance. Hamstring curls and double-leg presses to a maximum of 70° knee flexion are also permitted but no open chain exercises at this stage.

Over the next 8–10 weeks, the patient will progress through a number of strength, motion, and balance exercises, consistent with the standard goal-based rehabilitation of an ACL reconstruction. Prior to a return to full sporting activities, the patient should have a full ROM, no instability, muscle strength that measures 85 % of the contralateral side, satisfactory proprioceptive ability, no MCL tenderness, and no effusion [78]. Consideration should be paid to the usage of knee bracing during sport if required.

### 34.5.4 Role of Osteotomy

Long-standing knee instability adds an additional degree of complexity to ligament reconstruction surgery. It can be accompanied by bony abnormalities and joint degeneration caused by joints that drift into either excessive varus or valgus over time [102]. An additional high tibial osteotomy (HTO) combined with soft tissue reconstruction can often mean the difference between success and failure in cases like these [103, 104].

The larger proportion of the literature on this topic exists for genu varum or hyperextension and varus thrust where HTO has been shown to halt the progression of arthritis in the medium term [103, 105–107]. Comparatively, very little has been written on the use of HTO to correct valgus malalignment that may be the result of medial-sided soft tissue injuries. Nevertheless, varus osteotomies are an option in the setting of chronic medial-sided laxity and valgus malalignment (see Fig. 34.8) [108]. HTO or distal femoral osteotomies (DFO-lateral opening wedge or medial closing wedge) may be performed for a weight-bearing line that falls lateral to the lateral tibial spine in the lateral compartment and beyond or a mechanical axis of 10° valgus. Due to the concern of joint obliquity of varus-producing HTOs, a DFO is often utilized [109].

Very few reports exist on the use of varus osteotomy to address ligamentous laxity. Cameron and Saha treated 37 patients with chronic MCL instability with distal femoral osteotomy [110]. An improvement in gait pattern was observed in 34 patients. Although laxity in the MCL remained even after osteotomy, this did not result in a functional deficit in being able to conduct daily activities. Phisitkul et al. described a similar experience where they felt in active patients or athletes that a second-stage procedure to reconstruct the ligaments was often required to address residual laxity [109].

## 34.6 Summary

High-level evidence does not exist in the literature to instruct us on how to manage combined injuries of the ACL and MCL. However, there appears to be no benefit to the repair or reconstruction of the MCL and ACL in the acute phase. From our own experience, we have seen that acutely presenting grade III MCL injuries often heal after 4–6 weeks of protection or at worst have residual grade II laxity that does not require operative attention. A "Stener lesion of the knee" (ligament tear from its tibial insertion) is an indication for acute MCL repair. A "wait and see" approach is the preferred strategy taken by the vast majority of surgeons. If valgus instability is present after ACL reconstruction, MCL reconstruction is indicated using allograft or autograft. A superficial MCL reconstruction or a superficial MCL plus posterior oblique ligament (POL) reconstruction technique can be used. Clinically, both techniques provide equally good results. Important technical points to all reconstructions include anatomic tunnel placement at the femur and tibial insertions and fixing the superficial MCL graft at 30° of flexion with varus stress.

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