Management of collateral ligament laxity in ACL revision

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Introduction

Collateral ligament injury can be a cause of ACL graft failure. These ligament injuries must be addressed at revision surgery in order to prevent failure of the revision surgery. In malalignment with associated collateral ligament injury, osteotomy may be the preferred choice to manage the collateral ligament laxity. This outline will describe techniques for managing collateral ligament injury in revision ACL reconstruction and also for identifying patients where osteotomy is indicated.

Managing fibular collateral ligament and posterolateral corner injuries

1. FCL and Posterolateral Compartment Function

The fibular collateral ligament (FCL) is the primary restraint to varus stress in the knee. At 5° of knee flexion, it provides 55% of restraint and at 25° it provides 69%. The popliteus structure limits posterior tibial translation, external tibial rotation, and varus rotation.

Injuries to the FCL and posterolateral compartment result when a force is directed at the medial side of the knee or leg. These injuries occur in about 7 to 16% of all knee ligament injuries. They are reported less commonly than injuries to the medial collateral ligament as they are less frequently recognized and are usually prevented by the presence of the opposite leg which can block direct blows to the knee’s medial side.

2. FCL and Posterolateral Corner Anatomy

The lateral compartment of the knee contains both dynamic and static stabilizers. The dynamic stabilizers include the biceps femoris, the iliotibial band, the popliteus muscle, and the lateral head of the gastrocnemius muscle. The fibular collateral ligament, popliteo-fibular ligament and the arcuate ligament make up the static ligamentous complex.

The lateral capsular complex of the lateral aspect is further divided into three parts. The anterior third is attached to the lateral meniscus anterior to the FCL. The middle third is attached proximally at the femoral epicondyle and distally at the proximal tibia, while the posterior third is found posterior to the FCL.

3. Evaluation of Lateral Compartment Injuries

*History:* A direct force applied to the weight-bearing knee which causes excessive varus stress, external tibial rotation and/or hyperextension can cause posterolateral corner injury. This force
commonly demonstrates as a posterolaterally directed force to the medial tibia while the knee is in an extended position. This frequently occurs during motor vehicle accidents and athletic injuries. Injury to the fibular and posterolateral structures often occur in conjunction with cruciate injury rather than as isolated injuries. Patients with this injury present with instability of the knee near full extension. They may have difficulty ascending and descending stairs and performing cutting or pivoting movements. They may also complain of lateral joint-line pain.

**Physical:** The injured extremity should be examined by performing adduction stress at both 0° and 30° of knee flexion. Signs of posterolateral injury include footdrop, peroneal nerve injury, posterolateral corner tenderness and pain with posterior-internal rotation of the tibia. If the knee demonstrates isolated laxity at 30°, injury to the FCL is likely. Laxity at both 0° and 30° however, is indicative of combined injury to the FCL and ACL, PCL or arcuate complex.

In chronic injuries, it is also important to evaluate their gait. This can help determine whether there is a varus or hyperextension thrust. Neurovascular injuries must also be assessed, as peroneal nerve deficits have been reported along with acute posterolateral corner injuries in up to 29% of cases.

**Imaging:** Plain radiographs should be taken for all patients suspected to have injuries to their FCL and posterolateral corner. These images are used to rule out associated osteochondral fracture, fibular head avulsion, Gerdy tubercle avulsion, and fracture of the tibial plateau. MRI is the preferred imaging tool to assess the integrity of the FCL, popliteus tendon, and cruciate ligaments. MRI can be used to determine the severity and location of the knee injury.

**Classification:** Isolated injury to the FCL rarely results in coronal plane laxity. Rotatory instability demonstrating as multiplanar laxity can be seen with combined injury to the FCL and other structures such as the ACL and mid-third capsular ligament or arcuate ligament, popliteus tendon, and fabellolobular ligament. Chronic isolated injury to the FCL rarely occurs. Most patients with this type of injury will eventually develop injury patterns of the other posterolateral corner structures.

Grading of posterolateral corner injuries (grade I, II, or III) is determined based on the degree of ligament disruption – minimal, partial or complete. However, a more precise method exists which relies on quantification of lateral joint opening with varus stress.

4. Treatment Approaches

**Nonsurgical:** Nonsurgical treatment is indicated by grade I and II (partial) isolated injuries of the FCL. Such patients have little functional instability. Nonsurgical treatment consists of limited immobilization with protected weight bearing during the first 2 weeks after injury. As the patient improves, progressive ROM, quadriceps strengthening and functional rehabilitation are encouraged. The patient may return to sports in about 6-8 weeks. If associated injuries to the posterolateral structures fail to be identified, nonsurgical treatment can, however, lead to progressive varus/hyperextension laxity.
Surgical: Surgical treatment is indicated by complete injuries or avulsions of the FCL, rotatory instabilities of the FCL and arcuate ligament, popliteus tendon, and fabellofibular ligament, and combined instability patterns of the FCL/posterolateral corner and ACL or PCL.

Acute injuries can be treated surgically by primary repair of torn or avulsed structures or reconstruction of the tissue. Direct repair can be hindered by the formation of scar tissue and distortion of the tissue planes, so it must be done within two weeks if performed. Reconstruction has been shown to have a lower failure rate than isolate repair in two comparative studies.

Surgical treatment of chronic FCL and posterolateral corner dysfunction can be done using allograft tissue to form a single-stranded graft. Some authors advocate a separate graft to reconstruct the popliteo-fibular ligament from the femur to the tibia, but no comparative studies have been done.

Full-length upright radiographs of both lower extremities of patients with chronic instability should be taken to determine whether or not varus mechanical axis is present. If so, a high tibial osteotomy may be indicated.

5. Complications

Chronic injuries can result in persistent varus or hyperextension laxity due to advancement of attenuated lateral and posterolateral structures. Surgical treatment may cause peroneal nerve injury as a result of exposure of the fibular neck or during drilling or graft passage. Hardware irritation at the lateral femoral condyle may also occur and knee range of motion may be lost, as can occur after the reconstruction of multiple knee ligaments.

Medial Collateral Ligament Injuries

1. MCL function

The medial collateral ligament (MCL) is the primary restraint to valgus stability of the knee. At 20-30° flexion it provides approximately 80% of the restraining force, whereas at full extension, it provides approximately 60% of the restraining force with the posteromedial capsule, posterior oblique ligament (POL), and ACL providing the remaining restraint [1]. Failure in recognizing dysfunction of this ligament in the setting of concomitant ligament reconstruction surgery (ACL or PCL) can result in excessive valgus stresses applied to the reconstructed ligaments, subsequently leading to graft stretch-out and failure.

2. MCL anatomy

The MCL has three major components:

(1) The superficial MCL which is the largest component, originating 3.2 mm proximal and 4.8 mm posterior to the medial epicondyle and inserting on the proximal tibia, just anterior to the posteromedial crest of the tibia and posterior to the pes anserinus insertion [2].
(2) The deep MCL which is a thickened part of the medial joint capsule, lying deep to the superficial part of the MCL, and has meniscotibial and meniscofemoral components. The femoral attachment is 12.6 mm distal and deep to the femoral attachment of the superficial MCL, and the tibial attachment lies just distal to the edge of the articular cartilage of the medial tibial plateau, 3.2 mm distal to the medial joint line [2].

(3) The POL, functioning as an additional medial knee restraint when the knee is extended. This is a fibrous extension of the distal aspect of the semimembranosus that blends with the posteromedial joint capsule. Its major and central portion attaches on the femur 7.7 mm distal and 2.9 mm anterior to the gastrocnemius tubercle. This is just proximal and posterior to the femoral insertion of the superficial MCL [2].

3. Assessment of MCL dysfunction

**Physical examination:** Physical examination should begin with assessing alignment and gait. When excessive valgus is identified in the injured limb and confirmed with AP hip-to-ankle axis view, varus-directed osteotomy to correct the alignment should be thought-of as a first step before ligament reconstruction is considered [3]. This may result in decreasing valgus moments and consequently may lead to the resolution of the sense of instability. Following assessment of alignment and gait, the knee is thoroughly examined, including laxity assessment of all ligaments. The uninjured contralateral knee is used as a baseline for comparison. MCL laxity—laxity Grade 0 corresponds to 0–2 mm side-to-side medial opening difference, Grade 1+ corresponds to 3–5 mm difference, Grade 2+ corresponds to 6–10 mm difference, and Grade 3+ corresponds to more than 10 mm difference [4-6].

**Imaging:** Stress x-rays can also be used to provide further quantification of medial laxity. However, the amount of medial opening on stress x-rays that correlates with a specific grade of MCL laxity has not been well documented in vivo. Recently, reference values were provided, but this was tested in an old-age population cadaveric model which may not apply to young or middle-age living humans [7].

**Examination under anesthesia:** The operated knee should be examined under anesthesia and compared with the nonoperated side for range of motion and ligament laxity prior to surgery. While in the awakened patient physical examination of MCL laxity relies both on the patient’s ability to relax and the clinician’s skill to detect the amount of medial opening and existence or absence of an endpoint, in the anaesthetized patient the former is avoided allowing the clinician a more objective evaluation of ligament laxity without muscle guarding.

**Arthroscopic evaluation:** Following an orderly arthroscopic examination of the knee, emphasis is applied to the medial compartment in cases where increased medial constraints laxity is suspected. Quantitative assessment of medial compartment opening can then be performed using the tip of the arthroscopic probe as a scale after its length is measured and confirmed outside the knee. Medial compartment opening of above 5mm is suggestive of Grade 2+ MCL laxity [8], whereas 10mm or more medial opening is suggestive of Grade 3+ MCL laxity [9].
4. Surgical approaches to address MCL dysfunction

**Direct repair:** An absolute indication for direct repair of the MCL is bony avulsion with displacement of the femoral insertion of the ligament.

**Medial & posteromedial plication/reefing:** In cases where residual medial laxity at the end of a cruciate reconstruction remains and arthroscopic assessment reveals Grade 2+ medial laxity (medial opening > 5mm), reefing of the medial constraints should be considered, unless chronic distal lesions with poor-quality scarring excludes this alternative [8].

**MCL reconstruction:** In cases where Grade 3+ medial laxity is observed (medial opening > 10mm) reconstruction of the MCL should be considered. Surgical techniques which have been described to reconstruct the MCL include semitendinosus autograft with preservation of the tibial insertion [10-13], allograft tissues [14,15], and double-bundle reconstructions [6,12,14-16]. Drawbacks related to these techniques include a long incision across the medial aspect of the knee with up to 20° loss of knee flexion or extension in 20% of the operations [13], keeping the semitendinosus insertion distally and using it as an MCL graft [10-13] resulting in a too-anterior tibial attachment (i.e. the tibial insertion of the MCL should be posterior to the pes anserinus [2,17]), harvesting a dynamic medial stabilizer that applies adduction moment during gait (i.e., semitendinosus) in a knee with an already medial instability, and the relative complexity of double-bundle reconstructions, compared to single bundle reconstructions, corresponding to their need for multiple attachment sites on the femur as well as on the tibia, more graft tissue, and number of fixation devices (i.e. screws, washers, staples, etc.) required [6,12,14-16]. Recently, a new technique to reconstruct the MCL has been described that uses Achilles tendon allograft [9]. Benefits include avoiding donor site morbidity, secure fixation with bone-to-bone healing on the femur, small skin incisions that do not cross the knee, and isometric reconstruction.

**Surgical technique** [9]: With the patient under anesthesia, after confirming MCL laxity that requires reconstruction as indicated previously by physical examination and arthroscopic examination, the following steps are carried out (after fixing the cruciate graft on the femur): (1) the Achilles allograft is prepared creating a 9-mm diameter by 18-mm length bone plug; (2) a 3-cm longitudinal skin incision is made over the medial femoral epicondyle; (3) a guide pin is inserted 3 to 5 mm proximal and posterior to the medial femoral epicondyle, parallel to the joint line, and in a 15° anterior direction to avoid the intercondylar notch. Location of the pin is confirmed with fluoroscopy; (4) the skin is undermined from the femoral guide pin to the anatomic MCL insertion on the tibia, creating a tunnel for the graft under the subcutaneous fat; (5) a nonabsorbable suture loop is placed around the guide pin and brought distally under the skin through the tunnel just created; (6) the distal suture is held against the tibia at the estimated anatomic insertion, just posterior to the pes anserinus insertion. Isometricity is tested through knee motion from 0° to 90°. The tibial insertion point is modified, if needed, until the loop is isometric; (7) the isometric point is marked on the tibia with a Bovey; (8) soft tissue around the guide pin is débrided to allow for insertion of the Achilles bone plug into a socket created around this pin later; (9) a 9-mm diameter reaming is performed over the guide pin to a depth of 20 mm; (10) the Achilles bone plug is inserted into the femoral socket and fixed with a 7-mm diameter by 20-mm length metal interference screw; (11) the Achilles tendon tissue is passed under the
skin and distally; (12) the cruciate graft is now tensioned and fixed on the tibia; (13) the MCL graft is tensioned with the knee at 20° flexion under varus stress and fixed at the isometric point on the tibia with a 4.5-mm cortical screw and a 17-mm spiked washer; and (14) subcutaneous tissue and skin are closed. Tunnels position and hardware placement are confirmed postoperatively with radiographs.

Outcomes after MCL reconstruction: In the literature, except for this recent description of an MCL reconstruction technique using Achilles allograft [9], there are only two studies reporting ROM and function in patients that had MCL reconstruction with one similar graft tissue in all patients and a similar specifically described MCL reconstruction technique in a combined MCL and another cruciate reconstruction [12,13]. Both described a technique that uses the semitendinosus tendon with preservation of the insertion site at the pes anserinus on the tibia, creating anterior and posterior limbs to reconstruct the MCL. However, in both studies, the group of patients was heterogeneous and included isolated MCL reconstructions as well as concomitant cruciate reconstructions, but ROM was reported for all patients as one group, not differentiating the combined reconstructions from the isolated MCL reconstructions. In one of these, which included six cases of isolated MCL reconstruction and 18 cases of MCL with another cruciate reconstruction, the investigators found motion limitation between 5° and 10° in extension or in flexion in five patients (21% of the patients) [12], whereas in the other study, which included 11 cases of isolated MCL reconstruction and 39 cases of MCL with another one or both cruciate ligament reconstructions or posterolateral corner reconstruction, the investigators noticed motion loss of between 5° and 20° in extension or in flexion in 10 patients (20% of the patients) [13]. Both studies did not report ROM specifically for the combined reconstructions, and therefore the comparison to the technique described here, using the Achilles allograft, is limited. The fact all MCL grafts, using the Achilles allograft technique [9], demonstrated Grade 0-1+ valgus laxity on physical examination is comparable to previous reports after double-bundle MCL reconstruction in a combined ligament reconstruction scenario that described Grade 0 to 1+ valgus laxity in more than 90% of their cases [12,13]. The fact mean IKDC-subjective and Lysholm knee scores demonstrated excellent (i.e., above 90 points) [18-20] function in patients with MCL reconstruction and primary ACL reconstruction, using the Achilles allograft technique [9], is comparable to the mean Lysholm score reported by others when creating a double-bundle MCL reconstruction with the semitendinosus, preserving its tibial insertion [12]. Mean KOOS subscores in the Achilles allograft technique were between 77 and 96 for the five categories of the score in cases with primary ACL reconstruction, which is comparable to another study that created a double-bundle MCL reconstruction and reported mean KOOS subscores between 75 and 89 for MCL reconstruction in a multiligament reconstruction scenario, the vast majority of which were MCL with ACL reconstructions [13]. In patients with the Achilles allograft MCL reconstruction with revision ACL reconstruction, IKDC-subjective, Lysholm, and KOOS subscores demonstrated inferior outcome [9]. Tegner and Marx activity level scores demonstrated patients with concomitant primary ACL reconstruction were able to return to preinjury activity levels, which were at means of between 6 and 7 points, indicating that cutting and pivoting sports on a recreational level may be a realistic goal after this type of Achilles allograft MCL reconstruction, but when this technique is performed in the setting of revision ACL reconstruction, return to pre-injury activity levels may not be achieved despite regaining normal knee laxity.
Indications for osteotomy

Patients who have lateral side laxity with varus alignment may require realignment osteotomy either prior to ACL reconstruction or at the same time. Patients with varus alignment but no lateral side laxity compared to the other side can be treated with isolated revision ACL reconstruction without collateral ligament reconstruction. In the chronic setting, varus deformity should be corrected prior to lateral side reconstruction in revision ACL surgery. The osteotomy may be performed prior to revision ACL reconstruction or at the same time. If it is done prior to the revision surgery, in some cases the patient may not complain of instability and ACL revision may not be necessary. For that reason, I generally perform isolated osteotomy in that setting and defer revision ACL reconstruction.

In rare cases, the patient may have MCL laxity in the setting of a failed ACL reconstruction with valgus deformity but no lateral compartment arthritis. In this situation, ACL reconstruction can be deferred because the patient may not complain of instability after the osteotomy. We generally perform lateral opening wedge distal femoral osteotomy to correct valgus deformity due to the simplicity of the technique and ease of exposure [21].

References: