Medial and Posteromedial Instability of the Knee: Evaluation, Treatment, and Results

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Abstract: Medial-sided knee ligament injuries are complex and require a thorough understanding of the anatomy and the scope of injury to successfully treat. Patients with isolated medical collateral ligament (MCL) tears can normally be treated with bracing followed by physical therapy with outstanding results. Patients with isolated Grade III injuries to the MCL are controversial. A reason for the disparity in results reported may be due to the fact that many (if not most) Grade III MCL tears have associated injuries to the anterior cruciate ligament and/or posteromedial corner injury. Patients with combination injuries should be treated surgically with repair or reconstruction in most cases. Either allograft or autograft reconstructions of both the MCL and posteromedial corner can be successful. Successful elimination of anteromedial rotary instability is the key to successfully treating posteromedial corner injuries.

Key Words: medial collateral ligament, posteromedial corner injury, multi-ligament knee injury, autograft reconstruction, allograft reconstruction, anteromedial rotary instability

(*Sports Med Arthrosc Rev* 2010;18:263–268)

The medial side of the knee has been relatively overlooked compared with the central pivot and the lateral side. It has also been the source of a moderate amount of controversy regarding the appropriate treatment of medial instability. It is critical to distinguish between a pure medial injury in the form of a torn medial collateral ligament (MCL) and a posteromedial corner (PMC) injury that also has a rotatory component to the instability. It is also crucial to determine if the patient has an isolated injury to the MCL or whether the medial ligament injury is a component of a multi-ligament knee injury (MLKI).

The MCL is the most commonly injured ligament in the knee, and has the greatest healing potential of any ligament in the knee.[1] It is the primary medial stabilizer against valgus stress, and along with the PMC provides resistance to external rotation forces applied to the lower leg.[2] A thorough understanding of a medial knee injury requires a clear understanding of the anatomy.

ANATOMY

There are 2 major systems that have been proposed for describing the anatomy of the medial side of the knee. Warren and coauthors described the anatomy using a 3-layer system.[2] An alternative scheme evaluates the structures of the PMC by dividing the medial side into thirds: anterior; middle; and posterior.[3,4] Both systems have advantages and should be understood, but the system of Robinson et al[4] that divides the medial side into thirds is more clinically relevant.

The anterior third of the knee consists of capsular ligaments covered by the extensor retinaculum of the quadriceps.[3] It is by far the least important third of the medial part of the knee. The middle third has a layer of fascia, the superficial MCL and the deep MCL.[4] The posterior third has the structures that make up the PMC. This includes a layer of fascia, the posterior oblique ligament (POL), the oblique popliteal ligament, the semimembranous attachments, and the posteromedial meniscus.[3–6] The middle third has a more prominent role of stability against valgus stress, whereas the posterior third has a greater role in resisting anteromedial rotary instability (AMRI).

The layered approach describing the anatomy of the medial side of the knee originated with Warren et al[2] and has been presented by many others.[3,4,7] Layer I is composed of the crural fascia, which blends with the tendons of the pes anserinus and tibial periosteum distally. It covers the Sartorius and Quadriceps muscles proximally. Layer II includes the superficial MCL; the medial patellofemoral ligament; and the ligaments of the PMC (merges with layer III at this point). Layer III consists of the capsule of the knee joint, the deep MCL, and the ligaments of the PMC. The conjoined tissues of layers II and III form the PMC. Figure 1 is an axial drawing demonstrating the layered concept of anatomy around the knee.

The PMC has been referred to by Muller as the semimembranosus corner of the knee.[3] It plays a role in dynamic stabilization and reinforces the PMC. The semimembranosus has 5 expansions or insertions. They are: (1) the anterior arm, which passes anteriorly beneath the MCL and inserts onto the tibia; (2) the direct arm, which inserts onto the posteromedial tibia; (3) an oblique popliteal ligament arm; (4) a capsular arm with an expansion to the POL; and (5) an inferior arm with a popliteus aponeurosis expansion.[3] The major insertions onto the tibia are important for knee stability and must be replicated to achieve optimal reconstruction results.

Selective sectioning cadaveric studies have helped elucidate the role of various structures on the PMC. The posteromedial capsule and POL help control valgus, internal rotation, and posterior drawer in extension. The superficial MCL resisted valgus stress at all angles of flexion and was the dominant structure from 30 to 90 degrees of flexion. It also resists internal rotation in flexion. The deep MCL controlled tibial anterior drawer of the flexed and externally rotated knee and was also a secondary restraint to valgus stress.[8] Cadaveric studies have also demonstrated

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that the POL and posteromedial capsule have a significant role in the prevention of additional posterior translation in a posterior cruciate ligament (PCL)-deficient knee.[6] This role makes a functional PMC particularly important in the MLKI patient who is undergoing PCL reconstruction. An unstable PMC will place high stress on the reconstructed PCL, increasing the risk of failure.

EVALUATION

Physical Examination

The history of the injury and a good examination of the medial side of the knee remain the most valuable diagnostic tools when evaluating patients with medial knee injuries. Most low-grade sprains occur as noncontact injuries, whereas complete MCL disruptions often result from a direct blow to the lateral leg. These pure valgus forces result in an isolated MCL injury.[1] The addition of external rotation forces to the tibia expands the zone of injury to include the PMC and/or the anterior cruciate ligament.[9] The likelihood of injury to multiple structures within the knee rises with high energy injuries such as involvement in a motor vehicle collision. The index of suspicion for an MLKI or PMC tear should be high in patients involved in high energy injuries.

A thorough physical examination of the knee involves careful assessment of the skin for degree of soft tissue injury, palpation of the anatomic structures, assessment of knee motion, and tests for joint stability.[3] There are several important principles that must be followed to obtain a good physical examination of the medial side of an injured knee. First, the patient must be relaxed as muscle spasm and guarding may yield an inaccurate examination. Second, the contralateral limb should be used for side-to-side comparisons. Third, a thorough examination must be conducted looking for associated pathology.[1] It is very important to document the neurologic and vascular status of the limb. This last point becomes even more important in patients who have sustained high energy injuries.

Initially, the examiner must establish that the neurologic and vascular examinations of the extremity are normal. This is critical if the patient has an MLKI, as two-thirds of the knee dislocation patients present with the knee reduced.[10] If there is any abnormality in the vascular examination, a vascular consultation and additional diagnostic studies should be performed immediately.[11] After this, a careful examination of the knee for point tenderness can provide important information regarding the precise location of the injury. Hughston et al found that point tenderness enabled them to localize the site of the injury in 78% of cases.[12]

Valgus stress testing with the knee in full extension and 30 degrees of flexion is the most important test of the stability of the medial side of the knee. To perform the test, the patient should be supine and the examiner should grasp the foot while applying a valgus stress to the knee (Fig. 2). This maneuver with the knee in 30 degrees of flexion helps isolate the medial side of the knee. It is important to try to differentiate between an isolated MCL injury and an AMRI pattern that includes the PMC. The difference is an isolated valgus laxity compared with valgus laxity coupled with anterior rotatory subluxation of the medial tibial plateau on the medial femoral condyle. The difference is easier to appreciate when the examination is performed while holding the limb by the foot rather than the distal portion of the leg.[3,13] The difference between the 2, however, cannot always be determined on the valgus stress examination. Instability in full extension implies that there is a tear of the MCL as well as in 1 or both of the cruciate ligaments.[1] Sims and Jacobson documented that anterior cruciate ligament tears occurred in 78% of Grade III ACL tears.[13]

Perhaps the most useful test to differentiate between an isolated MCL injury and a PMC injury is the anterior drawer test performed with the foot in external rotation.[1,3,13,14] The examiner should evaluate for anterior subluxation of the medial tibial plateau from under the medial femoral condyle while the foot is internally rotated 10 to 15 degrees. The presence of anterior subluxation of the medial tibial plateau from under the femoral condyle is diagnostic of a PMC injury. It is very important to evaluate your patient for AMRI and to document the results. Sims and Jacobson found that 99% of their patients with a medial-sided injury that required surgical treatment had AMRI and a POL injury.[13]

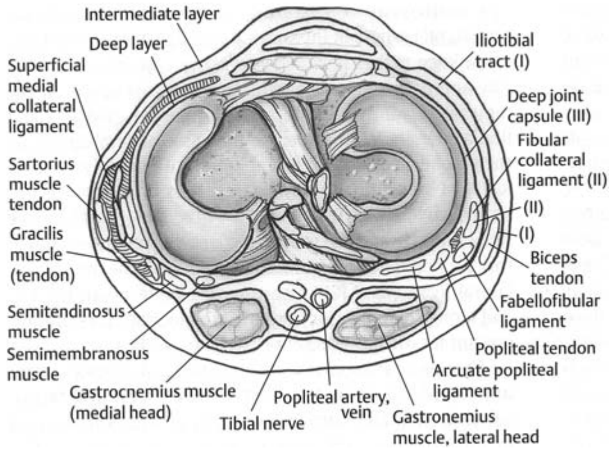

FIGURE 1. An axial drawing of the anatomy of the knee. Reprinted with permission from Thieme Medical Publishers Inc, 2007.

FIGURE 2. Valgus stress testing of a patient with a posteromedial corner injury. Note the examiner is holding the patient's foot with his hand, allowing a better appreciation of any rotatory instability.

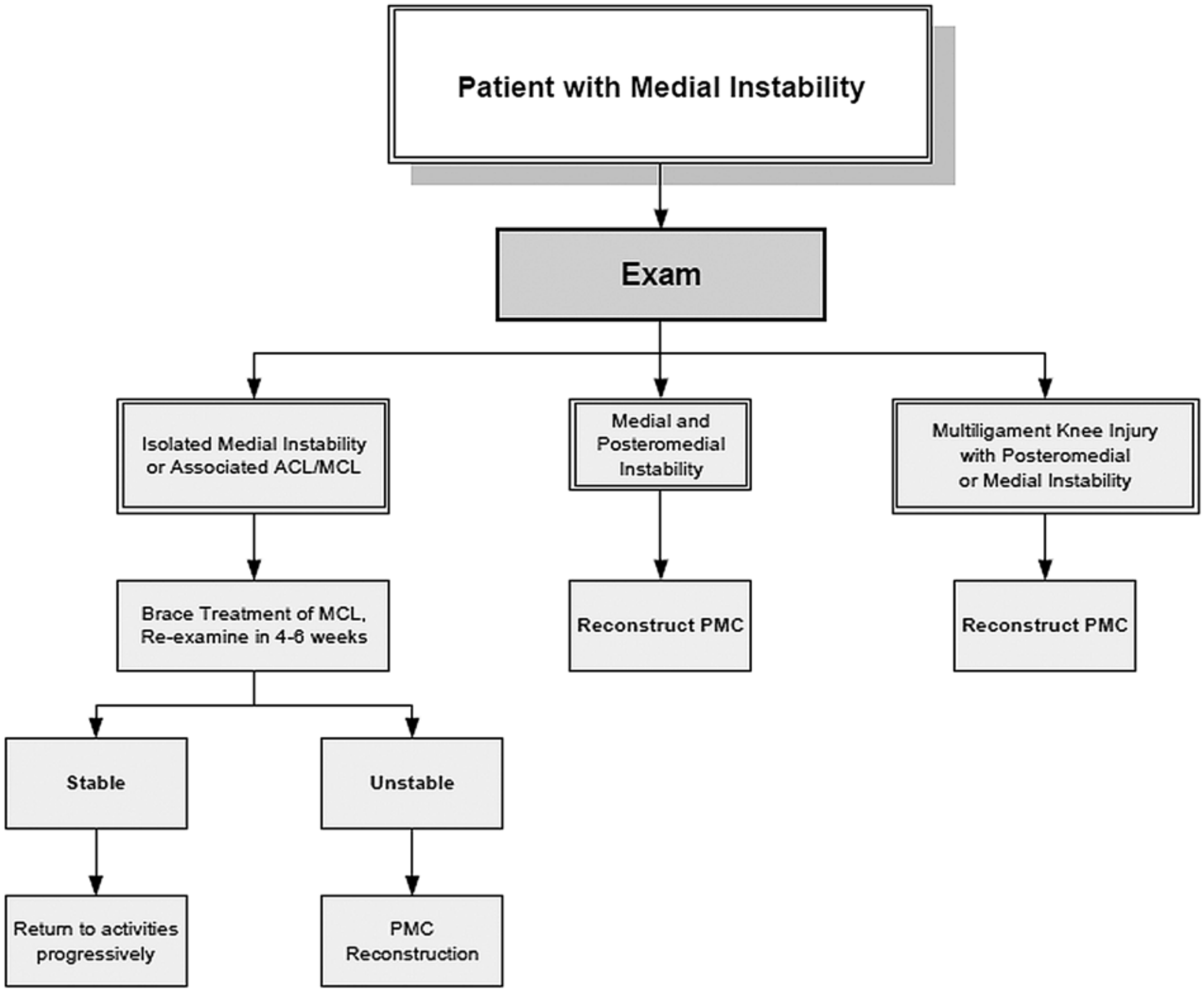

FIGURE 3. Algorithm for treatment of patients with medial instability of the knee.

FIGURE 4. Patient positioned supine with the knee in a figure 4 position for reconstruction of the posteromedial corner.

Imaging Studies

All patients should have plain radiographs taken in orthogonal planes to evaluate for fractures, avulsions, or a dislocation. Stress radiographs are occasionally helpful, particularly in pediatric patients to help distinguish between physeal and ligament injuries. Magnetic resonance imaging is the imaging study of choice to evaluate the MCL and the PMC. A cadaveric study demonstrated that T1-weighted fat-saturated sequences acquired after injection of intra-articular contrast demonstrated the best visualization of the POL and posteromedial capsule. However, most surgeons do not obtain magnetic resonance imaging scans with contrast. Noncontrast T1 coronal images showed the course of the MCL and segmental visualization of the oblique course of the POL, but poor visualization of the semimembranosus attachments. Axial images provide visualization of the MCL, POL, and the semimembranosus attachments,[15] and are the images that are most helpful to evaluate the PMC. It is important to realize that magnetic resonance images obtained in general practice may not have the resolution to routinely elucidate the full extent of the injury to the posteromedial structures. Physical examination remains the cornerstone of diagnosis of these injuries.

FIGURE 5. Fluoroscopic technique for finding the isometric point on the medial side of the knee. A line is drawn from the anterior aspect of the posterior femoral cortex to Blumensaat line. Reprinted with permission from Thieme Medical Publishers Inc, 2007.

TREATMENT

Nonoperative

Of the 4 major ligaments in the knee, the MCL, as a result of its anatomic and biologic properties, has the greatest capacity for healing.[16] Because of these properties, nonoperative treatment is recommended for most of the Grade I and II isolated tears of the MCL. Treatment in a hinged knee brace for 3 to 6 weeks with rehabilitation yields good results in most cases.[1,3] However, the treatment of isolated Grade III injuries is more controversial. Initially, many authors recommended surgical treatment of isolated Grade III MCL tears.[1,3] More recently, several authors have reported good results with nonoperative management of isolated MCL tears.[17,18]

Kannus published a study with 9-year follow-up of patients with MCL tears. He noted that patients with Grade I and II injuries did well, but patients with Grade III injuries did not have good results. This study was not limited to athletes. Patients experienced multiple reinjuries to their knee, 22% had to change occupations because of their knee, and 63% had to decrease their level of physical activity as a result of their knee injury. The mean Lysholm score in patients with long-term follow-up of Grade III injuries was only 66. He noted that many of his Grade III patients had either ACL instability or AMRI. His conclusion was that nonoperative treatment was ideal for Grade I and II MCL tears, but that it was not an appropriate choice for patients with Grade III tears.[19]

Combined ACL/MCL tears represent a completely different injury than isolated tears, and their treatment is quite controversial. Some authors advocate nonoperative treatment of the MCL initially with combination ACL/MCL tears.[1,3,20] After brace treatment of the MCL, the ACL is reconstructed if medial stability has been restored. If the patient remains unstable medially, then both the ACL and MCL are reconstructed. Biomechanical studies indicate that the 2 ligaments share responsibilities to an extent. The ACL is the primary restraint to anterior translation, and acts as a secondary restraint to valgus stress. On the other hand, the MCL is the primary restraint to valgus stress at 30 degrees, whereas the POL, the posteromedial capsule, and the posterior horn of the medial meniscus all act as secondary restraints to anterior instability.[21] Whether the MCL is treated operatively or nonoperatively, it is important that medial stability is restored for optimal function of the knee. There is a current trend toward nonoperative care of the MCL initially, but medial stability must be restored to achieve good results.[19]

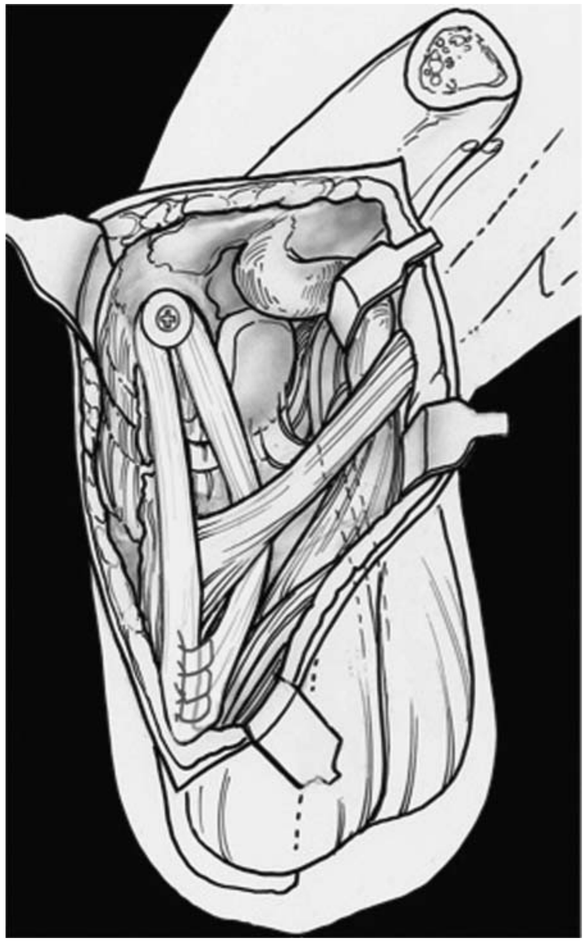

FIGURE 6. Drawing of the autograft technique of posteromedial corner reconstruction. Reprinted with permission from Thieme Medical Publishers Inc, 2007.

When MCL tears are combined with other ligament injuries or with injuries to the structures of the PMC, surgical treatment is necessary. Failure to achieve PMC stability will lead to failure of the MCL repair or reconstruction in many cases. The same is true for patients with a torn PCL and posterior instability. My algorithm for treatment of patients with medial instability is depicted in Figure 3.

Operative

Many techniques have been proposed for repair or reconstruction of the MCL and/or PMC.[1,3,14,22] If repair is undertaken, it is very important to understand the anatomy of the medial side of the knee and to repair all structures that are torn. The PMC was torn in 99% (92/93) of operatively treated medial knee ligament injuries in the experience of Sims and Jacobson.[13] Failure to address PMC injuries or anterior instability leads to poor outcomes in most patients.[19] Kim et al[22] have published a technique that provides a concomitant reconstruction of both PMC and MCL using semitendinosus autograft. They reported excellent results in 24 knees with minimum 2 years of follow-up using stress radiographs and the Lysholm knee score. Stannard[23] reported on the results of repair versus reconstruction of the PMC in patients who had sustained a knee dislocation. He noted significantly better results in patients treated with a reconstruction (4% failure) when compared with patients treated with a repair (20% failure). On the basis of these results, I recommend reconstruction of the MCL/PMC in patients who have sustained a knee dislocation and have medial instability.

Surgical Technique: Autograft Reconstruction

My preferred autograft reconstruction is based on the technique reported by Kim et al.[22] The patient is placed supine, the hip is externally rotated, and the knee flexed for the majority of the operation. This figure four position allows easy access to the posteromedial part of the knee (Fig. 4). The posteromedial border of the tibia is palpated, and a straight incision is made from the level of the insertion of the pes anserinus tendons to the medial femoral condyle. A fluoroscope is then brought into the surgical field and a good lateral view of the knee and distal femur is obtained. The isometric point is determined by the intersection of a line drawn down the anterior aspect of the posterior femoral cortex and Blumensaat line (Fig. 5). A 3.2-mm drill is placed at the isometric point and the drill is directed approximately 30 degrees proximally and 30 degrees anteriorly to avoid interference with tunnels for ACL, PCL, and posterolateral corner reconstructions in patients with multi-ligament knee injuries. A bicortical 4.5-mm screw and an 18-mm spiked ligament washer are placed at this isometric point and inserted approximately three-quarters of the way in. Decortication of the femur is performed for a radius of approximately 6 mm under the washer as described by Kim.[22] The end of the semitendinosus graft is prepared using whip stitching with a strong permanent suture. The graft is then passed around the screw and washer, under the direct head of the semimembranosus tendon, and then back to the intact insertion of the semitendinosus on the tibia. The graft is then tensioned with the knee in approximately 40 degrees of flexion and a slight varus stress. The 4.5-mm screw and washer are then tightened down to the femoral condyle and the graft is sutured back to the insertion of the semitendinosus using a strong permanent suture (Fig. 6). The stability of the PMC is then assessed. If it is not as tight as desired, it can be further tightened by suturing the distal 2 arms of this triangular construct together in a V—Y fashion. My results with this technique in knee dislocation patients with a minimum 2-year follow-up were excellent with only a 3.7% failure rate (1/27).

Surgical Technique: Allograft Reconstruction

Patient positioning and surgical approach are identical to the autograft technique described above. The isometric point is identified using the fluoroscopic technique described above, and a guide pin for a biotenodesis screw (Arthrex Inc, Naples, FL) is drilled into the femoral condyle. A socket is drilled to a depth of 20 mm. Allograft choices are either 1 large tibialis anterior tendon split in half or 2 semitendinosus tendons. The 2 grafts are affixed to the femur using the biotenodesis screw with 1 end emerging in line with the superficial MCL and the other in line with the POL. The 2 grafts are then routed exactly as described in the autograft technique. A 3.2-mm drill bit is used to drill a bicortical screw at the point of insertion of the conjoined tendon of semitendinosus and gracilis. A 4.5-mm screw with a ligament washer is placed into the drill hole and inserted three-quarters of the way into the bone. The knee is then flexed approximately 40 degrees and a slight varus stress is applied. The 2 grafts are passed around the screw in opposite directions and tensioned, and the 4.5-mm screw and washer are tightened securely to the tibia. Results with this technique have also been outstanding, with only a 4.8% failure rate (1/21) in knee dislocation patients with a minimum 2-year follow-up.

CONCLUSIONS

Medial-sided knee ligament injuries are complex and require a thorough understanding of the anatomy and the scope of injury to successfully treat. Patients with Grade I or II isolated MCL tears can normally be treated with bracing followed by physical therapy with outstanding results. Patients with isolated Grade III injuries to the MCL are controversial. A major reason for the disparity in results reported may be due to the fact that many (if not most) Grade III MCL tears have associated injuries to the ACL and/or PMC. Patients with combination injuries should be treated surgically with repair or reconstruction in most cases. In my practice, I have had very good results with either allograft or autograft reconstructions of both the MCL and PMC. Successful elimination of AMRI is the key to successfully treating PMC injuries.

REFERENCES

1. Fanelli GC, Harris JD. Surgical treatment of acute medial collateral ligament and posteromedial corner injuries of the knee. *Sports Med Arthrosc Rev*. 2006;14:78–83.
2. Warren LF, Marshall JL, Girgis FG. The prime static stabilizer of the medial side of the knee. *J Bone Joint Surg*. 1974;56: 665–674.
3. Jacobson KE, Chi FS. Evaluation and treatment of medial collateral ligament and medial-sided injuries of the knee. *Sports Med Arthrosc Rev*. 2006;14:58–66.
4. Robinson JR, Sanchez-Ballester J, Bull AM, et al. The posteromedial corner revisited. An anatomical description of the passive restraining structures of the medial aspect of the human knee. *J Bone Joint Surg Br*. 2004;86:674–681.
5. LaPrade RF, Engebresten AH, Ly TV, et al. The anatomy of the medial part of the knee. *J Bone Joint Surg Am*. 2007;89: 2000–2010.
6. Petersen W, Loerch S, Schanz S, et al. The role of the posterior oblique ligament in controlling posterior tibial translation in the posterior cruciate ligament-deficient knee. *Am J Sports Med*. 2008;36:495–501. Epub January 8, 2008.
7. Wymenga AB, Kats JJ, Kooloos J, et al. Surgical anatomy of the medial collateral ligament and the posteromedial capsule of the knee. *Knee Surg Sports Traumatol Arthrosc*. 2006;14:229–234. Epub October 26, 2005.
8. Robinson JR, Bull AM, Thomas RR, et al. The role of the medial collateral ligament and posteromedial capsule in controlling knee

laxity. *Am J Sports Med.* 2006;34:1815–1823. Epub June 30, 2006.

9. Shapiro MS, Markolf KL, Finerman GA, et al. The effect of section of the medial collateral ligament on force generated in the anterior cruciate ligament. *J Bone Joint Surg Am*. 1991; 73:248–256.
10. Twaddle BC, Bidwell TA, Chapman JR. Knee dislocations: where are the lesions? A prospective evaluation of surgical findings in 63 cases. *J Orthop Trauma*. 2003;17:198–202.
11. Stannard JP, Shiels TM, Lopez-Ben RR, et al. Vascular injuries in knee dislocation following blunt trauma: evaluating the role of physical examination to determining the need for arteriography. *J Bone Joint Surg Am*. 2004;86-A:910–915.
12. Hughston JC, Andrews JR, Cross MJ, et al. Classification of knee ligament instabilities. Part I. The medial compartment and cruciate ligaments. *J Bone Joint Surg Am*. 1976;58: 159–172.
13. Sims WF, Jacobson KE. The posteromedial corner of the knee: medial-sided injury patterns revisited. *Am J Sports Med*. 2004; 32:337–345.
14. Benjamin Jackson J III, Ferguson CM, Martin DF. Surgical treatment of chronic posteromedial instability using capsular procedures. *Sports Med Arthrosc*. 2006;14:91–95.
15. Loredo R, Hodler J, Pedowitz R, et al. Posteromedial corner of the knee: MR imaging with gross anatomic correlation. *Skeletal Radiol*. 1999;28:305–311.
16. Woo SL, Inoue M, McGurk-Burleson E, et al. Treatment of the medial collateral ligament injury. II: structure and function of canine knees in response to differing treatment regimens. *Am J Sports Med*. 1987;15:22–29.
17. Hasting DE. The non-operative management of collateral ligament injuries of the knee joint. *Clin Orthop Relat Res*. 1980;147:22–28.
18. Indelicato PA. Non-operative treatment of complete tears of the medial collateral ligament of the knee. *J Bone Joint Surg Am*. 1983;65:323–329.
19. Kannus P. Long-term results of conservatively treated medial collateral ligament injuries of the knee joint. *Clin Orthop Relat Res*. 1988;226:103–112.
20. Halinen J, Lindahl J, Hirvensalo E, et al. Operative and nonoperative treatments of medial collateral ligament rupture with early anterior cruciate ligament reconstruction: a prospective randomized study. *Am J Sports Med*. 2006;34: 1134–1140. Epub February 1, 2006.
21. Fischer RA, Arms SW, Johnson RJ, et al. The functional relationship of the posterior oblique ligament to the medial collateral ligament of the human knee. *Am J Sports Med*. 1985; 13:390–397.
22. Kim SJ, Lee DH, Kim TE, et al. Concomitant reconstruction of the medial collateral and posterior oblique ligaments for medial instability of the knee. *J Bone Joint Surg Br*. 2008; 90:1323–1327.
23. Stannard JP. "Posteromedial Corner Injury in Knee Dislocations." Podium Presentation, American Orthopaedic Society for Sports Medicine. 35th Annual Meeting, Keystone, CO, July 2009.

