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Combined Anterior Cruciate Ligament and Medial Collateral Ligament Knee Injuries: Anatomy, Diagnosis, Management Recommendations, and Return to Sport

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Abstract

Purpose of review The diagnosis and management of combined anterior cruciate ligament (ACL) and medial collateral ligament (MCL) injuries have been a controversial topic for several decades. No single approach has proven optimal for treatment and there is no consensus between most specialists. This review seeks to describe and clarify the current state and the future of management.

Recent findings Most authors agree on reconstructing of the ACL with non-operative management of the MCL in grade I and II injuries, respectively. However, controversy still exists about the optimal method of treating a combined ACL with higher grade MCL injuries.

Summary Management should be customized based on acuity, injury grade, and specific goals for each patient. Future research with clinical outcomes may facilitate creating guidelines to optimize recovery.

Keywords Anterior cruciate ligament · Medial collateral ligament · Combined injuries

Introduction

Management of a combined ACL/MCL injury remains controversial. A review of both historical and recent literature yields conflicting reports on not only whether surgical management is indicated for the ACL, MCL, or ACL/MCL, but also whether timing of the management should be acute or delayed. This article thus aims to provide an overview of currently accepted methods of management for combined ACL/MCL injuries based on the extent of injury to the MCL by grade and laxity, and finally submit a recommendation for treatment and studies going forward.

This article is part of the Topical Collection on *ACL*: *Risk Factors*, *Outcomes*, *Preventions*

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Background

Anatomy

The knee is the largest joint in the human body and is frequently injured. Knowledge of normal anatomy may assist in understanding pathology and corrections necessary to restore function to the injured knee.

While often viewed simplistically as a simple hinge between the femur and tibia, the knee articulation is much more complex. Force is transmitted across the joint via the menisci and hyaline cartilage covering the femoral condyles and tibial plateaus. Upon flexion, the femur initially rotates laterally to reduce tension on the collateral ligaments and ultimately rolls posteriorly. On extension, the medial side of the tibial plateau remains behind its lateral aspect and rotates externally in what has been termed "the screw-home movement" [1].

While bony architecture frames the knee, the ligamentous structures provide stability to the articulation. The function of ligaments in the knee contrasts starkly to the hip and the shoulder, which rely upon osseous congruity and periarticular musculature, respectively, to provide joint constraint [1]. The major ligaments of the knee include the anterior cruciate (ACL) and posterior cruciate ligaments (PCL), which provide anteroposterior stability, and the medial collateral (MCL) and lateral collateral ligaments (LCL), which limit valgus and varus laxity, respectively. The ACL and PCL are located within the articular space of the knee and, due to their biomechanical design, allow "hinge-like" knee movement during flexion and extension. The ACL is composed of two bundles (anteromedial and the posterolateral bundles) and each is proposed to serve unique roles: the anteromedial bundle prevents anterior translation of the tibia while the posterolateral bundle assists in rotatory control. The bundles arise from the medial aspect of the lateral femoral condyle within the intercondylar notch and insert into the anterior aspect of the tibia's intercondyloid eminence. Conversely, the PCL and its two bundles (anterolateral and posteromedial) originate from the anterolateral aspect of the medial femoral condyle within the intercondylar notch and attach to the posterior aspect of the intercondylar area within the posterior facet of the tibia.

While the cruciate ligaments provide stability in the sagittal plane, the collateral ligaments confer stability in the coronal plane. The MCL is the primary restraint to valgus stress of the knee. Much like the ACL, the MCL consists of multiple functional components and is composed of two layers, a deep layer and a superficial layer, and form the medial meniscoligamentous complex [1]. Fibers from the deep layer directly connect the medial femoral condyle to the medial tibial metaphysis and are contiguous with fibers of the medial meniscus. The superficial layer of the MCL is located deep to the gracilis and semitendinosus tendons and connects the medial epicondyle to the medial tibial metaphysis, the pes anserinus insertion, and the posterior joint capsule [2]. The superficial MCL is the more important component in providing stability to valgus stress and can be subdivided into anterior and posterior segments. The anterior segment contains long parallel fibers and lies anterior to the joint capsule, while the posterior portion contains superior and inferior oblique fibers [3]. The extensive organization of these fibers increases the stability of the MCL.

Biomechanics

Ligaments transmit tensile force along the direction of its fibers. The MCL can generate up to 30 times greater force along its longitudinal direction than its transverse direction [4]. The ACL and MCL are responsible for the stability of the knee in different loading directions, specifically anterior translation and valgus-directed forces. Therefore, injury to these ligaments contributes to instability and altered function.

The ACL actively stabilizes the knee through flexion and extension and when subjected to valgus forces. The anteromedial and posterolateral bundles of the ACL act differently under various loading conditions. For example, at greater than 30° flexion of the knee, the anteromedial bundle exhibits a greater force than the posterolateral bundle. At knee flexion angles less than 30°, including extension, the posterolateral bundle assumes greater load [4]. When the knee is subjected to valgus and internal tibial torques while flexed to 15° (such as during a pivot shift test), both bundles exhibit nearly identical loads [4].

Similarly, the components of the MCL behave differently depending upon loading conditions. The superficial MCL restrains 57% of the valgus moment at 5° of knee flexion and 78% at 25° when measured against the medial capsule. Thus, the superficial MCL becomes increasingly important to restrain valgus stress when the knee flexion angle increases [5]. Forces absorbed by the MCL are amplified when the ACL is insufficient. While valgus rotation increased 21% when the MCL alone was transected, the valgus rotation increased 123% when the both the MCL and ACL were intentionally transected. Thus, when the tibia is free to rotate, the ACL is most important in resisting the varus-valgus moment [6].

Diagnosis

History

Obtaining a careful and comprehensive history from a patient may perhaps be the most important factor in making the diagnosis of a combined ACL/MCL injury. The most commonly reported mechanism of injury is valgus stress, which can often be combined with flexion and external rotation that leads to injury [7]. Direct blows combined with rotational forces are often associated with multiple ligament injuries [2]. Other common mechanisms for a combined ACL/MCL injury may include a pivoting movement, a sharp deceleration, or a forced hyperextension.

Key questions that should be asked during the history include location of pain (both acute and subacute in clinic), ability to ambulate immediately after injury, presence and location of swelling (focal versus an effusion), and any "pop" or tearing sensation at the knee at the moment of injury [7]. The answers to these questions may reveal the extent and approximate location of the injury. For example, Hughston et al. reported that 67% of patients with complete MCL tears were able to ambulate to the office without any aid, and that pain reported by patients was often worse with incomplete tears rather than complete [8], while those who sustain an acute ACL disruption typically presents with an effusion, restricted range of motion, and difficulty ambulating. Combined injuries often resemble the complaints of an injury to the ACL presumably because of the greater apparent loss in knee stability seen in ACL injuries.

Physical Examination

Once a combined ACL/MCL injury is suspected, the goal of the physical examination is to determine the severity of the MCL injury. This assessment has the greatest impact on management decisions [9]. Higher grade MCL injuries seen as increased valgus laxity are less likely to be successfully managed non-operatively and are more likely to contribute valgus overload on a reconstructed ACL and chronic knee instability and [10].

The most reliable time interval to examine the knee is immediately after the injury. Examination at this time avoids interference by muscle spasms and excessive effusion which causes pain and guarding. Unfortunately, many patients visit clinic days after injury and acute examination is not possible [7]. If a patient has severe spasms, examination after 1-day immobilization period may permit the clinician adequate access [7].

Key findings in the initial inspection include acute effusion (hemarthrosis), consistent swelling 24 h after injury (synovial effusion), and absence of any swelling (extravasation to surrounding tissues from severe tear) [8]. Presence of hemarthrosis points to intra-articular involvement, while local swelling is more commonly associated with an isolated MCL injury [2].

A focused inspection and palpation of the area includes joint lines, femoral condyles, tibial plateau, patella and patellar facets, tibial tubercle, tibial metaphysis, and pes anserine area. Bruising and point tenderness are common following an MCL injury and often locate the site of rupture.

Range of motion should be examined via passive, active, and resistive knee flexion and extension. A valgus stress test should be performed at 0 and 30° of knee flexion and compared to the contralateral limb. Fetto and Marshall, for instance, have shown an incidence of concurrent ACL tears in 20% of patients with no valgus laxity, 53% with laxity at 30° of knee flexion, and 78% with laxity at 0° knee flexion [11]. If the patient complains of pain, some clinicians place a pillow beneath the flexed knee to allow for examination. Laxity observed at 0° flexion is indicative of a complete medial-sided injury and likely secondary ligament involvement [5].

The degree of laxity is quantified using the American Medical Association's classification scheme [8]. Severity is graded I through III, and laxity by 1+ through 3+. A grade I injury has microscopic tearing but no joint widening or instability; grade II has a partial tear with minor joint widening but no instability; grade III has complete loss of integrity and instability. Grade III tears are further separated based on laxity of joint separation at the knee with 30° flexion. Various laxity grading include 1+ with 3–5 mm laxity, 2+ with 6–10 mm laxity, and 3+ with more than 10 mm laxity of medial joint opening [7]. Grade III tears have an associated 78% risk of concurrent ligament injury, and 95% of these will include an ACL injury [12].

Integrity of the ACL is tested using the Lachman, anterior drawer, and pivot shift tests. These maneuvers are the most sensitive and specific of all physical evaluations [13]. The Lachman examination evaluates anterior subluxation of the tibia while the knee is flexed to 30° and distal femur is stabilized. A positive Lachman occurs with significant anterior translation and lack of a firm endpoint compared to the unaffected knee. The anterior drawer test is performed with the knee flexed to 90° and the tibia subjected to an anteriorly directed force. During a pivot test, the knee is extended with internal rotation and valgus stress applied. If there is a "clunk," the test is positive. Literature unfortunately reports varying sensitivity and specificity of these examinations, and thus a combination of positive and negative examinations may indicate partial tears [13].

Imaging

Ottawa knee rules should guide the clinician in determining which imaging modalities, if any, are indicated. Radiographs are generally not helpful in diagnosing ligament injuries but are used to rule out knee dislocation, avulsion fractures, or other concurrent osseous injuries [13]. Current guidelines recommend anterior-posterior, lateral, patellar with 45° knee flexion, tunnel view, and stress view if the injury is suspected to be grade III [14]. MRIs are also generally not indicated for MCL injuries unless there is a suspected grade III injury. The increased resolution from MRI aids the clinician in determining the location of the MCL injury, and whether the ACL truly is injured [15]. These observations will be confirmed via arthroscopy if surgical management is chosen.

Management Decisions

Management

Although widely dismissed, conservative treatment of both the ACL and the MCL in combined injuries has been successfully described by Jokl [16]. After immobilization for 7 days, patients in this study underwent aggressive physical therapy. Follow-up between 8 months to 11 years demonstrated that 68% returned to original activity level. In total, 74% of contact athletes and 67% of non-contact athletes had successful outcomes, while patients who were reported as "recreational athletes" had a 50% return to activities [16]. The authors concluded that the initial approach to combined injuries should be conservative measures, with surgical management becoming a possibility if the initial results are unsatisfactory. These results may be particularly applicable in situations in which surgical intervention is contraindicated to other underlying conditions [9].

Hughston, known for standardizing the grading of MCL tears, advocated for isolated MCL repair regardless of grade. He found no long-term difference in instability of the knee or joint deterioration based on ACL condition [17]. Frolke also favored isolated MCL repair, but suggested that if stability was unsatisfactory, a delayed ACL reconstruction should be considered [18].

More recently, surgeons have advocated this approach only when the MCL component is a grade III tear. Shirakura et al. compared 14 combined ACL/MCL patients with repaired grade III MCL tears with conservative treatment to the ACL against 11 similar patients treated non-operatively for both ligaments. They found that although there was no significant difference in Tegner scores, there was a significant increase in Lysholm score in the operative group [19].

Robins investigated surgical management versus conservative treatment with physical therapy. He based the decision upon where the MCL tear occurred rather rehabilitation time. Distal lesions managed surgically were able to gain greater range of motion and more rapidly than proximal lesions. This outcome was most likely due to the decreased impact of scarring in the joint [3]. He suggested that proximal lesions should undergo aggressive physical therapy rather than repair. This recommendation was based on the anatomical finding that the superficial MCL lies directly over the joint capsule center of rotation. Therefore, any scar tissue that may be created over time as a result of surgery may impede motion [3]. This observation has been repeatedly verified in the literature whereby surgical management of the MCL in a combined ligament injury has led to increased flexion loss and increased patellofemoral pain [20]. For this reason, MRI may be very useful in diagnosing specific locations of the MCL tear [15].

The most accepted method of managing combined ACL/MCL injuries is ACL reconstruction with conservative MCL treatment [21]. Hillard-Simbell compared outcomes of patients with combined ACL/MCL injuries treated with only ACL reconstruction against outcomes of patients with only ACL tears, and found no difference in laxity, return to sport, functional imitation, strength, or one-legged hop testing for distance [22]. Shelbourne based a similar rationalization for ACL reconstruction with conservative MCL treatment on the observation that isolated MCL injuries generally heal well without surgical management. His group found that 96% of their combined ACL/MCL injury patients who received only ACL reconstruction and non-operative management of the MCL reported no instability in the knee, little laxity during valgus stress test at 30° flexion, and no significant difference in stability or reoperation rate when compared to patients previously treated with surgical management for both the ACL and MCL [23]. Halinen compared patients with combined ACL/MCL injuries who received acute ACL reconstruction and conservative MCL management against similar patients who received both acute ACL reconstruction and concomitant MCL repair. He also found no significant difference in post-operative stability, subjective function of the knee, range of motion, muscle power, return to normal activity, or outcome scores after an average of 27 months follow-up [24]. In a follow-up study, Halinen measured early operative treatment of combined ACL/MCL injuries without MCL repair and found that the non-operative MCL group had faster restoration of flexion and quadriceps muscle power [25].

While most surgeons agree that non-operative management for MCL tears with reconstruction of the ACL is an acceptable and well-studied management, there is significant controversy on the ideal timeframe for surgical reconstruction of the ACL. Acute ACL reconstruction supporters cite that MCL healing is impaired by ACL insufficiency, while delayed reconstruction supporters cite better functional outcomes when patients have early motion and late reconstruction [26]. Harner investigated differences in an acute (within 3 weeks) ACL reconstruction versus a delayed (after 3 weeks) ACL reconstruction in knee dislocations. Both groups received non-operative treatment of the MCL. While patients treated acutely reported higher subjective and objective knee stability than those treated after 3 weeks of injury, nearly all were able to return to their daily routines [27]. Conversely, others like Miyamoto recommend delayed ACL reconstruction until knee range of motion, quadriceps activation, and knee effusion return to normal in order to protect the MCL [28, 29].

Mangine proposed an algorithmic approach to surgical management and timing of ACL reconstruction in a combined ACL/MCL injury:

- If the MCL is judged to be a grade I, the patient should have ACL reconstruction within 1 week with no pre-surgery motion restriction.
- If grade II, the patient should have ACL reconstruction within 2 weeks. Pre-surgery, the patient should have 7 days of a knee brace locked at 30°, with daily rehabilitation to full motion. After 7 days, the brace may be unlocked and allowed full motion and followed by surgical reconstruction.
- If grade III, the patient should have delayed ACL reconstruction at 3 weeks. Pre-surgery, the patient should have 10 days of motion restriction with the brace locked at 30°, with daily rehabilitation to full motion after day 7. After 14 days, the brace should be unlocked to full motion and followed by surgical reconstruction [9].

Grant proposed a similar treatment algorithm for combined injuries with high-grade MCL tears. The patient should wear a leg brace locked in for 14 days after injury and work from full extension to 90° knee flexion [12]. The patient should then undergo physical therapy for at least 6 weeks to reduce the present effusion, to regain knee extension and flexion, and to regain quadriceps muscle power. Once the MCL injury is healed, the ACL is reconstructed. If there is a significant residual instability that is confirmed by arthroscopy during the ACL reconstruction, an MCL repair is done prior to reconstructing the ACL.

Smyth proposed another tiered approach to combined ACL/MCL injuries that is also based on the severity of the

MCL tear. For partial MCL injuries that are grade I or grade II, the medial side of the knee is treated non-operatively and the ACL is reconstructed once the MCL is healed and the knee range of motion is recovered [21]. In situations where valgus laxity or anteromedial rotatory instability remains after non-operative treatment, or if an MCL injury is associated with two other concurrent ligament injuries, the MCL is reconstructed. This reconstruction is done by stripping and using the proximal end of the semitendinosus tendon to replicate the MCL and provide rotational stability by reproducing the posterior oblique ligament [21]. The knee is then placed in a brace and subjected to early physical therapy to regain motion.

Most recently, researchers have investigated the value of concurrent MCL reconstruction in the setting of combined ACL and grade III MCL injuries [30••, 31••, 32]. Large-scale studies are currently lacking, and further research is needed to draw reliable conclusions. Gallo suggested the use of a single allograft to simultaneously reconstruct the ACL and MCL in this specific patient population [30••], while others used semitendinosus, gracilis, or quadriceps tendon autografts with success [31••, 32].

Return to athletic activity

Data on return to athletics (RTA) varies based on both the degree of injury and treatment. Results are complicated by the myriad number of options to manage these injuries.

For post-operative rehabilitation, Mangine proposed a phased approach focusing on post-surgical pain control, reduction of post-surgical hemarthrosis, re-establishing ROM, increasingly progressive weight bearing, early exercise sequences, proprioception program to re-train the mechanoreceptor system, measuring functional progression, and a gradual return to sports [9].

The early rehabilitation period should focus on re-establishing ROM and progression of the weight-bearing [9]. Some studies that advocate the use of continuous passive motion (CPM) in the early rehabilitation period have described improvement of ROM, decreased hemarthrosis, decreased scar tissue, and maintenance of viable articular cartilage in patients undergoing CPM [33–35].

Weight-bearing progression is another goal in the early rehabilitation period. Some protocols advocate immediate full weight-bearing in a locked extension brace, while others prescribe immediate partial weight-bearing in either a protective ROM device or no brace at all and gait training program focusing on proper position and strength [9].

The protocols for muscle control re-establishment in the post-surgical period have also changed over the past 30 years. Emphasis is placed on training the entire kinetic chain, not only the lower extremity. For this reason, referring to qualified physical therapists knowledgeable in these injuries is a must.

Conclusions

A wide variety of management approaches have been described for combined ACL/MCL injuries. While most agree that reconstruction of the ACL and non-operative management of the MCL is the standard for combined ACL and grade I and II MCL injuries, controversy exists about the optimal method of treating a combined ACL and grade III MCL injury. Therefore, providers should customize their treatment recommendations based on acuity of injury, grade of injury, and the specific outcome goals for each patient.

Compliance with Ethical Standards

Conflict of Interest Joshua L. Elkin, Edgar Zamora, and Robert A. Gallo have not received (or agreed to receive) from a commercial entity something of value (exceeding the equivalent of US$500) related in any way to this manuscript.

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