

Conservative and Postoperative Rehabilitation of Isolated and Combined Injuries of the Medial Collateral Ligament

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Abstract: Injuries to the medial collateral ligament (MCL) are very common and there seems to be a consensus supporting the conservative management of grade I and II tears. Grade III tears are also usually treated conservatively unless associated with injuries to the anterior cruciate ligament or posterior cruciate ligament. This article outlines rehabilitation programs for conservative treatment of MCL injuries, and postoperative programs after anterior cruciate ligament or multiple ligament reconstruction. In addition, the use of functional and prophylactic bracing for injuries of the MCL is reviewed.

Key Words: medial collateral ligament, conservative treatment rehabilitation, anterior cruciate ligament, posterior cruciate ligament, functional bracing

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Injury to the medial collateral ligament (MCL) is one of the most common injuries of the knee.¹ The management of these injuries is dependent on several factors including the severity of the injury, associated injuries to other ligaments [anterior cruciate ligament (ACL), posterior cruciate ligament (PCL)], and surgeon preference. Although there are differing opinions regarding treatment of these injuries, specific rehabilitation protocols have not been well elucidated. The purpose of this chapter is to provide an overview of conservative and postoperative management of medial knee injuries, either isolated or combined with other ligament injuries, in regards to rehabilitation and return to sports or functional activities.

CLASSIFICATION OF MCL INJURIES

To effectively manage MCL injuries, the severity of the injury must be established because the parameters of rehabilitation are based on the degree of injury. The most common mechanism of MCL injury is a direct blow to the lateral aspect of the leg or knee, or landing on the leg in such a way that a severe valgus force is sustained at the knee. The American Medical Association distinguishes sprains on the basis of indirect evidence of ligament injury

based on symptoms and physical examination. Subsequently, a grade I injury consists of a minimal number of fibers torn, localized tenderness, and no instability.² Grade II injuries involve a greater degree of ligamentous disruption with slight to moderate abnormal motion. Grade III sprains involve a complete tear of the ligament with disruption of fibers and demonstrable instability. Gardiner and associates³ found that the most common location for MCL injuries is the femoral insertion. When grade II or III injuries are suspected, further testing should be conducted to rule out associated ligamentous injury. For instance, if medial instability is demonstrated when a valgus force is applied to the knee in fully extended position, than injuries to the ACL or PCL should be considered.

CONSERVATIVE MANAGEMENT OF ISOLATED GRADE I AND II MCL INJURIES

The fact that grade I and II MCL injuries heal with conservative management has been well supported by several studies.^{3–7} The sequence of this healing has also been shown to be relatively predictable including sequential phases of hemorrhage, inflammation, proliferation, and remodeling.⁸ What is less obvious is the most effective rehabilitative program to incorporate that will maximize healing while allowing a progression of motion, strengthening, and function. When reviewing the literature, there is no apparent consensus regarding the most efficacious approach for treatment, and specific rehabilitation programs are usually based on surgeon preference and experience. Subsequently, the rehabilitation strategies presented below are not intended to be all-inclusive and should not be viewed as the only or “best” approach for treatment of these injuries. Nonetheless, they are based on current scientific principles as they relate to ligament remodeling resulting from the forces applied through exercises and activities.

In many animal studies, the healed MCL is inferior to controls in regards to tensile strength, collagen type, and alignment.^{9–11} Although the similarities between animal models and the human MCL are not clearly defined, it is logical that, when rehabilitating these MCL injuries, it is important to control adverse forces on the knee, especially during the early phases of healing. For it is during this initial phase of healing that the optimum healing environment exists.¹¹ Gardiner and associates³ found that the highest strains in the MCL were at full extension but distributed evenly over the ligament.

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TABLE 1. Rehabilitation of Grade I MCL Injuries

- Weight-bearing as tolerated with assistive device if necessary
- Active ROM exercises to achieve full ROM as soon as tolerated
- Active strengthening exercises—open and closed chain as tolerated
- Progress to agility, proprioceptive and sport-specific drills as tolerated
- Bracing is encouraged for contact sports to prevent against valgus forces
- Return to sports when strength, agility, and proprioception are equal to the uninvolved side

Conversely, various flexion angles distributed the forces over varying portions of the MCL. Because it is important to begin early alignment of collagen as a reaction to force along the ligament, after grade I injuries, the patient is allowed weight bearing as tolerated assuming the patient's anatomic alignment is not one of the significant valgus. Typically, weight bearing results in a slight "closing down" of the medial side, thus minimizing forces on the MCL. The exception to this principle would be those patients who demonstrate a valgus alignment in normal stance. In these cases, the patient is sometimes limited to partial weight bearing with crutches for the first 1 to 2 weeks of recovery. During this early period of healing, the patient is encouraged to perform gentle, active-assisted range of motion (ROM) exercises 2 to 3 times per day to avoid joint stiffness and arthrofibrosis. Quadriceps strengthening is emphasized during this time and may include quad sets, straight-leg raise, and/or electrical stimulation. Patella mobilization is also encouraged. Hip extension and adduction exercises may be performed; however, abduction is avoided to prevent valgus force on the knee.

The type of bracing and the amount of time the knee is immobilized in full extension is related to the severity of the injury. With grade I MCL tears, immobilization is generally not necessary and the patient may not require any bracing or, at most, be placed in a hinged, short-leg brace to allow for early motion. Consequently, quadriceps strengthening is more aggressive and closed chain exercises are often used as long as valgus forces are avoided. Once full ROM is attained, progressive resistive exercises are added as tolerated. Many a time the individual can return to sports or desired activity once strength and proprioception are restored, and pain has resolved (Table 1). Return to sports is also contingent upon the athlete's ability to complete sport-specific drills without pain and/or instability. Bracing for sports may be used as a prophylactic measure but often is not necessary if the athlete can perform all activities without pain or feelings of medial instability.

Grade II MCL Sprains

As discussed earlier, grade II MCL sprains consist of greater interstitial damage to the superficial MCL, however, there is a firm end point when a valgus force is applied. When this injury is identified, the presence of concomitant ligamentous injuries, especially involving the ACL, need to be ruled out. Physical examination,

arthrometric testing, and magnetic resonance imaging studies can be helpful in diagnosing the presence of additional injuries. In addition, meniscus pathology should be excluded before patient is progressed through a rehabilitation program.

Similar to grade I injuries, the literature is sparse for specific rehabilitation programs as they relate to grade II MCL. In 1981, Derscheid and Garrick¹² published a study of nonoperative treatment of grade I and II MCL injuries in athletes and the rehabilitation program was advanced based on the completion of specific functional tests (Table 2). Kannus¹³ studied grade II and III MCL injuries but did not differentiate the treatment between the 2 groups. Because grade II injuries involve greater disruption of the ligament and a greater degree of valgus instability than their grade I counterparts, a long-leg hinged brace is often used as this provides more protection than can be afforded through a short-leg brace. Depending upon pain with ambulation the brace may be locked in extension for a short period of time during this initial phase. Bracing is often continued for the first 3 weeks after injury. Using a mouse model, Wright and associates¹¹ demonstrated a decrease in inflammatory cells at 21 days. In addition, collagen precursors were noticeably increased at 21 and 28 days, indicating the proliferation of new collagen cells at the injury site. During this 3-week period, weight bearing as tolerated with crutches is often permitted. Again, if the patient has a valgus bias to the knee, then weight bearing is minimized and allowed at toe-touch only. During this early phase, quadriceps strengthening is done in non-weight bearing that is, quad sets, straight-leg raising (SLR), and electrical stimulation. Hip strengthening exercises may also be employed as long as valgus forces are avoided. Cryotherapy is used as needed to control pain and swelling. After 3 weeks, if not already adjusted, the brace is set to allow full ROM and weight bearing is

TABLE 2. Rehabilitation of Grade II MCL Injuries

- Long-leg brace for ambulation with weight bearing as tolerated with assistive device. Brace may be locked in extension for 1 to 2 wk depending upon pain, valgus opening, and anatomic alignment. Assistive device can be discontinued when patient attains a nonantalgic gait
- Active ROM exercises are started immediately in brace (if opened) or out of the brace if locked in extension
- Electrical stimulation to the quadriceps, quad sets, and SLR are initiated immediately
- Long-leg brace is opened at end of postinjury week 3 and full weight bearing is encouraged. Discontinuation of brace is dependent on pain, anatomic alignment and degree of valgus laxity. Severe grade II injuries may require 6 wk of bracing.
- Stationary cycle and progressive resistive exercises are instituted as tolerated
- Once full ROM and functional strength is attained, proprioceptive and agility drills can be initiated. Straight-line running is permitted at this time
- Return to sports is permitted once ROM, strength, and proprioception are equal to the contralateral limb and valgus opening has been eliminated. A functional brace is recommended for contact or high-risk sports

progressed to full weight bearing as tolerated. ROM exercises are initiated once the brace is opened and full ROM is desirable by the end of the sixth week. Stationary biking is employed early for ROM and closed chain quadriceps are instituted once the patient has attained full weight bearing. Once full ROM and weight bearing are achieved, rehabilitation mirrors that of the grade I MCL injury.

In those patients who are required to remain in the brace for the full 6 weeks, a staged, progressive weight-bearing regimen is instituted at the end of the third week so that the patient is full weight bearing by the end of the sixth week. ROM exercises are also initiated at the end of the third week and can be done out of the brace, or the patient may be shown how to unlock the brace for the exercises and then locking it in extension for weight bearing activities. After 6 weeks, the patient is then progressed through the rehabilitation program as outlined above.

CONSERVATIVE MANAGEMENT OF GRADE III MCL SPRAINS

It is generally accepted that grade I and II MCL sprains heal without surgical intervention. The controversy occurs when considering the proper management of grade III MCL sprains. In reviewing the literature, studies supporting both surgical and nonsurgical management are found.^{4-6,8,12-16} Adding to this controversy is the apparent predilection for concomitant injuries to occur with grade III MCL sprains, especially ACL tears. In a review of the literature, Pressman and Johnson¹⁷ found that the incidence of combined ACL-MCL tears in skiers ranged from 16% to 57%. In the next section, we will examine the rehabilitation for these combined injuries. For now, our focus will be on isolated grade III MCL injuries (Table 3). As this type of injury likely involves both superficial and deep fibers of the MCL, a longer period of immobilization is advisable. Typically, patients are braced for the entire 6-week period, regardless of alignment. Several authors have advised against prolonged periods of immobilization owing to the deleterious effects on the healing ligaments and articular surfaces.¹⁸⁻²⁰ To guard against such adverse effects such as arthrofibrosis and subsequent motion loss, patients are often allowed to come out of the brace to perform gentle ROM exercises at the end of the third postinjury week. Arthrofibrosis is a specific process in which scar tissue or fibrous adhesions form diffusely within the joint.¹⁹ This can result in loss of either flexion or extension at the knee. Millett and associates²¹ cited certain nonsurgical risk factors associated with motion loss including prolonged immobilization, reflexive sympathetic dystrophy, infection, and synovitis. Therefore, it is crucial to be aggressive with ROM once sufficient healing has occurred. If full extension and flexion beyond 90 degrees is not attained by the end of the 4 to 5 weeks, then manipulation under anesthesia may be beneficial. In severe cases, arthroscopic debridement may be a necessary adjunct to the

TABLE 3. Rehabilitation of Isolated Grade III MCL Injuries

- Immobilization in long leg brace locked in extension for 3 to 6 wk depending on anatomic alignment. Nonweight bearing for 3 wk in patients with significant valgus alignment. Toe-touch weight bearing for neutral or varus alignment
- Immediate ROM out of the brace 2 to 3 times a day for those with nonvalgus alignment ROM after 3 wk for patients with valgus alignment. Brace is unlocked at 3 wk and progressive weight bearing is permitted for patients with neutral or varus alignment
- Patients with valgus alignment begin ROM out of the brace after 3 wk but brace remains locked for full 6 wk. Weight bearing is based on degree of valgus laxity. Some patients may need to be nonweight bearing for full 6 wk. If so, progressive weight bearing begins after week 6 and is progressed to full-weight bearing as tolerated. Brace is opened at this time if not done previously
- Strengthening is done throughout the 6-wk period in the form of quad sets, SLR, and electrical stimulation. Closed chain exercises are initiated at the appropriate time depending upon patient's weight bearing status
- Progressive ROM and strengthening are progressed until patient has full ROM and functional strength to begin running, proprioception, and agility drills as described with grade II injuries
- A functional brace is used for all sports for 6 to 12 months depending upon residual laxity

manipulation. If reflexive sympathetic dystrophy is the suspected cause of motion loss, continuous epidural analgesic may be helpful in breaking the cycle of pain and improving motion.²¹

Toe-touch weight bearing for grade III MCL injuries is usually allowed in those patients with neutral or varus anatomic alignment with the brace locked in full extension. Quadriceps exercises are encouraged and electrical stimulation can be a useful adjunct to retard muscle atrophy. The patient is also instructed in self-patella mobilization exercises. As stated above, by the end of 3 weeks, if physical examination reveals the presence of an end point with valgus force, the brace may be opened to permit ROM exercises in patients with neutral or varus alignment. In conjunction, weight bearing is progressed at grossly one-third of body weight, and progressed by one-third each week so that the patient is full weight bearing at the end of week 6. Again, extra precautions are recommended for patients with considerable valgus alignment and their brace remains locked in extension for the entire 6 weeks. In regards to weight bearing at the end of the third week, this decision is left to the surgeon and is often based upon physical examination and patient's pain level. If weight bearing is deferred for the entire 6 weeks, then the patient is progressed to full weight bearing as safely and rapidly as possible. After the end of 6 weeks, the patient is progressed through ROM and strengthening exercises as previously outlined in grade I and II injuries.

Often times, a short-leg brace is used to provide medial support during rehabilitation. Depending upon the patient's goals, sport participation, and risk of reinjury, a functional brace may be recommended. These braces are primarily designed for ACL injuries; however, they also provide medial and lateral support. There are numerous braces on the market, each citing specific

rationale for the particular design of their brace. The risks and benefits of bracing will be reviewed at the end of this chapter.

COMBINED ACL-MCL INJURIES

When an injury results in multiple ligament damage, additional steps must be taken to ensure that all structures are protected and given a chance to heal. The census in the literature seems to favor conservative management of the MCL and then surgical reconstruction of the ACL.²²⁻²⁴ Ma and associates²⁵ have shown that laxity in one of the structures has a direct effect on the other. The other concern with these combined injuries is the timing of the surgery. Shelbourne and associates²⁶ have demonstrated that early surgical intervention in acute ACL injuries resulted in poorer results in regards to ROM and function. It has also been shown that the severity of the MCL injury may contribute to the ultimate outcome of combined ACL-MCL injuries, when the MCL is treated conservatively.²⁷ The following rehabilitation program will describe the treatment of conservative management of the MCL, followed by reconstruction of the ACL.

As in isolated injuries of the MCL, the extent of the injury will determine the period of bracing and the progression of ROM, weight bearing, and strengthening exercises. For example, grade I MCL injuries combined with a complete tear of the ACL allows the surgeon to perform the ACL reconstruction as soon as the patient attains full ROM and functional strength. Conversely, a grade III MCL tear will require the full 6 weeks of bracing followed by restoration of ROM and strength as previously outlined, before considering ACL reconstruction. If, at the time of the ACL reconstruction the surgeon determines that the MCL has not healed sufficiently and the resultant valgus stability is unacceptable, a combined ACL-MCL reconstruction will likely be necessary. Assuming the MCL has healed, a standard ACL protocol is then followed. This includes immobilization for a period of 10 to 14 days and weight bearing as tolerated with crutches. Immediate ROM is permitted and the goal for flexion is to attain 90 degrees in 1 week. The patient also begins prone hangs immediately postoperatively to acquire full extension equal to the contralateral side. As weight bearing is progressed, the crutches are discontinued. This usually occurs within 3 to 7 days. The postoperative brace is discontinued once the patient has established sufficient quadriceps strength to exhibit a nonantalgic gait. Quadriceps strengthening is initiated immediately in the form of quad sets and SLR, with progression to closed chain exercises on the patient is full weight bearing. Active hamstring exercises are also initiated with the first postoperative week and are progressed to include resistance once the patient has attained flexion of 120 degrees or greater. Closed chain aerobic activities are used within the first 2 to 3 weeks postoperatively starting with stationary biking, and progressing to stair climbers, elliptical trainers, and/or

rowing machines. This progression is based on the patient's status and access to equipment. Proprioceptive training is also initiated once the patient is full weight bearing. At the end of postoperative month 3, straight-line jogging is permitted provided the patient has quadriceps strength equal to or greater than approximately 80% of the uninvolved side. Patients are progressed through functional training and sport-specific activities beginning at the end of the fourth postoperative month through the end of postoperative month 6. Return to unrestricted activity is permitted at that time provided the patient's strength and proprioception have been restored to a sufficient level. Some surgeons may recommend that the patient use a functional brace for running or they may defer bracing until the patient begins to engage in more demanding activities that require cutting, pivoting or twisting. Conversely, due to the lack of scientific studies that consistently demonstrate the efficacy of functional braces following ACL reconstruction, many surgeons do not use any type of bracing following surgery and the successful completion of a progressive rehabilitation program. The combined ACL-MCL treatment approach is detailed in Table 4.

COMBINED MCL-PCL INJURIES OR MULTIPLE-LIGAMENT INJURIES

PCL injuries are rarely isolated, often occurring in combination with other structures including the ACL,

TABLE 4. Rehabilitation of ACL-MCL Injuries

- Initial rehabilitation mirrors that of grade III MCL sprains for 6 wk
- After 6 wk and when ROM is full, ACL reconstruction is performed. If valgus laxity is found to be excessive a combined ACL-MCL reconstruction is performed
- If only ACL is reconstructed patient begins weight bearing as tolerated and a long-leg brace locked in extension is used for 10 to 14 d. ROM is permitted out of the brace during this time and quadriceps strengthening is initiated in the form of quad sets, SLR, and electrical stimulation (if necessary)
- The long-leg brace is discontinued by the end of post-operative week 2, and the patient proceeds with ACL rehabilitation as per surgeon preference
- ACL-MCL reconstruction protocol:
 1. Nonweight bearing for 6 wk and brace locked in extension for 3 wk. ROM is deferred but patella mobilization, quad sets, and SLR are encouraged
 2. Brace is unlocked after 3 wk to begin ROM as tolerated. Flexion goal of 90° to 120° is encouraged by end of postoperative week 6
 3. Partial weight bearing of approximately 25% of body weight is initiated at end of postoperative week 6 and progressed by 25% over the next 3 wk (full weight bearing by end of postoperative week 10)
 4. Functional brace is used at the end of postoperative week 10 and patient begins progressive ROM and strengthening program
 5. Proprioception drills/exercises are initiated when patient is full weight bearing
 6. Running is permitted between end of postoperative month 3 or 4 depending upon quadriceps strength, pain, swelling, and proprioception
 7. Return to sports is permitted at the end of postoperative month 6 if patient demonstrates strength, agility, and proprioception equal to uninvolved side

MCL, LCL, or capsular damage resulting in rotary instability. Subsequently, injuries involving the PCL rarely do well with conservative treatment. In addition, as multiple ligament injuries can be associated with knee dislocations, it is critical to rule out any type of vascular pathology before surgical reconstruction. The following section will outline a rehabilitation regimen following multiple ligament reconstruction.

Regardless of what additional structures are reconstructed or the patient's anatomic alignment, all patients maintain a strict nonweight bearing gait for 6 weeks. The patient is permitted to rest the foot of the involved side on the floor when at rest or during functional activities requiring prolonged standing. The patient is placed in a long-leg brace locked in full extension for the first 3 weeks. Quadriceps strengthening is encouraged in the form of quad sets, SLR (in the brace), and electrical stimulation. The patient is also instructed in patella mobilization as soon as the surgical wounds permit. For the majority of patients, the brace is unlocked and low-intensity passive (or assistive) ROM exercises are initiated at the end of postoperative week 3. The patient is advised to maintain neutral alignment of the lower extremity during these early ROM exercises. Nonweight bearing is maintained. At the end of the sixth postoperative week, partial-weight bearing is initiated at grossly 25% of body weight. Weight bearing is then increased by 25% body weight in a progressive fashion over the next 4 weeks so that full weight bearing occurs by the end of postoperative week 10. Concurrently, ROM is gradually progressed although active flexion exercises involving the hamstrings are avoided. Although flexion goals of 90 degrees by the end of the eighth week and 120 degrees at the end of 10 to 12 weeks are imposed, the patient is cautioned about aggressively forcing this motion. To facilitate ROM, a stationary bike is often used once the patient has attained 90 degrees of flexion. Prone hangs are also employed once the brace is opened as they are best done out of the brace. At the end of the tenth postoperative week, the long-leg brace is discontinued and the patient is placed in a combined instability functional brace. This allows the patient to proceed through a progressive ROM, strengthening and proprioceptive exercise program while the ligaments continue to heal and remodel. Once full weight bearing is achieved, closed chain exercises are initiated; however, they are restricted to a range of 60 to 0 degrees to minimize posterior tibial displacement. Strengthening is progressed and the patient is allowed to begin jogging between postoperative months 4 and 5. Isolated hamstring exercises without resistance are permitted at the end of postoperative month 5. Resistive hamstring exercises in conjunction with functional exercises and sport-specific drills are added to enable the patient to return to sports somewhere between postoperative months 7 and 8, provided strength and proprioception are comparable to the uninvolved side, and static stability has been restored to an acceptable level. The patient is encouraged to continue with the functional brace during high-risk

TABLE 5. Rehabilitation of Multiple Ligament Injuries Involving the MCL

- All patients remains nonweight bearing for the full 6 wk and use a long-leg brace locked in extension. Quad sets, SLR (in brace), and electrical stimulation can be initiated
- Brace may be opened at end of postoperative week 3 depending upon anatomic alignment, potential ROM complications and patient compliance. ROM is initiated slowly but is done out of the brace for those who remained locked in extension and no hamstring activity is permitted if the PCL is involved. The brace is opened at end of postoperative week 6 for all other patients
- Partial weight bearing of 25% body weight is permitted at the end of postoperative week 6 and progressed by 25% over the next 3 wk after. Patient continues to use long-leg brace but can remove it at night for sleep
- Patient is fitted with combined instability brace at the end of postoperative week 10 to begin progressive ROM and strengthening
- Rehabilitation proceeds at this point as outlined in ACL-MCL reconstruction with the following exceptions:
 1. With PCL involvement, active hamstring exercises are deferred until the end of postoperative month 4. Resistive hamstring exercises are deferred until the end of postoperative month 5
 2. The functional brace is recommended for all high-risk activities for 1 y (18 mo postoperative) after the patient resumes sports

activities until the eighteenth postoperative month to provide some protection until complete remodeling occurs. An overview of this program has been outlined in Table 5.

BRACING FOR THE MCL

The use of prophylactic and functional braces for protection of the MCL has been, and remains controversial. Anderson and associates²⁸ first reported on the use of a brace to prevent injury to the MCL. Early design consisted primarily of a single lateral hinge and gradually evolved into bilateral uprights with a polycentric hinge.²⁹ The efficacy of these braces to prevent injuries to the MCL was questioned over the next several years and in 1989, Montgomery and Koziris³⁰ reported that prophylactic bracing had not been proven to be useful in decreasing the number or severity of knee injuries citing the lack of reliable studies. This controversy spawned further studies over the next several years. Najibi and Albright³¹ provided an exceptional and thorough review of these studies, and several conclusions were drawn. First, the use of these braces was not found to increase the severity or frequency of injuries, as had been previously reported.³² In fact, there was credible evidence that braces might be effective in reducing the risk of MCL injuries in football. This conclusion was drawn from separate studies from West Point, and the Big Ten Football Conference. In addition, prophylactic braces were shown to provide 20% to 30% greater resistance to a lateral blow. Also, the so-called custom-fit braces were found to provide significantly more protection for the MCL and this occurred in positions of full extension and mild flexion. Conversely, there is some evidence that these braces may inhibit the athlete's forward sprint speed and cause early muscle fatigue.^{33,34} In this day of exorbitant

contracts and the economic impact of professional and collegiate sports, it is easy to see why there seems to be a movement for the use of functional braces, especially by football linemen. Further studies are needed to provide precise and definitive advantages of prophylactic bracing.

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