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Minimal Invasive Acute Medial Collateral Ligament Stabilization with Partial Anterior Cruciate Ligament Deficiency

Preliminary Results of 16-Patients Case Series and Review of the Literature

Mahmut Nedim DORAL [1,2], Defne KAYA [2], Gazi HURİ [3], Egemen TURHAN[4], Gürhan DÖNMEZ [2], Onur BİLGE [5], Akin ÜZÜMCÜGİL [1], Özgür Ahmet ATAY [1] and John NYLAND [6]

[1]Hacettepe University, School of Medicine, Dept. of Orthopedics & Traumatology

[2] Hacettepe University,School of Medicine, Dept. of Sports Medicine

[3]Cukurova University, School of Medicine, Dept. of Orthopedics & Traumatology

[4]Zonguldak Karaelmas University, School of Medicine, Dept. of Orthopedics & Traumatology

[5]Selcuk University, School of Medicine, Dept. of Orthopedics & Traumatology

[6]University of Louisville School of Medicine, Dept. of Orthopaedic Surgery, Division of Sports Medicine

Corresponding Author: Mahmut Nedim DORAL
Address: Hacettepe University School of Medicine, Head of Dept. of Orthopedics & Traumatology, Head of Sports Medicine, Sıhhiye, 06100, Ankara, Turkey
e-mail: ndoral@hacettepe.edu.tr

Abstract

Medial collateral ligament (MCL) can be frequently damaged with ACL injuries, especially during external rotation, slight flexion and valgus loading of the knee. Inpatients combined ACL (partially ruptured) and MCL injuries, percutaneous MCL reefing by using PDS suture material, shrinkage with radiofrequency and regularization of the ACL was performed. The aim of this study was to describe the functional and clinical results of the 16-patients with combined partial ACL rupture and MCL injury who were treated by percutaneous MCL reefing. The functional level was evaluated using hop test, IKDC, Lysholm, Tenger, KOS-ADLS scores. Hamstring and Quadriceps isokinetic muscle strength were collected at 60 -/sc and 180 -/sec velocities. There were no differences in muscle strength, hop test between the affected and unaffected sides. Scores for the functional level were near the high score. Likert scale for satisfaction of the treatment was 5. Acute reinforcement of MCL in association to regularization of ACL is safe and reliable, reduce stress on the repaired ligaments and provide us more stable and strength knees.

Keywords: Medial collateral ligament, injury, reefing. partial, anterior cruciate ligament, rupture,

1. Introduction

Anterior cruciate ligament (ACL) consists of anteromedial and posterolateral bundles, and in the presence of rupture of one of these bundles, knee instability may occur. Partial tears of the ACL are common, representing 10% to 28% of all ACL tears. It should be treated immediately to prevent complete rupture in up to 42% of cases [5, 7]. Frequently concomitant medial collateral ligament (MCL) injury may also be detected with ACL ruptures as a result of excessive valgus stress and external rotation (15° flexion, 10°tibial external rotation, 20° valgus). Fetto and Marshall reported associated injury rates (eg, ligaments, menisci) as high as 78% in grade III MCL sprains[12].The incidence of combined ACL–MCL tears was reported up to 20% of all knee ligament injuries[19].

Anterior cruciate ligament is crucial for the stabilization of the knee joint but not the unique one. MCL reinforces the medial joint capsule, and it is the primary restraint to valgus stress. ACL and MCL prevent anteromedial displacement of the knee and limit valgus opening of the joint. Previous studies concluded that an isolated, partial ACL ruptured knees have an acceptable function after long-time follow-up, however concomitant collateral ligament tear lead to instability and further deterioration of knee function[14]. Valgus force necessary to create a complete MCL injury may also causes rupture of ACL [2]. And it is crucial to repair MCL simultaneously with ACL tear, to restore stability, decrease degeneration, and return patients to previous activity level. To our opinion, MCL evaluation is frequently neglected during ACL repairs. In this study, percutaneous MCL reefing (plication) by using PDS suture and regularization of ACL by shrinkage with radiofrequencywas performed to the patients with both MCL and partial ACL injuries.

To our knowledge, there is no previous report about clinical and functional outcomes of patients with acute ACL injuries treated by MCL reefing. The purpose of this prospective study was to analyze, symptoms (laxity, pain etc.), muscle strength of the Quadriceps and Hamstrings, functional level of the lower extremity, and satisfaction of the treatment in patients with acute MCL reefing.

2. Methods

2.1. Design: This is a prospective study with each subject acting as their own internal control by using the unaffected limb.

2.2. Subjects: Between January 2007 and May 2012, 23 partial ACL ruptured knees with grade II-III MCL injury were included to the study. After the diagnosis was made both clinically and radiologically (stress radiography and/or magnetic resonance imaging) arthroscopic approach was performed. Patients with chondral lesion at medial femoral condyle or complex ligamentous injuries, such as combined posterior cruciate ligament injury or posterolateral injury, revisions and patients under 18 years were excluded for the study. According to inclusion criteria, 16 male patients were participated in the study.32 knees were divided into two groups. First group consisted of the unaffected knees and was used as the control group to which no surgical procedure was applied. Second group involved the knees to which percutaneous MCL reefing (plication) and regularization of ACL by shrinkage was performed. In 6th month follow-up, all the assessments, which are described below, were done bilaterally.

Patients were informed about aims of the study and the testing procedure prior to their participation. Written informed consent was obtained.

2.3. Assessment: Pivot shift, anterior drawer, and valgus stress tests were applied to control the laxity of the ligaments. An 11-point numeric rating scale (0 to 10) was used to assess pain in 1 cm intervals, anchored on the left with the phrase "No Pain" and on the right "Worst Imaginable Pain”. Patients rated their worst level of pain during squat, stairs activity, sportive activity and rest. The IKDC Knee Examination Form, Lysholm Knee Scale, Tegner Activity Level Scale, KOS-ADSL were used for knee scales. Functional level was evaluated with Single-leg hop test. Quadriceps and hamstring muscle strength were assessed by using Biodex® Pro 3 at 60°/s and 180°/s. Likert scale and percentage were used to assess the satisfaction of the patients (surgery and rehabilitation).

2.4. Surgery technique: Prior to surgical procedure, ligamentous examination (pivot shift test, Lachman test, anterior drawer test, varus/valgus stress tests) was evaluated under general anesthesia in supine position. Arthroscopy was performed through the standard anteromedial and anterolateral portals by senior surgeon (M.N.D). Both anteromedial and posterolateral bundles of the ACL were evaluated precisely. Shrinkage with radiofrequency and regularization was applied if one of these bundles are ruptured (teared) or elongated. Percutaneous reefing and augmentation of MCL with bioabsorbable #2 PDS (Ethibond) suture was (Storz, Gentek Medical) applied from distal femur over adductor tubercle to proximal part of the tibia. At the end of the operation platelet riched plasma(PRP) was injected to injured ligaments (ACL and MCL). Patients were discharged with rigid hinged knee brace. To gain early full range of motion (ROM) and full weight bearing, post-operative physiotherapy program was started immediately.

2.5. Statistical Analysis: All data were analysed with the Statistical Package for the Social Sciences version 14.0. The paired sample t tests were used to investigate differences between affected and unaffected sides. Statistical significance was set at $\alpha = 0.05$.

3. Results

The mean age of the patients was 30.00±6.18 years, height was 180.31 ± 8.65 cm, and weight was 88.00 ± 21.84 kg.

3.1.Laxity: There were no sign for laxity at 6th month after the surgery. Pivot shift, anterior drawer and valgus stress tests were all normal.

3.2. Pain: There were not recorded any pain during stairs, squatting, and rest for all patients. Three patients gave 1-pointwhile one patient gave 2-point for pain during the sports.

3.3. Functional Level: HopTest: There were no significantly differences in the hop tests between affected and unaffected sides (See Table 1). **Scales: IKDC:** Six patients were recorded as a normal while 10 patients were recorded as nearly normal. **Lysholm Knee Scale (Max points:100):** Seven patients notified as 100 points, scores of the others were 95 points. **Tegner Score:** Means and standard deviation of the Tegner score of the patients were 6.94±1.29 at pre-injury, while was 5.31 ±1.19 at 6th month after the surgery. **KOS-ADLS (Max: 70) (Level of the daily living activity):** Means and standard deviation of the KOS-ADSL were recorded as a 69.38 ± 0.96.

3.4. Muscle Strength: There were no significantly differences in the peak torque of the M. Quadriceps Femoris and M.Hamstrings at 60º/s between affected and unaffected sides. There were no significantly differences in the peak torque of the M. Quadriceps Femoris and M.Hamstrings at 180º/s between affected and unaffected sides (See Table 1).

3.5. Satisfaction: Likert scale: 5-point was given for the treatment by all patients (5: very good). Means and standard deviation of **percentage for satisfaction** was recorded as 85.63 ± 10.31.

4. Discussion

The clinical and functional outcomes of open surgical repairs and reconstructions of MCLinjuries are well discussed in the literature. However there is lack of information about percutaneous treatment. To our knowledge this is the first study, which describes the outcomes of partial ACL ruptures with concomitant MCL injuries treated by percutaneous MCL reefing and shrinkage. The symptoms (laxity, pain etc.) and satisfaction of the patients, difference of functional level and the strength of quadriceps and hamstrings, between the two groups were evaluated. In both groups, pivot shift, anterior drawer and valgus stress tests were all normal. There was no pain during the daily living activities. In addition to, there were no significantly differences in muscle strength and hop tests between the two groups. The scores for functional level were nearly same.

Complex knee ligament injuries are characterized by simultaneous rupture of the anterior cruciate ligament and/or the posterior cruciate ligament and at least one collateral ligament. These complex injuries require careful assessment and a systematic approach to evaluation and treatment[10]. Since concomitant ACL and MCL injuries may cause anteromedial instability of the knee, also lead to gross deterioration of both menisci or articular cartilage, these type of injuries should be treated and the medial compartment kinematic and anatomy should be restored [20].

Many kinds of researches and clinical studies have been designed about isolated ACL injuries and isolated MCL injuries. Fritschy et al. followed with a rehabilitation protocol of 43 patients who were diagnosed arthroscopically as suffering from a partial rupture of the ACL and they reported 25 patients had a stable knee after 5 years, whereas 18 eventually suffered a complete ACL rupture[5]. Thermal modification of partial tears of native ACL has been reported as another viable treatment option in selected patients[7]. Recent studies suggest that intra-articular bone marrow transplantation using fresh whole bone marrow cells may be an effective treatment for ACL partial rupture[16]. On the other hand some authors suggested surgical treatment modalities for partial ACL tears, while the intact bundle could be preserved. Buda et al. approached partial ACL tear augmentation with quadrupled distally inserted hamstrings and over-the-top fixation, while preserving the intact ACL bundle[25]. Sonnery-Cottet et al. reconstructed anteromedial bundle by using an outside-in technique with quadrupled hamstring tendon graft and doubled semitendinosus graft[3].

It’s clear that ligament healing depends on a variety of factors, including anatomic location, presence of associated injuries, and selected treatment modality[27,33].Previous animal studies have proved superior healing capacity of MCL plenty of times[17, 26, 27,28, 33].Bray et al. studied to explain high healing capacity of MCL and they stated that differences in healing properties of the ACL and MCL reflect their vascular responses to joint injury[28]. We know that all phases of ligament healing require an adequate blood supply after ligament damage and so Bray et al. investigated standardized blood flow and vascular volume of both ACL and MCL after direct injury of these ligaments. Results showed increased weight after PCL transection on both MCL and ACL and the lack of a long-term vascular response in the ACL, whereas good long-term vascular response in MCL[28].In another animal study in a rabbit model, the application of porcine small intestine submucosa to the healing MCL resulted in improved mechanical properties with the formation of larger collagen fibrils[26].But trials of treating MCL injuries with gene therapy, growth factors, and small intestine submucosa are in their infancy and may hold promise with regard to restoring the biomechanical properties of the native ligament[29].Since MCL has high healing capacity and isolated injury to the MCL usually heals spontaneously, most isolated MCL injuries are treated nonsurgically even grade III sprains [29].Surgical treatment is considered when the patient, particularly an elite athlete, notes persistent valgus laxity that compromises athletic function[29].

Despite numerous experimental and clinical studies have been designed, treatment of combined ACL and MCL injuries remains controversial. The treatment options for such an injury include surgical restoration of both ACL and MCL, surgical reconstruction of the ACL alone, surgical repair of the medial complex, or nonsurgical treatment of both the ACL and medial structures. Jokl et al. was a proponent of nonoperative treatment of both ligament structures [23]. Likewise, two clinical studies proposed bracing and physiotherapy[10].Recent studies, however, have shown that the MCL injury need not be surgically repaired in a knee with a combined ACL/MCL injury when the ACL is reconstructed with a tendon graft [11, 32, 33,34].In the early 1990s, Shelbourne and Porter reported that solitary repair of the ACL can result in excellent stability and good to excellent functional outcome in their series of 68 patients with combined ACL and MCL injury[32]. Halinen et al. compared surgical and conservative management of MCL with ACL was early reconstructed and they did not report any significant differences between the groups with regard to knee function, stability, ROM, strength, and return to activity[11].It was proposed that acute repair of collateral ligament injuries is possible only in the first 2 or 3 weeks after trauma [11]whereas the complications occur more frequently when the operation has been performed early [34].Slocum et al. claimed that in three months or more after the acute injury the ligaments have lost their healing potential and the anatomic restoration [6].

In contrast with this point of view some authors treated only MCL surgically in combined injuries[18]. Shirakura et al. evaluated the associated injuries with torn ACL and their results revealed that patients with repaired MCL tears (while no surgical procedure was done on the torn ACL) showed significantly higher functional scores than those of the patients with unrepaired MCL ruptures[18].

Similarly, Ohno et al. compared reconstruction of the ACL with and without repair of the MCL in a rabbit model of a combined injury of these two ligaments

[17]. They found that repair of the MCL lead to significantly less varus-valgus rotation of the knee than did no repair, but the anterior-posterior translation of the knees in the repair and non-repair groups were not significantly different at any study time. Nevertheless, Hara et al. compared 53 patients undergoing medial hamstring ACL reconstruction and conservative management for grade-2 valgus laxity with a group of 289 patients who underwent ACL reconstruction for isolated ACL tear without valgus laxity and they did not report statistically significant difference between two groups on clinical outcomes[15].

Although it has been widely accepted that an isolated injury of the MCL will heal satisfactorily without surgical treatment, many authors believe that a combined injury is best treated with operative intervention and simultaneous repair of all damaged structures[2,17].These reports claimed that repair of the MCL with reconstruction of the ACL may ensure better healing of the MCL than will reconstruction of the ACL alone. Gorin et al. described a case report involving a tear of the ACL and MCL in a skeletally immature athlete[30]. They repaired the ACL with an allograft posterior tibialis tendon through intra-articular tunnels. A trial of conservative therapy for the MCL was performed. No improvement was seen in stability, so a primary repair of the MCL was performed and augmented with an autograft gracilis tendon. The patient did well postoperatively, subsequently achieving equal stability and range of motion when compared with the opposite limb after MCL repair[30]. Frölke et al. suggested immediate arthroscopically guided repair of the MCL and reconstruction of the ACL seems safe and effective when conservative treatment has failed[13].Sun et al. proposed ACL reconstruction with autograft of the bone-patellar tendon-bone and transposition of semitendinosus tendon combined with femur insertion of MCL proximal transfer is a reliable treatment method for MCL laxity complicated by old ACL injury of the knee[24]. Osti et al. proposed surgical repair of the MCL in association with contralateral hamstring tendon ACL reconstruction as a suitable and reliable option to restore knee stability and allow return to pre-injury activity level in selected athletes with chronic symptomatic valgus laxity of the knee combined with ACL insufficiency [21].On the other hand, Schmid was reported the results of 112 extra-articular *Lemaire ligamento-plasties* performed on the knee which includes isolated tears of the ACL and MCL as well as combined tears of both ligaments. Head vocated that the operation for a torn ACL should be performed as soon as possible to avoid secondary meniscal lesions with subsequent severe osteoarthritis and to reduce stress on reconstructed ACL[9].

There are several experimental studies that explain the reason and support the repair of these two ligaments at the same time[1, 2,17,22].Shapiro et al. by in vivo study [22]and Ma et al. by in vitro study[4] reported that valgus laxity due to MCL injury increased the load on the ACL. Ma et al. designed a study to examine the mechanical interaction between the ACL graft and the MCL in a goat model and their findings show that ACL deficiency can increase the in situ forces in the MCL while ACL reconstruction can reduce the in situ forces in the MCL in response to an anterior tibial load[4]. On the other hand, the ACL graft is subjected to significantly higher in situ forces with MCL deficiency during an applied valgus moment [1]. Therefore, the ACL-reconstructed knee with a combined ACL and MCL injury should be protected from high valgus moments during early healing to avoid excessive loading on the graft[4]. Mazzocca et al. showed that average ACL strength in MCL ruptured knees was statistically lower than that for control knees[2].However, findings of Zaffagnini et al. suggested that residual laxities remained when ACL reconstruction was performed in patients with combined ACL+MCL lesion [31].

Although nonsurgical management of isolated MCL injuries remains the preferred treatment in most cases, controversy exists regarding the ideal treatment when there is concomitant damage to the ACL[29].We treat the medial instabilities accompanying partial ACL tears with considering other medial stabilizers of knee joint and perform ACL shrinkage and percutaneous MCL reefing. Treatment of these types of injuries should be individualized according to the patient's age, occupation, sports activity level, and other knee-related pathologies. New techniques utilizing growth factors and cell and gene therapies may offer the potential to enhance the quality of healing of knee ligaments[33].The use of growth factors (PRP injections) also seems promising to improve tissue healing response[8].Early physiotherapy and appropriate rehabilitation protocols are crucial for restoring the proprioception of the knee and improving outcomes. As a result of our clinical evaluations, the majority of the cases demonstrated stable healing of the MCL and ACL and good or excellent knee functions and muscle strength. Preliminary results provide satisfying clinical outcomes but limited number of patients was weakness of our study. Moreover, for better comparisons we need randomized controlled trials.

The limitation of our study was that, although we had opportunity to compare with the asymptomatic side, we were not able to assess on an age matched healthy population.

5. Conclusion

Many surgeons usually focus on just ACL and it seems MCL is neglected probably because of its high healing capacity. But ACL is not a unique ligament plays role as a functional stabilizer of the knee and surgeon must also keep in mind the MCL and its role in medial stability. Mismanaged or misdiagnosed MCL tears may cause chronic symptomatic valgus instability after ACL surgery. Therefore, we believe that ACL reconstruction is not sufficient alone in presence of combined anteromedial laxities. Acute reinforcement of MCL in association to regularization of ACL is safe and reliable, reduce stress on the repaired ligaments and provide us more stable knees.

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Table1. Differences in peak torque, volume and cross-sectional area of Quadriceps Femoris muscle between affected side and unaffected side of PFPS patients.

			Affected side (n=16)	Unaffected side (n=16)	
			Mean±SD	**Mean±SD**	**p***
Peak torque	**M. Quadriceps Femoris**	**60º/s**	115.00±32.79	131.19±52.21	0.26
		180º/s	82.31±34.59	95.31±55.65	0.12
	M. Hamstrings	**60º/s**	98.63±32.79	96.69±37.94	0.71
		180º/s	79.38±22.35	79.63±22.89	0.93
Hop test (cm)			128.06±22.32	131.69±23.59	0.23

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