Research Article

Pattern in Simultaneous Rupture of the Medial Collateral Ligament and Anterior Cruciate Ligament Assessed by Magnetic Resonance Imaging

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Abstract

Background: Determining the exact details of complex traumatic injuries such as knee ligament rupture will be a crucial point in planning the surgical approach, which is determined through accurate imaging techniques such as magnetic resonance imaging (MRI). We aimed to evaluate the pattern of medial collateral ligament (MCL) rupture in patients who presented with simultaneous rupture of the anterior cruciate ligament (ACL) and MCL.
Methods: We evaluated knee MRI in 44 patients (25 women and 19 men, mean age: 38.6 ± 5.4 years) who suffered from clinically acute simultaneous ACL and MCL injuries. Meniscus status, MCL rupture patterns, and pivot bone bruise were analyzed.
Results: Concerning ACL rupture, 38.6% had a partial ACL rupture, and 61.4% had a complete rupture. The meniscus ruptured in 61.4%. The most common site of the meniscus rupture was related to the medial posterior horn (37.0%). The vertical type rupture was the most common (37.0%), followed by the horizontal rupture (29.6%). MCL rupture was present in all patients with grade 2 rupture revealed in 52.3%. Regarding the location of MCL ligament rupture, the highest ratio was found in the femoral site (65.9%). Semimembranosus rupture was observed in 2.3%. Pivot bone bruise was positive in 34.1%. Medial patellofemoral ligament (MPFL) rupture was also revealed in 68.2%. There was a significant relationship between the grade of rupture in the MCL and the presence of pivot bone bruise ($P < 0.001$).
Conclusion: Femoral detachment of MCL and posterior horn of medial meniscus (PHMM) are the most common sites of MCL injury and meniscus rupture in the context of ACL rupture. Besides, our results show a relevant influence of the extent of bone bruise on the grade of MCL rupture.

Keywords: Anterior Cruciate Ligament; Bone; Medial Collateral Ligament; Magnetic Resonance Imaging; Posterior Horn; Medial Meniscus

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Background

Rotatory knee instability, known as a critical contributor to patient morbidity, was presented in 1870 by French surgeon Paul Segond (1). Aside from cruciate ligament tears, it embraces various surrounding soft tissue injuries (2-7). Anterolateral rotational instability (ALRI) has been the primary focus of concerns over the last decade; nevertheless, anteromedial rotatory instability (AMRI) has been on the investigational sidelines, and it is inconceivable due to several reasons. First of all, injuries sustained by both the anterior cruciate ligament (ACL) and the medial collateral ligament (MCL) entail the most prevalent two ligament injuries of the knee (8). Second, one can assume that the majority of MCL injuries are accepted for conservative treatment (9). And last but not least, ACL-revision risk is higher with non-surgical treatment of a concurrent MCL injury in the context of an ACL reconstruction (10, 11).

Recent studies elaborate on the significance of the MCL complex concerning an ACL injury in which deep MCL (dMCL) failure will result in higher external rotation laxity and AMRI, since it carries out a crucial function in keeping the knee stable in rotation (12-14).

It is clarified that according to an injury leading to ACL deficiency, simultaneous intra- and extra-articular injuries have occurred (15-17). In terms of precision, magnetic resonance imaging (MRI) is similar to diagnostic arthroscopy, and also allows the internal structures of the knee to be evaluated (18). Although a high occurrence of MCL injuries in isolated ACL ruptures was reported (9) and the impact of MRI on ALRI has been evaluated in detail (19-22), the studies that assessed the medial side injuries are insufficient.

The purpose of this investigation was to look into the pattern of MCL ruptures, as it is assumed that an actually isolated ACL rupture is a sporadic event, and injuries to the MCL complex occur in most cases.

Methods

Following ethical approval granted by the Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.MSP.REC.1399.637), we evaluated knee MRI in 97 patients who suffered from clinically acute ACL rupture injuries between 2019 and 2021. Among them, 44 patients (25 women and 19 men, mean age: 38.6 ± 5.4 years, range: 21 to 64 years) with ACL and MCL rupture were included in our study whether the MCL was treated operatively or not. All patients were examined under anesthesia by the senior author, a knee and sports injury specialist, by a thorough ligamentous examination, including anterior and posterior drawer tests, Lachman test, the pivot shift test, and the valgus and the varus stress tests.

Pre-operative MRI was performed within the three weeks of injury using a 1.5T scanner (Sigma LX 1.5T, GE Medical Systems, Milwaukee, WI) or a 0.23T open scanner (Outlook GP, Picker Nordstar, Helsinki, Finland), with routine clinical sequences and knee coils. For 0.23T (N 33), the usual protocol includes coronal images [repetition time (TR): 1000 milliseconds (ms), echo time (TE): 16 ms, inversion time (TI): 90 ms], T1 spin echo (SE) (TR: 380 ms, TE: 25 ms) images, axial T2 fast SE (FSE) (TR: 1900 ms, TE: 80 ms), and SE sagittal images (TR: 2400, TE: 22/80), supplemented with T2 SE coronal images (TR: 1600 ms, TE: 81 ms) if required. Images were typically obtained with the DE sequence (TR: 2340 ms, TE: 20/90 ms) or the proton density (PD) SE sequence (TR: 1800-2700 ms, TE: 20 ms). T2 FSE coronal images (TR: 3500-5200 ms, TE: 96 ms) were obtained if necessary. The recorded findings included ligament structures, meniscus rupture, cartilage damage, and bone lesions reported by a radiology specialist in our center with musculoskeletal experience. The MCL injuries were categorized according to Rasenberg et al. (23) as follows:

"Grade I: peri-ligamentous swelling with minor tearing of superficial MCL (sMCL) fibers without complete disruption, grade II: complete disruption of the superficial layer, and grade III: as grade II plus additional fluid extravasation from the joint into peri-ligamentous tissue." MCL injury locations are categorized as femoral insertion, intra-ligamentous or mid-substance, tibial insertion, and multiple (rupture in more than one location).

SPSS software (version 23.0, IBM Corporation, Armonk, NY, USA) was used for the statistical analysis. Results were shown as mean ± standard deviation (SD) for quantitative variables and extracted by frequency (percentage) for categorical variables. The categorical variables were compared using the chi-square test. A P-value less than 0.05 was defined as statistically significant.

Results

In the first stage, the frequency of each type of ACL rupture was evaluated. Among 44 patients with complete data, 38.6% had a partial ACL rupture, and 61.4% had a complete rupture.

In addition, the meniscus was normal in 38.6% and ruptured in 61.4%. As shown in table 1, the most common site of meniscus rupture was related to the posterior horn of medial meniscus (PHMM) (37.0%), followed by the medial meniscus bucket handle (29.6%). The vertical type rupture was the most common (48.1%), followed by the horizontal rupture (33.3%) concerning the type of injury.

Table 1. Meniscus status

Meniscus		Frequency (%)
Meniscus status	Intact	17 (39.0)
	Torn	27 (61.0)
Site of meniscus ruptures	Posterior horn of medial	10 (37.0)
	Medial bucket handle	8 (29.6)
	Posterior horn of lateral	6 (22.3)
	Multiple	2 (7.4)
	Lateral bucket handle	1 (3.7)
Type of meniscus ruptures	Vertical	13 (48.2)
	Horizontal	9 (33.3)
	Complex	5 (18.5)

Similar to ACL, MCL rupture was present in all patients which type 2 MCL tear was revealed in 52.3%, type 3 in 31.8%, and type 1 in 15.9%. Regarding the location of MCL ligament rupture, the highest proportion was found in the femoral in 65.9%, and the lowest proportion was related to the multiple type in 2.3% (Table 2).

Table 2. Medial collateral ligament (MCL) status

MCL		Frequency (%)
MCL status	Intact	0 (0)
	Torn	44 (100)
Side of MCL ruptures	Femoral	29 (65.9)
	Tibial	10 (22.7)
	Mid substance	4 (9.1)
	Multiple	1 (2.3)
Type of MCL ruptures	I	7 (15.9)
	II	23 (52.3)
	III	14 (31.8)

MCL: Medial collateral ligament

Semimembranosus rupture was observed in only 1 of 44 patients (2.3%). On the other hand, pivot bone bruise was positive in 15 patients (34.1%). Medial patellofemoral ligament (MPFL) rupture was also revealed in 30 patients (68.2%). In one case, out of 44 patients, there was edema in the posteromedial area (2.3%).

In the final, we investigated the relationship between the grade of rupture in the MCL and the presence of pivot bone bruise that indicated a significant association [χ^2 (1, n = 44) = 8.33, P < 0.001].

Discussion

Our results in this investigation showed that the highest ratio of rupture in the ACL ligament was specified to complete type and in the MCL ligament to grade 2. In 61.4% of cases, meniscus rupture co-occurred, and the highest ratio of rupture was related to the PHMM and in vertical shape. The most prevalent type of MCL rupture was the femoral type. Our results also demonstrated apparent relevancy between the high grade of MCL rupture and the presence of pivot bone bruise.

Pivot bone bruise is a good indication of the injury mechanism (24-28), and several mechanisms have been suggested for knee joint ligament injury. Ten different mechanisms of knee ligament injury may be present in light of the knee posture, force orientation, and the attendance of a rotating parameter (26). Among these types, valgus flexion and external rotation, further known as the pivot shift mechanism, are about 50% accompanied by cruciate ligament injuries.

The concomitance of excessive valgus and external rotation could result in AMRI, which is defined as an injury to the ACL and the medial compartment, specially MCL and posteromedial corner (PMC) which includes the PHMM, posterior oblique ligament (POL), semimembranosus expansions, meniscotibial ligaments, and oblique popliteal ligament (OPL) (3, 9).

An absolute valgus force usually impairs the sMCL to diverse degrees. With the addition of a rotational force, ACL and PMC abscission also takes place, and with extended valgus force, the ACL may also rupture after an MCL tear (28).

It is clarified that the pattern and size of the bone bruise may be relevant to the simultaneous intra- and extra-articular findings and the mechanism of injury (29). Viskontas et al. explained that the non-contact mechanism of injuries demanded a higher energy load, and the medial compartment was more involved (30). However, song et al. noted that acute ACL rupture during a non-contact mechanism involved the lateral compartment, and the lateral plateau was the most involved site (31). other studies have declared similar patterns (17, 32). As the impact of energy increased, the bone bruise progressed from the lateral compartment to the medial, so that the lateral compartment bone bruise could suggest lateral menisci injury; still, both compartment involvement is associated with collateral injuries in addition to the lateral meniscus injuries. Not only the pattern of a bone bruise but also the extent of the bone bruise is relevant to collateral injuries. In 2018, Aravindh et al. showed that diffuse bone bruises (more than two sites out of four) might increase the occurrence of MCL injuries (29).

The ACL is the main obstacle against anterior tibial translation and the second hurdle to valgus forces during extension. The sMCL stabilizes the knee to valgus and external rotation forces throughout knee range of motion (ROM). The POL and PMC provide stability to the valgus and internal rotation in extension and the first 30 degrees of knee flexion (33, 34). The semimembranosus offers dynamic stability to the knee during flexion by tensioning the capsular attachments and POL (28). Additionally, PHMM acts as a restraint to external rotation (35).

Former studies have shown that the frequency of medial meniscus rupture grows as time passes from an ACL injury. In contrast, the prevalence of lateral meniscus rupture is relatively constant over time (36-38). It is shown that medial meniscus tears are more prevalent in patients with chronic ACL injuries than lateral meniscus tears. However, this is not clear which medial or lateral meniscus tears are more common in patients with acute ACL injury (39).

Studies have shown that frequency of MCL injury in acute cases of ACL rupture is between 24% and 44%, as well as other intra- and extra-articular structures (36, 40). Surprisingly, Willinger et al. showed even more co-occurrence, which was 67% (9). A scenario is acknowledged by the authors of the current study that some knees, when examined after ACL graft fixation, despite no residual ACL laxity, a negative pivot shift, and no residual valgus laxity, may have some abnormal anteromedial tibial laxity. When this occurs, pre-operative recognition of MCL (specifically dMCL) abnormality is beneficial, as it will allow us to take a much closer clinical evaluation to seek occult AMRI. Hopefully, fewer of these situations that jeopardize ACL reconstruction will go unnoticed. Being aware of these circumstances enables us to look for them on MRI and during arthroscopic surgery (15-17, 32, 41, 42).

The most critical limitation of this investigation was the MRI-based study which a correlation with clinical and arthroscopic findings was not made.

Conclusion

The most important findings of our study were: first, the most common type of MCL injury among those who underwent surgical treatment diagnosed with ACL and MCL injury was grade 2 and femoral attachment rupture. Second, there was 68.2% ruptured MPFL among our patients.

Femoral detachment of the MCL and PHMM were the most common sites of MCL injury and meniscus rupture in the context of ACL rupture. Besides, our results show a relevant influence of the extent of bone bruise on the grade of MCL rupture.

Conflict of Interest

The authors declare no conflict of interest in this study.

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