

## ORIGINAL RESEARCH

# Point-Of-Care Ultrasonography for Diagnosis of Medial Collateral Ligament Tears in Acute Knee Trauma; a Diagnostic Accuracy Study

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**Abstract:** **Introduction:** The use of point-of-care ultrasonography (POCUS) for identifying medial collateral ligament (MCL) tears has increased in recent years. This study aimed to evaluate the diagnostic accuracy of POCUS in the diagnosis of acute MCL tears of the knee. **Methods:** This prospective cross-sectional study was performed on patients with suspected MCL tear of the knee in the emergency department (ED). After history taking and primary physical examination, radiographic imaging of the knee was done. If there was no fracture in the knee X-ray, the POCUS examination was done. All of the patients were asked to refer to an orthopedic clinic, 7-10 days after discharge from ED, for Magnetic Resonance Imaging (MRI) evaluation. The second POCUS was done in the orthopedic clinic. Finally, the findings of POCUS and MRI were compared in diagnosing MCL injury. **Results:** Two hundred and fifty patients with a mean age of  $25.05 \pm 9.12$  years were analyzed (86.8% male). According to the MRI findings, as the gold standard, 55(22.0%) patients had MCL injury. The sensitivity, specificity, positive and negative predictive values (PPV and NPV), and accuracy of ultrasound in detection of MCL injury, in comparison with MRI were 83.64 (95% CI, 71.20 to 92.23), 94.36% (95% CI, 90.13 to 97.15), 80.70% (95% CI, 69.95 to 88.25), 95.34% (95% CI, 91.83 to 97.38), and 92.00% (95% CI, 87.92 to 95.05), respectively. The area under the receiver operating characteristic (ROC) curve of POCUS was 0.890 (95% CI, 0.844 to 0.926). **Conclusion:** It seems that POCUS can be applied in screening patients with MCL tears following blunt knee trauma.

**Keywords:** Medial Collateral Ligament, Knee; Ultrasonography; Magnetic Resonance Imaging; Emergency Service, Hospital

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## 1. Introduction

The medial collateral ligament (MCL) is one of the four major ligaments of the knee (1). It extends from the medial femoral epicondyle to the medial tibial condyle and medial surface of its body (2). The superficial MCL is the most commonly damaged ligament of the knee after direct knee trauma and is mostly caused by valgus stress (3).

An MCL injury is a sprain or tear to the medial collateral ligament (4). It is usually diagnosed through physical examination of the knee (5). But initial pain and swelling sometimes make it very difficult to judge the severity of the

injury; therefore, it is important to use an imaging modality to confirm the diagnosis (6, 7). Early and accurate diagnosis of MCL injury is very important for determining the suitable treatment to return to function in a short time (4, 8).

MRI has been considered as the non-invasive diagnostic gold standard modality, but it is costly, not available in all centers, and needs long waiting periods (5, 9). Also, MRI has major limitations and cannot be used for those with metal implants, indwelling cardiac pacemakers, and claustrophobia (10, 11).

Recent studies showed that point-of-care ultrasound (POCUS) is an alternative, portable, non-invasive, and real-time imaging modality for evaluating the soft tissue pathology of the knee (9, 10, 12-14). POCUS is easier to access, has lower costs, and is quicker than MRI for diagnosis of MCL tear (3, 5). Therefore, the use of POCUS for identifying MCL tears has increased in recent years. This study aimed to assess the accuracy of POCUS in diagnosis of MCL tears in

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comparison with MRI, as the gold standard reference.

## 2. Methods

### 2.1. Study design and setting

This prospective cross-sectional study was conducted between 2020 and 2021 in the emergency department (ED) of Kashani Hospital, Isfahan, Iran. The study received ethics approval from the ethics committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1397.091). All patients were included after obtaining written informed consent. Researchers adhered to ethical principles of declaration of Helsinki and confidentiality of patients' information.

### 2.2. Participants

All patients with acute knee injuries and suspected acute MCL injury following blunt trauma based on clinical examination findings were included in the study. Suspected acute MCL injury has been defined as medial knee pain, tenderness, and swelling following acute blunt knee trauma (trauma in the last 3 days). Using convenience sampling, patients were enrolled 24 hours a day during all days of the week.

Patients younger than 18 years, those with multiple trauma, unstable hemodynamics, loss of consciousness, history of a previous MCL tear or previous injury on the injury site, diagnosis of a fracture in the knee, and contraindications to MRI, and those who declined to participate in the study and refused to continue treatment and orthopedic follow-up were excluded.

### 2.3. Study protocol

After history taking and primary physical examination, two-view radiographic imaging (AP and lateral X-ray) of the knee was performed. If there was no fracture in the knee X-ray, the point-of-care sonographic (POCUS) examination on the knee was carried out by one of the four trained emergency medicine specialists. Each sonographer received two hours of theoretical and two hours of practical instructions by a radiologist who was an expert in musculoskeletal US.

After the POCUS examination, the US findings were recorded on data collection sheets. The injured knee was always treated with a cylindrical splint of the lower limb. All of the patients were asked to refer to an orthopedic clinic with prior coordination and arrangement 7-10 days after discharge from ED. Second POCUS was done in the orthopedic clinic and then the patient was examined by a specific orthopedic specialist who was blinded to the POCUS results. Ultrasounds were performed by two different sonographers. After that, MRI was performed. The diagnosis of MCL tear was made based on MRI findings. The radiologists who were blinded to the POCUS findings evaluated the MRI. The MRI

machine used in this study was GE Tesla (General Electric Company of America).

The collected variables included age, sex, clinical findings, first and second POCUS, and MRI findings were recorded on data collection forms. Finally, POCUS findings were compared to MRI findings in diagnosing MCL injury.

### 2.4. Ultrasound technique

Ultrasound was performed using Philips Affiniti 50G ultrasound machine with Liner probe (5-12 MHz). The ultrasound examination was done in prone position with 20-30 degrees of knee flexion and slight external rotation of the hip joint. The transducer was placed on a longitudinal plane at the medial aspect of the knee at the MCL site. MCL with hyperechoic and fibrillar structure in a longitudinal plane was considered intact, while thickening and heterogeneously hypoechoic changes in the MCL were considered as injured MCL (3, 5).

### 2.5. Statistical analysis

The sample size was calculated at the confidence interval of 95%, with sensitivity of 84.6% based on the results of a previous study (9), and the error level of 0.06. Thus, the required sample size was 244. Finally, the collected data was entered into SPSS software (Ver. 25) and was presented as number (%) or mean  $\pm$  standard deviation (SD). Accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of POCUS for the identification of MCL tear were calculated.

## 3. Results

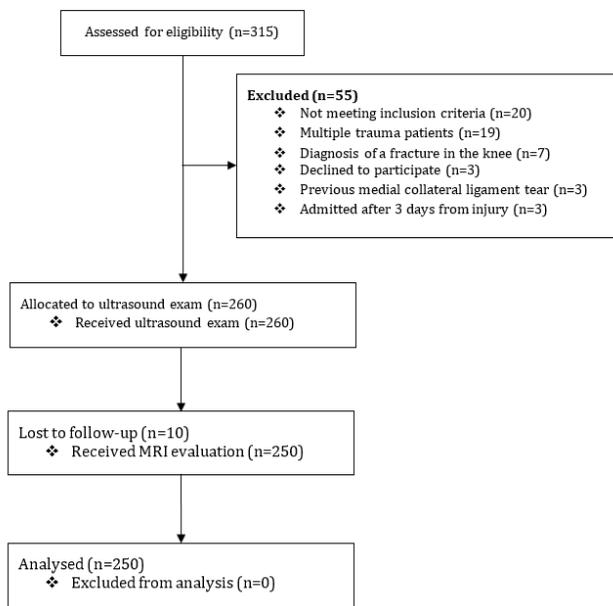
### 3.1. Baseline characteristics of studied cases

A total of 315 patients with suspected MCL injury after acute blunt knee trauma were initially assessed for eligibility, 55 of whom were excluded. Thus, two hundred and sixty patients were enrolled in the study. Then ten patients did not undergo MRI due to the lack of orthopedic follow-up. Finally, 250 patients with a mean age of  $25.05 \pm 9.12$  years were studied (86.8% male). The study flow diagram is shown in Figure 1. The patients' demographic and clinical findings are presented in Table 1. According to the MRI findings, as the gold standard, 55(22.0%) patients had MCL injury, while POCUS showed that 57 (22.8%) patients had MCL injuries (Table 1).

### 3.2. Screening performance characteristics

In comparison with MRI scans, the sensitivity, specificity, PPV, NPV, and accuracy of ultrasonography in the detection of MCL injury were 83.64 (95% CI, 71.20 to 92.23), 94.36% (95% CI, 90.13 to 97.15), 80.70% (95% CI, 69.95 to 88.25), 95.34% (95% CI, 91.83 to 97.38), and 92.00% (95% CI, 87.92 to 95.05), respectively. The area under the receiver operating





**Figure 1:** CONSORT Flow Diagram of patient enrollment.

**Table 1:** Baseline characteristics of the studied patients

Variable	Value
<b>Gender</b>	
Male	217 (86.8)
Female	33 (13.2)
<b>Age (year)</b>	
Mean ± SD	25.05 ± 9.12
<b>Clinical Findings of knee</b>	
Pain	250 (100)
Tenderness	248 (99.2)
Swelling	226 (90.4)
<b>MCL tear on Ultrasonography</b>	
Yes	57 (22.8)
No	193 (77.2)
<b>MCL tear on MRI</b>	
Yes	55 (22.0)
No	195 (78.0)

Data are presented as mean ± standard deviation (SD) or frequency (%). MCL: medial collateral ligament; MRI: magnetic resonance imaging.

characteristic (ROC) curve of the POCUS exam in the detection of MCL injuries was 0.890 (95% CI, 0.844 to 0.926). The sensitivity, specificity, PPV, NPV, and accuracy of the second POCUS exam after one week are shown in table2.

### 4. Discussion

In the current study, sensitivity, specificity, PPV, NPV, and accuracy of US in diagnosis of MCL tears following acute blunt knee trauma, as compared to MRI, were 83.64%, 94.36%, 80.70%, 95.34%, and 92.00%, respectively.

Recently, the US exam has been widely used as a screening musculoskeletal imaging modality. The advantages of ultrasound include safety, saving health care costs, ease of use, and portability of the equipment. However, there are limitations to the use of ultrasound, such as dependence on operator’s training, skills, and experience. The US has been used for detecting knee injuries in various studies with different results (15). Therefore, in the current study, the accuracy of POCUS in diagnosis of MCL tears was evaluated.

The mean age in the present study was 25 years and 217 participants were male (86.8%), which were similar to previous studies (9-11). The males are more likely to have traumatic knee injuries because they are more physically active during the day (9). According to the MRI findings, 55(22.0%) patients had MCL injuries. A study on sixty patients with clinically suspected meniscal/ligamentous injury of the knee demonstrated that 13 patients had MCL injuries based on MRI (9). Ghosh et al. evaluated 9 patients with medial knee pain scheduled for a knee MRI (3). They had three cases with MCL pathology on MRI (1 chronic and 2 acute). The prevalence of MCL injury in these studies is similar to the present study.

In the current study, sensitivity, specificity, PPV, NPV, and accuracy for the US, as compared to MRI, in diagnosis of MCL tears were 83.64%, 94.36%, 80.70%, 95.34%, and 92.00%, respectively. Consistent with the results of the present study, Singh et al. demonstrated that sensitivity, specificity, and accuracy of ultrasound in diagnosis of MCL injuries, compared with MRI were 84.6%, 100%, and 96.6% (9). In another study, the US had 83.33% sensitivity 97.73% specificity, and 96% accuracy for MCL tears (10). These results are compatible with the current study.

Ghosh et al. showed that US had a sensitivity of 67%, and specificity of 83%, PPV of 67%, and NPV of 83% for identifying MCL tears (3). They evaluated acute and chronic knee injuries and only subjects with chronic MCL changes were missed on ultrasound. They suggested that the US may have a limited role in evaluating chronic ligamentous injuries. In a study performed by Najafi et al., the sensitivity, specificity, PPV, NPV, and accuracy of US in diagnosis of complete MCL tears were 66%, 98%, 50%, 99%, and 97%, respectively (5). In this study, which was performed in a referral sports medicine center for arthroscopic candidate patients with acute and chronic knee trauma, a small proportion of patients had complete MCL tears; therefore, the results could not be generalized. In the present study, the specificity slightly decreased after one week (94.36% and 93.33%). Despite the low sensitivity of US in diagnosis of chronic MCL ligament injuries, it is a useful tool for the immediate diagnosis of acute MCL injuries in selected subjects, for whom MRI is contraindicated, or when MRI is not available, so that treatment can be started earlier.



**Table 2:** Diagnostic value of ultrasound in diagnosis of medial collateral ligament injury in emergency department on admission (first) and one week after the injury (second)

MRI	First Ultrasound		Second Ultrasound	
	Positive (n=57)	Negative (n=193)	Positive (n=59)	Negative (n=182)
Positive (n= 55)	46	9	46	9
Negative (n= 195)	11	184	13	182
<b>Screening performance characteristics</b>				
Characteristic	First Ultrasound		Second Ultrasound	
AUC	0.890 (0.844 - 0.926)		0.885 (0.839 - 0.922)	
Sensitivity	83.64 (71.20 - 92.23)		83.64 (71.20 - 92.23)	
Specificity	94.36 (90.13 - 97.15)		93.33 (88.87 - 96.40)	
Positive Predictive Value	80.70 (69.95 - 88.25)		77.97 (67.39 - 85.84)	
Negative Predictive Value	95.34 (91.83 to 97.38)		95.29 (91.74 - 97.35)	
Negative Likelihood Ratio	0.17 (0.09 to 0.32)		0.18 (0.09 - 0.32)	
Positive Likelihood Ratio	14.83 (8.25 - 26.64)		12.55 (7.33 - 21.49)	
Accuracy	92.00 (87.92 - 95.05)		91.20 (86.98 - 94.40)	

Data was expressed with 95% Confidence Interval.

AUC: Area under the receiver operating characteristic (ROC) curve; MRI: magnetic resonance imaging.

Finally, POCUS is a highly sensitive, specific, and accurate modality for acute MCL tears. This study examined the role of POCUS as an initial first-line modality in the evaluation of MCL tears. For patients with clinical suspicion to MCL injury, POCUS was suggested as an initial imaging tool of choice. MRI can be recommended as the next line modality for further evaluation.

## 5. Limitations

There are limitations in the present study. This was a single-centered study with limited generalizability. It was better to perform it with a larger sample size as well as in several centers. Also, only MCL was examined. To determine the simultaneous medial meniscus tear, it was better to evaluate the internal compartment of the knee with ultrasound.

## 6. Conclusion

The present study found that POCUS is a useful adjuvant diagnostic modality for evaluating MCL tears. POCUS helps in taking a decision regarding management of an MCL tear, while the patient can avoid undergoing the costly and time-consuming confirmatory MRI if the result is negative, unless they do not improve during the follow-up period. Therefore, POCUS is recommended as a useful initial modality in patients with suspected MCL injuries.

## 7. Declarations

### 7.1. Acknowledgments

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### 7.2. Authors' contributions

O.A., F.H., K.G., S.D.; Contributed to conception and design. O.A., F.H., S.D.; Contributed to the all-experimental works, data gathering and statistical analyses, as well as interpretation of data. O.A., F.H.; Were responsible for overall supervision. F.H.; Drafted the manuscript, revised by O.A., K.G. and S.D. All authors performed editing and approving the final version of this paper for submission. They also participated in the finalization of the manuscript and approved the final draft.

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### 7.4. Competing interests

The authors declare no conflict of interest.

### 7.5. Ethics approval and consent to participate

Ethical approval was obtained from the ethics committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1397.091).

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