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Dr. Gayathri Mohanan
Senior Resident, Government (TD) Medical College, Alappuzha, Kerala, India

Dr. Unnikrishnan J
Assistant Professor, Government (TD) Medical College, Alappuzha, Kerala, India

Dr. Suma Job
Additional Professor, Government (TD) Medical College, Alappuzha, Kerala, India

Corresponding Author:
Dr. Gayathri Mohanan
Senior Resident, Government (TD) Medical College, Alappuzha, Kerala, India

Sonological evaluation of medial knee injuries and its comparison with magnetic resonance imaging findings: A study

Dr. Gayathri Mohanan, Dr. Unnikrishnan J and Dr. Suma Job

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Abstract
Background: Ultrasonography (US) offers several unique strengths over MR imaging, that make it a promising technique for the evaluation of certain disorders of the knee. US has higher spatial resolution than MR imaging, which may be helpful in evaluating the superficial structures and popliteal fossa of the knee in detail. Visualizing the MCL under ultrasound is relatively easy due to its superficial location, spanning from the medial femoral condyle to the medial tibial metaphysis. Meanwhile MRI is costly, not advisable to all due to its claustrophobia and ferromagnetic property. Ultrasound (US) on the other hand is an inexpensive, widely available and non-invasive technique which also allows dynamic imaging Our objective is to assess the validity of ultrasound in the diagnosis of medial knee injuries in comparison with MRI findings.
Materials and Methods: Patients attending Department of Orthopaedics is referred to Department of radiodiagnosis of T.D. Medical College Alappuzha, who were clinically suspected to have medial knee injury, during the study period. This study was a prospective study. Prospective patients with clinically suspected medial knee injuries scheduled for MRI of the knee were evaluated by Ultrasound examination prior to the MRI. Sonographic findings were then compared to MRI results.
Results and Discussion: 60 patients were enrolled in the study. 73.3% of the study population were males (1) and most of them belonged in their 2nd and 3rd decades. Most of the injuries were left sided [60%] and majority [65%] presented for radiological evaluation within 1 week to 1 month of history of injury.
Accuracy of ultrasound in the diagnosis of MCL and MM injuries were 86.7% and 85% respectively.US demonstrated 89.6% sensitivity and 75% specificity for medial collateral ligament (MCL) injuries and 85.3% sensitivity and 84.6% specificity for medial meniscus (MM) tears. The most frequent knee finding in this study was joint effusion which was seen in 50(83.3%) of patients.
Conclusion: US gives high accuracy and specificity in detection of MCL and MM injuries.
Ultrasound may have a role as the initial rapid imaging modality in patients with suspected MCL or medial meniscus injuries and it may serve as an effective low-cost screening tool for patients with MM or MCL injuries and avoid performing the high-cost MRI.

Keywords: Medial collateral ligament injury, medial meniscal injury, musculoskeletal ultrasound, magnetic resonance imaging

Introduction
Among the non-invasive investigations, MRI is the most accurate for detecting intra articular lesions of the knee. When compared with other diagnostic methods, MRI has the advantage of demonstrating the cartilages, bones, soft tissues and ligaments directly, in detail and in different planes. However, MRI has the disadvantage of high cost, is not always available on demand, does not allow dynamic testing and is a rather lengthy imaging modality. Other limitations of using MRI, such as the presence of indwelling cardiac pacemakers, metal implants, patient intolerance due to claustrophobia and delay in treatment due to long wait periods.
Ultrasound (US) on the other hand is an inexpensive, widely available and non-invasive technique which also allows dynamic imaging.
Ultrasonography (US) offers several unique strengths over MR imaging, that make it a promising technique for the evaluation of certain disorders of the knee.

First, US has higher spatial resolution than MR imaging, which may be helpful in evaluating the superficial structures and popliteal fossa_of the knee in detail. Second, US allows for dynamic assessment, which can be particularly helpful in differentiating partial from complete tears involving the quadriceps and patellar tendons. Third, the ability to interact with patients during US evaluation allows one to obtain a relevant history and guide the US examination to identify the cause of specific patient complaints. US also allows easy comparison with the contralateral knee, which can be very helpful for problem solving. Fourth, US may be the modality of choice in evaluating patients with contraindications to MR imaging and claustrophobia. Finally, US is lower cost than MR imaging and has the added advantage of portability [2].

Medial collateral ligament (MCL) is one of the most commonly injured ligaments of the knee and it mostly results from a valgus force in sport events, motor vehicle accidents or fall from height. MCL injury occurs either in isolation or together with other knee ligaments such as O'Donoghue unhappy triad or knee dislocations. Visualizing the MCL under ultrasound is relatively easy due to its superficial location, spanning from the medial femoral condyle to the medial tibial metaphysis. The MCL has two layers, a superficial and deep layer, with the deep layer being continuous with the medial meniscus. Because of this continuity of the deep layer of the MCL with the medial meniscus, they are often injured together. If not well diagnosed and treated, these injuries might end up with persistent instability, pain and loss of function [3, 4]. Bucket handle Meniscal tears causes profound pain and locking in patients and also is an indication of early surgery. Also, an early detection of these injuries is vital for early intervention to prevent further degeneration. An accurate and rapid diagnosis of injury to the MCL or medial meniscus is important so as to determine the treatment plan and whether immediate surgical intervention will be necessary [5].

While there are a few studies in radiology literature that support the efficacy of ultrasound in identifying medial knee injuries, there is a paucity of literature that directly compares ultrasound to MRI. The primary aim of this study was to determine the validity of ultrasound in diagnosing medial meniscus and MCL injuries when compared to MRI. So, the purpose of this study was to assess the accuracy of sonographic examination for the detection of medial knee injuries, taking MRI findings as the gold standard. And thereby to assess if sonography is an ideal screening tool to diagnose medial knee injuries and to determine whether more detailed knee examination is warranted.

Aim and Objective

To assess the validity of ultrasound in the diagnosis of medial knee injuries in
comparison with MRI findings

Study population

Patients attending department of Orthopaedics and referred to department of Radiodiagnosis of T.D. Medical College Alappuzha, who were clinically suspected to have medial knee injury, during the study period.

All patients of age more than 18 years presenting with knee injury and clinically suspected to have medial knee injury.

Exclusion criteria

- Contraindication for MRI such as cardiac pacemaker, cochlear implants, aneurysmal clips etc
- Patients who are not willing to participate.
- Patients who have undergone prior knee surgery/arthroscopy.
- Patients with severe osteoarthritis.

Material and Methods

Fig 1: USG Machine

Fig 2: MRI Machine

MRI

Patient preparation

The procedure was briefly explained to the patient and consent was taken. Detailed history for contraindication of MRI was specifically taken. They were provided with earplugs to minimize the noise within the MRI room. MRI examination was done with 1.5 Tesla Magnetom Aera MRI Machine using knee extremity circumferential coil. (Fig 1)

Magnetic resonance imaging protocol

The following sequences were attained
PDFS Coronal, Axial and Sagittal,
PD Coronal,
T1 Coronal,
T1 Axial,
T2 Sagittal,
Gradient T2 Sagittal (Sagittal taken with a 15-degree internal rotation axis)
3D Sagittal

Image interpretation

MRI: All images are interpreted with adequate Gray-scale centre level and window width settings.

Ultrasound examination

US evaluation of the medial knee was performed with high-frequency linear transducer with the patient in the supine

position, with hip in external rotation. (Fig 2, 3)
Initial evaluation was done in the coronal plane by finding the MCL along the medial aspect of the joint line. This was done by placing the transducer along the knee in the true coronal plane and toggling the transducer anteriorly and medially until the bulky fibrillar tissue of the MCL was identified. The entire extent of the MCL was evaluated in the long and short axes.

Fig 3: Ultrasound Examination

Next the body of the medial meniscus was identified in the coronal plane along the joint line, between the femur and tibia, deep to the MCL. The transducer was then moved anteriorly to the oblique sagittal plane and then the anterior horn of the meniscus was evaluated. Then the transducer was oriented sagittally and placed over the posterior medial knee, whereby the posterior horn of the medial meniscus was evaluated.
The pes anserine tendons were evaluated with the transducer returned to the coronal view of the MCL, then moved distally along the MCL to about 4–5 cm beyond the joint line and slightly anteriorly.

MCL Injuries
In MRI, MCL injuries were graded as follows

- **Grade I:** Lesions are defined as high signal intensity superficial to the MCL representing oedema, with intact MCL fibres.
- **Grade II:** Lesion in which fluid signal extend partially through MCL, although some fibres remain intact
- **Grade III:** Lesion with complete discontinuity of the MCL fibres seen along with surrounding oedema, consistent with a complete tear.

In USG, MCL ligamentous thickening and/or heterogeneous hypo echogenicity of the ligament was taken as MCL injury

MM Tear
In MRI, linear high or intermediate signal intensity that extends to the superior and/or inferior articular surface of medial meniscus was taken as tear.
In USG focal hypoechoic or anechoic linear defects extending to the superior or inferior meniscus surfaces was taken as tear.
Other findings such as abnormal meniscal morphology and secondary signs of meniscal injury such as parameniscal cyst and meniscal extrusion were also assessed.

Results

Table 1: Characteristics of study population (N=60)

Age group-no (%)	
0-20 years	2(3.3)
21-40 years	32(53.3)
41-60 years	26(43.3)
Gender-no (%)	
Male	44(73.3)
Female	16(26.7)
Side-no (%)	
Left	36(60)
Right	24(40)
Time since injury-no (%)	
Within 1 week	4(6.7)
>1 week to 1 month	39(65)
>1 month to 1 year	17(28.3)
Medial meniscus tear in USG-no (%)	
Yes	33(55)
No	27(45)
MCL thickening in USG-no (%)	
Yes	29(48.3)
No	31(51.7)
MCL hypoechogenecity in USG-no (%)	
Yes	46(76.7)
No	14(23.3)
MCL tear in USG-no (%)	
Yes	46(76.7)
No	14(23.3)
Effusion in USG-no (%)	
Yes	48(80)
No	12(20)
Other findings in USG-no (%)	
Parameniscal cyst	6(10)
Meniscal extrusion	2(3.3)
Medial meniscus tear in MRI-no (%)	
Yes	34(56.7)
No	26(43.3)
MCL tear in MRI-no (%)	
Yes	48(80)
No	12(20)
MCL tear grades in MRI-no (%) (N=48)	
Grade 1	22(45.8)
Grade 2	22(45.8)
Grade 3	4(8.3)
Effusion in MRI-no (%)	
Yes	50(83.3)
No	10(16.7)
Other findings in MRI-no (%)	
Parameniscal cyst	8(13.3)
Meniscal extrusion	2(3.3)
Semimembranosus tendinosis	1(1.7)

Discussion

This study, conducted in the Department of Radiodiagnosis, Government T.D Medical College Alappuzha had a total of 60 subjects. Among them 44 were men and 16 were women. All had undergone MRI and high-resolution ultrasonography for their knee joint with symptoms and clinical findings suggestive of MCL or MM injury and was detected to have either or both of these injuries.
In our study, among the subjects with MCL or MM injuries, 73.3% were males and 26.7% were females. This result was similar to a study conducted by Amandeep Singh *et al.* [6], where 70% of the study population were males and only 30% were females. This could be explained by the fact that men are more vulnerable to traumatic knee injury during daily

activity and sports injury, while females are more vulnerable to meniscal degeneration.

Fig 5: MCL tear in MRI

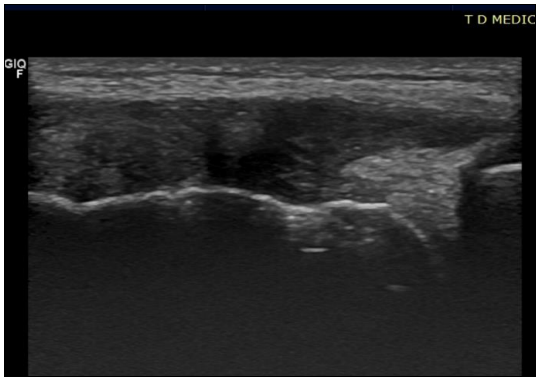

Fig 6: MCL tear in USG

Fig 7: Medial meniscal tear in MRI

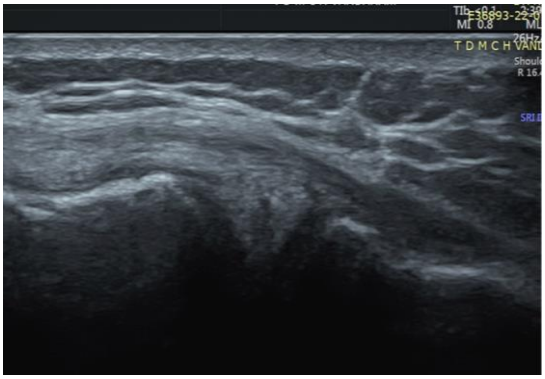

Fig 8: Medial meniscal tear in USG

In the present study, the most common age group of patients presenting with medial knee injuries were in the 2nd and 3rd decades, constituting 53.3% of the cases, followed by people in the 4th and 5th decades, constituting 43.3% of the cases. Two of the study subjects were in the 18-20 age group and none of the study subjects were above 60 years.

In the present study, in about 60% of the study subjects, left knee was injured, and right knee was injured in the remaining 40%. This was similar to a study conducted by Amandeep Singh *et al.* [6], where 60% had injury in the left knee and 40% had injury in the right knee. Thus, the left knee was more frequently involved than the right knee.

Most of the patients, 65%, presented to the department of radiodiagnosis after 1 week and within 1 month of the knee injury.

In our study, the most frequent knee finding was knee effusion. About 83.3% of the study subjects showed effusion in MRI and about 80% of the study subjects showed effusion in USG. This is correlating with a study by Singh B *et al.* [7], in which joint effusion was the most frequent finding, seen in about 88% of the study population. So, knee joint effusion is commonly seen associated with MCL and MM injuries.

In the current study, the sensitivity of ultrasound in assessing knee joint effusion was 96.0%. This is slightly higher compared to a study by Chung-Yuan Wang *et al.* [8] The sensitivity of sonographic examination in detecting effusion was found to be 79.1%.

The importance of detecting effusion is that, it is a common sign of knee pathology, either traumatic. In the same study by to a study by Chung-Yuan Wang *et al.*, the sensitivity of knee effusion to internal derangement was 80.0% and the specificity was 60.0% [8]. So sonographic examination is a useful imaging tool for detecting knee effusion. (Table 1)

MRI was regarded as the gold standard examination for evaluation of MCL and MM injuries and sensitivity, specificity and accuracy of US in evaluating the same were computed.

MCL Injuries

In the present study, out of the 60 patients, 48 patients [80%] had MCL injury. US detected MCL injury in 46 patients in the study population. In the current study, 3 MCL injuries were detected by USG, which were not seen in MRI and 5 injuries were missed on US. The sensitivity and specificity of US in detection of MCL injuries were 89.6% and 75% respectively. And USG had a PPV of 93.5% and NPV of 64.3%.

In our study, the accuracy of USG in assessing MCL injuries was found to be 86.7%.

According to a study done by Singh B *et al.* [7], accuracy, sensitivity and specificity of USG in diagnosing medial collateral ligament tears were 96%, 83% and 97% respectively. This is slightly higher compared to the present study.

In comparison to the study done by Amandeep Singh *et al.* [6], where the sensitivity and specificity of USG in detecting MCL injuries were 84.6% and 100% and the sensitivity obtained in the present study is comparable to this.

In another similar study by Gosh EN *et al.* [9], Ultrasound was able to show a 67% sensitivity and 83% specificity and a PPV of 67% and NPV of 83% for MCL injuries.

In the current study, on assessing the grading of the MCL injuries by MRI, it was found that most of the tears were grade I or grade II [45.8% each]. In the present study only 4 [8.3%] of the MCL injuries were in the grade III category and

all the Grade III injuries were detected by USG. (Fig 5, 6)

MM Tears

In the present study, out of the 60 patients, 34 patients [56.7%] had MM tear. Out of these, US detected MM tear in 33 patients. 4 of the MM tears detected by USG, were not found in MRI. 5 MM tears were missed on US. The sensitivity and specificity of USG in detection of MM tear in our study, were 85.3% and 84.6% respectively. And the PPV and NPV are 87.9% and 81.5% respectively. The accuracy of USG in the current study in assessing MM tears were found to be 85%.

According to a study by Ravichandra G *et al.* [10], the sensitivity and specificity of USG in diagnosing medial meniscus tear was 62% and 80% respectively. In comparison to the study done by Amandeep Singh *et al.* [6], the sensitivity and specificity of USG in detecting MM tears were 77.7% and 90.4%. The specificity obtained in our study is comparable to this study, however sensitivity is higher in the present study.

In another similar study by Gosh en *et al.* [9], Ultrasound was able to show a 100% sensitivity and 50% specificity and a PPV of 87.5% and NPV of 100% for MM tears. (Fig 6, 7)

In our study, about 8 cases parameniscal cysts were detected along with meniscal tear in MRI, out of these 6 were detected by USG and these appeared as well defined sonolucent structures in USG. In our study, about 2 cases of meniscal extrusion was seen in MRI, which were also detected in USG. Meniscal extrusion was noted as abnormal displacement of meniscal tissue and associated oedema.

There was a single case of semimembranosus tendinosis in our study which was detected in MRI, however this could not be picked up in USG.

It was found that US was limited in differentiating the type of meniscal tears and is unable to detect bucket handle tears of meniscus. However, for medial collateral ligament tears, USG is more sensitive investigation compared to medial meniscal tears. USG is highly sensitive in detecting grade III MCL injuries which may require surgical intervention, and hence USG may serve as an effective presurgical evaluation tool.

Conclusion

The MCL and MM are among the commonly injured ligaments of the knee.

If there is a patient with history of knee trauma and clinical suspicion of MCL or MM injuries, we recommend starting with high resolution ultrasound as a screening tool. For negative examinations, follow up, if no improvement, then the second step is MRI examination to rule out ligamentous injuries.

For positive results, MRI examination is recommended to prove MCL and MM injuries, to assess the grading as well as the type of ligamentous injuries and for further details.

Ultrasonography even though cannot replace MRI, is a good low-cost alternative and may be used as a screening tool prior to arthroscopy in selected cases where MRI is contraindicated, is not available or if the patient is not affording or when the waiting period for MRI can cause unnecessary delay in management.

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