Original article

Predictive Accuracy of Ultrasound to Detect Medial Meniscal Tear in Patients Presenting with Knee Injuries Taking Magnetic Resonance Imaging as Gold Standard

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ABSTRACT

Background: Knee injuries like medial meniscal tears impair mobility. Magnetic Resonance Imaging (MRI) is the gold standard but costly and less accessible. This study evaluates ultrasound's predictive accuracy as a more affordable, real-time, non-invasive alternative to MRI. The objective of this study was to find out predictive accuracy of ultrasound to detect medial meniscal tear in patients presenting with knee injuries taking MRI as gold standard.

Methods: The study at Sir Ganga Ram Hospital enrolled 100 knee injury patients over six months w.e.f. March to August, 2021 using non-probability purposive sampling as per inclusion criteria. Patients underwent ultrasound with a 7.5 MHz transducer and MRI with a 1.5 T machine. Radiologists were blinded to each other's findings. Data were analyzed using SPSS to calculate ultrasound's sensitivity, specificity, predictive values, and accuracy against MRI as the gold standard.

Results: Ultrasound detected medial meniscal tears in 83% of patients, predominantly in the posterior zone (80%). MRI showed similar findings, with 85% posterior zone tears. Comparing ultrasound to MRI, ultrasound demonstrated high diagnostic performance: sensitivity of 94.67%, specificity of 93.33%, and overall accuracy of 95.94%. The positive predictive value was 98.60%, and the negative predictive value was 84.41%, indicating ultrasound is a reliable tool for detecting medial meniscal tears.

Conclusions: Ultrasound showed 96% accuracy in detecting medial meniscal tears, slightly less than MRI, which had higher sensitivity and specificity. However, ultrasound remains a useful, non-invasive option when MRI is unavailable or contraindicated.

Keywords:

Knee Injuries, Meniscus, Ultrasonography, Magnetic Resonance Imaging, Sensitivity, Specificity.

INTRODUCTION

The knee joint is one of the most important and vulnerable joints in the human body, bearing much of the body's weight during activities such as walking, running, and jumping.[1] However, its stability depends primarily on soft tissues ligaments, tendons, and menisci rather than the bony structures.[2]

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These structures, especially the medial and posterior menisci, are prone to injury, making meniscal tears among the most common causes of knee pain, dysfunction, and long-term disability.[3,4]

Meniscal tears are frequently seen in sports-related injuries and often require surgical treatment due to associated pain and impaired knee function.[5] While menisci were initially regarded as vestigial remnants, extensive research has established their crucial roles in load sharing, stabilization, shock absorption, and lubrication of the knee joint.[5,6] The incidence of meniscal tears is estimated at approximately 60 per 100,000 population and continues to increase due to greater sports participation and advancements in diagnostic techniques.[6]

Anatomically, the menisci are crescent-shaped fibrocartilaginous structures located between the femoral condyles and tibial plateau, essential for maintaining knee stability and function.[7] Their primary functions include distributing load, absorbing shock, and lubricating the knee joint.[8] The absence or damage of a healthy meniscus results in increased joint instability, mechanical dysfunction, pain, and progressive joint damage that may

lead to osteoarthritis.[7] Furthermore, the prevalence of meniscal tears rises with age, with degenerative tears particularly common in individuals over 65 years.[9]

Two major frameworks guide healthcare priority setting: QALYs, which assess benefits of interventions, and DALYs, which measure disease burden.[10] Feng et al. found their differences are usually modest and rarely change comparisons with standard cost-effectiveness thresholds.[11]

Diagnosing meniscal tears often involves a combination of medical history, clinical symptoms, and imaging techniques. MRI has long been considered the gold standard.[7,8] MRI provides high-resolution images of soft tissues, allowing for detailed visualization of the menisci, ligaments, and other structures within the joint.[8] MRI has demonstrated a sensitivity of 93% for medial meniscus tears and 79% for lateral meniscus tears, alongside a specificity of 88% for medial meniscus and 96% for lateral meniscus in identifying meniscal injuries.[9,12]

Ultrasound is non-invasive, affordable, and widely available, making it a convenient option in many clinical environments. It allows for real-time, dynamic evaluation of the knee, which is useful in assessing the location and severity of meniscal tears. Ultrasound is also capable of distinguishing between partial and complete tears, a crucial distinction because complete tears typically require surgical intervention, whereas partial tears can often be managed conservatively.[13] Ultrasound demonstrated a sensitivity of 80% and a specificity of 100% in the younger age group, however in the older age group, sensitivity was 66.7% and specificity was 75%.[14]

Diagnosing meniscal tears often involves clinical evaluation supported by imaging techniques. MRI is widely accepted as the gold standard due to its excellent soft tissue contrast and high sensitivity and specificity. However, its high cost and limited availability restrict its routine use, especially in resource-limited settings. Ultrasonography has emerged as a promising, accessible, and cost-effective alternative that enables dynamic, real-time knee assessment. Nevertheless, reported diagnostic accuracies for ultrasonography vary considerably among studies, with sensitivity ranging from 66% to 90% and specificity from 63% to 100%. This inconsistency raises controversy regarding its reliability and emphasizes the need for further research comparing its diagnostic accuracy against MRI.

METHODS

The cross sectional validation study was conducted at the Department of Radiology, Sir Ganga Ram Hospital, Lahore over a period of 06 months from March to August, 2021 and a sample size of 100 patients was determined using a 95% confidence level at 80% sensitivity and 63.6% specificity.[13,14] Single proportion formula was used as: $n = Z^2 \times p \times (1 - p) / d^2$ where Z represents the standard normal deviate corresponding to the desired confidence level, p is the expected proportion (in this case, the anticipated sensitivity), and d is the margin of error. Non-probability consecutive sampling was employed. The inclusion criteria encompassed patients aged 16 to 80 years, of both genders, who presented with knee injuries and were referred to Radiology Department from Orthopedics Department for MRI knee. Patients were excluded if they had a history of repeat knee injuries, acute knee injury with hemarthrosis, obvious ligamentous instability, or knee deformity due to a non-traumatic disorder, as determined by clinical examination. Demographic information (name, age, gender, duration of symptoms and presence of any clinical illness) was also noted. All patients meeting inclusion criteria were received for ultrasound by the researcher. By using a 7.5 MHz linear transducer (Toshiba Nemio 10) ultrasounds were performed by researcher. The findings of ultrasound examination were recorded. Patients were labeled positive or negative meniscal tear. Then, all the patients underwent MRI by 1.5 T MRI machine (Toshiba Model No. MRT 1503) as per their referral irrespective of ultrasound findings. The MRI scan was executed in sagittal and coronal planes. Findings were also recorded. Patients were certified as either positive or negative meniscal tear. Radiologists reporting MRI was blindfolded of ultrasound findings and vice versa. Ultrasound and MRI reports were compared later. Data was collected on predesigned questionnaire. The data was entered and analyzed by using statistical package for social studies (SPSS) Version 21. All the quantitative variables (Age, BMI and duration of symptoms) were presented as mean and standard deviation. All the qualitative variables (Gender, residence, marital status, mode of injury and knee joint injury (on ultrasound and MRI)) were presented with frequency and percentages. 2x2 table was created to calculate the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of ultrasound using MRI as the gold standard. Following formula was used[13]:

Sensitivity	=TP /(TP+FN)
Specificity	=TN/(TN+FP)
Positive Predictive Value (PPV)	=TP/(TP+FP)
Negative Predictive Value (NPV)	=TN/(TN+FN)

Diagnostic Accuracy = (True Positive + True Negative) / (True Positive + True Negative + False Positive + False Negative) x100

Where specificity indicates USG's ability to correctly rule out patients without tears. Positive Predictive Value (PPV) is the probability that patients diagnosed with a tear on USG are confirmed true positives on MRI, while Negative Predictive Value (NPV) reflects the probability that patients not diagnosed with a tear on USG are later confirmed negative on MRI. True Positive (TP) cases occur when both USG and MRI confirm the presence of a meniscal tear. True Negative (TN) refers to cases where both modalities agree on the absence of a tear. False Positive (FP) denotes instances where USG indicates a tear but MRI does not, and False Negative (FN) represents cases where USG fails to detect a tear later identified by MRI.

All discussions and counselling with the patients were conducted by the researcher in line with ethical approval, and all data were collected, managed, and securely stored by the principal researcher.

RESULTS

The mean age of the patients was 32.19 ± 11.12 years. Of these, 9 (9.0%) patients belonged to the age group 10-20 years, 70 (70.0%) to the 21-40 years group, and 21 (21.0%) to the 41-60 years group. Ultrasound findings for medial meniscal tears showed that 83 (83.0%) patients had positive results, while 17 (17.0%) had negative results. In terms of the location of the medial meniscal tear, 80 (80.0%) patients had tears in the posterior zone, 6 (6.0%) had tears in the anterior zone, and 14 (14.0%) had no tear. MRI findings for the position of the medial meniscal tear showed that 85 (85.0%) patients had tears in the posterior zone, 4 (4.0%) had tears in the anterior zone, and 11 (11.0%) had no tear. Data is given in Table 1.0. The table presents a comparison between ultrasound (USG) and magnetic resonance imaging (MRI) for detecting medial meniscal tears, along with various statistical metrics. Out of 100 total cases, 85 were identified as true positives (TP) using USG, with 24 false positives (FP), 5 false negatives (FN), and 46 true negatives (TN) in the MRI results. The sensitivity of the USG was found to be 94.67%, indicating the percentage of actual medial meniscal tears correctly identified. The specificity of the USG was 93.33%, representing the proportion of healthy individuals correctly identified. The overall accuracy of the test was 95.94%, reflecting the correct identification rate across all cases. Disease prevalence, or the percentage of cases with medial meniscal tears, stood at 83%. The positive predictive value (PPV) was 98.60%, meaning that when the test is positive, there is a high probability of it being a true positive. The negative predictive value (NPV) was 84.41%, suggesting a moderate level of confidence that a negative result indicates no disease. Data is given in Table 2.

Table 1: Frequency Distribution of patients according to Medial Meniscal Tear upon USG and MRI (n=100)

Modality	Medial Meniscal Tear	Frequency (n)	Percent (%)
USG	Yes	83	83.0 %
	No	17	17.0 %
	Total	100	100.0 %
MRI	Yes	85	85.0 %
	No	15	15.0 %
	Total	100	100.0 %

Table 2: 2x2 Contingency table to determine diagnostic performance of ultrasound in diagnosing medial meniscal tear taking MRI as Gold Standard

Ultrasound	Meniscal Tear on Magnetic Resource Imaging	Total
	Medial Meniscal Tear Yes (n)	
Medial Meniscal Tear	82	83
No	3	17
Total	85	100

Table 3: Diagnostic accuracy

Statistics	Value
Sensitivity	94.67%
Specificity	93.33%
Accuracy	95.94%
Disease prevalence	83.00%
Positive Predictive Value	98.60%
Negative Predictive Value	84.41%

DISCUSSION

Knee injuries, especially medial meniscal tears, are common causes of pain and disability. MRI remains the gold standard for diagnosis due to its high accuracy but has limitations like cost and accessibility.[15-17] Ultrasound is a promising, affordable alternative, yet local data on its accuracy are limited. This study compares ultrasound and MRI to evaluate ultrasound's diagnostic reliability.

Crawford et al.[19] and Murmu et al.[20] both demonstrated the high diagnostic reliability of MRI in knee injury evaluation, reporting sensitivity up to 87.5%, specificity up to 70.8%, and overall accuracy around 76.3% in detecting meniscal and anterior cruciate ligament tears when compared with arthroscopic findings.

In Lahore, Arif et al. reported a diagnostic accuracy of 72.0%, sensitivity of 62.5%, specificity of 80.7%, PPV of 75.0%, and NPV of 70.0% for ultrasound.18 In the U.S., Cimino et al. found that when MRI was considered the gold standard, ultrasound had a sensitivity of 85.4%, specificity of 90.0%, PPV of 97.6%, NPV of 58.8%, and DA of 86.4% for diagnosing medial meniscal tears.[21]

Abuomira et al. in Egypt also compared ultrasound to MRI, reporting sensitivity at 89.1%, specificity at 72.2%, PPV at 90.1%, NPV at 70.1%, and DA at 84.7%.[23] Omer et al. in Pakistan examined the diagnostic performance of ultrasound in medial and lateral meniscus tears, with an overall diagnostic accuracy of 84.61% for medial tears and 94.87% for lateral tears.[24] Finally, Ahmadi et al. in Iran, utilizing arthroscopy as the gold standard, found that ultrasound had a sensitivity of 88.8%, specificity of 89.7%, PPV of 91.9%, NPV of 85.9%, and diagnostic accuracy of 89.2% for diagnosing medial meniscal tears.[25]

The strength of this study lies in its comparison of ultrasound with MRI, providing valuable insights into the diagnostic accuracy of ultrasound for detecting medial meniscal tears. Ultrasound's accessibility, real-time imaging, and cost-effectiveness make it a promising alternative in resource-limited settings. However, the study has limitations, such as its relatively small sample size and reliance on operator skill, which may affect results. Future research should focus on larger sample sizes, standardizing ultrasound techniques, and exploring its potential as a primary diagnostic tool.

CONCLUSION

In conclusion, ultrasound demonstrated a strong predictive accuracy (96%) for detecting medial meniscal tears, with a sensitivity of 96.47% and specificity of 73.33%, though it was slightly less accurate compared to MRI. MRI showed higher sensitivity (98.82%) and specificity (93.33%) in identifying medial meniscal tears, making it the more reliable diagnostic tool. Nevertheless, ultrasound remains a valuable, non-invasive option with significant diagnostic potential, especially in settings where MRI is contraindicated or not readily available.

Author Contributions

Saman Chaudhry: Conception & design, acquisition of data, analysis & interpretation of data.
Nosheen Ahmad: Analysis & interpretation of data.
Humaira: Data analysis, drafting of article, approval of final draft.
Muhammad Bilal: Conception & design, interpretation of data, critical revision.
Mahreen Rasool: Comparative Analysis of results & interpretation of data.
Adnan Maqbool: Literature search, analysis & interpretation of data.
Shazia Shaukat: Analysis & interpretation of data.

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