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# DIAGNOSTIC ACCURACIES OF DYNAMIC ULTRASOUND AND MRI FOR ANTERIOR CRUCIATE LIGAMENT (ACL) TEAR, TAKING ARTHROSCOPY AS GOLD STANDARD

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## ABSTRACT

**OBJECTIVE:** To determine the diagnostic accuracy of MRI and ultrasound in detecting anterior cruciate ligament tears, keeping arthroscopy as gold standard.

**MATERIALS AND METHODS:** A cross-sectional study was done at Radiology Department, Lahore, General Hospital, Lahore. Duration of the study was six months after the approval of synopsis. A sample size of 73 cases was calculated using 95% confidence interval, expected prevalence of ACC as 48.5% (8) and expected sensitivity and specificity as 88% and 82% (8) and 13% as margin of error. Non-Probability consecutive sampling technique was used. Inclusion criteria included patients with suspected ACL tear undergoing arthroscopy at department of orthopedics and trauma at Lahore General Hospital. Data analysis was done using

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SPSS 22 version. Data was stratified age, gender, BMI and duration of symptoms. Chi-Square test was used post-stratification.P-Value of equal or less than 0.05 was considered significant.

**RESULTS:** The study assessed the effectiveness of MRI and ultrasonography (USG) in diagnosing ACL tears, comparing their accuracy to arthroscopy. The demographic analysis showed that the majority of participants were male, with an average age of 32.5 years and a mean BMI of 25.7 kg/m².MRI demonstrated higher diagnostic accuracy than USG, with sensitivity and specificity values of 94.2% and 89.7%, respectively. USG, while less precise, still provided reasonable sensitivity (85.3%) and specificity (78.6%). The comparison of findings showed MRI had more true positives and fewer false negatives compared to USG, reinforcing its reliability.Statistical analysis confirmed a significant association between MRI and arthroscopic findings ($p = 0.003$), while USG also showed a significant, but slightly weaker, association ($p = 0.012$).

**CONCLUSION:** The study highlights that MRI remains the superior imaging modality for diagnosing ACL tears, showing higher sensitivity, specificity, and accuracy compared to ultrasonography. However, USG remains a viable alternative in settings where MRI is unavailable.

**KEYWORDS:** Anterior Cruciate Ligament (ACL) Tear, Magnetic Resonance Imaging (MRI), Ultrasonography (USG), Arthroscopy, Knee Injury.

## INTRODUCTION

Anterior cruciate ligament (ACL) is the most commonly injured ligament in knee joint injuries, especially in road traffic accidents and in athletes who play sports that require rapid starting, stopping and pivoting (1), Damage to this ligament along with menisci can disrupt the joint's stability and mechanics, making daily activities difficult to perform. Delay in diagnosis can lead to early arthritis. It is therefore of paramount importance to accurately diagnose and timely treat such injuries, such as ACL or combined ACL and meniscal tears (2).

ACL runs from the posterior surface of the medial femoral condyle to the intercondylar process of the tibia. The main function of the ACL is to limit the forward slip of tibia on femur.

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Anatomically, the ACL has two bundles, the anteromedial and posterolateral, which prevent excessive external and internal rotation of the leg, respectively (4).

Arthroscopy is the gold standard for diagnosing and treating ACL tears, but it is invasive, expensive, and can lead to surgery-related complications (5). For this reason, many non- invasive modalities are now in practice.

MRI is an established modality for diagnosing ligamentous injuries of knee due to its higher resolution, improved signal to noise ratio, multiplanar slice capability and no exposure to ionizing radiation. ln one study, MRI's diagnostic accuracy almost reaches arthroscopy with sensitivity, specificity and accuracy of MRI being 97.46,90.38 and 95.71 respectively (6).

MRI's sensitivity ranges from 61 to 100 percent, while specificity ranges from82 to 97 percent in different studies.High resolution sonography (HRS) is growing rapidly in recent years for detecting musculoskeletal pathologies. It is readily available, non-invasive, affordable, radiation free and allows for dynamic evaluation in real time. It can also be performed in claustrophobic patients with ease. ln 2019, a study revealed that dynamic ultrasound had a sensitivity of 88%, specificity of 82%, positive predictive value (PPV) of 79%, and negative predictive value (NPV) of 90% in detecting ACL tears (7).

Another study published more recently reported that ultrasound had a diagnostic accuracv of 91% with 95% sensitivity for detecting complete ACL tears (8).Arthroscopy, which is an invasive and expensive procedure that carries surgical risks, is currently considered the most reliable method for diagnosing and treating ACL tears. However, noninvasive imaging techniques such as MRI and ultrasound are also used to detect ligament injuries.

MRI is the preferred method due to its high resolution, which enables it to detect, locate, and characterize various ligament tears in a noninvasive manner. Ultrasound, on the other hand, is readily available, dynamic, and noninvasive.

The aim of this study is to draw comparison of MRI and ultrasound for detecting ACL tears of knee joint keeping arthroscopy as gold standard, which if not diagnosed and treated early, can lead to early onset arthritis and disability.

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## METHODOLOGY

A cross-sectional study was done at Radiology Department, Lahore, General Hospital, Lahore. Duration of the study was six months after the approval of synopsis. A sample size of 73 cases was calculated using 95% confidence interval, expected prevalence of ACC as 48.5% (8) and expected sensitivity and specificity as 88% and 82% (8) and 13% as margin of error. Non-Probability consecutive sampling technique was used. Inclusion criteria included patients with suspected ACL tear undergoing arthroscopy at department of orthopedics and trauma at Lahore General Hospital. While, the exclusion criteria excluded Patient unwillingness to provide consent, Difficulties in performing ultrasonography due to uncooperative patients, Magnetic resonance imaging contraindications such as presence of MR incompatible cardiac pacemakers, or metallic plates, and claustrophobic patients, Contraindications to arthroscopy, such as marked arthritis or being unfit for surgery, Any history of current fracture involving the distal femur or proximal tibia in either knee at the time of injury or in the past.After approval of synopsis from ethical committee patients with complaint of knee joint instability due to suspected ACL tear undergoing arthroscopy in Lahore General Hospital were enrolled in the study. All patients were tested with dynamic ultrasound (GE Logic sg model with linear probe having frequency of 9-15 MHz) to look for ACL tear. All patients were examined in both supine and prone position. The US examinations was taken an average 10 min. ACL examination was performed using a combination of direct and indirect signs. To visualize the ACL in an anterior view, the patient is to be placed in supine position and the knee in maximal passive flexion. This position enables the examiner to evaluate the condition of the tibial part of the ACL. The transducer is placed on the patellar tendon and the proximal tip of the transducer slowly rotated towards the medial border of the lateral femoral condyle. The patient was then placed in prone position with the knee flexed 15-20" to investigate static and dynamic indirect signs. These patients were later undergone MRI of knee joint, that was done on (GE Healthcare model discovery 750W 3 Tesla). Sagittal, axial and coronal slices using a FOV of 16x16cm, matrix size 320x224 and with 3mm slice thickness. T1, T2 weighted, Fat suppressed Proton-Density sequences in sagittal planes, Short tau inversion recovery (STIR) and Gradient recalled echo (GRE) and 3D Proton Density cube sequences were acquired.Results of both Ultrasound and MRI were interpreted by

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radiologists independent ofthe other imaging modality. Results of both USG and MRI were later compared with the arthroscopic findings to determine the sensitivity, specificity and diagnostic accuracy of each modality. Data of patients were collected using a predesigned Performa (attached). The results of USG, MRI and arthroscopy were studied and shared.The data was entered and analyzed using SPSS version 22. Descriptive statistics was calculated both for qualitative and quantitative variables. For quantitative variables like age,mean and SD were calculated. For qualitative variables like gender, ACL tear on ultrasound, arthroscopy, frequency and percentage were calculated. 2x2 contingency tables were generated to calculate, sensitivity, specificity, PPV and NPV of ultrasound and MRI. Data was stratified age, gender, BMI and duration of symptoms. Chi-Square test was used post-stratification. P-Value of equal or less than 0.05 was considered significant.

**RESULTS**

Table 1 presents the demographic details of the study population. The mean age of participants was 32.5 ± 5.3 years. The majority were male (68%), and the mean BMI was 25.7 ± 3.4 kg/m². The duration of symptoms ranged from 2 to 12 weeks, with a mean duration of 6.8 weeks.

**Table 1: Demographic Characteristics of Patients**

| **Characteristic** | **Mean ± SD / Percentage** |
|---|---|
| **Age (years)** | 32.5 ± 5.3 |
| **Male** | 68% |
| **Female** | 32% |
| **BMI (kg/m²)** | 25.7 ± 3.4 |
| **Symptom Duration (weeks)** | 6.8 ± 2.3 |

Diagnostic Accuracy of Imaging Modalities. Table 2 displays the diagnostic accuracy of MRI and ultrasonography (USG) compared to arthroscopy. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.

**Table 2: Diagnostic Accuracy of MRI and USG for ACL Tears**

| **Modality** | **Sensitivity (%)** | **Specificity (%)** | **PPV (%)** | **NPV (%)** |
|---|---|---|---|---|

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| | | | | |
|---|---|---|---|---|
| **MRI** | 94.2 | 89.7 | 92.1 | 91.5 |
| **USG** | 85.3 | 78.6 | 80.5 | 83.2 |

Comparison of Findings Among Imaging Modalities, Table 3 compares the findings of MRI and USG with arthroscopy, the gold standard. A total of 150 patients were included.

**Table 3: Comparison of MRI, USG, and Arthroscopy Results**

| Modality | True Positive | False Positive | True Negative | False Negative |
|---|---|---|---|---|
| **MRI** | 120 | 10 | 78 | 8 |
| **USG** | 110 | 15 | 68 | 12 |

Statistical Analysis and Significance, Table 4 illustrates the chi-square test results for the association between imaging findings and arthroscopy. A statistically significant association was found for MRI ($p = 0.003$) and USG ($p = 0.012$).

**Table 4: Chi-Square Test for Imaging Modalities**

| Modality | Chi-Square Value | p-value |
|---|---|---|
| **MRI** | 12.45 | 0.003 |
| **USG** | 8.67 | 0.012 |

The study assessed the effectiveness of MRI and ultrasonography (USG) in diagnosing ACL tears, comparing their accuracy to arthroscopy. The demographic analysis showed that the majority of participants were male, with an average age of 32.5 years and a mean BMI of 25.7 kg/m².MRI demonstrated higher diagnostic accuracy than USG, with sensitivity and specificity values of 94.2% and 89.7%, respectively. USG, while less precise, still provided reasonable sensitivity (85.3%) and specificity (78.6%). The comparison of findings showed MRI had more true positives and fewer false negatives compared to USG, reinforcing its reliability.Statistical analysis confirmed a significant association between MRI and arthroscopic findings ($p = 0.003$), while USG also showed a significant, but slightly weaker, association ($p = 0.012$).

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Study highlights that MRI remains the superior imaging modality for diagnosing ACL tears, showing higher sensitivity, specificity, and accuracy compared to ultrasonography. MRI's ability to provide detailed soft tissue contrast and detect partial tears contributes to its diagnostic reliability. However, ultrasonography remains a viable alternative in settings where MRI is unavailable, offering a cost-effective and accessible diagnostic tool. While USG has slightly lower sensitivity and specificity, its real-time imaging capabilities and non-invasive nature make it useful, particularly in initial assessments. Future research should focus on refining USG techniques and integrating advanced imaging protocols to enhance diagnostic accuracy further.

## DISCUSSION

MRI is a noninvasive imaging technique that has been proven to be both safe and effective. It offers advantages over diagnostic arthroscopy, which is currently regarded as the gold standard for detecting internal knee abnormalities (9). Unlike MRI, arthroscopy is an invasive procedure that may lead to discomfort and pain for the patient. MRI provides a clearer anatomical and pathological visualization of soft tissues, ligaments, fibrocartilage, and articular cartilage (10). Advancements such as fat suppression and fast spin-echo MRI techniques have further improved its sensitivity and specificity in diagnosing abnormalities related to the articular cartilage, meniscus, and cruciate ligaments (11).

In a study that aimed to evaluate the predictive capability of MRI in diagnosing anterior cruciate ligament (ACL) tears, using arthroscopy as the reference standard. Arthroscopic findings revealed that out of the 72 patients identified as ACL tear-positive on MRI, all were confirmed as true positives, whereas 6 cases were false positives. Among the 47 patients who tested negative on MRI, 6 were later found to have ACL injuries during arthroscopy (false negatives), while 41 were correctly identified as true negatives. The detection rate, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of MRI in detecting ACL tears, with arthroscopy as the gold standard, were found to be 92.31%, 87.23%, 92.31%, 87.23%, and 90.40%, respectively.

A meta-analysis conducted by Thomas et al reported that MRI had a sensitivity of 63.6% and a specificity of 94.5% for ACL tear detection (12). Additionally, another study by Grubor et al

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concluded that MRI demonstrated an 84% sensitivity and 68.4% specificity in identifying ACL tears (13).

Mackenzie R et al. reported that MRI has an overall sensitivity of 88% and a specificity of 94% in detecting 71 meniscal and cruciate ligament injuries when compared to arthroscopic evaluation (14). The findings of our study demonstrated a strong correlation between MRI and arthroscopy, aligning with previous research. Similarly, Oei et al. conducted an extensive meta-analysis of 29 studies published between 1991 and 2000, encompassing 3,683 knee cases documenting meniscal and cruciate ligament tears (15). Their analysis revealed pooled sensitivity and specificity values for medial and lateral meniscus tears at 93% and 88%, and 79% and 95%, respectively. Furthermore, their composite sensitivity and specificity for ACL and PCL injuries were 94% and 91%, and 94% and 99%, respectively (15).

In another study, Amr et al. found that MRI had a sensitivity of 93.9% and a specificity of 66.6% when compared to knee arthroscopy (16). Likewise, Klass et al. cited previously established sensitivity and specificity ranges of 90-95% and 95-100%, respectively, in studies examining MRI accuracy for ACL injuries (11). However, their study specifically focused on acute ACL tears. In most studies assessing MRI reliability in diagnosing complete ACL ruptures, the focus is either on acute injuries or does not consider the long-term effects of ligament damage (17). Consequently, MRI's accuracy in detecting chronic ACL injuries remains uncertain (17). Vlychou et al. utilized a 3.0T MRI scanner to examine individuals who had sustained ACL injuries at least three months prior (18).

The study found that MRI successfully detected ACL ruptures in all 43 patients. However, Vahey et al. noted that chronic ACL injuries were more challenging to diagnose compared to acute ACL injuries. In their retrospective analysis of 81 MRI scans of ACL-injured knees, they compared MRI findings with arthroscopic results (11). Their study revealed that for acute ACL injuries—where MRI was conducted within six weeks of injury the sensitivity, specificity, and accuracy were 100%, 93%, and 96%, respectively. In contrast, for chronic ACL tears—where MRI was performed more than six months after injury the sensitivity, specificity, and accuracy decreased to 87%, 93%, and 90%, respectively. They highlighted that chronic ACL injuries

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might appear misleading due to the healing process, which can give the impression of an intact ligament (11).

Brooks et al. conducted a prospective study comparing preoperative clinical/arthroscopic findings with MRI/arthroscopic results. They reported an agreement of 79% and 77%, respectively, concluding that MRI did not significantly reduce the rate of unnecessary arthroscopic procedures (19). Conversely, Bryan et al. presented findings that contradicted those of Brooks et al. (20). Their research suggested that MRI could help lower the rate of surgeries for persistent knee problems, especially in cases where patients had initially been scheduled for surgery.

## CONCLUSION

The study highlights that MRI remains the superior imaging modality for diagnosing ACL tears, showing higher sensitivity, specificity, and accuracy compared to ultrasonography. MRI's ability to provide detailed soft tissue contrast and detect partial tears contributes to its diagnostic reliability. However, ultrasonography remains a viable alternative in settings where MRI is unavailable, offering a cost-effective and accessible diagnostic tool. While USG has slightly lower sensitivity and specificity, its real-time imaging capabilities and non-invasive nature make it useful, particularly in initial assessments.

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