Diagnostic Accuracy of Magnetic Resonance Imaging (MRI) in the Detection of Anterior Cruciate Ligament (ACL) Tear, keeping Arthroscopic Findings as Gold Standard

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ABSTRACT

Objective: To determine the diagnostic accuracy of Magnetic Resonance Imaging (MRI) compared to arthroscopy in detecting anterior cruciate ligament (ACL) tears.

Study Design: Cross-section study.

Place and Duration of Study: Combined Military Hospital, Kharian Pakistan, from Jan 2020 to Jan 2021.

Methodology: Adult patients of either gender coming to the Radiology Department for an MRI knee joint followed by arthroscopy were included in the study after the institutional ethical review committee approved the study. A consultant with experience in musculoskeletal imaging reviewed the MRI images. An experienced orthopaedic surgeon performed arthroscopy. Findings of MRI and arthroscopy were noted. The diagnostic features of MRI, including sensitivity, specificity, negative predictive values (NPV), positive predictive values (PPV) and diagnostic accuracy were calculated.

Results: The study included 200 patients aged between 21-68 years, a mean age of 40.89±11.49 years. Magnetic resonance imaging had a sensitivity of 93.20%, specificity of 76.31%, positive predictive value (PPV) of 94.37%, negative predictive value (NPV) of 72.5% and diagnostic accuracy of 90%.

Conclusion: Magnetic resonance imaging is an efficient imaging investigation for diagnosing ACL tears.

Keywords: Anterior cruciate ligament, Arthroscopy, Magnetic resonance imaging, Tear.

INTRODUCTION

Among the ligamentous injuries of the knee joint, anterior cruciate ligament (ACL) injury is the most common. It occurs due to partial or complete tearing of the ACL.[1] Various mechanisms have been suggested for ACL injury, including sudden stop, sudden change in direction, direct contact to the knee and landing after a jump. It is one of the common orthopaedic disorders of athletes.[2,3] In the United States, about 200,000 people are affected annually by this health issue. Another estimate indicates that prevalence of ACL ranges from 30-78 per 100,000 individuals per year.[4,5] After the recovery from primary ACL, a re-rupture can also take place. This re-rupture can be very painful. The reported prevalence of re-ruptures is 1-11%, which can occur due to biologic graft failure, traumatic re-injuries, or technical surgical errors.[6]

The gold standard for diagnosing ACL tears has been arthroscopy, with a diagnostic accuracy of 94%.[7] However, it is costly and invasive with the possibility of infection, the requirement of hospitalization and anaesthesia, which often make it less desirable. Resultantly, surgeons are orienting towards MRI due to its non-invasive nature.[8]

Magnetic resonance imaging (MRI) is commonly employed for imaging ACL tears. Better soft tissue contrast, high signal-to-noise ratio, high resolution, non-requirement of ionizing radiation, and multi-planar slice capability make MRI increasingly desirable for this purpose.[9] However, the accuracy of MRI and various clinical tests is still debatable. Although substantial research works have evaluated the accuracy of MRI, results about the utilization of MRI are still contradictory.[10] Keeping this in view, this study was designed to determine the diagnostic accuracy of MRI in comparison to arthroscopy.

METHODOLOGY

The cross-sectional study was conducted between January 2020 and January 2021 at Combined Military Hospital, Kharian Pakistan. Patients with a history of knee injury were included by consecutive non-pro-bability sampling, and the Institutional Ethical Review Committee approved the study (Ethical Committee

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Certificate number 38/2020). The sample size was calculated with expected prevalence of ECL injury of 51.4%.[11]

Inclusion Criteria: Patients of either gender aged 18-60 years, presenting with undiagnosed knee pain or injury with symptoms of locking of knee persisting for more than six weeks were included in the study.

Exclusion Criteria: Patients with claustrophobia, cardiac pacemakers/metal implants, and those with a previous history of surgery or prosthesis and active knee joint infection were excluded. Individuals with evidence of loose body degenerative changes on radiography were also excluded.

Informed consent was obtained from all participants. The demographics of patients were recorded. Magnetic resonance imaging of the affected knee of each patient was carried out, followed by arthroscopy. Imaging was performed with the Mangnetom Avanto system (1.5 Tesla), Germany. The patient's knee was imaged using a dedicated knee coil and externally rotated about 50°-100° (not exceeding 100°) to put the anterior cruciate ligament in the imaging plane. Multiplanar images were obtained in axial, coronal and sagittal views in T1 weighted, T2 weighted, PD FS weighted and STIR sequence and were reviewed by a radiologist with experience in musculoskeletal imaging. Non-visualization or disruption of the ACL with multi-fragmented appearance was taken as primary evidence of tear. An experienced orthopaedic surgeon performed an arthroscopy within two months, and the findings were recorded.

Statistical Package for Social Sciences (SPSS) version 23.0 was used for the data analysis. Quantitative variables were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages. The 2x2 table was made for calculating sensitivity, specificity, predictive values and diagnostic accuracy.

RESULTS

The study included 200 patients aged between 21 and 68 years, with a mean age being 40.89±11.49 years. There were 106(53%) males and 94(47%) females. Magnetic resonance imaging showed 160(80%) positive, with either ACL being not visualized or having a disrupted and multi-fragmented appearance (Figure) and 40(20%) negative results. Arthroscopically, 162 (81%) cases were positive and 38(19%) were negative. Thus, there were 151 (75.5%) true positive, 29(14.5%) true negative, 11(5.5%) false negative and 9(4.5%) false

positive cases in the study (Table-I) with diagnostic parameters as given in Table II.
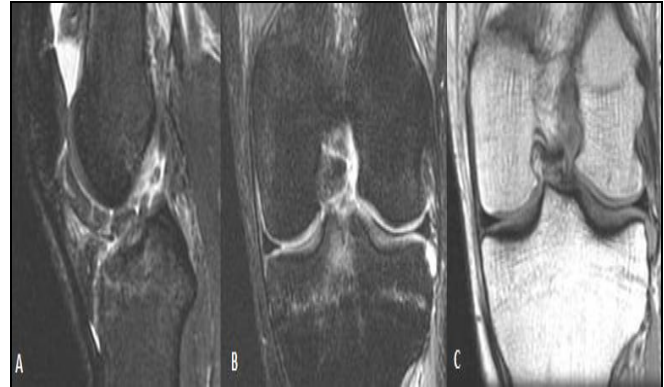

Figure: Primary Signs of an ACL Tear. A. Sagittal view of the knee joint showing high-signal disrupted ACL with multi fragmented appearance. B and C. Coronal T2 and T1 weighted images showing non visualization of ACL fibers and abnormal increased edema and fluid in the lateral inter condylar notch.

Table-I: Comparative Magnetic Resonance Imaging and Arthroscopic Results (n=200)

MRI Results	Arthroscopy Results	
	Positive	Negative
Positive	151(75.5%)	9(4.5%)
Negative	11(5.5%)	29(14.5%)

Table-II: Values of Diagnostic Parameters (n=200)

Diagnostic parameters	values
Sensitivity=True Positive/(True Positive +False Negative)	93.20%
Specificity=True Negative /(True Negative +False Positive)	76.31%
Positive Predictive Value=True Positive/(True Positive+ False Positive)	94.37%
Negative Predictive Value=True Negative/(True Negative +False Negative)	72.5%
Diagnostic Accuracy=(True Positive +True Negative)/All Patients	90%

DISCUSSION

The arthroscopic approach to diagnosing ACL tears adequately visualises all intra-articular structures. Thus, arthroscopy is well known for its high accuracy in diagnosing and treating ACL tears, making it a gold standard for assessing knee-related disorders.[12,13] However, arthroscopy is an expensive and invasive method. Although MRI is less effective in the evaluation of extracapsular soft tissues, it is a non-invasive method along with the benefits of high spatial resolution, good soft tissue contrast, multi-range imaging and multi-parameter management for the assessment of knee lesions.[14] It has merits of displaying injury site, damage extent, injury degree and

associated damage to nearby structures of ACL. Despite the benefits associated with the use of MRI in the assessment of knee lesions, its diagnostic capabilities are limited and unreliable.[15]

Recent research works have extensively compared the diagnostic accuracy of MRI with physical examination and ultrasonography in knee injury.[16,17] The exact diagnostic value of MRI for diagnosing ACL tear is, however, still to be determined. This research work attempts to assess the diagnostic potential of MRI in diagnosing ACL tears with arthroscopic findings considered a gold standard.

The present study included 200 patients aged 21-68 years, with a mean age of 40.89±11.49 years. Most patients were male 106(52%), whereas the number of females in the study was only 94(48%). The diagnostic features of MRI included sensitivity of 93.20%, specificity of 76.31%, positive predictive value (PPV) of 94.37% and negative predictive value (NPV) of 72.5%. The overall diagnostic accuracy for MRI in diagnosing ACL tear was estimated to be 90%. This was in accordance with Ahmed et al who concluded that MRI was a non-invasive and accurate imaging investigation for assessing injuries to the knee ligaments and could be used as the first-line investigation in cases of ACL trauma.[18] Khandelwal *et al.* performed the largest Indian study to compare MRI and arthroscopic findings for ACL tear.[7] The sensitivity of 97.46%, specificity of 90.38% and diagnostic accuracy of 95.71% were found for MRI. The study advocated using MRI as a non-invasive imaging method for accurately detecting ACL tears. Ahmed et al. compared outcomes of MRI with arthroscopic findings.[19] The sensitivity of 93.3%, specificity of 96.4%, PPV of 95.5% and NPV of 94.6% were associated with MRI. Moreover, the diagnostic accuracy was calculated to be 95%, which indicated that MRI is a highly accurate diagnostic method for ACL tears. The study further recommended MRI for screening of knee injuries in place of arthroscopy.

Despite the research in support of MRI for diagnosing the tears of ACL, much work has advocated the inverse scenario. Brady and Weiss (2018) assessed findings from three cross-sectional design studies that compared accuracy of MRI and clinical tests in diagnosing ACL tears.[3] One study indicated that clinical evaluation was superior to MRI in assessing ACL tear.[20]

Despite the importance of MRI in detecting ACL injuries, clinical evaluation still has a very important role. Based on good clinical assessment, patients' outcomes can be decided even before imaging is done, thus saving both time and money for the patients because of the comparable accuracy of clinical evaluation and MR imaging.[3] Research also indicates that the application of clinical evaluation and arthroscopic strategy can help in saving time and money for patients.

CONCLUSION

Magnetic resonance imaging is an efficient imaging investigation for diagnosing ACL tears.

Conflict of Interest: None.

Author's Contribution

Following authors have made substantial contributions to the manuscript as under:

AJ: & WA: Conception, study design, drafting the manuscript, approval of the final version to be published.

HU: & TA: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

RM: & SUDB: Critical review, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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