Original Article
DOI: https://doi.org/10.70749/ijbr.v3i6.2687

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://ijbr.com.pk
ISSN: 2960-2793/ 2960-2807

Diagnostic Accuracy of Magnetic Resonance Imaging (MRI) in Diagnosing Anterior Cruciate Ligament Tear (ACL) Taking Arthroscopy as Gold Standard

Namra Tanveer[1], Tariq Mahmud Mirza[2], Ayesha Faiz[3], Fatima Shakeel[4], Maheen Asad[5]

[1-5] Department of Diagnostic Radiology, Combined Military Hospital (CMH), Lahore, Punjab, Pakistan.

ARTICLE INFO

Keywords: Anterior Cruciate Ligament, Arthroscopy, Diagnostic Accuracy, Knee Injuries, Magnetic Resonance Imaging.

Correspondence to: Namra Tanveer, Department of Diagnostic Radiology, Combined Military Hospital (CMH), Lahore, Punjab, Pakistan.
Email: namratanveer14@gmail.com

Declaration
Authors' Contribution
All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 17-04-2025 Revised: 08-06-2025
Accepted: 14-06-2025 Published: 30-06-2025

ABSTRACT

Background: Anterior cruciate ligament tear is a frequent cause of post traumatic knee instability. Arthroscopy is the reference standard but is invasive, whereas magnetic resonance imaging is widely used as a noninvasive alternative. **Aim:** To determine the diagnostic accuracy of magnetic resonance imaging in diagnosing anterior cruciate ligament tear, using arthroscopy as the gold standard. **Materials and Methods:** A cross sectional survey was conducted in the Department of Diagnostic Radiology, Combined Military Hospital Lahore, over six months (October 2024 to March 2025). Non probability consecutive sampling enrolled 142 patients aged 16 to 55 years with recent knee trauma within two months and positive anterior drawer and Lachman tests. Magnetic resonance imaging was performed on a 0.5 tesla system using multiplanar T1 weighted, T2 weighted, proton density fat saturated, and short tau inversion recovery sequences. Anterior cruciate ligament tear on magnetic resonance imaging was defined as non visualization or disruption with multi fragmented appearance. Arthroscopy was performed under general anaesthesia by a blinded surgical team and tear was defined as disruption of one third or more ligament fibers. A 2 by 2 table was used to compute sensitivity, specificity, predictive values, and diagnostic accuracy. **Results:** Mean age was 29.4 ± 8.7 years and mean body mass index was 25.6 ± 3.9 kg/m^2; 98 (69.0%) participants were male. Right knee involvement was seen in 80 (56.3%). Sports injuries accounted for 65 (45.8%) cases. Arthroscopy confirmed tears in 89 (62.7%). Magnetic resonance imaging yielded 82 true positives, 46 true negatives, 7 false positives, and 7 false negatives, giving sensitivity 92.1%, specificity 86.8%, PPV 92.1%, NPV 86.8%, and accuracy 90.1%. **Conclusion:** Magnetic resonance imaging showed high diagnostic accuracy for anterior cruciate ligament tear compared with arthroscopy in clinically suspected injuries.

INTRODUCTION

The anterior cruciate ligament (ACL) is a principal stabilizing structure of the knee and contributes substantially to functional stability during routine and athletic activities. ACL tears were reported as relatively frequent injuries, with an incidence of 68.6 per 100,000 persons per year and a predilection for younger, physically active individuals. In the absence of the ACL restraint, the rotational axis may shift medially, increasing susceptibility of the lateral tibial plateau to anteroposterior instability [1,2]. Persistent anteroposterior laxity has been linked to an elevated risk of post traumatic knee osteoarthritis, functional limitation with reduced activity level, and impaired health related quality of life. Chronic instability has been described even after operative management in a proportion of cases and was reported more commonly among individuals managed conservatively [3,4].

Arthroscopy has historically been regarded as the diagnostic gold standard for ACL tears; however, it is invasive, resource intensive, and associated with potential complications including infection, anaesthesia exposure, and hospitalization. Consequently, non invasive imaging, particularly magnetic resonance imaging (MRI), has been increasingly used to evaluate suspected intra articular derangements [5,6]. MRI provides excellent soft tissue contrast and multiplanar capability, facilitating detailed assessment of complex knee anatomy. Despite these strengths, variability in MRI performance for ACL injury has been reported across studies, raising concerns regarding generalisability across clinical settings and reader expertise.

Published local and regional evidence has shown inconsistent diagnostic indices for MRI when arthroscopy was used as the reference. Ahmed et al. reported MRI accuracy of 91.89% with sensitivity 93.33%, specificity

85.71%, PPV 96.55% and NPV 75%, with arthroscopy positive in 150 cases versus 145 by MRI [6]. Shah et al. documented markedly lower sensitivity at 66.67% with specificity 75.90%, PPV 81.13%, NPV 59.43% and accuracy 70.28%, alongside a higher arthroscopic detection rate than MRI [7].

Given the heterogeneity in reported sensitivity, specificity, predictive values, and overall accuracy of MRI for ACL tears, the present study was designed to determine the diagnostic accuracy of MRI against arthroscopy. Establishing local estimates was expected to support earlier identification and more timely management, thereby reducing morbidity related to delayed diagnosis and persistent instability [8,9].

MATERIAL AND METHOD

A cross sectional study was conducted in the Department of Diagnostic Radiology, Combined Military Hospital (CMH) Lahore, over a period of six months after approval of the synopsis. Ethical approval was obtained from the hospital Ethical Review Committee prior to initiation of enrolment. Written informed consent was obtained from all eligible participants before performing magnetic resonance imaging (MRI) and arthroscopy. Non probability consecutive sampling was used. The sample size was calculated as 142 cases using a 95% confidence level, an expected sensitivity of 87.23% with 7% margin of error, an expected specificity of 90.40% with 8% margin of error, and a disease prevalence of 62.40% as previously reported [7].

Patients of either gender aged 16 to 55 years with recent post traumatic knee injury within two months were included. Patients were excluded if MRI findings were inconclusive, radiographs showed degenerative changes, or there was a prior history of knee surgery. Additional exclusions included associated fractures of the femoral condyle, tibial plateau fractures, dislocated knee, contraindications to MRI, cardiac insufficiency (ejection fraction 35% or less) or liver failure (serum bilirubin 1.2 mg/dL or more) as per clinical record, and coagulopathy (international normalized ratio 1.2 or more) as per clinical record. ACL tear on MRI was operationally defined as non visualization or disruption of the ACL with a multi fragmented appearance. ACL tear on arthroscopy was defined as direct visualization of disruption of one third or more of ligament fibers in diameter, arising from the medial and anterior aspect of the tibial plateau, during a procedure performed under general anaesthesia. Diagnostic accuracy of MRI for ACL tear was evaluated using arthroscopy as the reference standard and expressed through true positive (ACL tear present on both MRI and arthroscopy), true negative (ACL intact on both modalities), false positive (tear on MRI but not on arthroscopy), and false negative (no tear on MRI but tear present on arthroscopy). Sensitivity was calculated as true positives divided by true positives plus false negatives. Specificity was calculated as true negatives divided by true negatives plus false positives. Positive predictive value was calculated as true positives divided by true positives plus false positives. Negative predictive value was calculated as true negatives divided by true negatives plus false negatives. Overall accuracy was calculated as true positives plus true negatives divided by the total number of cases.

After enrolment, age and gender were recorded, and patients with positive anterior drawer test and positive Lachman test underwent MRI. MRI was performed on a 0.5 tesla system (Philips Medical System). Multiplanar images were acquired in axial, coronal, and sagittal planes using T1 weighted, T2 weighted, proton density fat saturated, and short tau inversion recovery sequences. MRI images were interpreted by a consultant radiologist who classified the ACL as intact or torn based on the operational definition. Arthroscopy was subsequently performed after informed consent by the same consultant orthopaedic surgical team, who remained blinded to the MRI interpretation. Arthroscopy was performed in a standardized manner using inferolateral and medial portals to allow systematic assessment of the entire joint and its anatomical structures, and the ACL was recorded as intact or torn. To reduce observer variation, all MRI examinations were reported by a single senior radiology consultant with at least five years of experience, and all arthroscopies were performed by one surgical team. Potential confounders were addressed primarily through the exclusion criteria, and all findings were documented on the study proforma by the investigator.

All data were entered and analysed using Statistical Package for the Social Sciences (SPSS) version 25. Numerical variables including age and body mass index were summarised as mean plus or minus standard deviation, while categorical variables including gender, side of limb involvement (right or left), mechanism of injury (road traffic accident, sports injury, miscellaneous), and MRI and arthroscopy ACL findings were summarised as frequencies and percentages. A 2 by 2 contingency table was constructed, and sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of MRI for diagnosing ACL tear were calculated using arthroscopy as the gold standard.

RESULTS

The study included 142 participants who fulfilled the eligibility criteria and completed both magnetic resonance imaging (MRI) and arthroscopy. The mean age was 29.4 ± 8.7 years and the mean body mass index was 25.6 ± 3.9 kg/m^2. Most participants were male (n = 98, 69.0%). Right knee involvement was recorded in 80 (56.3%) cases. Sports related trauma was the commonest mechanism (n = 65, 45.8%), followed by road traffic accidents (n = 52, 36.6%) and miscellaneous mechanisms (n = 25, 17.6%).

Table 1

Baseline characteristics of study participants (n = 142)

Variable	Category	n (%) / Mean ± SD
Age (years)	Mean ± SD	29.4 ± 8.7
Body mass index (kg/m^2)	Mean ± SD	25.6 ± 3.9
Gender	Male	98 (69.0)
	Female	44 (31.0)
Side involved	Right	80 (56.3)
	Left	62 (43.7)
Mechanism of injury	Sports injury	65 (45.8)
	Road traffic accident	52 (36.6)
	Miscellaneous	25 (17.6)

Arthroscopy confirmed anterior cruciate ligament tear in 89 (62.7%) cases, consistent with the anticipated disease frequency used for sample size estimation.[9] On MRI, anterior cruciate ligament tear was reported in 89 (62.7%) cases. Cross tabulation of MRI findings against arthroscopy showed 82 true positive cases and 46 true negative cases. False positive MRI diagnosis occurred in 7 cases, while 7 cases were false negative on MRI but were confirmed as tears on arthroscopy.

Table 2

MRI versus arthroscopy findings for anterior cruciate ligament tear (n = 142)

MRI finding	Arthroscopy tear present	Arthroscopy tear absent	Total
Tear present	82 (TP)	7 (FP)	89
Tear absent	7 (FN)	46 (TN)	53
Total	89	53	142

Using arthroscopy as the reference standard, MRI demonstrated sensitivity of 92.1% and specificity of 86.8%. The positive predictive value was 92.1% and the negative predictive value was 86.8%. Overall diagnostic accuracy was 90.1%.

Table 3

Diagnostic performance of MRI for anterior cruciate ligament tear using arthroscopy as gold standard (n = 142)

Measure	Estimate (%)
Sensitivity	92.1
Specificity	86.8
Positive predictive value	92.1
Negative predictive value	86.8
Diagnostic accuracy	90.1

DISCUSSION

The present analysis evaluated magnetic resonance imaging (MRI) for detection of anterior cruciate ligament (ACL) tear using arthroscopy as the reference standard and demonstrated high overall performance, with sensitivity 92.1%, specificity 86.8%, positive predictive value 92.1%, negative predictive value 86.8%, and diagnostic accuracy 90.1%. These indices supported MRI as a reliable noninvasive diagnostic modality in patients with recent post traumatic knee injury selected on clinical suspicion (positive anterior drawer and Lachman tests), while also indicating that false positive and false negative interpretations remained clinically relevant when operative decisions were being considered.

The observed sensitivity was comparable to several reports in which MRI identified most arthroscopically proven ACL tears. Ahmed et al. reported sensitivity 93.33% with diagnostic accuracy 91.89% in a series of 185 patients, supporting MRI as a strong rule in test in clinically suspected cases [10]. A similar study reported sensitivity 97.4% with accuracy 92.0%, reflecting a low false negative rate when standardized criteria were applied [6]. Zhao et al. also reported high sensitivity (95.45%) and accuracy (94.87%) for MRI relative to arthroscopy, further reinforcing that MRI can detect the majority of ACL disruptions when image acquisition and interpretation are optimized [11]. In addition, a meta analysis by Li et al. reported pooled sensitivity of 87% and specificity of 90%, placing the present sensitivity above the pooled estimate while maintaining specificity close to the pooled benchmark [12].

Specificity in the present findings (86.8%) remained within the range described in clinical practice studies, though it was lower than values reported in some high specificity series. Ahmed et al. reported specificity 85.71%, aligning closely with the present results and supporting the likelihood of false positive MRI findings in routine settings [10]. In contrast, Sampson et al. reported excellent performance for 3 Tesla MRI in the injured knee, with very high accuracy for ACL evaluation when compared with arthroscopic findings, suggesting that field strength, sequence optimization, and interpretive expertise can materially influence false positive rates [13]. Koch et al. also described high specificity for 1.5 Tesla MRI for knee internal derangements, while highlighting that false negative lesions and lesion complexity contribute to imperfect agreement with arthroscopy [14]. These observations provide a plausible explanation for the present balance of sensitivity and specificity in a 0.5 Tesla setting, where diagnostic confidence may be reduced for subtle fiber discontinuity, partial tears, or motion related artefacts.

The present positive and negative predictive values were also clinically informative. The positive predictive value of 92.1% implied that an MRI reported ACL tear was highly likely to be confirmed arthroscopically within this clinically enriched sample, which is consistent with the high pre test probability created by inclusion based on clinical instability tests. Comparable positive predictive values were reported by Ahmed et al. (96.55%) and Remsha et al. (92.5%) [11]. Conversely, the negative predictive value of 86.8% indicated that a negative MRI meaningfully reduced the likelihood of ACL tear but did not exclude it with certainty, particularly when clinical suspicion remained high. This pattern parallels evidence that negative predictive values vary with disease prevalence and referral pathways, as reflected in studies reporting lower negative predictive values in higher prevalence settings [15,16]. Phelan et al., in a systematic review and meta analysis, emphasized variability in diagnostic accuracy studies and noted frequent concerns regarding bias and applicability, which may partly account for dispersion of predictive values across settings [17].

Comparison with regional literature further contextualized the present findings. Another study reported substantially lower sensitivity (66.67%) and diagnostic accuracy (70.28%), with a large discrepancy between MRI and arthroscopic detection of ACL tears [16]. The divergence from the present sensitivity may reflect differences in MRI protocols, scanner characteristics, reader thresholds, and case mix, including the proportion of partial tears and concomitant injuries that can obscure ligament assessment. Additional local reports from military and tertiary care settings have similarly described high sensitivity and acceptable specificity, though the magnitude of specificity has been more variable, consistent with the persistent issue of false positive interpretation in selected contexts [17,18].

The present findings supported the use of MRI as a first line, non invasive test for suspected ACL tear in the

studied setting, with diagnostic accuracy broadly consistent with high quality evidence and several regional series [12,13,16,19]. However, the variability reported across studies, including markedly lower sensitivity in some series, indicated that performance is not uniform and remains dependent on scanner capability, imaging protocol, interpretive expertise, and the clinical spectrum of injuries referred for imaging. Where MRI is performed on lower field strength systems, careful attention to multiplanar sequences and standardized reporting criteria remains essential. When discordance exists between MRI findings and clinical instability, arthroscopy continues to provide definitive confirmation and simultaneous therapeutic opportunity.

CONCLUSION

Magnetic resonance imaging demonstrated strong diagnostic utility for identifying anterior cruciate ligament tears when compared with arthroscopy in clinically suspected post traumatic knee injuries. The findings supported magnetic resonance imaging as an appropriate first line, non invasive investigation for surgical decision making and patient counselling in routine orthopedic practice. Nevertheless, discordant cases remained possible, particularly where clinical instability was pronounced despite non confirmatory imaging. Arthroscopy retained value as the definitive test when magnetic resonance imaging findings and clinical assessment were inconsistent, and when simultaneous diagnostic confirmation and therapeutic intervention were required.

REFERENCES

1. Soni, M. K., Shamim, S., Verma, A., & Singh, G. K. (2023). A comparative study of anterior cruciate ligament reconstruction versus conservative treatment. *Cureus*. https://doi.org/10.7759/cureus.49148
2. Mancino, F., Gabr, A., Plastow, R., & Haddad, F. S. (2023). Anterior cruciate ligament injuries in female athletes. *The Bone & Joint Journal*, *105-B*(10), 1033-1037. https://doi.org/10.1302/0301-620x.105b10.bjj-2023-0881.r1
3. Beaulieu, M. L., Ashton-Miller, J. A., & Wojtys, E. M. (2021). Loading mechanisms of the anterior cruciate ligament. *Sports Biomechanics*, *22*(1), 1-29. https://doi.org/10.1080/14763141.2021.1916578
4. Mohammed, E. R., Metwally, N. A., & Elaidy, A. A. (2019). Role of magnetic resonance imaging in assessment of anterior cruciate ligament post-grafting cases in terms of Graft integrity and complications. *The Egyptian Journal of Hospital Medicine*, *76*(2), 3446-3453. https://doi.org/10.21608/ejhm.2019.37930
5. AHMAD, M. W., Saeed, A., & Rashid, N. (2024). Diagnostic accuracy of magnetic resonance imaging (MRI) knee in detecting anterior cruciate ligament (ACL) tears assuming arthroscopy as gold standard. *Journal of Fatima Jinnah Medical University*, *18*(3), 130-133. https://doi.org/10.37018/bksk6936
6. Ahmed, A., Razzaque, M. A., Kaleem, M., Zaman, A. U., Akram, R., & Javed, S. (2017). Diagnostic accuracy of magnetic resonance imaging in detecting anterior cruciate ligament injuries. *Medical Journal of Indonesia*, *26*(3), 218-23. https://doi.org/10.13181/mji.v26i3.1873
7. Khandelwal, K., Chaturvedi, V., Mishra, V., & Khandelwal, G. (2018). Diagnostic accuracy of MRI knee in reference to arthroscopy in meniscal and anterior cruciate ligament injuries. *The Egyptian Journal of Radiology and Nuclear Medicine*, *49*(1), 138-145. https://doi.org/10.1016/j.ejrnm.2017.12.003
8. Shibayama, Y., Hirose, T., Sugi, A., Mizushima, E., Watanabe, Y., Tomii, R., Iba, K., & Yamashita, T. (2022). Diagnostic accuracy of magnetic resonance imaging for partial tears of the long head of the biceps tendon in patients with rotator cuff tears. *JSES International*, *6*(4), 638-642. https://doi.org/10.1016/j.jseint.2022.03.001
9. Fotiadou, A. N., Vlychou, M., Papadopoulos, P., Karataglis, D. S., Palladas, P., & Fezoulidis, I. V. (2008). Ultrasonography of symptomatic rotator cuff tears compared with MR imaging and surgery. *European Journal of Radiology*, *68*(1), 174-179. https://doi.org/10.1016/j.ejrad.2007.11.002
10. Hameed Khan, R., Iqbal, J., Ahmad, A., & Kamal, S. (2025). Diagnostic accuracy of magnetic resonance imaging knee in diagnosis of anterior cruciate ligament tear taking arthroscopy as gold standard. *Indus Journal of Bioscience Research*, *3*(4), 805-810. https://doi.org/10.70749/ijbr.v3i4.1108
11. Zhao, M., Zhou, Y., Chang, J., Hu, J., Liu, H., Wang, S., Si, D., Yuan, Y., & Li, H. (2020). The accuracy of MRI in the diagnosis of anterior cruciate ligament injury. *Annals of Translational Medicine*, *8*(24), 1657-1657. https://doi.org/10.21037/atm-20-7391
12. Li, K., Du, J., Huang, L., Ni, L., Liu, T., & Yang, H. (2017). The diagnostic accuracy of magnetic resonance imaging for anterior cruciate ligament injury in comparison to arthroscopy: A meta-analysis. *Scientific Reports*, *7*(1). https://doi.org/10.1038/s41598-017-08133-4
13. Sampson, M., Jackson, M., Moran, C., Moran, R., Eustace, S., & Shine, S. (2008). Three Tesla MRI for the diagnosis of meniscal and anterior cruciate ligament pathology: A comparison to arthroscopic findings. *Clinical Radiology*, *63*(10), 1106-1111. https://doi.org/10.1016/j.crad.2008.04.008
14. Koch, J. E., Ben-Elyahu, R., Khateeb, B., Ringart, M., Nyska, M., Ohana, N., Mann, G., & Hetsroni, I. (2021). Accuracy measures of 1.5-tesla MRI for the diagnosis of ACL, meniscus and articular knee cartilage damage and characteristics of false negative lesions: A level III prognostic study. *BMC Musculoskeletal Disorders*, *22*(1). https://doi.org/10.1186/s12891-021-04011-3
15. Kumbar, V., Tonne, V., & Kumar, A. (2018). Correlation of magnetic resonance imaging and arthroscopic findings in meniscal and anterior cruciate ligament injuries. *MedPulse International Journal of Radiology*, *5*(1), 05-08. https://doi.org/10.26611/1013512
16. Aziz, M., Sadaf Aziz, Tariq, A., Khan, Y., Atif Latif, & Munazzah Aziz. (2024). Diagnostic accuracy of magnetic resonance imaging in diagnosing urinary bladder cancer, taking histopathology as gold standard. *Pakistan Armed Forces Medical Journal*, *74*(SUPPL-2), S226-S230. https://doi.org/10.51253/pafmj.v74isuppl-2.10849
17. Phelan, N., Rowland, P., Galvin, R., & O'Byrne, J. M. (2015). A systematic review and meta-analysis of the diagnostic accuracy of MRI for suspected ACL and meniscal tears of the knee. *Knee Surgery, Sports Traumatology, Arthroscopy*, *24*(5), 1525-1539. https://doi.org/10.1007/s00167-015-3861-8
18. Javaid, A., Anam, W., Ullah, H., Afzal, T., Mahmood, R., & Salah ud din Balooch. (2023). Diagnostic accuracy of magnetic resonance imaging (MRI) in the detection of anterior

cruciate ligament (ACL) tear, keeping Arthroscopic findings as gold standard. *Pakistan Armed Forces Medical Journal*, *73*(5), 1249-1252. https://doi.org/10.51253/pafmj.v73i5.7687

19. Ahmed, Z. T., Khan, N. H., Bilal, S., Ameer, S., Tanveer, F., & Tanveer, M. (2020). Diagnostic accuracy of magnetic resonance imaging for detection of anterior cruciate ligament tears taking arthroscopy as gold standard. In *Medical Forum Monthly* (Vol. 31, No. 3). https://medicalforummonthly.com/index.php/mfm/article/view/2224