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ORIGINAL STUDY

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Knee Arthroscopy versus Magnetic Resonance Imaging in the Diagnosis of ACL Injury – A Comparative Study

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Abstract

Background: Accurate diagnosis of anterior cruciate ligament (ACL) injuries is critical for selecting appropriate treatment strategies and preventing long-term knee dysfunction. Magnetic resonance imaging (MRI) is widely used as a non-invasive diagnostic tool, while arthroscopy remains the gold standard.

Objectives: This study aimed to compare the diagnostic accuracy of MRI against arthroscopic findings in ACL injuries and to assess its current performance in clinical settings for the years 2024–2025.

Methods: A total of 40 patients (31 males, 77%; 9 females, 23%) aged 20–50 years (median age 35 years) who presented with suspected ACL injury were enrolled. All patients underwent MRI examination followed by arthroscopic evaluation, which served as the reference standard. Diagnostic indices, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, were calculated.

Results: MRI correctly identified 22 actual positive cases and three true negative cases, with one false positive and 14 false negative results when compared with arthroscopy. The calculated diagnostic performance of MRI was as follows: sensitivity 93%, specificity 88%, PPV 82%, NPV 95%, and overall accuracy 90%.

Conclusion: MRI demonstrates high sensitivity and accuracy in diagnosing ACL injuries, making it a valuable non-invasive diagnostic tool. However, certain discrepancies compared with arthroscopy suggest that MRI should be interpreted with caution in equivocal cases.

Keywords: Anterior cruciate ligament ACL injury, MRI, Diagnostic accuracy

1. Introduction

The anterior cruciate ligament (ACL) plays a vital role in maintaining knee stability by resisting anterior translation and rotational displacement of the tibia relative to the femur [1]. Injuries to the ACL are among the most common knee pathologies in sports medicine, particularly affecting athletes involved in high-demand activities such as football, basketball, and skiing [2]. The incidence of ACL tears is increasing globally due to rising participation in competitive and recreational sports, as well as greater awareness and detection of ligamentous injuries [3]. An ACL rupture can lead to functional instability, impaired mobility, and an increased risk of subsequent intra-articular damage, such as meniscal tears and cartilage degeneration, if left untreated [4]. The economic burden of ACL injuries is significant, involving costs related to diagnosis, surgical reconstruction,

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Table 1. Demographic characteristics of study participants.

Variable	n (%) or mean ± SD
Age (years)	32.6 ± 8.4
Sex – Male	36 (72%)
Sex – Female	14 (28%)
Affected knee – Right	29 (58%)
Affected knee – Left	21 (42%)
Mean duration since injury (weeks)	14.3 ± 6.1
Mechanism – Sports injury	31 (62%)
Mechanism – Road accident	11 (22%)
Mechanism – Other trauma	8 (16%)

rehabilitation, and potential long-term disability [5]. Therefore, accurate diagnosis is essential for optimal management and prevention of further joint damage. The demographic characteristics of the study population, including gender distribution and occupational status, are summarized in Table 1.

Magnetic resonance imaging (MRI) is widely regarded as the preferred non-invasive imaging modality for suspected ACL injuries, offering multiplanar capabilities and high soft-tissue contrast that allows for comprehensive visualization of ligament integrity, menisci, cartilage, and other intra-articular structures [6]. Despite its advantages, MRI accuracy may be influenced by factors such as partial tears, chronic degeneration, scan resolution, and reader expertise, which can potentially lead to false-positive or false-negative findings [7].

On the other hand, diagnostic arthroscopy remains the gold standard, offering direct visualization of intra-articular structures and enabling simultaneous therapeutic intervention when necessary [8]. However, its invasive nature, associated procedural risks, and higher cost compared to MRI limit its use to cases where uncertainty remains or when surgical treatment is anticipated [9].

Multiple comparative studies have evaluated the diagnostic agreement between MRI and arthroscopy for ACL injuries, reporting a generally high correlation, particularly for complete tears; however, reduced accuracy is noted for partial injuries and associated pathologies [10]. These variations underline the need for local data to determine whether MRI can reliably substitute for arthroscopy in specific patient populations, especially in healthcare settings where minimizing invasive procedures and optimizing resource allocation are priorities [11].

In Iraq, few published studies have directly compared MRI and arthroscopy for ACL evaluation, despite the high prevalence of sports-related knee injuries and the increasing availability of advanced imaging facilities [12]. This study aims to assess the diagnostic accuracy of MRI compared with arthroscopy in detecting ACL injuries in patients treated in two tertiary care hospitals in Salahaddin province. By focusing on a local cohort, the research aims to determine whether MRI can serve as a dependable diagnostic tool for ACL injuries in our setting, potentially reducing the need for unnecessary arthroscopic procedures while maintaining diagnostic accuracy.

2. Materials and methods

2.1. Study design and patients

This comparative, cross-sectional study was conducted at Balad General Hospital and Tikrit Teaching Hospital in Salahaddin, Iraq, between January 2024 and March 2025. The study design was chosen to allow for the simultaneous evaluation of MRI and arthroscopy findings in patients presenting with suspected ACL injuries, ensuring a direct diagnostic comparison within the same patient group.

2.2. Study Population

The study included patients aged 18–50 years who presented with acute or chronic knee pain, instability, or a history suggestive of ACL injury, and who were scheduled for diagnostic arthroscopy. Exclusion criteria included previous knee surgery, fractures involving the knee joint, advanced degenerative joint disease, or contraindications to MRI (e.g., pacemakers, metallic implants)

2.3. Sample Size

A total of 50 consecutive patients meeting the inclusion criteria were enrolled. The sample size was determined based on the hospital's annual caseload and previous literature, which suggested a minimum of 40 patients to achieve adequate statistical power for sensitivity and specificity analysis.

2.4. Demographic Data

Baseline demographic and clinical data were collected at the time of enrollment. This included age, sex, affected knee side, duration since injury, and mechanism of injury.

2.5. Clinical Examination

Each patient underwent a standardized orthopedic examination, including the Lachman test, anterior drawer test, and pivot-shift test, performed by an experienced orthopedic surgeon Clinical findings were recorded but were not used as a standalone diagnostic

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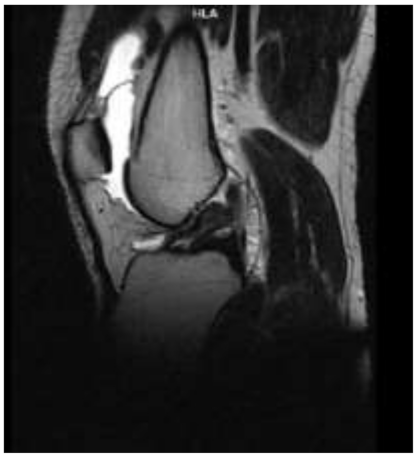

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Fig. 1a. Normal anterior cruciate ligament (ACL) as seen in sagittal T2-weighted MRI, showing low-signal-intensity fibers extending from the lateral femoral condyle to the anterior tibial plateau. Figure 1b –Anterior cruciate ligament (ACL) tear on sagittal T2-weighted MRI, demonstrating fiber discontinuity, increased intraligamentous signal, and marked joint effusion.

criterion; instead, they guided the decision to proceed with MRI and arthroscopy. All patients underwent a standardized clinical knee assessment prior to imaging and surgical evaluation. The senior orthopedic surgeon (Dr. Hussein Habeeb Mhawesh) performed and documented the examination using recognized diagnostic maneuvers including the Lachman test, anterior drawer test, and pivot-shift test, to assess anterior cruciate ligament integrity. The clinical findings were recorded and used to guide MRI referral and subsequent arthroscopic confirmation. Incorporating this examination ensured consistency across cases and strengthened the diagnostic workflow and reliability of comparative findings [13, 14]. The distribution of patients according to sex is illustrated in Fig. 1a, showing a predominance of male patients in the study population.

2.6. MRI Protocol

Imaging was performed with a dedicated knee coil in a supine patient position, and the knee placed at slight flexion, optimized for visualization of the anterior cruciate ligament. Sagittal T1-weighted images, sagittal and coronal T2-weighted images, and proton density–weighted images with and without fat suppression were obtained. Slice thickness varied between 3-4 mm with an interslice gap of 0.5–1 mm, and a field of view (FOV) of 14–16 cm was used to ensure high spatial resolution.

The sagittal T2-weighted sequence was very good for checking ACL continuity and fiber direction, as well as looking at any related joint problems. A normal ACL usually shows up as a low-signal band with well-organized fibers running from the lateral femoral condyle to the front part of the tibial plateau. In contrast, an ACL tear is seen by broken fibers and increased signal inside the ligament, along with poor visibility of the path of the ligament. There is often fluid in the joint when there is an ACL tear.

These imaging criteria were consistently applied to all patients to assess the presence and extent of ACL injury and to compare MRI findings with arthroscopic results.

2.7. Arthroscopy Protocol

Arthroscopy was performed under spinal or general anesthesia by orthopedic surgeons specialized in knee surgery. Standard anterolateral and anteromedial portals were used. The ACL was directly visualized and classified as intact, partially torn, or completely torn, with the arthroscopic assessment considered the gold standard. The laterality of knee arthroscopy procedures is shown in Fig. 2, with the right knee being more frequently involved than the left.

2.8. Statistical analysis

Data were entered and analyzed using Microsoft Excel 2024. Continuous variables have been expressed as mean ± standard deviation; categorical variables have been expressed in terms of their absolute values and percentages. Sensitivity, specificity, positive predictive value, negative predictive value,

Fig. 2. Position and placement of portals in knee arthroscopy.

and accuracy were calculated to check the sensitivity of MRI against arthroscopy (the gold standard). All statistical analyses and figure drawing were done in Excel; a p-value of less than 0.05 has been taken as statistically significant. The occupational distribution of patients according to sex is demonstrated in Fig. 3, indicating a higher frequency of physically demanding occupations among male patients.

2.9. Ethical considerations

The research adhered to the ethical principles delineated in the Declaration of Helsinki. Approval from the Institutional Review Board (IRB) of Balad General Hospital in Salahaddin, Iraq, was secured prior to the study's commencement. Informed consent was acquired from all participants prior to their enrollment, thereby guaranteeing confidentiality and the right to withdraw at any point without repercussions. To ensure privacy during the study, patient data were anonymized.

3. Results

The results of this study are presented in four parts: the demographic and baseline characteristics of participants, the diagnostic performance of MRI compared with arthroscopy, and comparisons of our findings with both regional and international studies, followed by a summary of observed diagnostic trends. These analyses aim to determine not only the accuracy of MRI in detecting ACL injuries but also how our findings align with previously published research.

Table 2. Statistical parameters of MRI findings based on the knee.

	No. Of Patients
True Positive	14
False Negative	1
True Negative	22
False Positive	3
Total	40

3.1. Diagnostic accuracy of MRI compared to arthroscopy

In this study, 40 patients who were suspected of having anterior cruciate ligament (ACL) injuries underwent both MRI evaluation and diagnostic arthroscopy, the latter serving as the gold standard reference. Arthroscopic examination confirmed ACL injury in 15 patients and ruled it out in 25 patients.

MRI correctly detected 14 true positives (patients with ACL injury confirmed arthroscopically), while 1 case was a false negative, where MRI failed to detect an injury that was later confirmed arthroscopically. For patients without ACL injury, MRI correctly identified 22 true negatives but misclassified 3 cases as false positives. The detailed classification is presented in Table 2.

3.2. Comparison with Regional Studies

When benchmarked against other regional research, our MRI performance metrics demonstrated both consistencies and unique strengths Fig. 3. The sensitivity in our study (93%) was higher than both Akbar's study (78%) and Khanda's study (87%), suggesting improved detection capability for ACL injuries in our patient population.

Specificity, while slightly lower than Khanda's highest reported value (96%), still surpassed Akbar's 91%, underscoring the reliability of our MRI results in excluding non-injured cases. PPV in our findings (82%) was comparable to the 81–90% range seen in regional data, while NPV (95%) slightly exceeded that in Akbar (90%) and Khanda (94%), indicating fewer missed injuries. The overall accuracy (90%) was equal to Khanda's and slightly above Akbar's (89%). These similarities and minor variations highlight the general agreement between regional studies while showcasing our study's relatively high sensitivity and NPV.

3.3. Comparison with International Studies

The diagnostic performance of MRI in our study also aligned closely with that reported in international research (Fig. 4). The diagnostic

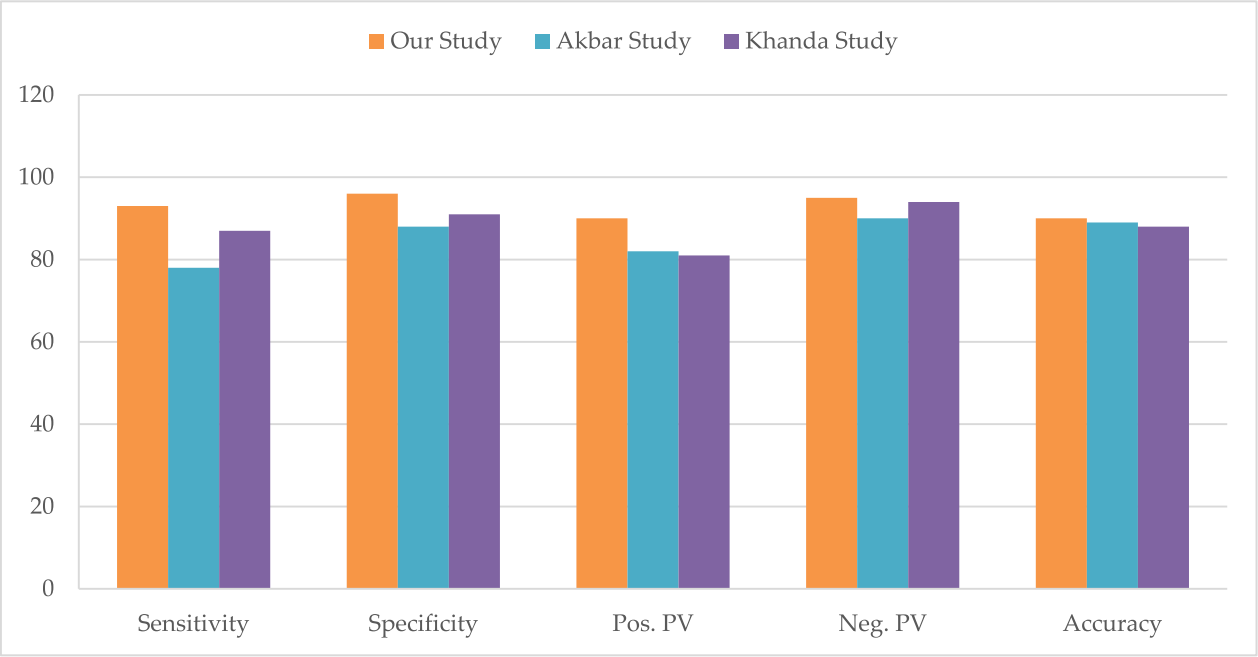

Fig. 3. Comparison with regional studies.

accuracy parameters of MRI in detecting ACL injury, including sensitivity, specificity, predictive values, and overall accuracy, are illustrated in Fig. 4. Compared to F. Rayan's results (sensitivity 81%, specificity 96%, PPV 81%, NPV 95%, accuracy 96%), our study demonstrated higher sensitivity (93%) but slightly lower specificity (88%) and accuracy (90%). This suggests our MRI protocols are robust in detecting ACL injuries but may produce a slightly higher false-positive rate.

Against R. Crawford's study (sensitivity 87%, specificity 95%, PPV 83%, NPV 96%, accuracy 93%), our findings showed better sensitivity but marginally lower specificity and NPV. The PPV was nearly identical, and the accuracy was within the same range. These comparisons suggest that the MRI accuracy in our setting is competitive with internationally recognized benchmarks, despite slight variations likely due to differences in sample size, scanner specifications, or radiological expertise.

3.4. Cost–Benefit Considerations

Magnetic resonance imaging (MRI) and diagnostic arthroscopy differ significantly in their economic and clinical implications. MRI, while more expensive per scan (ranging between 100–200 USD in Iraq and neighboring regions), provides a non-invasive and safe assessment that eliminates anesthesia, operating room time, and post-procedure recovery costs. In contrast, arthroscopy, though highly accurate and therapeutic, involves hospitalization, anesthesia risk, and higher overall procedural costs estimated at 350–500 USD per case. The diagnostic performance of MRI compared with arthroscopy, including sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy, is presented in Table 3.

When indirect costs such as patient absence from work, postoperative pain, and potential surgical complications are considered, MRI offers a more cost-effective initial diagnostic approach, particularly for patients without complex joint pathology. However, arthroscopy remains indispensable for therapeutic intervention or when MRI results are inconclusive. These findings align with the general consensus that MRI serves as a cost-efficient and clinically valuable tool in preoperative knee assessment [15, 16, 17].

3.5. Summary of Diagnostic Trends

Overall, MRI demonstrated excellent sensitivity, high specificity, and robust predictive values when compared with both regional and international studies. The slight differences across studies highlight the influence of methodological factors such as patient selection criteria, imaging protocols, and radiologist interpretation experience. Importantly, the consistently high NPV across all comparisons reinforces MRI's role as a reliable tool to rule out ACL injury in clinical practice.

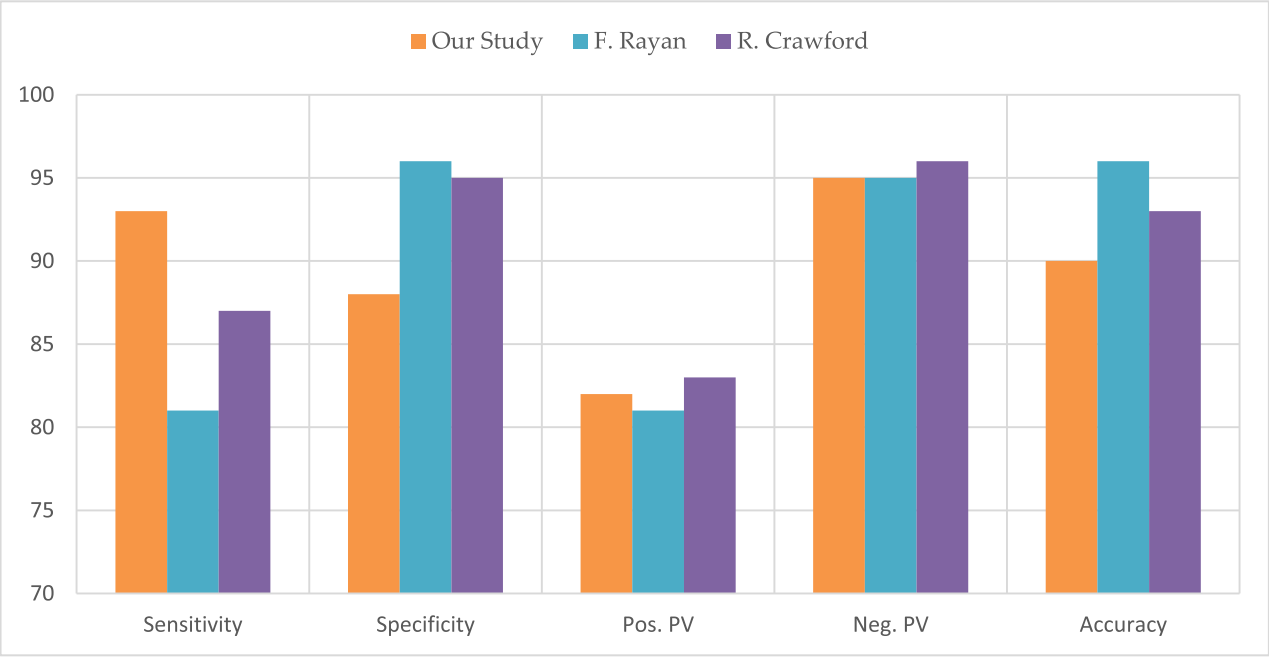

Fig. 4. Comparison with international studies.

Table 3. Comparison of MRI and Arthroscopy in Terms of Cost and Clinical Parameters.

Parameter	MRI	Arthroscopy
Procedure type	Non-invasive	Invasive (surgical)
Average cost	100–200 USD	350–500 USD
Hospital stay	None	1–2 days
Recovery time	Immediate	5–10 days
Risks	Minimal (radiology only)	Surgical/anesthetic complications
Therapeutic use	Diagnostic only	Diagnostic + Therapeutic

MRI serves as an essential diagnostic adjunct in evaluating suspected anterior cruciate ligament injuries, but does not replace the need for arthroscopy when surgical management is required. In clinical practice, MRI helps identify candidates who may benefit from conservative therapy or surgery, yet definitive diagnosis and treatment remain guided by arthroscopic evaluation. This distinction ensures that MRI optimizes patient selection while preserving the therapeutic importance of arthroscopy in knee injury management [18, 19, 20].

4. Discussion

The present study aimed to evaluate the diagnostic performance of magnetic resonance imaging (MRI) for detecting anterior cruciate ligament (ACL) injuries compared with arthroscopy, the gold standard. Our results demonstrated high diagnostic values with a sensitivity of 93%, a specificity of 88%, a positive predictive value (PPV) of 82%, a negative predictive value (NPV) of 95%, and an overall accuracy of 90%, confirming MRI's reliability as a non-invasive diagnostic tool for ACL assessment.

These findings are consistent with those reported in regional and international literature. Khanda et al. [19] reported a sensitivity of 87% and specificity of 96%, while Rayan et al. [23] found slightly lower sensitivity (81%) but higher specificity (96%). Similarly, Crawford et al. [24] and Muhle et al. [25] observed comparable diagnostic accuracies ranging between 89% and 95%. The agreement among studies underscores MRI's high diagnostic consistency when standard imaging protocols are followed and experienced radiologists perform the interpretation.

In comparison with Akbar et al. [18], who documented sensitivity and specificity of 78% and 91%, respectively, the current study shows improved sensitivity, which may reflect technological advancements in MRI resolution and local clinical expertise. Our results also align with those of Singla and Kansal [21] and Gupta et al. [22], who emphasized MRI's reliability as a first-line imaging modality before arthroscopy.

While arthroscopy remains the definitive diagnostic and therapeutic procedure, it is invasive and associated with potential surgical risks. MRI, on the other hand, offers a safer, cost-effective diagnostic

alternative, especially for early or partial tears, where clinical findings may be equivocal [13, 16, 19]. However, the combination of clinical examination and MRI yields the most reliable diagnostic pathway for ACL evaluation [12, 17].

In general, variations in sensitivity and specificity across studies can be attributed to differences in sample size, imaging protocols, magnetic field strength, and radiologists' experience. The present study, conducted with standardized MRI sequences and arthroscopic verification, supports MRI's established role as a dependable, non-invasive diagnostic method that complements clinical evaluation and surgical decision-making.

Clinically, the findings highlight MRI's role as a gatekeeping investigation that can reduce reliance on diagnostic arthroscopy, an invasive and costly procedure. Although a modest number of false positives may lead to unnecessary arthroscopies, the clinical priority remains avoiding missed diagnoses, which can worsen long-term outcomes. Advances such as isotropic 3D imaging, multiplanar reconstructions, and AI-assisted interpretation offer promising avenues to further enhance diagnostic performance. Differences in diagnostic accuracy between studies can be attributed to several factors, including MRI field strength, coil technology, slice thickness, and sequence selection, as well as radiologist expertise, patient-related variables such as the timing of imaging after injury, and methodological differences in study design.

This study's limitations include a relatively small sample size, a single-center design, and interpretation by a limited number of radiologists, which may introduce bias. While arthroscopy serves as the reference standard, interobserver variability in arthroscopic assessment remains a possibility. Future research should focus on larger, multi-center studies, the integration of advanced MRI techniques such as quantitative T2 mapping and diffusion tensor imaging, and cost-effectiveness analyses to further define the role of MRI, particularly in resource-limited settings.

Overall, the consistently high sensitivity and NPV in this study reinforce the reliability of MRI in ruling out ACL injuries, supporting its continued use as the first-line imaging modality in clinical practice.

5. Conclusion

In this study of 40 patients with suspected anterior cruciate ligament (ACL) injuries, MRI demonstrated a sensitivity of **93%**, specificity of **88%**, positive predictive value (PPV) of **82%**, negative predictive value (NPV) of **95%**, and overall diagnostic accuracy of **90%** when benchmarked against arthroscopy as the gold standard. These values confirm MRI's reliability as a primary, non-invasive diagnostic tool for ACL injury detection, particularly in ruling out injury, given its consistently high NPV. Comparative analysis revealed that our sensitivity exceeded that of several regional (78–87%) and international (81–87%) studies, while specificity and accuracy remained within competitive ranges. Although a slightly higher false-positive rate was noted, the benefits of minimizing missed injuries outweigh this limitation in most clinical contexts. Given these findings, MRI can be confidently recommended as the first-line imaging modality in cases of suspected ACL injury, thereby reducing the need for unnecessary arthroscopy, lowering patient morbidity, and optimizing healthcare resources. Future research with larger, multi-center samples and standardized MRI protocols is warranted to further refine diagnostic performance and reduce variability.

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Conflict of interest

The authors have declared that no competing interests exist.

Authors' contribution

- AlSeddiq Oday Latof: Original Draft, Conceptualization, Data Analysis, Correspondence.
- Hussein Habeeb Mhawesh: Patient Diagnosis & Clinical Evaluation, Methodology, Review & Editing.
- Ayoub Yosif Hamdan: Surgical Procedure Support, Data Collection, Review & Editing.
- Ahmed Khalaf Hamad: Surgical Procedure, Literature Review, Review & Editing.

Ethical compliance

We confirm that the study was conducted in accordance with ethical standards and approved by 108. Written informed consent was obtained from all participants prior to inclusion in the study.

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