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Research Article

Patterns of Radiological Misinterpretation of Complete Anterior Cruciate Ligament Tears on Routine MRI Reports: An Arthroscopic Validation Study

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Abstract

Background: Magnetic resonance imaging (MRI) is the primary noninvasive technique in the diagnosis of anterior cruciate ligament (ACL) injuries, and its performance is well described under ideal circumstances; however, the diagnostic accuracy in routine clinical practice is inadequately described. ***Objective***: To determine the diagnostic accuracy of routine radiological MRI reports in the diagnosis of complete ACL tears when arthroscopy is used as the reference standard. ***Methods***: This was a retrospective study, which involved 100 consecutive patients (28.8±7.8 years, and all males) who underwent knee arthroscopy with an intraoperative finding showing complete ACL tears. Preoperative MRI reports obtained from on-duty radiologists were reviewed and classified as complete, partial tear, or normal ACL. We calculated sensitivity for diagnosing complete tears in the ACL, and an exploratory analysis was done to examine the relationship between the MRI-arthroscopy interval and the accuracy of the diagnosis. ***Results***: Routine MRI interpretation correctly detected complete ACL rupture in 61 cases with a sensitivity of 61.0% (95% CI: 51.2–70.0). It is significant to note that 32% of complete tears were underestimated as partial injuries, and 7% were misinterpreted as normal. The MRI-arthroscopy interval significantly influenced diagnostic outcomes (p=0.038); however, subgroup analyses were underpowered and remain hypothesis-generating. ***Conclusions***: In routine clinical use, MRI interpretation achieved a suboptimal sensitivity (61%) in identifying arthroscopically proved complete ACL tears, and a significant proportion of cases were underestimated. To improve diagnostic accuracy, it is necessary to combine clinical examinations with imaging and employ radiologist-focused quality improvement programs.

Keywords: Anterior cruciate ligament injuries, arthroscopy, diagnostic accuracy, magnetic resonance imaging.

أنماط سوء تفسير التقارير الشعاعية الروتينية للتصوير بالرنين المغناطيسي في تمزقات الرباط الصليبي الأمامي الكامل: دراسة تحقق باستخدام التنظير المفصلي

الخلاصة

الخلفية: التصوير بالرنين المغناطيسي (MRI) هو التقنية الرئيسية غير الجراحية في تشخيص إصابات الرباط الصليبي الأمامي(ACL) ، وأداؤه موصوف بشكل جيد في الظروف المثالية؛ إلا أن دقته التشخيصية في الممارسة السريرية الروتينية ما تزال غير موثقة بشكل كاف. **الهدف**: تحديد الدقة التشخيصية للتصوير بالرنين المغناطيسي الروتينية في تشخيص تمزقات الرباط الصليبي الأمامي الكامل عند استخدام تنظير المفاصل كمعيار مرجعي. **الطرائق**: أجريت هذه الدراسة الاسترجاعية على 100 مريض من الذكور (28.8 ±7.8 سنة) خضعوا لتنظير مفصل الركبة مع تأكيد وجود تمزق كامل في الرباط الصليبي الأمامي أثناء الجراحة. جرى استعراض تقارير التصوير بالرنين المغناطيسي قبل الجراحة الصادرة عن أطباء الأشعة المناوبين، وتصنيفها إلى: تمزق كامل، تمزق جزئي، أو رباط صليبي أمامي طبيعي. تم حساب الحساسية في تشخيص التمزقات الكاملة للرباط الصليبي الأمامي، كما أجري تحليل استكشافي لدراسة العلاقة بين الفاصل الزمني بين التصوير بالرنين المغناطيسي والتنظير المفصلي ودقة التشخيص. **النتائج**: نجح التفسير الروتيني للتصوير بالرنين المغناطيسي في الكشف الصحيح عن التمزق الكامل للرباط الصليبي الأمامي في 61 حالة، بحساسية بلغت 61.0% (فاصل ثقة 95%: 51.2–70.0%). ومن الجدير بالذكر أن 32% من التمزقات الكاملة جرى التقليل من شدتها وتصنيفها كتمزقات جزئية، و7% من التمزقات الكاملة تم تفسيرها بشكل خاطئ على أنها طبيعية. وقد كان للفاصل الزمني بين التصوير بالرنين المغناطيسي والتنظير المفصلي تأثير ذو دلالة إحصائية على نتائج التشخيص(p=0.038) ؛ إلا أن تحليلات المجموعات الفرعية كانت محدودة القدرة الإحصائية وتُعد ذات طابع توليدي للفرضيات. **الاستنتاجات**: في الاستخدام السريري الروتيني، فإن تفسير التصوير بالرنين المغناطيسي لديه حساسية دون المستوى الأمثل (61%) في تحديد تمزقات الرباط الصليبي الأمامي الكاملة المثبتة بالمنظار، مع التقليل من تقدير شدة الإصابة في نسبة معتبرة من الحالات. مزيج الفحوصات السريرية مع التصوير واستخدام برامج تحسين الجودة الموجهة لأطباء الأشعة ضروري لتحسين دقة التشخيص.

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INTRODUCTION

Anterior cruciate ligament (ACL) injuries are one of the most common and clinically significant knee injuries, showing an incidence of 68.6 cases per 100,000 persons every year [1]. Anterior cruciate ligament tears occur by a non-contact mechanism in about 70% of cases. These injuries are observed to be particularly more common among the athletes involved in high-demand, pivoting sports such as football, basketball, and volleyball, in which the rapid change of directions, deceleration, and cutting maneuvers put considerable strain on the ligament [2–4]. Because of functional instability, many patients with ACL deficiency, especially young and physically active people, require surgical reconstruction, which is performed in a considerable proportion of ACL injuries, reported to be as high as 76.6% in some series [5]. In Iraq, the burden of sports-related knee injuries has increased significantly over the last ten years, with ACL

tears taking up a significant percentage of the orthopedic consultations. This increase reveals the necessity of ensuring the presence of the right diagnostic models that can inform timely and correct management. Accurate and timely diagnosis of ACL injuries is critical to provide the right management and excellent patient outcomes, which are achieved with the help of clinical assessment, which includes a focus on comprehensive history-taking, the mechanism of injury, and patient symptoms, and thorough physical examination along with MRI study and, finally, arthroscopic evaluation, because the delay in diagnosing ACL injuries may result in secondary meniscal injury, cartilage degeneration, and the development of long-term joint instability [5,6]. Magnetic resonance imaging (MRI) is the most popular non-invasive imaging modality for assessing the anterior cruciate ligament (ACL), which offers excellent soft tissue contrast and multiplanar imaging and thus allows assessment of ligamentous integrity to be comprehensive [7,8]. Meta-analyses conducted under controlled conditions have reported pooled MRI sensitivity and specificity in the detection of ACL tears is about 87% and 90%, respectively [9,10], Nevertheless, the diagnostic accuracy of MRI interpretation can differ substantially depending on the experience of the radiologist, subspecialty in musculoskeletal radiology, magnetic field strength (1.5T vs 3T), the MRI protocols and sequences used, and overall image quality [8,11]. Despite extensive literature on MRI performance under optimal conditions, few studies have evaluated its accuracy in routine clinical practice, where knee magnetic resonance imaging examinations are often reviewed by general radiologists with varying levels of musculoskeletal expertise. This variability can affect the accuracy of the diagnostic outcome, particularly in differentiating complete from partial ACL tears, as the distinction between these two types presents specific diagnostic challenges. Arthroscopy is considered the gold standard for assessing intra-articular knee structures because it provides direct visualization, which enhances both diagnostic and therapeutic accuracy [12]. In turn, the gap between radiological magnetic resonance imaging (MRI) reporting and arthroscopic confirmation is an important quality indicator that shows actual diagnostic performance in radiological practice. The current retrospective cohort study was conducted to determine the diagnostic accuracy of routine radiological MRI reports in detecting complete tears of the ACL, and arthroscopy was used as a reference tool. Additionally, we performed an exploratory analysis to determine whether the interval between MRI and surgery influenced the diagnostic accuracy.

METHODS

Study design and setting

This is a retrospective diagnostic accuracy study, which was carried out in the orthopedic department of the Al Diwaniyah Teaching Hospital in Iraq and involved consecutive patients who underwent knee arthroscopy due to the suspicion of anterior cruciate ligament injury between 2 June 2024 and 15 October 2025. The study protocol was approved by the local research ethics committee and carried out based on the Standards for Reporting Diagnostic Accuracy (STARD) guidelines, and a completed STARD checklist was available as a supplementary file [13]. Based on an expected MRI sensitivity of 90% for ACL tears, with a precision of ±6% and a 95% confidence level, the minimum required sample size was calculated to be 96 knees with ACL tears. We included 100 consecutive patients meeting the eligibility criteria.

Inclusion criteria

Patients aged 16 years or older (actual range in the included cohort was 17-50 years). History and physical examination showed a clinical suspicion of ACL injury. Preoperative knee magnetic resonance imaging (MRI) examination, which had a corresponding routine radiology report performed according to the established institutional protocols and doing arthroscopy with an arthroscopically proven complete ACL tear.

Exclusion criteria

Existence of multi-ligamentous knee injuries requiring emergency surgery. The low quality of MRI images did not allow accurate interpretation, and arthroscopic finding documentation was incomplete.

Data collection

Data were retrospectively retrieved from electronic and operative medical records. The variables obtained included patient age, sex, the time interval between MRI and arthroscopic surgery, and the MRI-reported classification of ACL integrity. A complete rupture of the anterior cruciate ligament, as confirmed during arthroscopic surgery, was the reference standard. Before analysis, the datasets were anonymized to protect the confidentiality of the patients. Preoperative MRI examinations were performed according to the standard knee MRI protocol using 1.5T systems. The MRI reports were issued by routine on-duty radiologists with varying experience levels. Radiologists were blinded to the finding of arthroscopy but were aware of the clinical pointer. There were no quality assurance processes. Retrospective rereading was not done. The current study was limited to the review of original clinical reports to reflect normal diagnostic performance. For analysis, MRI interpretation of the ACL was categorized into three groups based on the original radiology report (complete tear, partial tear, and normal/intact ACL). For the primary diagnostic analysis, MRI results were divided into two separate parts: positive, reported as a complete tear, and negative, reported as a partial tear or normal.

Reference standard

All patients were subjected to arthroscopy by experienced orthopedic surgeons. Arthroscopy was done either under general or spinal anesthesia with standard portals. A complete tear of the ACL was defined as complete fiber discontinuity with a nonfunctional remnant. The arthroscopic findings documented in the operative reports were extracted and used as the reference standard. Surgeons were not blinded to MRI.

MRI–arthroscopy interval

The interval between the index diagnostic test (MRI) and arthroscopic surgery was calculated in days for each patient. The patients were grouped based on the interval mentioned above into three preset groups: ≤42 days, 43–90 days, and >90 days. This classification is intended to establish the temporal relationship between the MRI and the arthroscopy, rather than the interval between the injury and the surgical intervention. Based on small sample sizes in the subgroups, the conducted analyses were not powered for firm conclusions and should be considered a way to generate hypotheses.

Outcome measures

The sensitivity of magnetic resonance imaging (MRI) to detect complete ACL ruptures was the main outcome measure with the use of arthroscopy as the reference standard. Since all included cases were confirmed to have complete tears through arthroscopy, it was not possible to calculate specificity, negative predictive value, and overall accuracy.

Statistical analysis

Data were entered into Microsoft Excel 365, and analysis was done by using IBM Statistics SPSS 21. Continuous variables were described in terms of their mean ± standard deviation, or median, as necessary, and categorical variables were described in terms of frequencies and percentages. MRI reports that described partial tears of the anterior cruciate ligament or a normal ligament appearance were classified as false-negative findings. Ninety-five percent confidence intervals were estimated using the Wilson score method. The two-sided Fisher-Freeman-Halton exact test was employed to determine the association between MRI-arthroscopy interval groups and diagnostic outcomes (true positive and false negative). A p-value less than 0.05 was regarded as statistically significant.

RESULTS

The analysis consisted of 100 male patients who had arthroscopically confirmed complete tears of the ACL and thus formed the reference standard. Baseline demographic characteristics and MRI report classifications are summarized in Table 1.

Table 1: Baseline characteristics of the study population (n = 100)

Characteristic	Value
Age (year)	28.8±7.8
Range	17–50
Sex	
Male	100(100)
The median MRI-to-arthroscopy interval (day)	44
MRI report classification	
Complete ACL tear	61(61)
Partial ACL tear	32(32)
Normal / intact ACL	7(7)
Arthroscopically confirmed complete ACL tear	100(100)

Values are expressed as frequency, percentage, and mean±SD. ACL: anterior cruciate ligament.

When arthroscopy was used as the reference standard, the routine preoperative MRI findings revealed moderate sensitivity for a complete ACL tear. The false negatives of the MRI essentially described partial ACL tears and those identified as normal ACL. The distribution of true-positive and false-negative and sensitivity and the corresponding 95% confidence interval are presented in Table 2.

Table 2: Diagnostic performance of MRI for detecting complete ACL tears (n = 100)

MRI result	Arthroscopy-confirmed complete ACL tear
True positive	61
False negative	39
Sensitivity (%)	61.0
95% CI (Wilson)	51.2–70.0

ACL: anterior cruciate ligament; CI: confidence interval.

Patients were grouped according to the time elapsed between MRI acquisition and arthroscopic surgery: early (less than 42 days), intermediate (43 to 90 days), and prolonged (more than 90 days). These groups had different sensitivity estimates, which are shown in Table 3. However, in spite of small sample sizes and overlapping confidence intervals, statistical comparison using the two-sided Fisher–Freeman–Halton exact test demonstrated a significant association between the MRI–arthroscopy interval group and the MRI diagnostic outcome (p= 0.038). The intermediate-delay group had the least sensitivity for detecting complete ACL rupture in which the participant group was small (n = 14), and the wide confidence interval (11.7–54.6%) indicates substantial statistical uncertainty. These findings are tentative and should be verified in larger studies.

DISCUSSION

The present study demonstrates that routine MRI interpretation in everyday clinical practice produces only moderate sensitivity (61.0%, 95% CI: 51.2–70.0%) for the detection of complete ACL tears when arthroscopy is used as the reference standard. The overall detection rate for any ACL pathology was 93%, which means that most injuries were recognized.

Table 3: MRI sensitivity stratified by MRI–arthroscopy interval

MRI-arthroscopy interval group	TP	FN	Total (n)	Sensitivity (%)	95% CI (Wilson)
Early (≤42 days)	29	15	44	65.9	51.1–78.1
Intermediate (43–90 days)	4	10	14	28.6	11.7–54.6
Prolonged (>90 days)	28	14	42	66.7	51.6–79.0
Overall	61	39	100	61.0	51.2–70.0

TP: true positive; FN: false negative.

However, the reported sensitivity for correctly diagnosed complete ACL tears (61.0%) was lower than the pooled MRI sensitivity of approximately 87% shown in meta-analyses of studies conducted in North America, Europe, Australia, and Asia [9,10]. Our results are in line with previous reports of an MRI sensitivity for ACL tears of 63.6 and 70 percent [14,15]. Remarkably, 32% of complete tears have been underestimated as partial tears, and 7% were completely missed and reported as normal ACL. These results suggest that, despite the MRI being effective for identifying ACL pathology, radiologic reporting in routine practice often does not succeed in characterizing tear severity as accurately as possible. The underestimation rate (32%) represents our most clinically significant finding of this study. This diagnostic grey zone highlights significant limitations in the diagnostic performance of routine radiological reporting for ACL injuries under real-world conditions. The differentiation between partial and complete ACL tears on MRI is inherently a difficult mission in the everyday practice setting. Complete tears include having discontinuity of all ligamentous fibers and the absence of normal linear low-signal structure, whereas partial tears show a break of some fibers with the remaining fibers still intact, maintaining a portion of ligament continuity [8]. Several possible underlying mechanisms are probably contributing to this diagnostic pattern. In chronic ACL injuries (≥6 weeks), scar tissue formation between disrupted ligament ends and persistence of the synovial sheath may produce intermediate signal intensity on MRI that mimics residual fiber continuity; notably, most cases in the present cohort were chronic, which likely increased the risk of misclassification [8,16]. A systematic evaluation of secondary findings on MRI has been found to improve the accuracy of diagnosing a complete ACL tear. In contrast, the under recognition of these signs may contribute to missed diagnoses when radiologists focus chiefly on direct visualization of the continuity of ligament fibers. These signs include anterior tibial translation relative to the femur (>7 mm suggests a complete tear), pivot-shift-related bone contusions, particularly involving the lateral femoral condyle and posterior lateral tibial plateau, posterior cruciate ligament buckling or an abnormal acute angle (<105°), exposure of the lateral meniscus's posterior horn, and an empty notch sign with the absence of normal ACL fibers in the intercondylar notch [8]. The variability in the radiologist's level of experience within the field of musculoskeletal radiology [11,17,18], the absence of structured ACL-specific reporting criteria in routine practice, and the usual tendency towards more conservative reporting in which the more equivocal findings are more readily interpreted as a partial tear [8,9,19]. Such factors may lead to underestimation of tear severity despite arthroscopically confirmed complete tears. Also, a partial tear of the ACL may progress to complete rupture with time, especially in young active patients. In addition to underestimation, the finding that 7% of complete tears of ACL were reported as normal on an MRI indicates a significant interpretive failure. Radiologists seem to have understated overt intraligamentous signal abnormality and have not sufficiently evaluated ligament orientation, tension, and secondary signs of instability. Cognitive bias toward normality in equivocal studies likely contributed to false reassurance by highlighting that a normal MRI report sometimes includes complete ACL rupture in routine clinical practice. The combination of these interpretive deficiencies explains the significant gap between the technical performance of MRI and the diagnostic performance in routine clinical practice [8,20]. An exploratory subgroup analysis examined whether diagnostic sensitivity varied with the interval between MRI and arthroscopy. Patients with early arthroscopy (≤ 42 days) were assumed to have severe and unequivocal injuries, which made accurate diagnosis easy. The intermediate group (43–90 days) may show less pronounced clinical presentations with equivocal findings and can have delayed surgical confirmation and an increased rate of diagnostic misclassification, especially in partial tears. Prolonged-delay patients (>90 days) were selected based on persistent instability despite initially equivocal findings that made the diagnosis more obvious than others. The differences in the MRI sensitivity across MRI–arthroscopy interval groups are unlikely to reflect biological change because the interval represents the time from MRI to surgery rather than injury chronicity. In general, this pattern aligns with selection bias as a result of confounding by indication, in which the determinants of surgical timing also affect the accuracy of diagnosis. This study is strengthened with the use of arthroscopy as the reference standard that provides definitive verification of a complete tear of the ligaments and offers a genuine assessment of MRI interpretation in the common clinical practice conducted by general radiologists. Therefore, it is a real-world diagnostic performance. Compliance with STARD reporting requirements and defining severity underestimation as the most common diagnostic error provide valuable and clinically useful information.

Clinical implications

The 61% sensitivity in detecting complete ACL tears in routine practice shows that reliance on MRI reports alone can result in underdiagnosis or inappropriate conservative treatment in a significant proportion of cases. When clinical examinations suggest ACL insufficiency, a referral to arthroscopic assessment by orthopedic surgeons should be considered even under the circumstances where MRI reports describe the presence of partial tears or an intact ligament, as these findings might represent false-negative interpretations of a complete tear. The combination of the physical examination findings, especially the Lachman test, anterior drawer test, and pivot shift test, with the imaging findings remains essential for diagnostic accuracy [21]. From a healthcare system's perspective, these results uncovered the necessity of subspecialty musculoskeletal radiology training, the use of ACL-specific reporting templates [22,23], and the use of quality assurance programs. Such feedback systems could detect systematic interpretation errors and aid in improving diagnostic consistency in everyday practice [24].

Study limitations and prospects

There were several limitations in this study. The retrospective, single-center design and only including surgical candidates might limit generalizability, because patients managed conservatively were not included, resulting in some selection bias, and it was not possible to assess MRI specificity or negative predictive value. The exclusively male composition of this surgical cohort is consistent with the predominant demographic of patients presenting for ACL surgery at our institution during the study period, and this represents an important limitation that restricts the generalizability of the findings to female patients, in whom injury mechanisms, anatomical features, knee biomechanics, and the MRI appearance of ACL tears may differ and potentially affect diagnostic performance. The interpretation of MRI examinations was performed by many radiologists, each with different levels of experience, and the impact of subspecialty training could not be examined separately. There was no available information regarding the interval between injury and MRI acquisition; this limited the ability to assess the chronicity of injuries and their potential influence on MRI diagnostic performance. Future studies should focus on using prospective multicenter designs with standardized MRI protocols and include both sexes. Blind interpretation should be graded based on radiologist training and subspecialty experience and examine the influence of injury chronicity. Given that radiologist expertise is the key modifiable determinant of diagnostic accuracy, research should focus on ways to improve interpretive performance in everyday practice. This could include subspecialty musculoskeletal radiology training that teaches more about ligamentous anatomy, injury patterns, and signs of a secondary ACL tear, which would make it easier to take a more systematic and less cautious approach to equivocal findings. The use of structured ACL-specific reporting templates improves diagnostic accuracy by promoting systematic assessment of ligament continuity, orientation, associated secondary features, a clear differentiation between a complete and a partial tear, and additional findings. The introduction of quality assurance programs such as systematic matching of magnetic resonance imaging (MRI) findings to arthroscopic outcomes and delivery of specific feedback to reporting radiologists is conducive to the identification of systematic interpretive errors and facilitates consistency of diagnostic findings in routine clinical practice. In addition, the availability of AI-assisted interpretation tools achieves an accuracy of over 96%, regardless of the user's level of experience, which necessitates validation [25]. Furthermore, it needs cost-effective analyses of subspecialist second-read or teleconsultation models. The improvement of radiologists' accuracy is fundamental in decreasing false-negative MRI diagnoses and optimizing ACL injury treatment.

Conclusions

In routine clinical practice, MRI interpretation achieves suboptimal sensitivity (61%) in detecting arthroscopically confirmed complete ACL tears, and a substantial proportion of cases are underestimated as partial injuries or misclassified as normal. The findings of the present study highlight the importance of integrating clinical examination with the interpretation of radiographic findings and the need for radiologist-focused quality improvement initiatives, like focused education, structured reporting, and systematic performance feedback, to achieve the highest possible diagnostic accuracy in routine clinical practice.

Conflict of interests

The authors declared no conflict of interest.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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