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Original Article

# THE PRECISION OF MRI IN THE DIAGNOSIS OF ANTERIOR CRUCIATE LIGAMENT INJURY AMONG ATHLETES IN RIYADH, KSA.

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## ABSTRACT

**Introduction:** An anterior cruciate ligament (ACL) is a frequently injured among athletes. ACL injuries occur due to strong contact or indirect knee trauma, causing the enlarging or destroying of non-contractile, and elastic soft-tissue articular structures.

**Aims:** anterior cruciate ligament injury is the most injured among young athletes. It could be a complete or partial tear. This study aimed to evaluate the role of MRI and physical examination in diagnosis of anterior cruciate ligament tears among athletes.

**Method:** The data on anterior cruciate ligament tears were collected retrospectively from Riyadh main hospitals, KSA. The diagnosis went through physical examinations and MRI knee protocol, and the final diagnosis in most cases was based on the physical examination combined with MRI image.

**Results:** Our data consist of 32 male athletic patients with anterior cruciate ligament tears. The incidence of athlete injuries was mainly among young males between 20-35 years old. The most commonly reported was a partial tear by 66% and a complete tear by 34%. MRI is the main tool to evaluate ACL injury and differentiate between partial and complete ACL tear

**Conclusion:** The final reported cases were diagnosed by using a special MRI knee protocol. A partial tear is the most common injury among young male Saudi athletes, which is a male injury in Saudi society.

## البحث: ملخص

**مقدمة:** الرباط الصليبي الأمامي هو إصابة متكررة بين الرياضيين. تحدث إصابات الرباط الصليبي الأمامي بسبب التلامس القوي أو صدمة الركبة غير المباشرة, مما يتسبب في توسيع أو تدمير الهياكل المفصلية المرنة ذات الأنسجة الرخوة غير القابلة للانقباض.

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**الاهداف:** تعتبر إصابة الرباط الصليبي الأمامي هي الأكثر إصابة بين الرياضيين الشباب. يمكن أن يكون تمزقًا كاملاً أو جزئيًا. هدفت هذه الدراسة إلى تقييم دور التصوير بالرنين المغناطيسي والفحص البدني في تشخيص تمزقات الرباط الصليبي الأمامي لدى الرياضيين.

**الطريقة:** تم جمع البيانات عن تمزقات الرباط الصليبي الأمامي بأثر رجعي من المستشفيات الرئيسية في الرياض, المملكة العربية السعودية. تم التشخيص من خلال الفحوصات الجسدية وبروتوكول الركبة بالتصوير بالرنين المغناطيسي, وكان التشخيص النهائي في معظم الحالات يعتمد على الفحص البدني مع صورة التصوير بالرنين المغناطيسي.

**النتائج:** تتكون بياناتنا من 32 مريضا رياضيا يعانون من تمزقات في الرباط الصليبي الأمامي. وكانت نسبة حدوث إصابات الرياضيين بشكل رئيسي بين الشباب الذكور الذين تتراوح أعمارهم بين 35-20 سنة. وكان الأكثر شيوعًا هو التمزق الجزئي بنسبة 66% والتمزق الكامل بنسبة 34%. التصوير بالرنين المغناطيسي هو الأداة الرئيسية لتقييم إصابة الرباط الصليبي الأمامي والتمييز بين تمزق الرباط الصليبي الأمامي الجزئي والكامل.

**الاستنتاج:** تم تشخيص الحالات النهائية المبلغ عنها باستخدام بروتوكول خاص للتصوير بالرنين المغناطيسي للركبة. التمزق الجزئي هو الإصابة الأكثر شيوعا بين الرياضيين السعوديين الشباب, وهي إصابة الذكور في المجتمع السعودي.

**الكلمات المفتاحية:** تمزق كامل في الرباط الصليبي الأمامي؛ تمزق جزئي في الرباط الصليبي الأمامي؛ التصوير بالرنين المغناطيسي. الرياضيين السعوديين؛ تشخيص تمزق الرباط الصليبي الأمامي؛ التصوير الطبي.

**Keywords:** Complete anterior cruciate ligament tear, Partial anterior cruciate ligament tear, MRI imaging, anterior cruciate ligament tear diagnosis, medical imaging

## 1. INTRODUCTION

The anterior cruciate ligament (ACL) is the most frequently injured large ligament in the knee among athletes. ACL injuries typically result from strong contact or indirect knee trauma, leading to the stretching or tearing of non-contractile, elastic soft-tissue articular structures [1, 2].

A partial ACL tear occurs when the ligament is not completely torn. In such cases, the ligament may exhibit instability and weakness but remains relatively intact, characterized by ACL laxity, meaning the ligament is looser than normal. While not as painful as a complete tear, a partial tear is still uncomfortable. It typically occurs when there is an unexpected shift in the joint, causing the joint to develop a tendency to give out [3–6].

Male and female athletes are both susceptible to ACL injuries, with females generally experiencing a higher incidence rate than males, according to various studies. However, this study focuses specifically on ACL injuries among professional athletes in the Kingdom of Saudi Arabia. We did not include injuries among female athletes due to the currently low number of registered professional female athletes in the country [7–10].

The ability to differentiate between various types of ACL ruptures preoperatively would enable surgeons to select the most appropriate surgical treatment [11–14]. A partial ACL tear involves damage to only a portion of the ACL and is primarily diagnosed through radiology or MRI rather than orthopedics. While many patients with a partial ACL tear can return to their prior activity levels without issues of instability, buckling, or giving way, some patients may not be able to resume their previous level of activity due to feelings of knee instability or weakness [6, 9].

Physiotherapists can often diagnose an ACL tear through an external examination of the knee. The diagnosis is usually confirmed with an X-ray or Magnetic Resonance Imaging (MRI) scan to determine the extent of the tear and check for additional injuries to the knee joint [15, 16]. During the physical examination, special stress tests are performed on the knee, with the Lachman, pivot-shift, and anterior drawer tests being the most commonly used. The Lachman test is the most sensitive, while the pivot shift is the most specific for diagnosing an ACL rupture. In these tests, the doctor places the patient's knee and leg in various positions and applies a load or force to the joint. Any unexpected movement or excess motion of the tibia relative to the femur may indicate ligament injury and insufficiency. These physical examination techniques form the basis of the clinical assessment for suspected cruciate ligament ruptures in the knee [17–19].

MRI examination is the preferred method for diagnosing ACL injuries as it provides precise information about lesions in various organs, including the knee. MRI is the ideal imaging technique to assess the status of the ACL—whether intact, ruptured, or healed.

Potter et al. conducted a prospective, observational study involving 40 patients with acute, isolated ACL injuries (14 treated nonoperatively and 28 treated with reconstruction). The study included imaging at the time of injury and annual follow-up for up to 11 years. Morphologic MRI and quantitative T2 mapping, along with validated outcome measures, were employed. The study concluded that MRI effectively diagnosed chondral injuries sustained at the time of the initial impact in all patients with acute, traumatic ACL disruption [13].

Filbay et al. reported that MRI is the most reliable method for detecting knee ligamentous injuries and recommended that ACL reconstruction (ACLR) should be tailored to individual needs and based on specific criteria. They emphasized that a gradual return to sports and activities should be a key component of the rehabilitation process. The main factors in determining an athlete's readiness to return to sport include physical readiness, psychological readiness, and biological healing. Athletes who return to pivoting sports after ACLR can lower their risk of re-injury by meeting both time-based and functional criteria before resuming their activities [20].

The protocol includes several pulse sequences for imaging the knee, such as axial PD FSE (fat sat), coronal PD FSE (fat sat), sagittal oblique PD FSE (fat sat), coronal T1 SE, and sagittal oblique T2 FSE (fat sat) [15, 21].

In Saudi society, there is an increasing tendency for ACL tears among young people who become professional athletes. This type of injury can lead to a long lay-off from sports, posing a career-threatening risk. Therefore, early diagnosis is essential. The primary aim of this study was to assess the value of MRI in diagnosing ACL tears, and its ability to distinguish between partial and full ACL tears.

## 2. MATERIALS AND METHOD

This is a retrospective study, where 32 medical records of patients with ruptured ACL at Physical therapy and MRI departments were reviewed. The criteria for chosen cases included a tear of the ACL verified by physical examination and MRI scans of the injured knee. In addition, the patient's information includes age at the time of injury, gender, physical examination, MRI exam, cause and diagnosis-based method. The data collected from Riyadh hospitals after obtain the appropriate IRB approval from the research committee at Princess Nourah Bint Abdulrahman University.

### 2.1 Lachman physical examinations:

The Lachman test is a specific clinical exam technique used to evaluate patients with a suspected anterior cruciate ligament (ACL) injury [21, 22]. The test relies on proper positioning and technique and is regarded as the most sensitive and specific test for diagnosing acute ACL injuries. For this examination the patient lies supine on the bed with their knee in about 20-30 degrees flexion, the tibia slightly laterally rotated and the anterior tibial translation force should be applied from the posteromedial aspect. The hand on the tibia should apply the translation force. With acute trauma, swelling prevents the examiner from getting a true indication of joint mobility [3, 22].

### 2.2 MRI measurements:

T1 and T2-weighted images are used to diagnose anterior cruciate ligament (ACL) injuries because they provide complementary information about the knee's anatomical structures and pathological changes.

T1-Weighted Images: These images offer excellent anatomical detail and tissue contrast, clearly delineating the normal anatomy of the knee, including the ACL, bones, and other soft tissues. They are particularly good at showing fat, which appears bright, helping in

visualizing the bone marrow and distinguishing it from other structures. T1 images also serve as a baseline for comparing T2-weighted images, aiding in the accurate assessment of changes and abnormalities.

T2-Weighted Images: These images are highly sensitive to fluid and edema, which appear bright, making them useful for detecting inflammation, tears, and other pathological changes in the ACL. T2 images provide better contrast between fluid-filled structures and surrounding tissues, helping to identify injuries and degenerative changes.

The combination of T1 and T2-weighted images allows radiologists to differentiate between normal and abnormal tissues, making it easier to identify partial or complete ACL tears. This comprehensive approach facilitates a detailed and accurate understanding of the ACL and surrounding knee structures, improving diagnosis and treatment planning.

Collecting MRI data on ACL imaging from different scanners does not compromise the accuracy of the results. This is because all MRI scanners use standardized protocols for imaging the ACL, ensuring consistency in the quality and type of images produced. Consequently, the research data quality and outcomes remain unaffected by the use of multiple data sources. The uniformity in imaging protocols across different MRI machines ensures that the diagnostic criteria and assessment of ACL injuries are consistent and reliable, allowing for robust and comparable results regardless of the scanner used.

The conventional MRI knee protocol includes several Spin-echo (SE) T1-weighted images (TR 330 ms/TE 15 ms, NEX 1), and T2 pulse sequences in various orientations, as shown in Table 1 . T1 sequence show the anatomy of the imaged area. T2 sequence is used to show the relation of ACL illnesses and injuries, and the appearance of these symptoms. All MRI images for these ACL study cases were imaged at 1.5 Tesla Philips magnetic resonance scanner. T1 and T2 weighted images are used in the diagnosis of anterior cruciate ligament (ACL) injuries because they provide complementary information about the knee's anatomical structures and pathological changes.

**Table 1** Conventional knee protocol

| Routine sequences | Additional sequences |
|---|---|
| 3-plane LOC Right or Lift | SAG T2 FS |
| Calibration | SAG PD |
| SAG T1 | SAG PD\T2 FS |
| SAG PD FS | AXIAL PD |
| AX PD FS | COR OBL |
| COR T1 FS | |
| SAG OBL T2 | |

Table 2 includes several primary and secondary signs that can be used to determine ACL integrity. Both primary and secondary magnetic resonance imaging signs have value in diagnosing an ACL tear [1].

**Table 2** Signs of ACL tear on MRI scan

| Primary signs | Secondary signs |
|---|---|
| anterior cruciate ligament discontinuity or abnormal course | bone bruise pattern |
| a loss of paralleling Blumen sats line | buckling of posterior cruciate ligament<br>anterior translation of the tibia |

## 3. RESULTS

### 3.1 Descriptive analysis:

The sample consisted of 32 patients. The presented results showed that the incidence of athlete injuries was mainly among young males between 20-35 years old, and only Three cases were in their forties. The mean of age of 28.1± 8.4 years.

**Table 3** Descriptive analysis

| | ***Column1*** |
|---|---|
| Mean | 28.75 |
| Standard Error | 0.521706 |
| Median | 28.5 |
| Mode | 30 |
| Standard Deviation | 2.951216 |
| Sample Variance | 8.709677 |
| Kurtosis | -0.86432 |
| Skewness | 0.405608 |
| Range | 10 |
| Minimum | 25 |
| Maximum | 35 |
| Sum | 920 |
| Count | 32 |
| Confidence Level (95.0%) | 1.064027 |

These patients were athletes in the first stage of their lives, and they practice steady physical training related to their field of sport; the most common professional sport in Saudi society is soccer. Therefore, all the reported injuries happened during physical activities.

### 3.2 The Sensitivity and Specificity Analysis:

**Table 4** Comparison of MRI and arthroscopy [n (%)]. CT: complete tear, PT: partial tear.

| MRI | MRI/ Lachman test | | |
|---|---|---|---|
| | CT | PT | TOTAL |
| CT | 12 (55%) | 9 (90%) | 21(66%) |
| PT | 10 (45%) | 1 (10%) | 11 (34%) |
| TOTAL | 22 | 10 | 32 |

**Table 5** Detection of ACL injury by MRI [n (%)]

| MRI | MRI/ Lachman test | | |
|---|---|---|---|
| | POSITIVE | NEGATIVE | TOTAL |
| POSITIVE | 22(81.5%) | 1 (20%) | 26 (81.3%) |
| NEGATIVE | 5(18.5%) | 4 (80%) | 6 (18.8) |
| TOTAL | 27 (84.4%) | 5 (15.6%) | 32 |

The most common reported injury was the partial tear, with 21 cases out of 32 all reported cases (66%) and 11 full ACL tears, as shown in Figure 1. In addition, all cases performed MRI, and 27 (84%) performed MRI with physical examination, while only 5 (15%) performed MRI directly with no physical examination. Sensitivity 81.5%, and specificity 80% as shown inTable 5.

Data showed that MRI is the main tool to evaluate ACL injury and differentiate between partial and complete ACL tear through an additional sequence with MRI knee protocol, as presented in Table 5 (81.5% positive).

## 4. DISCUSSION

Our data showed that ACL in Saudi Arabia is a male injury, and this can be explained based on the fact that this type of injury is related more to sports activities and becoming a professional athlete due to society's culture.

One of the major results of the current study indicates that partial ACL tear is more common than complete ACL tear among the cases in the current study samples. This outcome supports the fact that partial tears of ACL are more detectable in beginner athletes. In Saudi society, most athletes are considered trainees of sports more than full professional athletes. However, the data was collected from a small sample of athletes' patients, which might affect the outcomes.

All cases included in this study showed that MRI gives better information about lesions in the knee and enables diagnosis of ACL tear compared to the physical examination with

sensitivity of 81.5% and specificity of 80%. In addition, most studies have found that detecting partial tears on MRI is more accurate than other imaging modalities [20].

In some cases, the physiotherapist will often be able to diagnose an ACL tear after an external examination of the knee. The final diagnosis will normally be confirmed by an X-ray or MRI scan to determine the extent of the tear and to check for further damage to the knee joint. However, recently there has been a tendency to rely completely on the diagnosis on MRI and extra MRI sequences added to the general knee protocol to differentiate partial ACL tear as shown in table1. This tendency towards MRI is supported by research, proving the significance and efficacy of MRI over other diagnostic measures.

In this study, 5 cases did not perform physical examination and were sent directly for MRI scan. Unfortunately, we did not have enough information regarding why these cases did not have a physical examination since this is a retrospective study.

A previous study done by Allen and others [21] reported a limitation in using physical examination in ACL diagnosis due to many factors, such as in large patients, patients with strong secondary muscular restraints, and patients with an acute injury and soft-tissue swelling and guarding. This study found that partial ACL tears are difficult to diagnose based on physical examination. They support that MRI provides pivotal diagnostic information about the ACL in all knee injury cases.

Kulwin's study [23] prospectively assessed the effectiveness of the Lachman test, anterior drawer test, and lever test for diagnosing ACL injuries in 133 patients with knee pathology. The examiner was blinded to the patient's history, symptoms, and pain laterality during the examination. Among these patients, 123 underwent MRI, and 90 proceeded to arthroscopy. The study evaluated the performance of these examination manoeuvres and MRI. The findings indicated that the Lachman test and anterior drawer test demonstrated clinical utility, while the lever test results should be interpreted with caution. The clinical examination was found to be highly specific but less sensitive compared to MRI. These results align with the findings of the current study, which also identified MRI as the most sensitive tool for effectively diagnosing ACL injuries.

Although most studies in the literature support the idea that MRI is a good modality to detect ACL injuries, they all agreed that the use of MRI should be determined on a case-by-case basis, where in some cases, the patient cannot undergo MRI due to many reasons. For example, cases with metal-containing implants comprise a set of possible contraindications to MRI scanning, as they might heat or move during the procedure, or the functioning of mechanical or electronic implants might be interrupted or permanently altered. So many of these devices or patients who have these devices in situ will not be allowed to enter the scan room or be scanned. Patient size is another MRI contraindication where some patients can not fit inside normal MRI machines. Claustrophobia is another

limitation of using conventional MRI machines in ACL diagnosis.

## 5. STUDY LIMITATION

This study has several limitations that could impact its conclusions. The retrospective nature of the research and the absence of information on why certain patients did not undergo a physical examination are significant constraints. These missing data points might introduce bias, as the reasons for not undergoing a physical examination could be related to factors affecting the outcomes, such as injury severity or access to medical care. To mitigate these limitations and strengthen future research, the following steps are recommended:

1. Prospective Data Collection: Implement a prospective study design to ensure real-time data collection, documenting reasons for missing physical examinations.
2. Comprehensive Patient Records: Maintain thorough patient records with detailed notes on why certain procedures were not performed to better understand and account for these variables.
3. Sensitivity Analyses: Conduct sensitivity analyses to assess the impact of missing data on results, providing insights into the robustness of the findings.
4. Standardized Protocols: Establish standardized protocols for patient evaluation and data collection to reduce missing information and improve consistency.
5. Patient Follow-Up: Implement follow-up procedures for patients who did not undergo a physical examination to gather missing data and understand the reasons behind it.

By addressing these limitations and outlining strategies to mitigate them, future research can minimize bias and enhance the reliability of its conclusions.

## 6. CONCLUSION

This retrospective study confirms that the MRI knee protocol is the fundamental technique used to diagnose ACL-related injuries. The data collected indicates that partial ACL injuries are more prevalent among young Saudi male athletes compared to complete ACL tears. This trend may be attributed to the fact that most of these young athletes are amateurs, as professional athletics is not yet widespread in Saudi society.

It is notable that all reported ACL injuries in the study were among males. This finding aligns with the cultural context of Saudi Arabia, where females traditionally have limited

participation in athletic activities.

To further enhance the understanding of ACL injuries in this population, future studies with larger sample sizes are necessary. These studies should include comprehensive details about the circumstances of the injury and the patient's physical history at the time of injury.

## CONFLICT OF INTEREST

None

## ACKNOWLEDGMENT

None

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