



## Role of MRI in evaluation of a tear in the anterior cruciate ligament

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### Abstract

Magnetic resonance imaging is one of the most crucial procedures used to diagnose and follow up several orthopedic approaches and interventions. This study aimed to assess and evaluate the efficacy of MRI in diagnosing ACL among different patients who attend the radiology department. A case series correlational study was conducted among randomly selected patients with AC in different stages for 11 months of study correlations. The results revealed that among 40 patients with partial or complete ACL tears and assessing the MRI approaches with evaluating its accuracy, specificity, and sensitivity with selected cases under radiograph. This study concluded that MRI is main radiological procedure used to assess and evaluate the degree of bone and tendons injuries, specially, ACL tears.

**Keywords:** MRI – Magnetic Resonance Imaging - Tears Anterior Cruciate Ligament - ACL

### Introduction

The anterior cruciate ligaments are essential parts of the knee joint, playing crucial roles in preserving the stability of the knee joint (Zhao et al., 2020). ACL damage occurs when a powerful impact is applied to the back of the calf, while a PCL injury is the result of a hard strike to the front of the upper leg (Liu et al., 2019).



**Fig. 1** The ACL prevalence in European regions (Longo et al., 2021)

An evident correlation exists between ACL rupture and a heightened likelihood of developing knee osteoarthritis (OA) (Shah et al., 2021). Anterior cruciate ligament (ACL) surgery is commonly done to enhance the stability of a mechanically unstable knee, therefore decreasing the likelihood of further meniscus or cartilage injury and the onset of knee osteoarthritis (OA) (Song et al., 2019). ACL injuries are frequently observed from a clinical perspective. An ACL injury can result in harm to the meniscus and articular cartilage, thereby triggering the development of osteoarthritis (Helito et al., 2019). The primary factor contributing to ACL damage is abrupt alterations in movement trajectory, resulting in the partial debilitation of fiber bundles (Young et al., 2020; Koo et al., 2020). Arthroscopy is a frequently employed diagnostic technique for identifying ACL damage (Lynch et al., 2022). The procedure is highly sensitive, but it is invasive. The specific variables that contribute to the heightened vulnerability to osteoarthritis (OA) following an anterior cruciate ligament (ACL) injury are yet unclear (Cavinatto et al., 2019; Gunaydin et al., 2019). However, it is widely believed that multiple factors have an impact on the probability of developing posttraumatic osteoarthritis (Ferretti

et al., 2019). These factors encompass the extent of harm (Drogo et al., 2023), the specific joint structures affected, the age at which the event occurred, and the duration after the injury began (Jog et al., 2020).

Radiography can only detect osteoarthritic changes in joints at the advanced stages of the disease, when visible alterations in the bone become discernible (Shu et al., 2021). Nevertheless, MRI possesses the capability to detect tissue alterations before radiographic imaging, and these adjustments have been recorded in over 90% of knees that do not display radiographic indications of osteoarthritis (Roemer et al., 2021; Germann et al., 2020). ACL dislocation inevitably results in the formation of radiographic osteoarthritis (OA), irrespective of the treatment administered (Javed Awan et al., 2021; Awan et al., 2021).

Magnetic resonance imaging (MRI) is a commonly used diagnostic technique for detecting ramp lesions, a common condition that affects the soft tissues surrounding the knee joint (Shu et al., 2021). MRI demonstrates a significant level of effectiveness in detecting abnormal changes in these tissues, offering both a high level of sensitivity and specificity (Tran et al., 2022). Nevertheless, past research indicates significant disparities in the precision of MRI scans in identifying the intact anterior cruciate ligament (ACL) and the presence of injury (ranging from 40% to 80%) in severely compromised knees (Shah et al., 2021). The notable discrepancy in results can be attributed to several factors, such as the absence of a universally recognized and validated MRI technique for assessing the ACL (Marom et al., 2020), inconsistencies in MRI magnetic strengths (Liu et al., 2019), the inclusion of both acute and chronic knee injuries, and variations in the authors' proficiency in evaluating the ACL (Zhao et al., 2020).

## Subjects and methods

A total of 40 different subjects as patients who came to the radiology center and attended to various orthopedic complains, the period of conducting this study was from August 2022 till July 2023 with a certain ACL diagnosis and under orthopedics consultation who were exposed to magnetic resonance imaging using arthroscopy in the radiology department under supervision of certain radiologists.

Inclusion criteria:

Inclusion criteria are all suggested and readily diagnosed ACL tears and injury with meniscal injuries.

## Exclusion criteria

1. Any patients who are contraindicated to assess their injuries using MRI such as any prostheses, cardiac prosthesis, claustrophobia, and metallic plates.
2. Children and pregnant women
3. Patients with history of knee operations.

- Magnetic resonance imaging (MRI) with a 3-Tesla MRI machine in the radiology department.
- The patients had imaging in the supine position at the radiology department.

## MRI imaging Protocol

Localization scans were initially performed in sagittal, coronal, and axial planes. The axial view serves as a point of reference for acquiring the coronal and sagittal oblique slices. The sagittal sections are visually established by beginning from the lateral to the medial collateral ligament and aligning them parallel to the anterior cruciate ligament. The coverage included all the supportive structures of the knee, encompassing those situated in the medial, anterior, posterior, and lateral areas. Furthermore, the distal segments of the quadriceps tendon are included. Incorporating the distal attachments of the patellar tendon is necessary. The typical knee protocols were applied to all instances, which involved sagittal dual DRTSE, axial PD SPIR, coronal PD SPAIR, sagittal PD SPIR, coronal T1, and axial FFE imaging techniques.

## MRI Analysis

An assessment was performed to ascertain the ability to differentiate between the posterolateral bundles and anteromedial of the ACL at three distinct sites: the middle section, close to the tibial attachment, and near the femoral source. Uninformed musculoskeletal radiologists performed a thorough assessment of all knees magnetic resonance (MR) tests and arrived at a unanimous agreement regarding the condition of the anterior cruciate ligament (ACL), without being aware of the arthroscopic findings. At first, the imaging planes of the knee were examined to determine the condition of each ACL bundle, classifying them as either intact, moderately damaged, or completely torn.

An intact ACL is defined by the existence of both ACL bundles in their normal state. A partial ACL tear or complete ACL tear is identified by the presence of high signal intensity within the ACL, localized swelling or weakening of the ACL, and a curved route of the ACL with no interruptions in its structure. A complete ACL tear, often referred to as an ACL bundle tear, is defined by the complete absence of the ACL or a tear in the ACL bundle, with or without any gaps or retraction. Additional knee structures often experience damage alongside the anterior cruciate ligament (ACL), especially in instances involving intricate rotational trauma. Arthroscopic evaluation the arthroscopies were performed solely by orthopedic surgeons with specialized knowledge in knee arthroscopy. Throughout the arthroscopic surgery, each bundle was classified as either intact, partially torn, or completely ripped. The ACL was found to be completely intact, with fibers that were tightly stretched and undamaged from the connection on the tibia to the attachment on the femur. A diagnosis of partial ACL rupture was made when only a portion of the fibers were visibly torn upon direct

examination, while the remaining fibers showed the expected resistance to deformation when physically probed. The diagnosis indicated a complete rupture of the ACL, evidenced by the lack of any connection between its ends and a total absence of stress upon direct examination.

**Statistical analysis**

The data were analyzed utilizing the Statistical Program for Social Science version 21.0.

- The quantitative results were expressed as the mean ± standard deviation.
- The Chi-square (X2) was used to compare proportions between measures.
- Receiver operating characteristic technical analysis was utilized to assess the overall predictive capacity of the parameter and find the most effective threshold value.
- This investigation additionally evaluated the sensitivity and specificity using the identified threshold value.

PPV and NPV represent the accuracy of a diagnostic approach in correctly identifying positive and negative results, respectively:

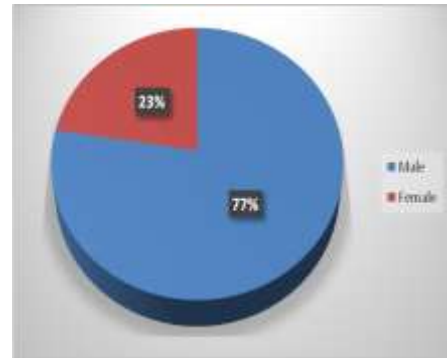
- Specificity= (true negative)/[(true negative)+(false positive)].
- Sensitivity= (true positive)/[(true positive)+(false negative)].
- Net Present Value = (true negative)/ [(true negative) + (false negative)].
- Positive Predictive Value= (true positive) / [(true positive) + (false positive)].

Probability and considerations at degree of significance

- The significance at P-value <0.05.
- The highest significance at P-value <0.001.
- The non significance at P-value >0.05.

**Results and discussion**

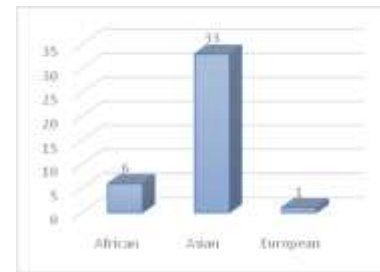
Among 40 selected patients with ACL in different degrees of tearing, the majority of being males with mean age 33.2±1.97 and equal percentage of partial and complete ACL tear (X2 = 13.11 and p = 0.000).



**Fig. 2 The gender distribution among these patients (n=40)**

**Table 1. The age distribution among these patients (n=40)**

Age group	Frequency
Less than 30	1
30 - 40	29
41 - 50	10



**Fig. 3 The race distribution among these patients (n=40)**

Asian patients have the most predominance than other races.

**Table 2. Tye of ACL tear among these patients (n=40)**

Type of tear	MRI	Arthroscopy	X2	P-value
Complete ACL tear	12	8	13.11	0
Partial ACL tear	9	11		

There are predominance of MRI in diagnosing complete ACL than partial tears in this study.

**Table 3. Specificity and Sensitivity in addition to PPV and NPV with accuracy for types of ACL tears**

Type of tear	Specificity	Sensitivity	PPV	NPV	Accuracy
Complete ACL tear	75%	92%	100%	81.30%	81%
Partial ACL tear	99.70%	88.10%	77.80%	100%	90%

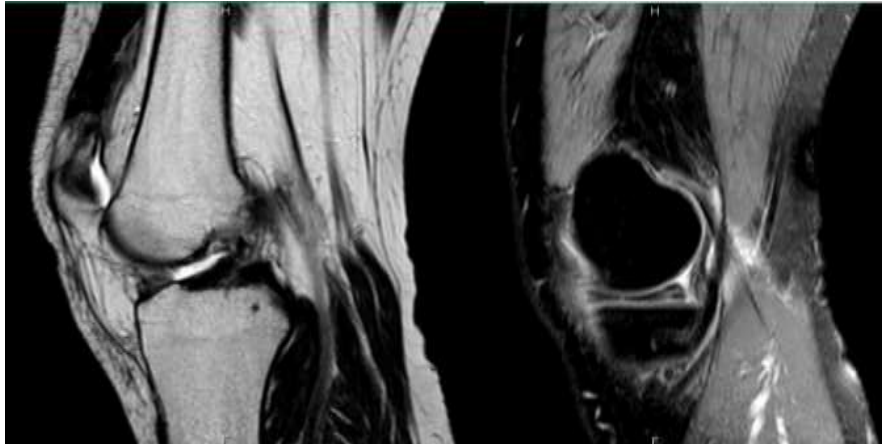
The highest specificity in partial ACL was more in complete one while sensitivity get increase in complete ACL with an closed accuracy in this study patients.

**Table 4. Injury ACL distribution among these patients (n=40)**

Type of tear	n	%
Isolated ACL torn injury	23	57.5
Combined ACL torn injury	17	57.5

There is an approximate equality of combined and isolated ACL tears in this study. Some cases presented in this study

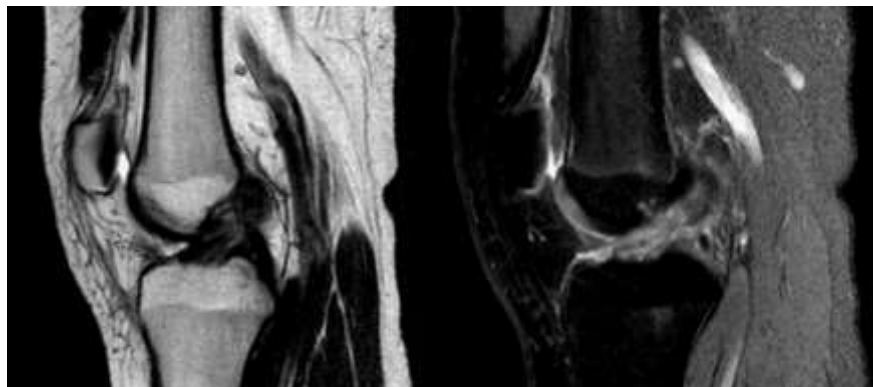
showing the degree of tear and MRI imaging accuracy.



**Fig. 4 PD SPIR and Sagittal T2 MRI imaging detected a partial tear of the anterior cruciate ligament (ACL) on the cartilaginous surface, along with the presence of joint effusion.**



**Fig. 5 The PDW SPIR and Sagittal T2 WI pictures show complete tears of the ACL in the back part of the inner meniscus, along with complicated tears seen on the upper joint surfaces. Nevertheless, the arthroscopy has verified the presence of a total rupture of the anterior cruciate ligament (ACL).**



**Fig. 6 The PDW SPAIR and Sagittal T2 MRI show swelling and thickening with a hazy appearance of the ACL, suggesting a severe partial tear. The MRI also indicates a significant signal intensity. This aligns with the results obtained from the arthroscopy, which verified a complete rupture of the ACL.**

Magnetic Resonance Imaging has emerged as the primary modality for diagnosing and managing various knee pathologies within the realm of orthopedics. For the evaluation of patients prior to and following surgical procedures. Because it does not require any surgical procedures and has a limited effect on the functioning of the kidneys and heart, it is an extremely advantageous choice. Arthroscopy is a dependable technique for confirming ambiguous instances of meniscal tears and has generally been regarded as the most efficient approach for diagnosing ACL damage. The diagnostic precision ranges from 71% to 93%. Nevertheless, this surgical treatment is characterized by its invasiveness and entails a plethora of dangers, notably a complication rate of 1.9%. The potential hazards encompass both surface-level and profound infections, injury to the peroneal and saphenous nerves, impairment to blood vessels, and the risk of developing a pulmonary embolism. Occasionally, arthroscopy may fail to identify any anomalies in relation to ACL tears and injuries. The study's analysis of age distribution indicated a span of 30 to 50 years, with a notable number of patients falling within the age range of under 30 to 40. With regards to the gender patients' distribution, the predominant demographic comprises of males. The results indicate a higher prevalence of knee injuries among teenage boys. Kostov et al. recently discovered that a substantial percentage of individuals who suffered knee injuries were males between the ages of 21 and 30. Subsequent researchers discovered similar results. Avcu et al. and Clayton et al. have demonstrated that males had a higher susceptibility to knee injuries as a result of their engagement in sports, with a greater incidence of injury observed in the right knee as opposed to the left. We conducted a study to differentiate between complete and partial injuries of the anterior cruciate ligament (ACL). Signs of a total rupture of the ACL were detected, including the absence of visibility and discontinuity in the ACL fibers. Consequently, an MRI scan indicated that 50% of the participants had a total rupture of the ACL, while the remaining 50% had a partial tear. The results align with the research undertaken by Panigrahi et al., which investigated the association between MRI data and arthroscopic observations in a group of 76 patients diagnosed with ACL rupture. The MRI demonstrated a sensitivity of 94.7%, specificity of 78.6%, positive predictive value (PPV) of 92.3%, negative predictive value (NPV) of 84.6%, and an accuracy of 90.4%. Nevertheless, it is imperative to underscore that MRI inaccurately identified four cases of total ACL injuries, instead categorizing them as partial tears. Our study was to rigorously evaluate the accuracy of ACL injury detection in MRI scans as compared to arthroscopy. Furthermore, we highlighted the differentiation between partial and total ripping. The study findings indicate that the ability to accurately detect partial ACL injuries had a sensitivity of 92% and a specificity of 75%. The sensitivity and specificity rates for diagnosing full ACL injuries were 88.1% and 99.7% respectively. The findings of this study closely corresponded to a prior examination carried out by Behairy et al., which documented a sensitivity of 77.8% and a specificity of 100% for MRI. Jah et al. determined that the MRI exhibited a sensitivity of 78.3%

and a specificity of 95.7%. AbdulBari and his colleagues have shown that the MRI exhibited a sensitivity of 87.8% and a specificity of 81.5%. Vincken et al. discovered that MRI scans exhibit a high level of accuracy in identifying the requirement for arthroscopic therapy, demonstrating a sensitivity rate of 87% and specificity rate of 88% (61). Oei et al. conducted a study to assess the MRI findings in individuals with suspected anterior cruciate ligament (ACL) injury. A group of 30 people was selected for their investigation using rigorous criteria. The researchers discovered that the combined sensitivities and specificities for diagnosing ACL rupture were 94% and 91% respectively. The study findings indicated that combination injuries, frequently accompanied with meniscus injury, were the most prevalent noticed during the MRI test, while independent injuries were less frequent. Moreover, we noted a greater incidence of medial meniscus tears compared to lateral meniscus tears. Hetta and Niazi discovered that a mere 28% of patients experienced a solitary injury, whereas a significant 72% of patients suffered from several injuries. Furthermore, they noted a greater occurrence of medial meniscal tears in comparison to lateral meniscal tears. The findings align with the results documented by Lim and Peh. This assumes that arthroscopy has an exceptional level of accuracy in detecting all possible ACL problems. Nevertheless, this is not invariably true. Arthroscopy necessitates proficient technical skills due to its intricate nature. The results of the procedure differ depending on the surgeon's expertise and understanding, particularly in more difficult cases.

### **Conclusion**

MRI demonstrates a significant level of sensitivity, accuracy, and specificity in detecting ligament injuries in joints. Other extensive investigations are offering strong evidence to substantiate the conclusion that MRI is very accurate in detecting ACL rupture which is commonly used as a standard procedure before diagnostic arthroscopy in most situations. This screening approach is widely considered to be very efficient for most patients due to its speed, non-invasive nature, and lack of problems associated with arthroscopy. MRI in before arthroscopy assists in ligament issues' management, hence improving the patient's prognosis.

### **Conflict of Interest**

The author hereby declares no conflict of interest.

### **Consent for publication**

The author declares that the work has consent for publication.

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