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Radio-Diagnosis

PREVALANCE OF ANTERIOR CRUCIATE LIGAMENT TEAR ON MRI IN A TERTIARY CARE CENTRE IN RURAL SETTINGS

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ABSTRACT **Objective:** To study the prevalence of anterior cruciate ligament tear in patients undergoing MRI knee and to determine the most common type of ACL tear. **Methods:** We conducted a retrospective review of MRI images for patients who underwent knee joint magnetic resonance imaging at our institution from January 1, 2024, to December 31, 2024. The MRIs, as reported by radiologists, were evaluated for the diagnosis of ACL tears. The locations of ACL tears were determined from 2-dimensional fast-spin echo images obtained along three anatomical planes: sagittal, coronal, and axial. A total of 378 patients underwent MRI of the knee joint. Among these, 241 were male and 137 were female; 174 patients had MRIs for the right knee joint, while 204 had MRIs for the left knee joint. Patients were excluded from the study if they were paediatric, defined as being younger than 18 years; if they had associated posterior cruciate ligament injuries; if they had chronic ACL tears; if they had associated bone tumours; if they exhibited mucoid degeneration of the ACL; or if they had a history of ACL reconstruction. After applying the aforementioned exclusion criteria, we identified 326 patients who were included in our study. **Results:** In this retrospective study, a total of 378 patients underwent MRI for knee joints. Among these, 241 were male and 137 were female; 174 patients had MRI performed on their right knee joint, while 204 had MRI on their left knee joint. Following the application of exclusion criteria, 52 patients were excluded, resulting in 326 patients being included in the study. Of the 326 patients, 177 had a normal ACL, whereas 149 had an ACL tear. Out of the 149 patients with an ACL tear, 4 patients were diagnosed with type I ACL tear (3%); 34 patients had type II ACL tear (23%); 55 patients were identified with type III ACL tear (37%); 50 patients had type IV ACL tear (33%); and 6 patients were classified with type V ACL tear (4%). Consequently, the prevalence of ACL tears is approximately 45.7%, with type III ACL tear being the most frequently occurring type. **Conclusion:** Consequently, the occurrence of ACL tears is approximately 45.7%, with type III ACL tears being the most prevalent variety. The ACL ligament plays a crucial structural role and is notably prone to injury. Imaging techniques, especially MRI, have facilitated a significantly more precise evaluation of ACL injuries and other related conditions, along with associated injuries.

KEYWORDS : Anterior cruciate ligament, knee, ligaments, Magnetic resonance.

INTRODUCTION

The anterior cruciate ligament (ACL) follows an oblique trajectory from the tibia to the lateral femoral condyle. It is classified as an intra-articular extra synovial ligament, consisting of fibers that extend from the anterior intercondylar region of the proximal tibia to the medial side of the lateral femoral condyle within the intercondylar groove (1). The ACL fibers are organized into two distinct bundles, referred to as the anteromedial and posterolateral bundles, based on their tibial insertion points (2)(3). The anteromedial bundle attaches at a more medial and superior location on the lateral femoral condyle, whereas the posterolateral bundle connects at a more lateral and distal position on the same condyle. In some cases, an additional intermediate bundle may be present between these two bundles (3). The total length of the ACL is approximately 38 mm, with a width of 11 mm (4). The anteromedial bundle measures 36.9 ± 2.9 mm in length, while the posterolateral bundle measures 20.5 ± 2.5 mm in length. Both bundles exhibit similar dimensions, with an average width of 5.0 ± 0.7 mm and 5.3 ± 0.7 mm in their mid-substance (5).

AIMS AND OBJECTIVE

To study the prevalence of anterior cruciate ligament tear in patients undergoing MRI knee and to determine the most common type of ACL tear.

MATERIAL AND METHODS

Patients Selection

A search was conducted within the electronic radiology patient archiving and communication system (PACS) (Workstation seamen's 1.5 T MRI) to identify patients who underwent magnetic resonance imaging of the knee joint at our institution from 1 January 2024 to 31 December 2024. The MRIs reported by radiologists were evaluated for the diagnosis of ACL tears. A total of 378 patients received MRI scans of the knee joint. Among these, 241 were male and 137 were female; 174 patients had MRIs for the right knee joint, while 204 had MRIs for the left knee joint.

Patients were excluded if they were paediatric, defined as being younger than 18 years; if they had concurrent posterior cruciate ligament injuries; if they had chronic ACL tears; if they had associated bone tumours; if they exhibited mucoid degeneration of the ACL; or if they had a history of ACL reconstruction. After applying the aforementioned exclusion criteria, we identified 326 patients who were included in our study.

MRI Measurements:

An MRI were conducted utilizing a 1.5-T superconducting magnet (Siemens Systems) in accordance with a standardized institutional protocol.

The locations of ACL tears were evaluated using 2-dimensional fast-spin echo images obtained across three anatomical planes (sagittal, coronal, axial) with the following parameters: repetition time [TR] of 4540 ms, echo time [TE] of 79 ms, acquisition matrix ranging from 240 to 320, number of excitations [NEX] set to 01, field of view [FOV] of 180 cm, and a slice thickness of 4.0 mm without any gap.

The examinations were carried out with the patient in a supine position, supported by a pillow under the knee to maintain extension and slight external rotation. The quadriceps muscle was kept relaxed, and no anesthesia was administered to any of the patients. The extremity was secured using a commercial extremity coil (08-channel knee coil) to ensure a uniform position of the extremity across all patients.

The sagittal, coronal, and axial planes were analyzed to determine the location of the ACL tear. Initially, the ligament was examined on the sagittal plane, tracing it from distal to proximal to identify the tear's location. Subsequently, both the coronal and sagittal planes were meticulously reviewed to validate the identified tear location. In instances where a spiral tear pattern was observed, the midpoint of the spiral section was designated as the tear location.

Data Collection

Additional collected data from the MRI intake information included patient sex, side of injury and date of MRI in order to calculate age and delay from injury to MRI. Subgroups were <18 & >18 years of age and male & female patients.

Type Of Study

The study conducted is a type of retrospective observational study.

Injury Mechansims

The ACL functions to resist anterior tibial translation during extension and offers rotational stability (6)(7). The anteromedial bundle is under tension when the knee is flexed, while the posterolateral bundle is taut during knee extension. In flexion, the anteromedial bundle is at its longest and may serve as the primary structure resisting anterior displacement of the tibia. Conversely, the posterolateral bundle appears to primarily counteract anterior tibial translation in extension and also aids in the rotational stability of the knee joint, particularly during the "screw home" mechanism; that is, at the end of knee extension, the tibia externally rotates in relation to the femur, effectively "locking" the knee in an extended position. Both the anteromedial and posterolateral bundles work together to stabilize the knee joint against anterior tibial forces and combined rotational stresses (8). ACL injuries can be classified as partial or complete. Partial tears may vary from minor injuries affecting only a few fibers to high-grade near-complete tears involving nearly all ACL fibers. A partial tear can affect both bundles or just one to varying extents. Occasionally, plastic deformation of the ACL may occur without fiber discontinuity, leading to ACL insufficiency. The mechanisms behind ACL injuries often involve internal rotation of the tibia relative to the femur, which frequently happens during falls while skiing or in contact sports like football. Valgus stress can distract the medial femorotibial joint compartment, resulting in medial collateral ligament injury and medial meniscal injury, commonly referred to as O'Donoghue's triad. Another cause of ACL injury is hyperextension, which can occur during jumping or high-kick actions, potentially resulting in contra-coup bone contusions on the anterior tibia and femoral condyle. ACL tears due to hyperextension often happen without associated collateral ligament or meniscal injuries (9).

The third mechanism involves the external rotation of the tibia in relation to the femur, accompanied by varus stress that results in medial impaction and bone edema, as well as lateral distraction, which can lead to the avulsion of the lateral tibial rim (Segond fracture) and a tear of the lateral collateral ligament. Most ACL injuries can be identified through patient history and clinical examination.

The anterior drawer test, Lachman test, and pivot shift test are the primary clinical assessments used to diagnose ACL tears; however, their effectiveness is contingent upon the clinician's experience and the level of cooperation from the patient. In cases of chronic ACL insufficiency, the pivot shift test has demonstrated high sensitivity for identifying ACL injuries, with reported rates ranging from 84% to 98.4%. The specificity of this test has shown greater variability, with values reported as low as 35% in alert patients and as high as 98.4% in anesthetized patients (10). Injuries associated with meniscal tears or chondral damage may hinder a comprehensive clinical examination. Consequently, magnetic resonance imaging (MRI) proves beneficial in evaluating suspected ACL injuries. Approximately 80% of ACL tears are complete, typically occurring in the middle one-third of the ACL (90%), with less frequent occurrences near the femoral (7%) or tibial (3%) attachments. In about 20% of cases, ACL tears are incomplete, characterized by partial disruption of the ACL fibers (11).

RADIOGRAPHY

On radiographic imaging, various indirect indicators may suggest the presence of an underlying ACL injury. An avulsion fracture of the ACL at its tibial insertion or femoral origin can be observed on radiographs, although it is more accurately characterized through computed tomography (CT) (12)(13). Additionally, an avulsion fracture of the lateral tibial rim, known as a Segond fracture, is frequently linked to an ACL tear (14)(15)(16).

COMPUTED TOMOGRAPHY

The visibility of the anterior cruciate ligament (ACL) on computed tomography (CT) is compromised when haemarthrosis is present, and the majority of patients with ACL injuries undergo evaluation via magnetic resonance imaging (MRI), as this method is most effective for identifying associated meniscal, ligamentous, or chondral injuries. In cases where ACL avulsion injuries are identified through radiography, CT scans can assist in assessing the size and comminution of the avulsed bone fragment, with three-dimensional CT providing enhanced visualization of the fracture. CT arthrography may also be conducted and demonstrates a level of accuracy comparable to that of MRI in detecting both cruciate and meniscal injuries (17).

MAGNETIC RESONANCE IMAGING

MR sequences utilized for optimal visualization of the ACL consist of 2D fast spin echo sequences, which may include fat suppression or not. In our facility, the standard knee protocol includes the following three sequences: (1) Coronal T2 weighted fat suppressed sequence; (2) TSE sagittal intermediate weighted sequence; and (3) TSE axial intermediate weighted with fat-suppression sequence. Additional sequences may include oblique views, flexion views, T1-weighted sequences, and small FOV or small coil images as required. T1-weighted sequences are particularly beneficial for identifying suspected fractures or characterizing loose bodies within the knee, as any osseous fragments may possess a central marrow component. MR images of the knees in flexion can create more space around the ACL within the intercondylar area, which helps to reduce volume-averaging artifacts and thus enhances the visualization of the femoral end of the ligament (18)(19). The normal ACL should exhibit a taut, low to intermediate signal intensity with continuous fibers across all planes and sequences. It runs parallel to or at a steeper angle than the intercondylar line. The PL bundle typically displays a higher signal intensity compared to the AM bundle. MRI demonstrates a high level of accuracy in diagnosing ACL tears, with accuracy, sensitivity, and specificity exceeding 90% (20)(21)(22).

Primary Signs

- swelling
- heightened signal on T2 or fat-saturated PD
- discontinuity of fibres
- abnormal orientation of the anterior cruciate ligament in relation to the intercondylar (Blumensaat) line
- ACL fibers appear to be less steep compared to a line tangent to the intercondylar roof (Blumensaat line)
- ACL angle (the angle formed between the intercondylar line and ACL) exceeds 15°, with the apex of the angle positioned anteriorly, suggesting a less steep ACL line - this indicates a ruptured and collapsed ligament
- empty notch sign: a fluid signal at the site of femoral attachment within the intercondylar notch, indicating avulsion at the femoral attachment.
- ACL tears generally occur in the middle section of the ligament (midsubstance tears) and manifest as discontinuity of the ligament or an abnormal contour. The signal of the ACL may appear more hyperintense on T2. If the angle remains normal and there is a hyperintense signal, a partial rupture is more probable than a complete rupture.
- An ACL tear may affect only one bundle. Imaging indicators of an isolated posterolateral bundle tear include:
- Gap sign: fluid signal and/or a gap between the medial side of the lateral femoral condyle and the lateral side of the mid-ACL, observable on either axial or coronal MRI images
- Footprint sign: incomplete coverage of the lateral side of the tibial spine of the tibia by the distal ACL attachment, visible only on coronal MRI images. (23)(24)(25).

Secondary Signs

Secondary indicators consist of (26)(27)(25)(24)

- bone contusion located in the lateral femoral condyle and the posterolateral tibial plateau
- anterior tibial translation exceeding 7 mm, commonly referred to as the anterior tibial translocation sign or anterior drawer sign
- uncovered posterior horn of the lateral meniscus: posterior displacement greater than 3.5 mm
- Segond fracture, and to a lesser extent, the arcuate sign
- Bowing of the PCL: a reduced PCL angle of less than 107° or a bowing ratio exceeding 0.39
- positive PCL line sign
- injury to the medial or lateral collateral ligament
- coronal lateral collateral ligament sign (28)
- lateral femoral sulcus measuring deeper than 1.5 mm.

Classification Of ACL Tear (29)(30)

All tears were categorized into one of the following types:

- Type I tear (proximal avulsion tear, situated at >90% of the distal-proximal length) (Figure 1),
- Type II tear (proximal tear, situated at 75%-90% of the distal-proximal length) (Figure 2),
- Type III tear (mid substance tear, situated at 25%-75% of the distal-proximal length) (Figure 3),
- Type IV tear (distal tear, situated at 10%-25% of the distal-proximal length) (Figure 4),
- Type V tear (distal avulsion tear, situated at <10% of the distal-proximal length) (Figure 5).

Type I and Type V tears were additionally classified as either soft tissue avulsion tears (Figure 5) or bony avulsion tears (Figure 6).

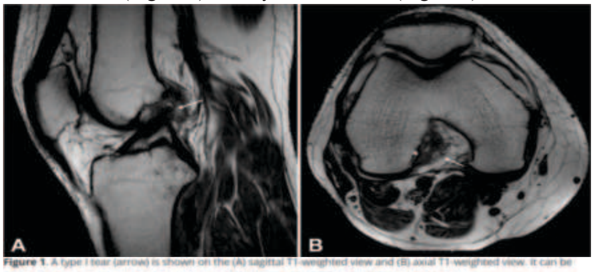


Figure 1. A type I tear (arrow) is shown on the (A) sagittal T1-weighted view and (B) axial T1-weighted view. It can be noted that the ligament is avulsed with only a few fibers remaining on the femoral wall (asterisk).

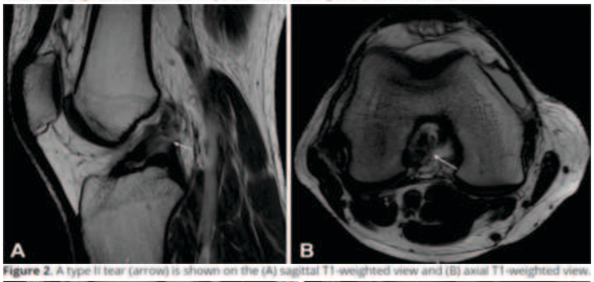


Figure 2. A type II tear (arrow) is shown on the (A) sagittal T1-weighted view and (B) axial T1-weighted view.

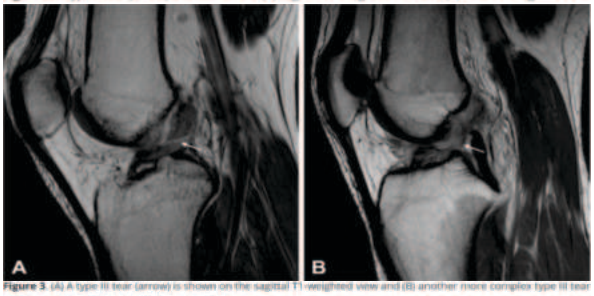


Figure 3. (A) A type III tear (arrow) is shown on the sagittal T1-weighted view and (B) another more complex type III tear (arrow) is shown on the sagittal T1-weighted view.

Figure 4. A type IV tear (arrow) is shown on the (A) sagittal T1-weighted view and (B) sagittal T2-weighted view.

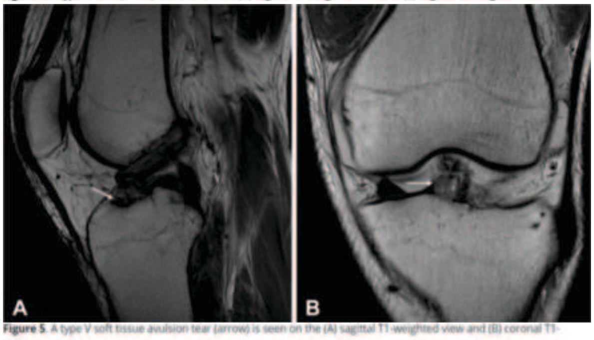


Figure 5. A type V soft tissue avulsion tear (arrow) is seen on the (A) sagittal T1-weighted view and (B) coronal T1-weighted view.

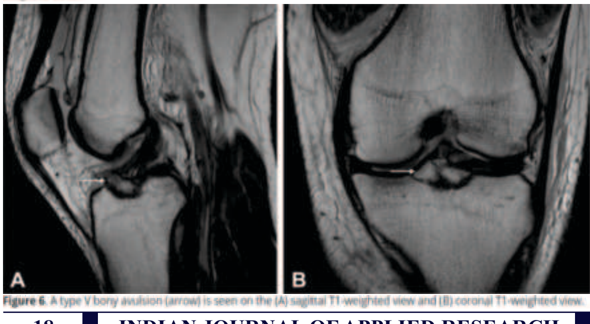


Figure 6. A type V bony avulsion (arrow) is seen on the (A) sagittal T1-weighted view and (B) coronal T1-weighted view.

Associated Injuries

Meniscal Injury

A meniscal tear is frequently linked to an ACL tear, with an occurrence rate of 65%-70%. The peripheral vertical tear located in the posterior horn of the lateral meniscus, often referred to as a 'posterolateral corner tear', is strongly correlated with acute ACL tears (31) (32) and is often missed during diagnosis. In fact, peripheral posterior horn tears represent over fifty percent of meniscal tears observed in patients suffering from either acute or chronic ACL injuries (33). When combined with a medial collateral ligament tear and an ACL tear, these injuries constitute the classic O'Donoghue's triad.

Posterolateral Corner Injury

Injuries to the posterolateral corner must be addressed due to their role in contributing to the three-dimensional instability of the knee, which includes sagittal, frontal, and rotational instability. The posterolateral corner injury encompasses the fibular collateral ligament, the popliteus muscle and tendon, the popliteofibular ligament, the lateral and posterolateral capsule, as well as the biceps femoris tendon. Typically, these structures, which usually exhibit low signal intensity, are classified as injured or sprained when there is thickening and intermediate signal intensity observed within the structure on fat-suppressed fast spin-echo T2-weighted images. They are considered torn when there is a discontinuity with a visible gap (34).

Ganglion Cyst And Mucoid Degeneration Of The ACL

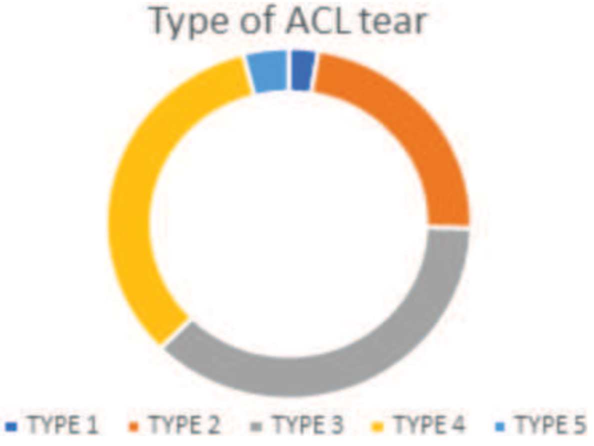
Cystic degeneration of the ACL has been linked to mucinous degeneration of connective tissue (35) (36) or regarded as an intrasubstance ACL tear. On MR imaging, cystic degeneration may present as well-defined ganglion cysts originating from the ACL, which occur in approximately 1% of patients (37), or as an increased signal intensity throughout the entire ACL, resembling a stalk of celery (38). This heightened signal intensity results from the accumulation of amorphous mucoid matrix among the ACL fibers. Clinical manifestations include pain, swelling, and mechanical locking.

RESULTS

In this retrospective study, a total of 378 patients underwent MRI for knee joints. Among these, 241 were male and 137 were female; 174 patients had MRI conducted on their right knee joint, while 204 had MRI on their left knee joint. Following the application of exclusion criteria, 52 patients were excluded, resulting in 326 patients being included in the study. Of the 326 patients, 177 had a normal ACL, whereas 149 had an ACL tear.

Among the 149 patients with ACL tears, 4 patients presented with type I ACL tear (3%); 34 patients had type II ACL tear (23%); 55 patients were diagnosed with type III ACL tear (37%); 50 patients had type IV ACL tear (33%); and 6 patients exhibited type V ACL tear (4%). Consequently, the prevalence of ACL tears is approximately 45.7%, with type III ACL tear being the most frequently occurring type.

Tear Type	Percentage
Type I	03
Type II	23
Type III	37
Type IV	33
Type V	04



CONCLUSION:

In this research, among 326 patients, 177 exhibited a normal ACL while 149 were diagnosed with an ACL tear. It was observed that 26% of these tears occurred in the proximal quarter, with 3% classified as type I tears and 23% as type II tears. Type III tears were the most prevalent in our cohort, accounting for 37%. Consequently, the overall prevalence of ACL tears is approximately 45.7%, with type III ACL tears being the most frequently encountered type. The ACL ligament is crucial both structurally and due to its high incidence of injury. Imaging techniques, particularly MRI, have facilitated a significantly more precise evaluation of ACL injuries and related conditions, as well as associated injuries. Further studies are essential to correlate these MRI findings with arthroscopic results to determine the percentage of patients suitable for ACL preservation surgery and primary ACL repair surgery.

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