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## **MRI in Anterior Cruciate Ligament Injury**

Kamalesh Majumdar and Dr Irandati Mukhopadhyaya

Associate Professor, Radio-Diagnosis, KPC Medical College and Hospital, Jadavpur,  
Kolkata-700 107, West Bengal, India

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### **ABSTRACT**

One of the main elements of stability and normal functioning of the knee joint is anterior cruciate ligament (ACL). Therefore injury to the ACL can lead to substantial morbidity. Accurate and early diagnosis of ACL injury is most important for short and long-term patient management. Magnetic resonance imaging (MRI) with high tesla unit is the investigation of choice for evaluation of status of the ACL and other associated structures in the knee joint. Sagittal section very well demonstrates the full sweep of ACL and has been commonly used in the evaluation. Coronal and axial images also contribute information about the ligament injury. Thus accuracy and confidence regarding diagnosis can be readily achieved. Different types of injuries like internal rotation and valgus and varus stress, hyperextension with external rotation etc are common way of ligamentous trauma. Understanding of these mechanisms of trauma is helpful in the MR diagnosis of ACL injury. MRI imaging can clearly demonstrate different internal derangement. Bone marrow oedema that commonly associates with the most cases of ACL injury can also be demonstrated.

**Keywords:** MRI Knee joint, Ligament tear, Knee stability, Joint cartilage, Marrow contusion, Collateral ligament, Tibial plateau, Osteochondritis, Epiphyseal trauma

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**Address for Correspondence:** Kamalesh Majumdar, Associate Professor, Radio-Diagnosis, KPC Medical College and Hospital, Jadavpur, Kolkata-700 107, West Bengal, India; E-mail: [qamalesh@gmail.com](mailto:qamalesh@gmail.com)

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## INTRODUCTION

In the maintenance of stability with mobility of knee joint anterior cruciate ligament prevent anterior translation and internal rotation of the tibial plateau with respect to the femoral condyle. If these rains are damaged substantial morbidity restriction can lead to secondary dysfunction of other structures in the knee. But in clinical practise, very often these injuries are missed or under rated. Therefore, early and precise identification of ACL injuries is important. Injuries commonly occur in outdoor sports activity, motor vehicle accidents or in falls (2,3). Acceleration, deceleration, twisting, or jumping etc are the mechanism of injury.

Because of the morbidity associated with the ACL-deficient knee, accurate diagnosis of ACL injury is essential for appropriate patient care. Clinically symptoms of ACL injury mimics meniscal and other ligamentous injury. Therefore making an accurate diagnosis is often difficult on history and physical examination .

Clinical examination depends on the demonstration anterior tibial motion relative to a fixed femur. Some tests has been advocated, like Lachman's test and pivot shift tests (3).

In markedly acutely swollen knee, these tests are difficult to perform because of pain and guarding. Accuracy is thus diminished. Haemarthrosis, if present is suggestive of a ligament injury but is nonspecific (3). Following are the radiological modalities available for investigation,

**X ray:** due to inferior soft tissue resolution, It has limited utility in the diagnosis of ACL injury. However, avulsion of anterior tibial spine and increased depression in the middle third of the lateral femoral condyle (lateral notch sign), if present are reliable sign of ACL tear (5).

**Arthrography:** It is an invasive technique requiring good expertise in technique and interpretation. Its accuracy is 60%-97% (6).

**MRI:** Magnetic resonance imaging is the most useful modality in the evaluation of knee injuries. Along ACL injury, it helps in diagnosing meniscal tears, ligament & muscle injuries and bone involvement.(1)

However there are difficulties in accurately imaging ACL. Angled sagittal images, double-oblique sagittal images and T2-weighted sagittal images improve the accuracy of MR imaging in the

diagnosis of ACL tears. In addition to sagittal plane, coronal and axial images increase the accuracy of diagnosis and eliminate the pitfalls in interpretation.

## ANATOMY

ACL is composed of collagen fescicles grouped to form 5 to 25 fibres. These Fibres then merge to form larger sub fascicular bundles that fan out into functional bands (14). Antero-medial and postero-lateral bands have been identified. The antero-medial band becomes taut in flexion, when rest of the ligament is relaxed. In extension, the postero-lateral portion is taut and the rest are relaxed.

Femoral end of ACL is attached at the posterior medial surface of the lateral femoral condyle, and the tibial end is attached at the anterior inter condylar area, slightly lateral and anterior to the anterior tibial spine in a fanlike fashion. On average ACL is 4 cm long and 1 cm thick (17).

Along with the posterior cruciate ligament, the ACL is completely covered by synovium and is thus extra synovial but intra articular in nature. The primary arterial supply to the ACL is the middle genicular artery, which arises from the popliteal artery. Other additional supply are from the medial and lateral genicular arteries. Nerve fibers are from branches of the tibial nerve (17).

## MATERIALS AND METHODS

Standard protocol includes T1, T2, GRE, STIR or TRIM and PD sequences in all axial, coronal and sagittal planes. Section thickness is 3.5mm with 15 to 20 cm field of view. Primary plan used for ACL is sagittal.(2) As the most examinations are done with knee extended with about 15 degree internal rotation, ACL should appear raut. However oblique sagittal plane is better than direct sagittal plane ACL is a well defined, smooth outlined low signal intensity structure along the inter condylar notch. It may show 3 to 4 bundle of parallel bands. It shows about 45 degree angle with the tibial plateau. Inferior part is thicker and shows more signals than the superior part. Commonest site of ACL injury is at the mid part. Femoral and tibial ends are less commonly frequently involved though femoral end is commoner.

On sagittal imaging, distal end of ACL is usually better seen than the proximal end due to partial volume averaging of the proximal ligament with the medial aspect of the lateral femoral condyle. Angle of imaging determines proper visualisation of ACL ends .If the distal part of the ACL is seen

running in the usual direction and is not associated with a soft tissue mass, it is most likely normal even if the proximal end is not optimally visualised.

On coronal images, the ACL can be readily traced in 3 to 4 sections of usual section thickness. Posteriorly, ACL is seen adjacent to the horizontal segment of PCL (posterior cruciate ligament) as a convex low signal band. More anteriorly ACL crosses the inter condylar notch to reach its tibial attachment.

On axial imaging, cephalic section shows the proximal ACL as low signal ovoid structure adherent with the medial surface of lateral femoral condyle. Mid section shows elliptical shape of the ligament. Due to oblique angle of insertion, distal part of the ligament is difficult to visualise.

## RESULTS AND DISCUSSION

Signs of ACL injury: irregular outline, lack of continuity, focal or diffusely increased signal intensity within the ligament and non or poor visualization. Joint fluid is hyper intense in T2-weighted sequence. Intra substance oedema and haemorrhage is also easily visualised within the torn ACL.

If there is intermediate-signal-intensity area on T1W and increases signal intensity on T2W image within ACL (with or without demonstrable discontinuity), tear is present. ACL injury is usually associated with injury of other knee joint structures, as in other ligaments, tendon, meniscus and bone contusion. During arthroscopy, in one series (2) 60 to 70% patients with ACL tear were found to have meniscal injuries also.

However meniscal injury may be present without ACL tear. So meniscal tear alone does not indicate presence of ACL tear. Medial collateral ligament injury very often co exist with ACL tear. Involvement of PCL and lateral collateral ligament depends on the severity of the injury.

Bone marrow contusion and osteochondral lesion are also associated with acute ACL injury. Marrow oedema is more common on the lateral compartment. After few weeks marrow contusion may disappear, lateral compartment bone lesion is of more indicative sign of ACL injury.

Osteochondral lesion is more indicative of associate ACL injury than marrow contusion. It appears as a area of low signal intensity on T1 sequence in the lateral femoral condyle overlying the anterior horn of the lateral meniscus. This corresponds to notch sign in plain X ray.

In spite of high accuracy of MR in the diagnosis of ACL injury, pitfalls in interpretation do exist and at times becomes troublesome for even for the experienced observer. Non visualisation of normal ACL in sagittal section can be helped by taking oblique sagittal section with 10 to 20 degree internal rotation and by taking thinner T2 sections. Coronal images may help in contributing more inputs.

Empty notch sign- ACL appears as inconspicuous area attached with the horizontal segment of the posterior cruciate ligament, on coronal image. It is most commonly seen in complete ACL tear Axial sequence enables a cross sectional evaluation of ACL injury. Indistinct out line of ACL, increased signal intensity within the ACL and non visualisation of the ACL are suggestive of ACL injury. Axial images serve to confirm initial interpretations and improve diagnostic accuracy

## MECHANISMS OF ACL INJURY

Although ACL injury can occur with fracture of the bones around the knee joint, wide variety of activity may account for the majority of ACL tears. Understanding of these mechanisms can tribute to accurate diagnosis both clinically and radiologically.

Internal rotation with valgus stress is the most frequently involved mechanism of ACL injury. Presence of meniscal tear and medial collateral ligament injury are variable and are related to the severity of stress applied and the precise vectors involved. Bone marrow contusion of the lateral compartment is much more commonly noted. Injury of the articular surface of the lateral femoral condyle is not associated with adjacent tibial contusion.

Second most common mechanism of ACL injury is hyperextension of the knee. It occurs much less frequently than does internal rotation. Hyperextension can occur during forward fall while jumping or during a high kick manoeuvres ACL tears resulting from hyperextension frequently occur in isolation from meniscal or collateral ligament injuries

A third mechanism of ACL injury, though less common, is varus stress with external rotation of tibia over femoral condyle. It is commonly associated with injury of lateral collateral ligament and lateral corner fracture of tibial plateau. Presence of such injury is a clue to ACL tear. Marrow oedema at lateral tibial, condyle is also seen. These give rise to severe knee instability.

Diagnosis of associated meniscal or ligamentous injury is of great importance to orthopaedic consultant because these points may modify the management planning. Arthroscopic meniscal repair before ACL reconstruction is determined with MR imaging features.

### CONCLUSION

MR study of knee joint has been proved to be a highly accurate and useful modality to precisely

evaluate ACL injury. However, multiplanar approach can improve the interpretation accuracy.

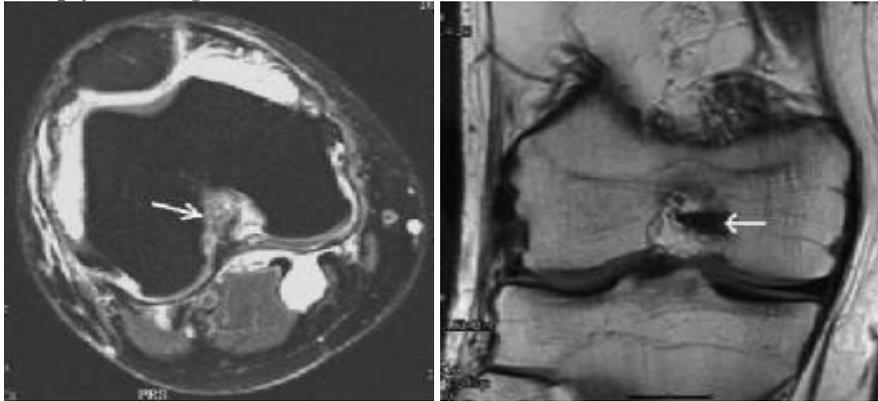
Multiplanar reconstructions obtained with three-dimensional data, mainly of T1 and T2 weighted sequences to evaluate the ACL is more useful. Associated meniscal, ligamentous and bone marrow injuries can be detected with multiplanar approach. Knowledge of ACL anatomy, normal variation and nature of injury in all planes are essential. Laxity of ACL and healed chronic tears can be optimally demonstrated on sagittal images.

### Figures

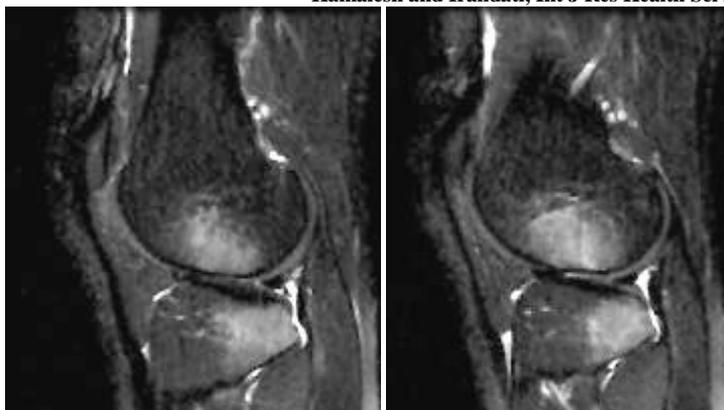
#### ACL Tear



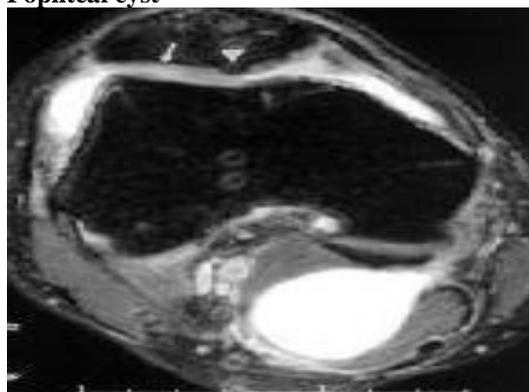
#### Empty notch sign



#### Kissing contusion



**Popliteal cyst**



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