INTRODUCTION

The anterior cruciate ligament (ACL) is composed of the anteromedial and posterolateral bundles. Functionally, these two distinct bundles act in a complementary manner to limit excessive femorotibial movement at the end of flexion and extension. [1] ACL is the most frequently injured large ligament in the knee. As injured ACL recovery is very limited long-term consequences are frequent including cartilage loss, secondary meniscal injuries and degenerative changes. [1]

Most ACL tears are complete, with the tear involving all of the anteromedial and posterolateral bundle fibers. Partial ACL tears occur less frequently and may involve both bundles to a variable degree or one bundle completely. Arthroscopic-based studies may reflect an underestimation of true prevalence as patients with complete rather than partial tears are more likely to undergo arthroscopy.[2]

Partial tear recognition is clinically relevant and important because:

1. Partial tears, unlike complete ACL tears, may have the capacity to heal with conservative treatment.[3]

2. One may be more inclined to opt for a trial of conservative treatment.[3]

3. If surgery is undertaken, partial ACL tears primarily

limited to only a single bundle may be amenable to isolated single bundle graft augmentation rather than full ACL graft reconstruction.[4]

Currently, multiple surgical reconstruction techniques are available to repair a ruptured ACL.[5] Accurate early evaluation of partial ACL tears is relevant to improving the clinical and surgical management of ACL tears.[6]

Partial ACL tears are difficult to diagnose during physical examination. On the other hand, many studies emphasise insufficiency of standard MRI protocol in diagnosing partial ACL tear.[7]

Lower accuracy of standard MR protocol for partial rupture of ACL can be improved by using additional, dedicated MR techniques.[7] Additional parasagittal and paracoronal imaging planes have been advocated in order to improve the accuracy of MRI for the ACL.[11,12] Oblique-sagittal technique clearly shows partial rupture because its' double angulation follows the specific course of the patient's ligament, due to approximate orientation of the external rotation of the foot. The advantages of this technique were described in MR studies of the knee after ligamentoplasty.[7] This prospective study is designed to compare sagittal-oblique MR technique for ACL imaging with standard knee MR protocol.

AIM OF THE WORK

The study goal is to value the role of sagittal- oblique technique of MRI adding to the standardized MRI technique in the diagnosis of anterior cruciate ligament injuries.

REVIEW OF LITERATURE

Anatomy of anterior cruciate ligament:

The cruciate ligaments, so named because they cross each other, are very strong intracapsular structures. The point of crossing is located at a little posterior to the articular centre. They are named anterior and posterior to the reference to their tibial attachements.

Composition:

The ACL has a microstructure of collagen bundles of multiple types (mostly type I) and a matrix made of a network of proteins, glycoproteins, elastic systems, and glycosaminoglycans with multiple functional interactions. The complex ultrastructural organization and abundant elastic system of the ACL allow it to withstand multiaxial stresses and varying tensile strains..

Coverings:

Synovial membranes almost surrounds the ligaments but is reflected posteriorly from the posterior cruciate to adjoining parts of the capsule. The intercondylar part of the posterior region of the fibrous capsule therefore has no synovial covering.

Length and width:

The average length and width of an adult cruciate ligament are 38mmand 11 mm respectively.

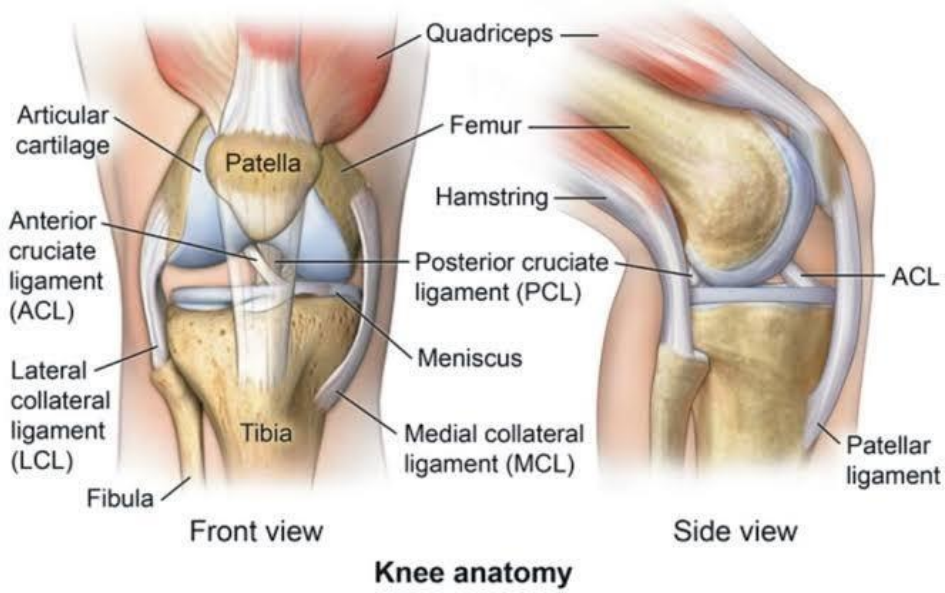

Figure (1): Knee anatomy.

Origin and insertion: the ACL arises from the anteromedial aspect of the intercondylar area on the tibial plateau and passes upwards and backwards to attach to the posteromedial aspect of the lateral femoral condyle. Like the posterior cruciate ligament the ACL is intracapsular but extrasynovial.[1,7]

The ACL consists of two components:

1. Anteromedial bundle which attaches to roof of intercondylar notch.

2. Posteromedial bundle which is more vertically oriented and slightly shorter. Attaches to the wall of the intercondylar notch.(1)

Absent anterior cruciate ligament: congenital absence of anterior cruciate ligament is rare. The condition is usually associated with lower limb dysplasia 9thomas et al 1985), and may be cause of instability of the knee.

Blood supply: The major blood supply of the cruciate ligaments arises from **popliteal artery** through its middle geniculate branch. (9) The distal part of both cruciate ligaments is vascularized by branches of the lateral and medial inferior geniculate artery. **[9]** The ligament is surrounded by a synovial fold where the terminal branches of the middle and inferior arteries form a periligamentous network. From the synovial sheath blood vessels penetrate the ligament in a horizontal direction and anastomose with a longitudinally orientated intraligamentous vascular network. **[8,9]** The density of blood vessels within the ligaments is not homogeneous. **[8,9]** In the ACL, an avascular zone is located within the fibrocartilage of the anterior part where the ligament faces the anterior rim of the intercondylar fossa. **[8,9]** The coincidence of poor vascularity and the presence of fibrocartilage is also seen in gliding tendons in areas that are subjected to compressive loads, and the coincidence of these two factors undoubtedly plays a role in the poor healing potential of the ACL. **[9]**

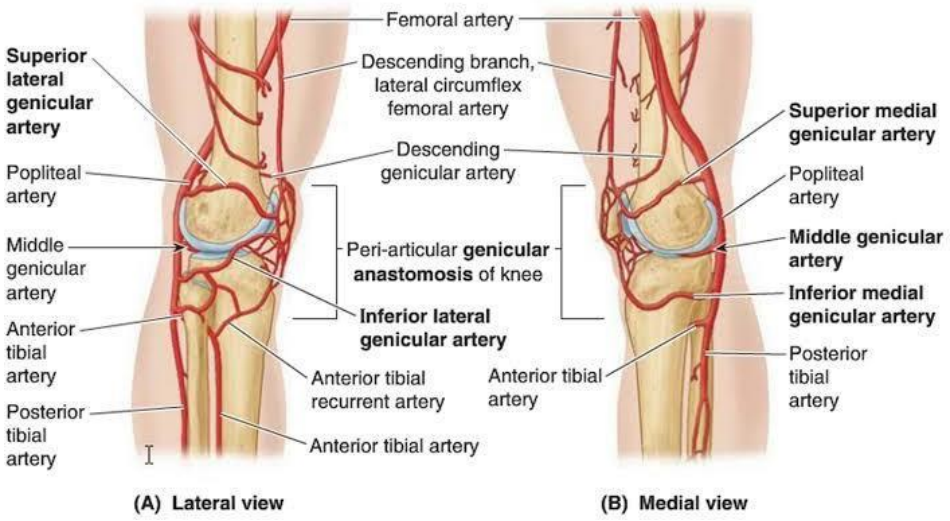

Figure (2): A) lateral view and B) Medial view.

Nerve supply:

The ACL receives nerve fibers from the posterior articular branch of the tibial nerve the fibers penetrate the posterior nerve capsule and run along with the synovialand the periligamentous vessels surrounding the ligament to reach as far to the infrapatellar fat pad. Most of the fibers are associated with the endoligamentous vasculature and have a vasomotor function. (9)

These mechanoreceptors are (Ruffini, Pacini, and Golgi-like receptors) have a proprioceptive function and provide the afferent arc for signaling knee postural changes. Deformations within the ligament influence the output of muscle spindles through the fusimotor system. [5] Hence, activation of afferent nerve fibers in the proximal part of the ACL influences motor

activity in the muscles around the knee; a phenomenon called ‘‘ACL reflex.’’ These muscular responses are elicited by stimulation of group II or III fibers (i.e. mechanoreceptors). The ACL reflex is an essential part of normal knee function and is involved in the updating

of muscle programs. [10] This becomes even more obvious in patients with a ruptured ACL, where the loss of feedback from mechanoreceptors in the ACL leads to quadriceps femoris weakness [10] Indeed, this afferent feedback from the ACL has a major influence on the maximal voluntary contraction exertion of the quadriceps femoris.

Function:

ACL functions is to prevent posterior translation of the femur on the tibia or anterior displacement of the tibia during flexion extention of the knee. The anteromedial bundle is responsible for the posterior translation of the femur at 30 degrees flexion, and the posterolateral bundle resists hyperextention and prevents posterior translation of the femur in extension.

Normal anatomy of the ACL as seen on magnetic resonance imaging

Magnetic resonance imaging (MRI) is becoming widely used in orthopaedic surgery. Over the past decades MRI has been a highly sensitive and specific test for diagnosing a variety of knee pathologies, including ligament injuries.[36]

It has unique advantages over other imaging modalities. First; it is totally non-invasive and has no known adverse effects on the human body. Secondly, it can provide information not only on the density of tissues but also on their chemical structure. Thirdly, MRI can provide a direct three-dimensional view of the partexamined. For the diagnosis of knee disorders, an understanding of the normal knee is clearly essential.[36]

Sagittal images

Sagittal images are best used to evaluate the anterior and posterior cruciate ligaments. They also provide excellent visualization of the menisci. The extensor mechanism, including the quadriceps and patellar tendons and the patello-femoral joint are well visualized on mid-sagittal images.[36]

Each sagittal image should be evaluated systematically, from one side of the knee to the other. The lateral compartment is identified by the presence of the fibular head as well as a convex contour of the tibial plateau. The medial compartment

characteristically has a concave tibial contour. When images are viewed from lateral to medial, the anterior cruciate ligament is seen before the posterior cruciate ligament.[36]

On most sequences the anterior cruciate ligament is easily identified as a structure of low signal intensity.[37] This ligament extends obliquely from the posteromedial aspect of the lateral femoral condyle to its insertion site 15 mm posterior to the anterior border of the tibial articular surface. The anterior cruciate ligament is usually seen on at least one sagittal image when 5 mm thick sections are used. The fibers of the anterior cruciate ligament usually display higher signal intensity than those of the posterior cruciate ligament.[38]

The normal anterior cruciate ligament (ACL), as shown in the image below **(Fig. 3)** appears as a solid band or as a striated band diverging slightly distally. The ACL is usually ruler-straight; however, mild sagging convex inferiorly may be evident in normal ACLs [38]. Occasionally, it is necessary to obtain images in the axial and coronal planes to confirm an intact ACL.[39]

The distal ACL further demonstrates relatively increased signal intensity owing in part to distal divergence of bands /striations. Although in elderly patients, internal degeneration accounts for some of the observed increased signal intensity.[40]

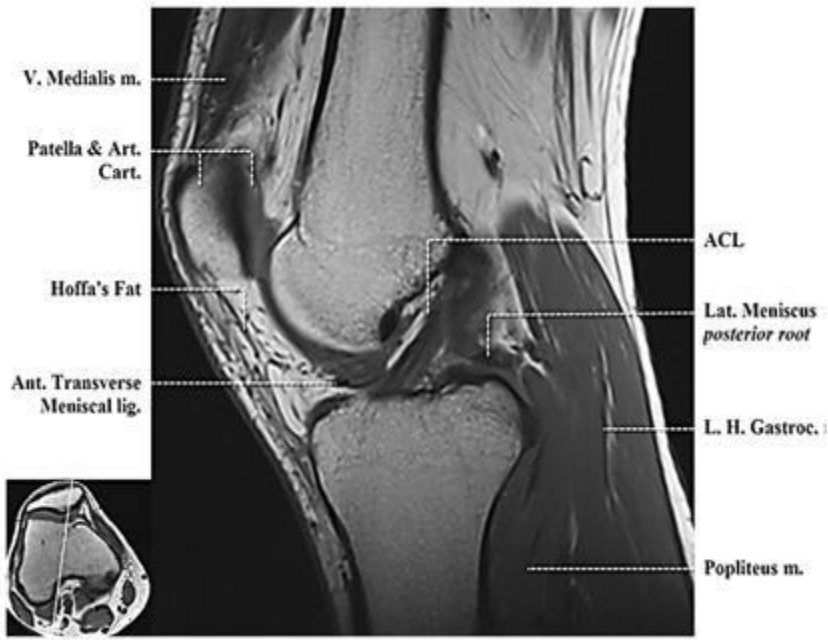

Figure (3): Sagittal T1-weighted MRI image showing intercondylar notch.

Normal ACL. ACL: anterior cruciate ligament.[41]

The anteromedial bundle is best seen on sagittal sections, where the taut ACL shows as a hypointense line which can be traced from origin to close to the insertion on the tibia. In the insertional area, the fibers of the anteriomedial bundle spread out and may therefore become poorly defined as the space between them is filled with fluid, fat or connective tissue. This apparent loss of continuity of the ligament should not be misinterpreted as an insertional tear. The posterolateral bundle is more poorly defined but can be identified as a number of strands separated by fluid and connective tissue. [37] **(Fig. 4)**

Figure (4): Sagittal PD MRI image of the knee demonstrates a normal anterior cruciate ligament (ACL) which is characterized by a taut, continuous, low signal intensity fibres extending from the tibial plateau anteriorly to the medial aspect of the lateral femoral condyle. The more anterior portion of ACL is the anteromedial (AM) bundle (black arrows) while the more posterior portion is posterolateral (PL) bundle (white arrows). They cannot be well delineated from each other on this sagittal image. The PL bundle shows higher signal intensity than AM bundle.[42]

Coronal Images (Fig. 5)

Although the cruciate ligaments are best seen on sagittal images, they can also be identified on coronal images. Coronal images should be followed from the posterior structures, including the popliteal vessels and the posterior aspect of the femoral condyles, to the anterior structures, including the extensor mechanism.[43] The anterior cruciate ligament is oriented more vertically relative to the posterior cruciate ligament in the intercondylar notch. A normal ACL is usually

well seen, although the band (or bands) often appears much more attenuated and less bulky than in the sagittal plane. The insertion of the anterior cruciate ligament on to the lateral aspect of the medial tibial spine is well seen on the anterior images. The lateral position of the ACL in the itercondylar notch of the femur is apparent in the coronal plane.[44]

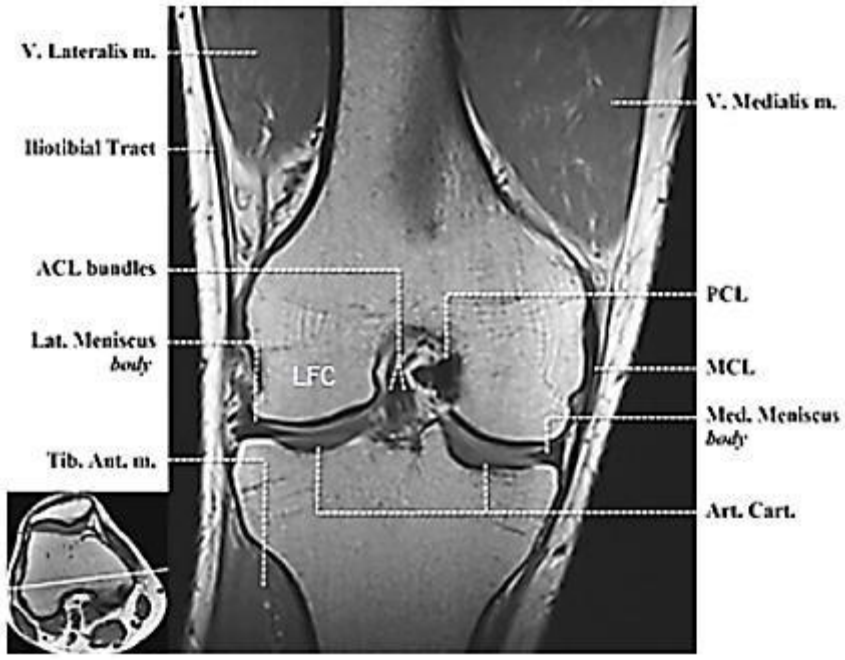

Figure (5): Coronal T1-weighted image at mid coronal plane showing normal ACL: The mid and distal ACL in the intercondylar fossa. The fibres are running superiorly and laterally within the intercondylar fossa from tibial attachment to the lateral femoral condyle (LFC). The more medial portion is the AM bundle while the lateral portion is the PL bundle. ACL: anterior cruciate ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament.[45]

Axial Images (Fig. 6)

It is seen coursing in a 15° to 20° anteromedial direction in the intercondylar notch from the medial aspect of the lateral femoral condyle to the anterior aspect of the tibia. It is especially well seen and appears as an elliptical low-signal intensity band adjacent to the lateral wall of the upper intercondylar notch. It gradually moves away from the wall and splits into a horseshoe (fan-shaped) array of fascicles as it approaches its tibial insertion. The distal ACL is difficult to critically evaluate on axial images.[44]

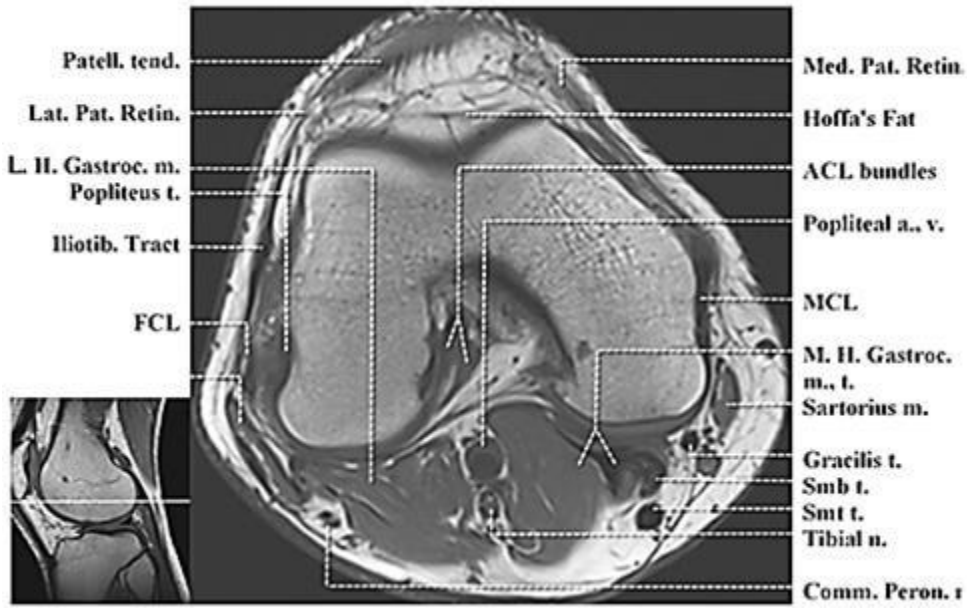

Figure (6): Axial T1-weighted image at inferior patellofemoral compartment showing normal ACL: The ACL is elliptical in appearance because it is running obliquely to the scan plane. The two bundles cannot be differentiated from each other. ACL, anterior cruciate ligament; Patell. tend: patellar tendon.[45]

Pitfalls in interpreting normal ACL findings: (Fig. 7)

The ACL is poorly visualized in 5-19% of healthy knees in the sagittal plane. T1-weighted images are especially likely to demonstrate an ill-defined indeterminate ACL appearance in normal knees. However, the absence of hemorrhage or edema in the expected location of the ACL, a normal appearance of the ACL in other planes and the absence of secondary signs of ACL injury is almost always sufficient to confirm that the ACL is normal**. Smith et al** noted that the ACL is highly likely intact when poorly visualized on either the T1- or T2-weighted sagittal sequence and normal in appearance on other sequences.[43] Partial volume superimposition of the inner aspect of the lateral femoral condyle on the proximal ACL may produce a pseudomass that mimics an acute ACL tear on sagittal images. If section thicknesses of 4 mm or less are routinely used and if other imaging planes are correlated, this is not a diagnostic problem.[43]

MR images of the knees in flexion can provide more space around the ACL within the intercondylar area, helping to decrease volume-averaging artifact and thereby allowing better visualization of the femoral end of the ligament.[42]