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MRI and Arthroscopic Correlation in Anterior Cruciate Ligament Injuries of Knee

Authors
Dr Seena CR, Dr Prashant Moorthy, Dr Natarajan, Dr Kulasekaran

INTRODUCTION

The knee joint is a common site for injury, mainly due to trauma and sports related injuries.[1]

Disruption in the anterior crucial ligament (ACL), a major stabilizer of the knee, leads to loss of stability, dysfunction and pain in the knee joint.

The ACL is the most common torn ligament of knee; the ACL tear has remained clinically elusive. History regarding mechanism of knee injury and clinical examination gives a vital clue to the internal derangements of knee joint.

Magnetic resonance imaging (MRI) is needed for early diagnosis in evaluation and treatment planning in acute injuries to knee joint.[2]

Use of arthrography and arthroscopy improves the accuracy of the diagnosis; but they are invasive and may cause complications. Advanced modality is arthroscopy, which can be used as dual mode, as diagnostic and/or as therapeutic modality.

Diagnostic arthroscopy is a vital tool, providing diagnostic precision to 87-96%. However, it is an invasive procedure with the possibility of infection, hemarthrosis, as well as complications related to anesthesia. MRI is a completely non-invasive diagnostic modality and there is no ionizing radiation.

Furthermore the ligaments of knee are categorized into intra and extra-articular, consequently. MRI plays the most important role in their overall evaluation. The extra-articular ligaments are not visible on routine arthroscopic procedures.[3]

The overall assessment of the entire joint is called composite diagnosis[4], is more relevant and important in overall assessment and evaluation and thus diagnostic arthroscopy can be avoided.

Although magnetic resonance imaging (MRI) scans are often considered to give the ultimate diagnostic certainty, in reality, the performance of MRI as a diagnostic tool of internal derangement of the knee, its accuracy, sensitivity and specificity vary widely in literature[5].

This study is therefore set out for a systematic review and to provide an outline with which MRI and arthroscopy studies can be precisely compared.

The purpose of this study is to find out the efficiency of MRI in the evaluation of knee injuries precisely ACL and correlate with arthroscopic findings.

AIM AND OBJECTIVES

To seek correlation between MRI and arthroscopy in patients with anterior cruciate ligament injuries of knee joint.

The purpose of this study is to explore the diagnostic capabilities and advantages of magnetic resonance imaging (MRI) in evaluating anterior cruciate ligament injuries of the knee joint.

REVIEW OF LITERATURE

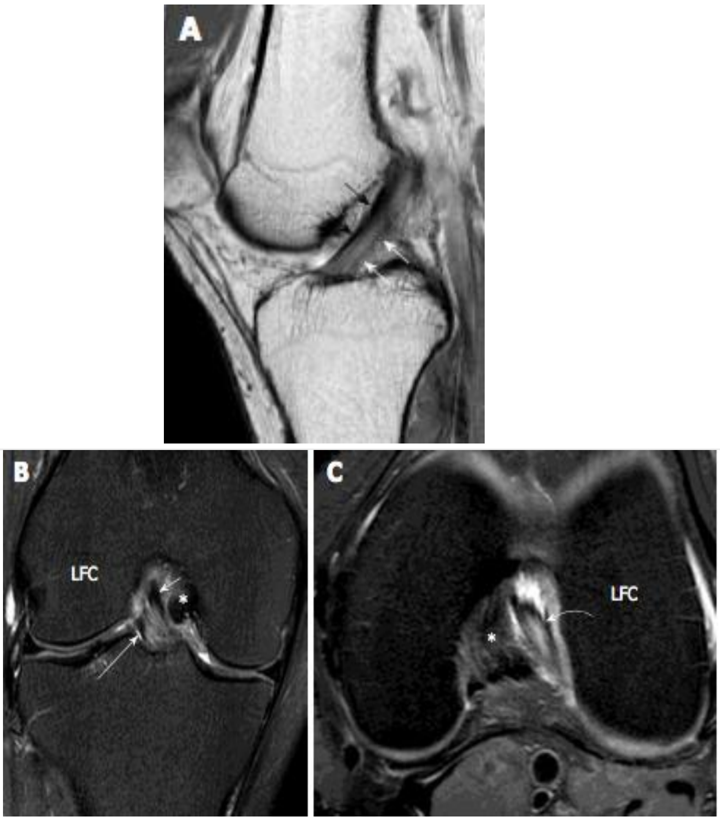
ANTERIOR CRUCIATE LIGAMENT

The anterior cruciate ligament (ACL) courses obliquely from the tibia to the lateral femoral condyle. It is an intra-articular extra synovial ligament comprised of fibers running from the anterior intercondylar region of the proximal tibia to the medial aspect of the lateral femoral condyle. The fibers of the ACL comprises of two bundles, namely the anteromedial and posterolateral bundle based on their tibial insertion.[6] The anteromedial bundle inserts more medially to the superior aspect of the lateral femoral condyle while the posterolateral bundle inserts more laterally and to the distal aspect of the lateral femoral condyle. Occasionally there is an additional intermediate bundle in between these two bundles[7,8].

The ACL measures approximately 38 mm in length and 11 mm in width [9]. The anteromedial bundle is 36 ± 2.9 mm in length; posterolateral bundle is 20.5 ± 2.5 mm in length. Both bundles are similar in size, with an average width of 5.0 ± 0.75 mm and 5.3 ± 0.7 mm in the mid-substance.[10]

The ACL resists anterior tibial translation in extension and also provides rotational stability[11-14]. The anteromedial bundle is taut when the knee is extended and the posterolateral bundle is taut during flexion. The anteromedial bundle is longest in flexion and is the primary component that resists anterior displacement of the tibia during flexion.

The posterolateral bundle primarily resist anterior tibial translation in extension and contributes to rotatory stability of the knee[14]being involved in the “screw home” phenomenon during terminal extension of the knee, the tibia externally rotates in relation to the femur serving in locking the knee in extension. The anteromedial and posterolateral bundles together stabilize the knee joint in response to tibial loads and combined rotatory loads in synergistic way[15].



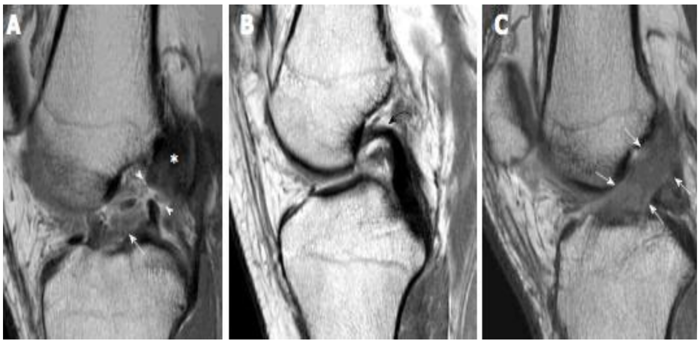
A: Normal anterior cruciate ligament is characterized by a continuous, low signal intensity extending from the tibial plateau to the medial aspect of the lateral femoral condyle

B &C: The mid and distal ACL in the intercom-dylar fossa. The fibers are running superiorly and laterally in the intercondylar fossa from tibial attachment to the lateral femoral condyle (LFC) .

ACL tears are partial/complete. Partial tears range from a minor tear involving a few fibres to a high-grade complete tear involving almost all the fibres. A partial tear may involve both or a single bundle. The mechanism of the ACL injury involves internal rotation of the tibia in relation to the femur. This very commonly occurs in falls while skiing, as well as well as contact sports eg. football. With valgus stress, the medial femorotibial joint compartment is impacted producing medial collateral and medial meniscal injury (O’ Donoghue’s triad). Another mechanism of injury is hyperextension such as occurs during high kick maneuvers and will cause contra- coup bone contusion on the tibia and femoral condyle.

Another mechanism is external rotation of the tibia in relation to femur leading to impaction and bone edema medially resulting in avulsion of lateral tibial rim (Segond fracture) and tear of the lateral collateral ligament.

Primary signs of anterior cruciate ligament tear.

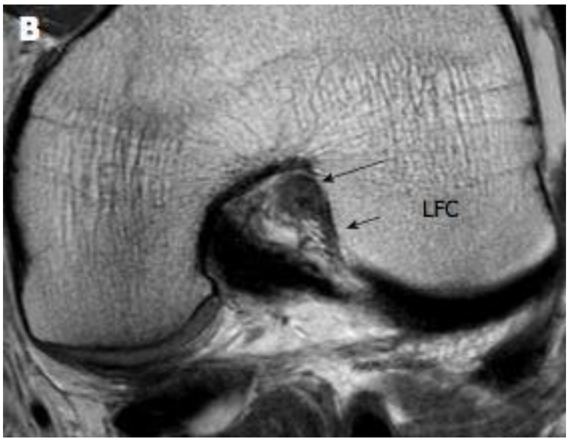


A: Typical appearance of ACL tears at the mid-substance with fibres discontinuity (arrowheads). Residual stumps on femur (asterisk) and tibial sides (white arrow) are thickened and show increased signal intensity.

B: Chronic ACL tear with absence of normal ACL fibres compatible with complete resorption of fibres.

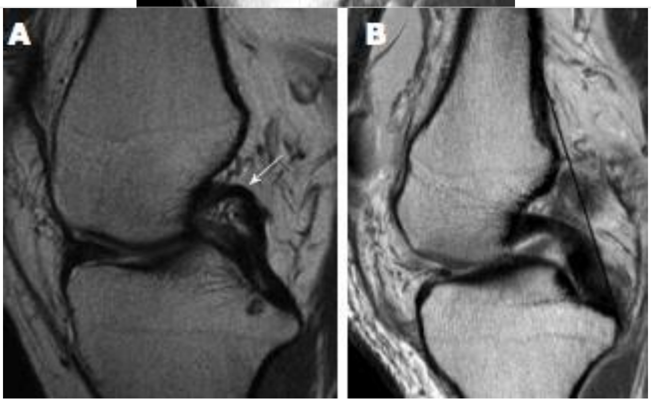
C: Acute high-grade intrasubstance tear as characterized by thickening and edematous change of ACL fibres, which show, increased signal intensity (white arrows). The fibres are in continuity suggestive of partial ACL tear.

The orientation of the ACL makes visualization of the entire ACL difficult in one plane, some authors support the use of oblique planed. Oblique coronal and sagittal views parallel to the ACL have been adviced and found to be effective in improving visualization of the ACL.



High resolution imaging ACL in oblique axial plane.

- Partial tear of the anterior cruciate ligament. Oblique axial image at the femoral side shows thickening and hyperintense signal of the AM bundle (black long arrow) while fibres are not visualized in the region of the PL bundle (black short arrow).
- Features are consistent with high grade partial AM bundle tear and complete PL tear, which were confirmed on arthroscopy.



- MRI sagittal images of knee joint showing complete ACL tear with buckling of PCL and anterior femoral translation.

Femorotibial translation and rotation gives rise to other signs which are all moderately indicative of ACL injury such as buckling of the patellar tendon, buckling of the posterior cruciate ligament29 a PCL line sign, uncovered posterior horn of the meniscusor visibility of the whole posterior cruciate ligament in one coronal image.

Shearing fat pad injury is associated too with ACL tear and results in fracture of the infrapatellar fat pad.

The two primary ACL reconstruction procedures are autologous bone–patella tendon bone graft and autologous four- strand hamstring graft, which is known as doubled semitendinosus and gracilis tendon graft.

The bone–patella tendon bone graft is being harvested by taking blocks from patella and the tibial tubercle with the central third of the patellar tendon. The second graft is constituted by distal semitendinosus and gracilistendons, which are being harvested from the musculotendinous junction to their tibial insertion.

They are sutured together and doubled back, giving four strands. Debate as to which procedure leads to long-term joint stability is ongoing.

However, the bone–patella tendon–bone procedure leads to more anterior knee pain at the harvest site than the doubled semitendinosus and gracilis graft. In the pediatric population, ACL repair by doubled semitendinosus and gracilis tendon graft is preferred because of the ability to avoid crossing the epiphysis with bone blocks.

Other types of procedures using other auto grafts, cadaveric grafts, synthetic materials. These procedures often use similar tunnels and have postoperative appearances similar to the bone–patella tendon– bone and semitendinosus and gracilis tendon procedures.

ARTHROSCOPIC RECONSTRUCTION

The two procedures stated replace only the anteromedial bundle (AMB) of the ACL. The ACL is divided into an AMB and a PLB on the basis of sites of attachment to tibia. Newer procedures using double-bundle techniques have been developed to replicate a more physiologic function of the ACL by replacing both the AMB and the PLB. The surgical techniques are different and vary using up to four bone tunnels.

ACL graft illustration

- Bone–patella tendon– bone graft, interference screw, and graft en vivo with interference screws in femoral and tibial tunnels.
- Lateral radiograph shows first line being drawn along posterior cortex of femur and second line being along intercondylar notch. Inferior portion of femoral tunnel is located at intersection of these two lines. AP radiograph shows that femoral tunnel can be seen as lucency between 10- and 11-o’clock positions.

MATERIALS AND METHODS

The study has been conducted at Saveetha Medical college and hospital after obtaining Permission from Institutional ethical committee of Saveetha University in the meeting conducted on 28/05/2015.

Sample size, sampling technique and statistical analyses

41 patients Sampling technique- 41 consecutive patients Statistical analyses - simple percentage and chi square test.

Inclusion criteria

Patient with knee trauma suspected to have anterior cruciate ligament and meniscal injuries.

Exclusion criteria

Patients with contraindication of MRI Patients with femoral condyle, tibial plateau fractures Patients with associated dislocations.

Patients with knee trauma of any age group were included in the study. The patients were clinically evaluated and referred from orthopedics department of our hospital for MRI of knee. The patient's with ligament and meniscal injuries diagnosed in MRI underwent arthroscopy as a diagnostic or therapeutic procedure. The patients with fracture of femur, tibial plateau and dislocation; contraindications for MRI imaging and previous knee surgeries were excluded. The sensitivity, range of curve, specificity, positive predictive value (PPV) and negative predictive values (NPV) were calculated from patients in whom the arthroscopy was done.

ACL tears are common sporting injuries. On MRI, complete tears appear as discontinuity of the fibers, increased signal and/or laxity. The mid-substance of the ligament is injured more frequently than the proximal or distal portions. Partial tears or sprains of the ACL were recognized on MRI by altered signal and/or laxity in the presence of continuity of some fibers.

The menisci are two-semi lunar fibro cartilaginous structures located between the articular cartilage of the femoral and tibial condyles. They each have a crescent shape with an anterior and posterior horn and a body. The tips of the horns are attached to the tibial plateau adjacent to the intercondylar eminence. These attachments are known as the meniscal roots. A tear is diagnosed on MRI when high signal is demonstrated extending to the articular surface of the meniscus. Tears may be horizontal or vertical depending on whether they reach one meniscal surface or two. A complex tear is diagnosed when two /more tear configurations are present.

An informed consent was obtained prior to study after explaining the procedure of the examination to the patient. The examinations were be carried out in a Philips 1.5 TESLA MRI machine. The patient was placed in supine position on the table. The knee was kept in extension fifteen to twenty degrees external rotation (gives better imaging of ACL). The knee was secured in the coil by centering the joint. MRI sequences include Proton density weighted sagittal, coronal, T1, T2 coronal, fat saturation and high resolution axial oblique.

MRI images were acquired digitally with the use of a picture archiving and communication system (PACS) in DICOM (digital imaging and communications in medicine) format. The assessment of images were be performed by the use of software by the radiologist. The ACL was evaluated on sagittal, coronal & axial images and categorized as intact or torn. It is a normal ACL when a hypointense band of anteromedial and posterolateral bundles are seen. The presence of focal discontinuity or complete absence of ligament, abnormal signal intensity of the ligament, poor definition of its ligamentous fibers were considered as ACL tear, primary signs include deep femoral notch sign, femorotibial translation, PCL line sign, secondary signs are segond fracture, bone contusions, O'Donoghue's triad together medial collateral ligament tear and medial meniscal tear.

A hypointense meniscus without any altered signal intensity is considered normal. Presence of an intrameniscal high signal intensity reaching the articular surface will be regarded as a tear.

High signal intensities that doesn't extend to the periphery are categorized as degenerative.

Associated other ligament injuries of knee joint effusions, intraarticular loose bodies, contusions were evaluated.

The patients with positive findings on MRI underwent arthroscopy. The Orthropedician performed all the arthroscopies under spinal anaesthesia.

In arthroscopy the joint is divided into suprapatellar pouch, patellofemoral joint, medial gutter, medial compartment intercondylar notch, posteromedial compartment, lateral compartment and posterolateral compartment. Through anteromedial and posterolateral ports ACL and meniscus are visualized. Findings are evaluated and further surgical intervention was be carried out accordingly, ACL reconstruction for ACL tears and partial/subtotal menisectomy for meniscal tears.

The sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV) range of curve and pain score were calculated between MRI and arthroscopic findings.

DISCUSSION

The Main objective of the study is to determine the accuracy and efficacy of MRI in detecting ACL and meniscal injuries of knee joint. The study group consisted of 45 patients who were clinically suspected to have ACL/meniscal injuries. All the patients underwent arthroscopic knee surgery. The findings on MRI were correlated with arthroscopic findings and sensitivity; specificity, positive predictive value, negative predictive value and range of curve were calculated.

Of the 45 patients in this study, 42 were male and 3 were female. The study showed a male predominance of about 93.3% due to associated sports injuries. The age groups were ranging from 17 to 45 years. The average age was 24.5 years.

MRI findings for the ACL injuries, which included both complete and partial tears, had 100%sensitivity. This suggests that MRI detected all positive cases of ACL injuries diagnosed by arthroscopy.

The sensitivity for complete ACL tears was 97.4%; this was due to the fact that one of the patient's for whom partial tear was diagnosed by MRI was found to have complete tear on arthroscopy.

Hristijan Kostov et al. stated that because the ACL crosses the knee joint at a slightly oblique angle, the complete ligament rarely is captured in its entirety by a single MRI scan in the true sagittal plane and makes it difficult sometimes to differentiate partial and near complete tears.79

The specificity of ACL injuries was 100 % stating that all 8 patients with normal ACL diagnosed by MRI turned out to be normal in arthroscopy.

Identification of ACL tears in our study was presented with 98.7% in range of curve, which is statistically significant. The results of this study are in accordance to the literature, which suggests an accuracy of 80 to 94 % for the ACL tears.

Rubin et al reported 93% sensitivity for diagnosing isolated ACL tears.52 Hristijan Kostov et al obtained 83% sensitivity and 88.37% specificity of MRI with respect to fair correlation with arthroscopy in diagnosing ACL tears.79

Posterior horn tears of menisci are sometimes likely to be missed on arthroscopy especially if anterior approach is used and if the menisci are not probed. Inferior surface of meniscus is in particular, vulnerable to this flaw in arthroscopy.

The average pain score for ACL and meniscal injuries taken from a scale of 1- 10 yielded results as follows, average score of about 7 – 8 with patients diagnosed with ACL and meniscal injuries and pain score of about 5-6 in patients with negative findings.

Contusion was present in 46.6 % of the patients and effusion was present in 35.5 % of the patients in this study.

Range of activity was also evaluated and was found that persons with only meniscal injury (13.33 %)were able to perform moderate to strenuous activities without pain when compared to people with ACL injuries (86.67%) who were only able to do mild activity.

In this study we have compared the results of MRI to that of arthroscopy keeping that as gold standard. This presupposes that arthroscopy is 100% accurate allows for the diagnosis of every possible intraarticular knee pathology, but is not always the case.

Arthroscopy is a technically demanding and an invasive procedure and has limited technical abilities.

Our study revealed a high sensitivity and specificity for ACL and meniscal injuries of knee joint in comparison with arthroscopy. Findings of this study population are consistent with other studies in this field.

So we have sufficient evidence to conclude that MRI is highly accurate in the diagnosis of ACL and meniscal injuries. MRI is an appropriate screening tool for therapeutic arthroscopy, making diagnostic arthroscopy unnecessary in most patients.

Magnetic resonance imaging is accurate and non-invasive modality for the assessment of ligamentous injuries. It can be used as a first line investigation in patients with soft tissue trauma to knee. MRI is advantageous overall in conditions where arthroscopy is not useful like peripheral meniscus tears and inferior surface tears and also associated contusions extra articular pathologies etc.

CONCLUSION

Thus this study concludes that MRI is a useful non-invasive modality having high diagnostic accuracy, sensitivity and negative predictive value making it a very reliable screening test for diagnosing internal derangements of knee joint.

One can rely on MRI to avoid diagnostic arthroscopy as MRI has a high sensitivity and specificity.

Oblique sagittal imaging helps in aiding to diagnosis.

Almost all the ligament injuries can be diagnosed with high level of confidence.

Pathological entities need to be carefully differentiated from normal variants and artifacts of imaging.

Despite the fact that arthroscopy is the gold standard modality in evaluating knee pathologies, there lies limitations of the procedure such as associated extra-articular pathologies, posterior and inferior meniscal tears.

Other shortcomings of arthroscopy include its invasiveness, and possible complications associated with the procedure.

Hence performing an MRI prior to arthroscopy is necessary in overall evaluation of internal derangements of knee joint.

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ABBRREVATIONS

MRI – MAGNETIC RESONANCE IMAGING
ACL- ANTERIOR CRUCIATE LIGAMENT
PCL-POSTEIOR CRUCIATE LIGAMENT
LM – LATERAL MENISCUS
MM- MEDIAL MENISCUS
LCL-LATERAL COLLATERAL LIGAMENT
MCL-MEDIAL COLLATERAL LIGAMENT
PD-PROTON DENSITY
SAG-SAGGITAL
AMB-ANTEROMEDIAL BUNDLE
PLB- POSTEROLATERAL BUNDLE
ATS-ANTERIOR TIBIAL SUBLUXATION

LFC-LATERAL FEMORAL CONDLYLE
MFC-MEDIAL FEMORAL CONDYLE
PPV-POSTIVE PREDICTIVE VALUE
NPV-NEGATIVE PREDICTIVE VALUE
ROC-RANGE OF CURVE