

Evaluation of Role of Magnetic Resonance Imaging in Knee Joint Injuries in Correlation with Arthroscopy

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Abstract

Introduction: Internal derangement of knee is common after injury. In acute stage, clinical examination of painful knee may be difficult and frequently the imaging studies are required to assess the injuries of the menisci, cartilage ligaments or bone.

Materials and methods: A prospective study was conducted at the department of orthopedic. A total of 50 patients (50 knees) were examined, 42 patients were males and 11 patients were females, their ages ranging from 16 to 61 years, presented with various knee joint injuries.

Results: Our evaluation between these two procedures in knee injuries concludes certain points which are in line with previous studies. Anterior cruciate and medial meniscal injuries more common than the posterior cruciate and lateral meniscal injuries. Description of the type of ACL and PCL tears by MRI helps the orthopaedic surgeon to decide the further course of treatment of either by conservative or definitive reconstruction by arthroscopy.

Conclusion: Ligamentous and meniscal injuries occur frequently in patients with trauma to the knee. It is noted that ACL and MM are more commonly torn when compared to PCL and LM. While ACL and medial collateral ligament tears show predilection toward MM tear, lateral collateral ligament tear showed a strong relationship with LM tear.

Key words: Arthroscopy, Correlation, Knee injuries, Magnetic resonance imaging (MRI)

INTRODUCTION

Trauma to the knee may result in injury to the menisci, cartilage, ligaments, or bone. Physical examination of the painful knee in the acute phase may be difficult, and frequently, imaging studies are required to aid in the assessment of these injuries.¹ Arthroscopy has a diagnostic accuracy of 64-94% but is an invasive procedure and is associated with complications. Anterior cruciate ligament (ACL) is commonly injured ligament in knee² and usually associated with meniscal injuries.³ In 1980's, used magnetic resonance imaging (MRI) in the knee.⁴ The accuracy of

MRI is very high in diagnosing knee lesions and has a sensitivity of 80-100%.⁵ MRI of the knee is currently the diagnostic procedure of choice for the diagnosis of injuries to the menisci, ligaments, and tendons as well as bone bruises and occult fractures in the knee,⁶ and in most centers, it has replaced arthrography and diagnostic arthroscopy.⁷

Failure to recognize and properly manage knee injuries can result in diminished lifestyle, time of work, and premature osteoarthritis. Accurate assessment of the nature of these injuries is a prerequisite for appropriate therapy.

MRI is noninvasive, has proved reliable, safe, and offers advantages over diagnostic arthroscopy, which is currently regarded as the reference standard for the diagnosis of internal derangements of the knee. Arthroscopy is an invasive procedure with certain risks and discomfort to the patient. MRI provides superior anatomical and pathological definition of soft tissues,

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ligaments, fibrocartilage, and articular cartilage. Fast spin echo and fat suppression MRI techniques have extended the sensitivity and specificity of MRI in the detection of articular cartilage, meniscal, and cruciate ligament injuries.

MRI detects bone contusions, marrow changes, and tibial plateau fractures. MRI has unique ability to evaluate internal structure as well as the surface of the ligaments. The most significant advances in knee imaging have been made in MRI, which has clearly emerged as a primary tool, to guide the management of knee pain. With the development of new sequences, improved signal to noise ratio, higher resolution, reduced artifacts, shorter imaging times, and improved accuracy, MRI has changed the traditional algorithm for workup of meniscal and cruciate ligamentous tears. MRI has made it possible to look into the injured knee noninvasively, thereby avoiding invasive procedures and further morbidity.

METHODOLOGY

Patient and Methods

A prospective study was conducted at the Department of Orthopedic. A total of 50 patients (50 knees) were examined, 42 patients were males and 11 patients were females, their ages ranging from 16 to 61 years, presented with various knee joint injuries.

MRI Examination: Instrument

The examination is done using 1.5 Tesla GE Signa HDxt scanner, with dedicated extremity coils (surface coils) as both transmitter and receiver of radio frequency waves were applied. The imaging system is enclosed in a radio frequency room.

Inclusion Criteria

Patients of the adult population (16-61 years) willing to undergo MRI scanning with clinically suspected injuries of the knee and consenting for the same were included in the study.

Exclusion Criteria

- All patients who present with pain and/swelling at the knee joint without any history of injury and inflammatory, degenerative, neoplastic, infective etiologies causing pain, and swelling at knee joint were excluded from the study. Patients who had previously undergone arthroscopy with repair of menisci and ligaments.
- Patients not consenting for the study
- Patients on cardiac pace maker
- Patients on metal implants
- Patients on neurostimulators.

Data Acquisition

Once a patient satisfied the inclusion criteria for this study, he or she was administered the study pro forma. The patients were briefed about the procedure. The noise due to gradient coils (heard once the patient was inside the bore of the magnet) and the need to restrict body movements during the scan time was explained to the patient.

Patient is placed in supine position with the knee in a closely coupled extremity coil. The knee is externally rotated 15-20° (to facilitate visualization of the ACL completely on sagittal images) and is also flexed 5-10° (to increase the accuracy of assessing the patellofemoral compartment). MRI scan was done using sagittal (T2 FSE, PDFATSAT, short-tau inversion recovery [STIR], T2 FRFSE FATSAT) Coronal PD FATSAT and axial STIR sequences using the standard imaging protocol.

Image Interpretation

The ACL was evaluated on sagittal, coronal, and axial images and categorized as intact or torn. It was considered normal when a hypointense band like structure was seen.



Figure 1: Sag proton density fat suppressed image showing non-visualization of anterior cruciate ligament - complete tear

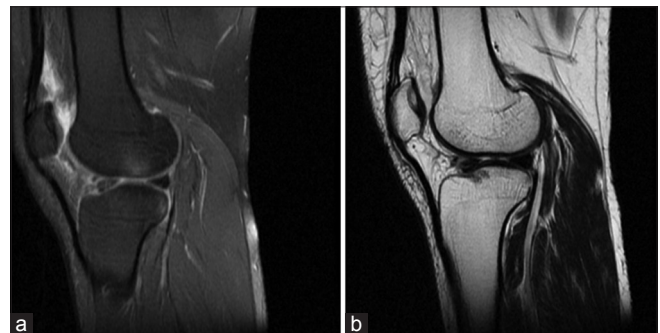


Figure 2: (a and b) Sag proton density fat suppressed and sag T2 images showing tear of anterior horn of medial meniscus

The presence of focal discontinuity or complete absence of ligament, abnormal signal intensity of the ligament, wavy contour, or poor definition of its ligamentous fibers were all considered as ACL tear (Figure 1). A hypointense meniscus without any altered signal intensity was considered normal. The presence of an intrameniscal high-signal intensity was regarded as a tear, and its grading was done according to whether it reaches to the articular surface or not (Figure 2a and b).

Arthroscopic Examination

Arthroscopy is an operative technique to allow the visualization and ideal treatment of structures within the knee joint. It is most commonly performed under a short general anesthesia. The arthroscope is a fiber-optic instrument which is put into the knee joint through two small incisions. A camera is attached to the arthroscope, and the image is viewed on a TV monitor. The arthroscope allows to fully evaluate the entire knee joint including the patella, cartilage surfaces, meniscus, ligaments, and joint lining.

RESULTS

In our study, MRI examination was performed on 50 patients with the complaints of knee injury. Regarding the most common age group, the affected were between 21 and 39 and this is explained by the fact that this age group being the most active group. From 50 patients examined in this study, 42 patients (76%) were males, and 8 of them were females. Of them, 36 (76%) had ACL tears, 3 (6%) had posterior cruciate ligament (PCL) tears, 17 (34%) had medial meniscus (MM) tears, and 11 (22%) had lateral meniscus (LM) injuries as shown in Table 1.

MRI diagnosis was placed into one of the four categories after arthroscopic evaluation as follows:

1. True positive: MRI diagnosis of tear confirmed on arthroscopic evaluation

Table 1: Various injuries in knee joint trauma in study population

| Type of tear | Number of cases n (%) |
|----------------|-----------------------|
| ACL | 38 (76) |
| PCL | 3 (6) |
| MM | 17 (34) |
| LM | 11 (22) |
| MCL | 14 (28) |
| LCL | 9 (18) |
| BC | 21 (42) |
| Fractures | 7 (14) |
| Joint effusion | 25 (50) |

ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament, MCL: Medial collateral ligament, LCL: Lateral collateral ligament

2. True negative: MRI diagnosis of no tear was confirmed on arthroscopy
3. False positive: MRI showed a tear, but arthroscopy was negative
4. False negative: If MRI images were negative, but arthroscopy showed a tear.

| Test | True positive | False positive | False negative | True negative |
|------------------|---------------|----------------|----------------|---------------|
| ACL MRI findings | 35 | 2 | 1 | 12 |
| PCL MRI findings | 3 | 0 | 0 | 47 |
| MM MRI findings | 13 | 4 | 27 | 6 |
| LM MRI findings | 9 | 2 | 35 | 4 |

ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament, MRI: Magnetic resonance imaging

Based on the above categories, sensitivity, specificity, positive predictive value, and negative predictive value (NPV) were calculated to assess the reliability of the MRI results.

DISCUSSION

Imaging of the knee presents a special challenge because of its complex structure. A variety of imaging modalities are currently used to evaluate knee abnormalities. These modalities include standard radiography, scintigraphy, computed tomography, MRI, and arthrography. MRI has

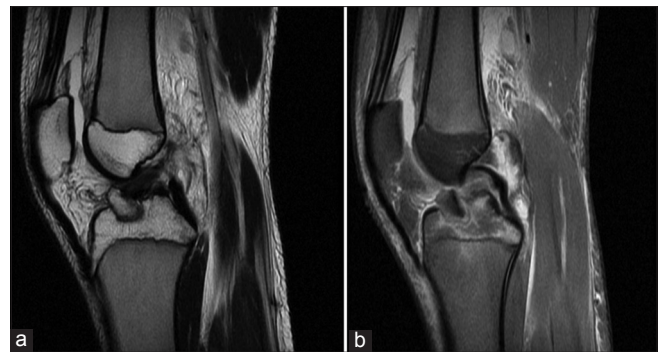


Figure 3: (a and b) Sag T2 and sag proton density fat suppressed images showing avulsion fracture of anterior cruciate ligament at tibial attachment site and buckling of posterior cruciate ligament

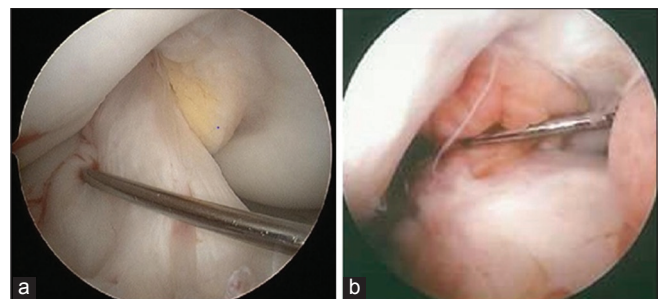


Figure 4: Arthroscopic images showing (a) normal anterior cruciate ligament and (b) torn anterior cruciate ligament

Table 2: Accuracy of MRI findings using arthroscopic findings as the reference data

| Tears | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Accuracy (%) |
|-------|-----------------|-----------------|---------|---------|--------------|
| ACL | 94.59 | 80.00 | 94.50 | 80.00 | 94 |
| PCL | 100 | 100 | 100 | 100 | 100 |
| MM | 68.42 | 86.66 | 76.47 | 81.20 | 80 |
| LM | 69.23 | 94.10 | 81.81 | 88.88 | 88 |

ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament, PPV: Positive predictive value, NPV: Negative predictive value, MRI: Magnetic resonance imaging

Table 3: Comparison of ACL tears with other studies

| Observation | Singh <i>et al.</i> IJRI 2004 n=173 (%) | Taryn <i>et al.</i> AJR 170/ MAY 1998 n=217 (%) | Present study n=50 (%) |
|-------------|---|---|------------------------|
| Sensitivity | 98.72 | 96.00 | 97.2 |
| Specificity | 98.94 | 98.00 | 85.7 |

ACL: Anterior cruciate ligament

Table 4: Comparison of ligament and meniscal tears with other study

| Type of injury | Present study n=50 (%) | Singh <i>et al.</i> 2004 n=173 (%) |
|----------------|------------------------|------------------------------------|
| ACL | 38 (76) | 78 (45.09) |
| PCL | 3 (6) | 10 (5.78) |
| MM | 17 (34) | 57 (32.95) |
| LM | 11 (22) | 28 (16.18) |
| MCL | 14 (28) | - |
| LCL | 9 (18) | - |

ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament, MCL: Medial collateral ligament, LCL: Lateral collateral ligament

Table 5: Comparison of MM tears of the present study with other study

| Observation | Taryn <i>et al.</i> RSNA 1997 n=293 (%) | Present study n=50 (%) |
|-------------|---|------------------------|
| Sensitivity | 89.00 | 68.42 |
| Specificity | 84.00 | 86.66 |

Table 6: Comparison of LM tears of the present study with other study

| Observation | Taryn <i>et al.</i> RSNA 1997 n=293 (%) | Present study n=50 (%) |
|-------------|---|------------------------|
| Sensitivity | 72.00 | 69.23 |
| Specificity | 93.00 | 94.10 |

revolutionized knee imaging. It has been compared by various studies between MR and arthroscopic findings Table 2. These studies validate the role of MRI in the clinical arena, especially for the evaluation of knee injuries.

The study population consisted in the age group of 16-61 years. A maximum number of patients who underwent MRI of the knee for injuries belonged to the age group of 18-28 years. Out of total 50 patients, ACL

tear was the most common finding affecting 38 patients (76%), and among which, 30 (79%) had complete tear and 8 patients (21%) had partial tear, followed by MM tear in 17 (34%) and LM tear seen in 11 patients (22%) Graph 1. In a similar study by Singh *et al.*, 45.08% showed ACL tear, and among which, 66.67% were partial and 21.13% were complete ACL tear. The authors concluded ACL tears to be more common than other ligamentous injuries Table 3.⁸

There was a preponderance of MM over LM in our study which was again correlated with the study done by Singh *et al.*⁸ Out of 173 they found, 57 (32.9%) patients showed MM tear, and 28 (16.1%) patients showed LM tear.

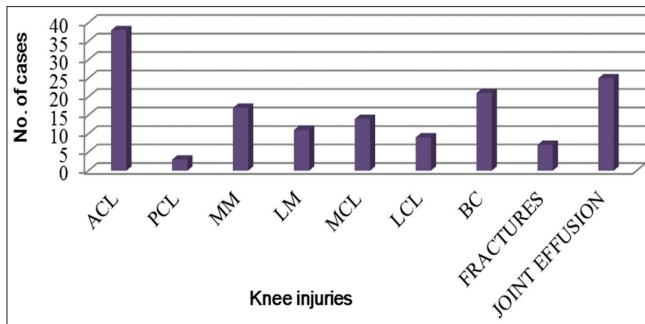
Sensitivity, specificity, and accuracy of MRI in detecting ACL tear were reported to be 98.7%, 98.9%, and 98.8%, respectively, in a study by Singh *et al.*⁸ Table 4. Ha *et al.*⁹ reported the sensitivity, specificity, and accuracy of MRI to detect ACL tears to be 96%. Sensitivity, specificity and accuracy of MRI in detecting ACL tear were reported to be 91.6%, 95.2%, and 94.4%, respectively, in a study by Yaqoob *et al.*¹⁰ Sensitivity was 88.5%, specificity was 71.4%, and positive and NPVs were 85.2% and 76.9%, respectively, in a study. which are in concordance with our study Graph 2.

Lower specificity is because of suboptimal selection of imaging planes and partial volume averaging effect.

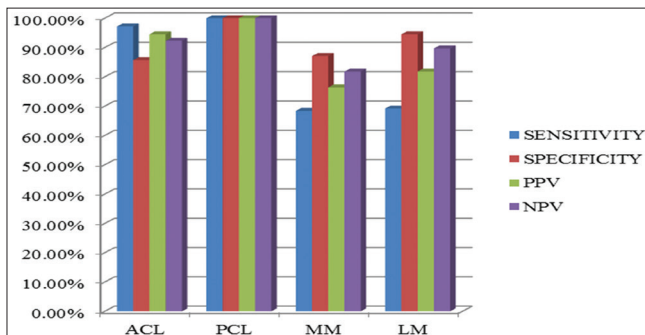
Singh *et al.*, IJRI 2004, studied on cruciate ligaments and menisci in twisting injuries, and in the present study, ACL tears are more because most of the injuries are road traffic accidents.

PCL injuries are less common than ACL injuries, and reported rates vary from 3% to 20%. The PCL being a stronger ligament has a low incidence of tears. The sensitivity, specificity, and accuracy of MRI in identifying PCL tear is 100% which is similar to a study by Manoj *et al.*¹¹ in which the accuracy of MRI in detecting PCL tears is 100%.

MRI of the knee has been found to be highly accurate in the diagnosis of meniscal tears. All the medial meniscal tears are associated with ACL tears in the present study.



Graph 1: Various injuries in knee joint trauma in study population



Graph 2: Sensitivity, specificity, positive predictive value, and negative predictive value of various ligament and meniscal injuries of knee joint in study population

The biomechanical forces that result in the ACL tear also result in medial meniscal tear. Due to multiple tears, the sensitivity of the medial meniscal tear is reduced. Due to the presence of multiple tears, one peripherally located meniscal tear was over looked on MRI in two patients. The sensitivity of medial meniscal tear is reduced in the presence of ACL tears.¹² The medial meniscal tears are usually peripheral tears when associated with ACL tears.

One patient interpreted as a MM tear on MRI was found to be normal at arthroscopy. That the posterior horn of the MM is an, especially, difficult area to visualize and the arthroscopic diagnosis of meniscal tears in this region is difficult. This misinterpreted MM tear was located in posterior horn Tables 5 and 6. It could likely that this tear was missed on arthroscopy. One patient had peripheral vertical tear of MM along with ACL tear, and PCL tear was over looked on MRI.

Lower sensitivity for MM tears in the present study is because of associated multiple injuries.

The sensitivity and specificity of the present study are comparable with the study of Taryn *et al.* RSNA 1997.

The results of this study are in accordance with the literature which suggests an accuracy of 68-88% for the meniscal tears¹³ and 80-94% for the cruciate ligament tears.¹⁴

CONCLUSION

- Ligamentous and meniscal injuries occur frequently in patients with trauma to the knee. It is noted that ACL and MM are more commonly torn when compared to PCL and LM. While ACL and medial collateral ligament tears show predilection toward MM tear, lateral collateral ligament tear showed a strong relationship with LM tear.
- MRI is highly sensitive and accurate at the identification of both anterior cruciate and PCL tears (Figure 3). A close agreement was obtained between MRI and arthroscopic diagnosis. The diagnostic yield is increased with the appropriate use of sequences and proper analysis of images in all planes.
- Misinterpretations are more likely to happen in the case of partial ACL tear where it can be missed or it can be over diagnosed on MRI (Figure 4).
- Description of the type of ACL and PCL tears helped the orthopedic surgeons as a conservative approach was indicated in partial tears while a reconstruction was indicated in a complete tear.

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