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## MRI evaluation of traumatic ACL and associated injuries of knee with arthroscopy correlation

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### Abstract

**Background:** Knee joint injuries causing internal derangements can lead to failure of the normal functions of the knee joint and can lead to disruption of the daily activities of the patient. Thus, it is of prime importance to accurately diagnose internal derangements of the knee.

**Aims & Objectives:** To study Anterior cruciate ligament injury (ACL) and other internal derangements of the knee with Magnetic Resonance imaging (MRI) and compare it with Arthroscopy, the gold standard modality.

**Methods:** A prospective observational study done from 2015 to 2016 at Kamineni Hospitals, Hyderabad, India on 45 patients. Sensitivity, Specificity, Positive predictive value (PPV) and Negative predictive value (NPV) were calculated and Statistical Package for Social Sciences version 17.

**Results:** Sensitivity, Specificity, PPV, NPV and Accuracy for Anterior Cruciate Ligament (ACL) injuries detected by MRI were 100%, 90%, 93%, 100% and 95% respectively. For Lateral Meniscal (LM) injuries, the values were 72%, 70%, 62%, 80% and 71% respectively. For Medial Meniscal (MM) injuries, the values were 70%, 78%, 67%, 81% and 76% respectively.

**Conclusion:** MRI has high accuracy in diagnosing ACL injuries and other causes of internal derangement of the knee. MRI should be the first line of investigation to avoid subjecting the patient to unnecessary arthroscopy.

**Keywords:** Anterior cruciate ligament injury, medial meniscal injury, lateral meniscal injury, knee injury arthroscopy, MRI knee

### 1. Introduction

Knee joint is not only a complex joint, but also the largest synovial joint in our body. Owing to its anatomical structure and the functional demands, injuries involving the menisci and the cruciate ligaments of the knee joint are one of the most frequently encountered problems.

These injuries can lead to failure of the normal functions of the knee joint such as walking, stabilization and weight bearing of the body which can lead to disruption of the daily activities affecting the patient both physically and economically. Thus, it is of prime importance to diagnose the injury, which can involve the meniscus, cruciate ligament or both.

Various imaging modalities used to evaluate the knee include Radiography, Computerized Tomography for fractures <sup>[1]</sup> and Magnetic Resonance Imaging (MRI) for soft tissue injuries in the knee joint <sup>[2]</sup>. Arthroscopy of the joint can be used for both diagnostic and therapeutic purposes.

### 2. Aims and Objectives

- To study and compare MRI and Arthroscopic findings of anterior cruciate ligament injuries (ACL) and other associated meniscal injuries of the knee.
- To study the efficacy of MRI in helping to direct the patient to specific management and early relief.

### 3. Methods

This is a prospective observational study conducted on 45 patients that were admitted after clinical suspicion of Anterior cruciate ligament injury at the Department of Orthopedics of

Kamineni Hospitals, LB Nagar, Hyderabad, India. and were scheduled to undergo Arthroscopic surgery following Radiological (MRI) evaluation. The study was conducted from November 2015 to October 2016.

### 3.1 Inclusion Criteria

- Both males and females of age group 18-60 years.
- All the patients who are clinically suspected/diagnosed of traumatic ACL injury.

### 3.2 Exclusion Criteria

- Patients not fit for undergoing MRI examination.
- Patients with major trauma and unstable vitals.
- Patient suffering from any degenerative knee disease

Clinical examination for ACL tear was done with Anterior Drawer test, Lachman test and Pivot shift test. For Posterior Cruciate ligament injury, Posterior drawer test was used.

In our hospital all the MRI examinations were done on a 1.5T Siemens Symphony MRI scanner.

MRI reporting was done by a single radiologist followed by Diagnostic arthroscopy of the knee joints.

Patient was positioned in the MRI machine Supine, feet first. The knee was positioned in a knee coil and immobilised in cushions. The laser beam localiser was centred over the lower border of patella. The MR Protocol for sequences was

T1 CORONAL, T2 MEDIC AXIAL, T2 SAGITTAL ACL, T2 FL 2D SAGITTAL, TIRM CORONAL, PD SAGITTAL, PD-FS AXIAL, PD-FS CORONAL and PD-FS SAGITTAL 3D

ACL tears were diagnosed on MRI using primary and secondary signs. Primary signs were Swelling of ligament, Increased signal on T2 or FAT SAT PD, fiber discontinuity, abnormal ACL orientation relative to Blumensaat line and the empty notch sign. Secondary signs were bone contusions in the lateral femoral condyle, increased anterior tibial translocation, Segond fracture and buckling of PCL.

PCL tears were diagnosed on MRI by the disruption of it's fibres or an enlarged and swollen PCL

For menisci, homogeneous low signal intensity was indicative of an intact meniscus where as an increased signal within the meniscus indicated degeneration or tears leading to imbibed synovial fluid resulting in shortening of both T1 and T2 values.

MRI classification of meniscal injuries used was as follows:

- Grade 0 - normal homogeneous signal intensity;
- Grade 1 and 2 - high signal intensity within the meniscus that doesn't go to the surface; and
- Grade 3 - High signal intensity that goes to the surface of the meniscus and is indicative of tear

All the surgeries were performed in an Operation theatre under antibiotic cover.

### 3.3 Methods of Statistical analysis

Findings of MRI were compared with that of Arthroscopy findings, which were treated as gold standard, and the analysis was done. Sensitivity, specificity, positive predictive value and negative predictive value were calculated and compared.

The results are presented in numbers and percentages in tables and figures.

The level of correlation was assessed using kappa statistics. Accuracy was calculated from the sum of the true positive and true negative results divided by the total number of patients who underwent Arthroscopy.

Kappa statistics were calculated for each and interpreted. Level of agreement was slight when Kappa value was 0 to 0.20. Level of agreement was fair when value of Kappa was 0.21 to 0.39. It was moderate when the Kappa value was between 0.40 and 0.59. It was substantial when the value was between 0.60 and 0.79. It was almost perfect when the value was between 0.80 to 1.

Interpretation of P value

$P > 0.05$  – Not significant

$P < 0.05$  – Significant

$P < 0.01$  – Highly significant

The whole data obtained was analyzed using Statistical Package for Social Sciences, version 17.

**Ethical consideration:** The study was approved by the institutional ethics committee

**Data sharing:** The authors confirm that data supporting the findings of this study are available within the article [and/or] its supplementary materials.

## 4. Results

A total of 45 patients were part of the study.

### 4.1 Age Distribution

Out of the total number of cases of 45 patients, 20 (45%) were between ages of 18 and 30 years. 15 (33%) were between 31 and 40 years. 6 (13%) were between 41 and 50 years and 4 (9%) were between 51 and 60 years.

### 4.2 Sex Distribution

Out of the total number of 45 patients, the number of male patients were 40 (89%) and the number of female patients were 5 (11%).

### 4.3 Mode of injury

Most common mode of injury were Road traffic accidents in 22 patients (49%) while others include sports injuries in 12 patients (27%), trivial injuries in 7 patients (15%) and other miscellaneous injuries in 4 patients (1.2%).

### 4.4 Structures injured.

Most common structure injured was ACL in 26 patients. Medial and lateral menisci were the next most commonly injured structures in 17 and 18 patients respectively i.e. few patients had injuries involving multiple structures. PCL was not found to be injured in any patient in our study.

### 4.5 Presenting complaints

Most common complaint was knee pain and instability.

**Table 1:** Presenting complaints

Symptoms	Number	Percentage
Pain	7	15%
Pain and swelling	10	22%
Pain and Stiffness	2	5%
Pain and Locking	3	7%
Pain and Sensation of giving way	19	42%
Click	4	9%
Total	45	100%

### 4.6 Anterior cruciate ligament

**Table 2:** MRI vs Arthroscopy correlation for ACL injury findings

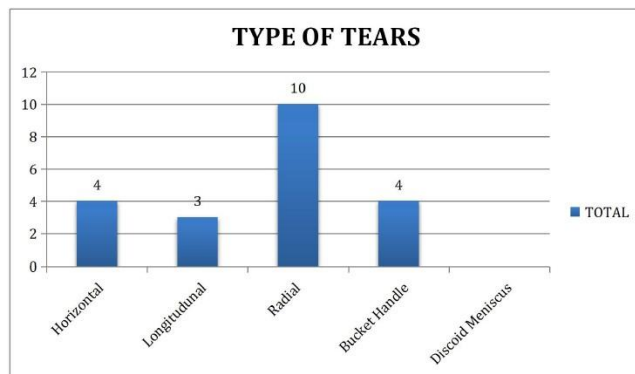
MRI	Arthroscopy		
	Yes (Injury present)	No (Injury absent)	Total
Yes (Injury present)	26	2	28
No (Injury absent)	0	17	17
	26	19	45

Sensitivity, Specificity, PPV, NPV and Accuracy were calculated for MRI findings with Arthroscopy as the gold standard. They were found to be 100%, 90%, 93%, 100% and 95% respectively.

Kappa statistics = 0.908, Almost perfect  
P value = 0.001, Significant

### 4.7 Associated injuries: Meniscal injury- Medial meniscus

Most common tears of the Medial Meniscus were Radial tears. Others include horizontal, longitudinal and bucket handle tears.



**Fig 1:** Types of medial meniscus tears in the study

Sites of medial meniscus tears were also noted. Among the 17 patients who had injuries involving the medial meniscus, most common site of medial meniscus to be injured was posterior horn in 12 patients while the body was involved in 6 patients and anterior horn were involved to a lesser extent in 3 patients i.e. medial meniscus was injured at multiple locations in a few patients.

**Table 3:** MRI vs Arthroscopy correlation for MRI findings of Medial Meniscal injury

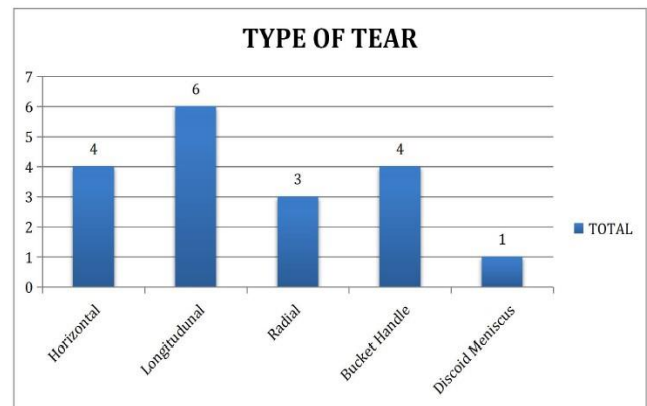
MRI	Arthroscopy		
	Yes (Injury present)	No (Injury absent)	Total
Yes (Injury present)	12	6	18
No (Injury absent)	5	22	27
	17	28	45

Sensitivity, Specificity, PPV, NPV and Accuracy were calculated for MRI findings with Arthroscopy as the gold standard. They were found to be 70%, 78%, 67%, 81% and 76% respectively.

Kappa statistics = 0.486, Moderate agreement  
P value = 0.001, Significant

### 4.8 Associated injuries: Meniscal injury- Lateral meniscus

Most Common type of Lateral Meniscus tear in the study was Longitudinal tear. Others include horizontal, radial and bucket handle tears. Discoid meniscus was found in one patient.



**Fig 2:** Types of Lateral Meniscal tears

Incidence of various sites of injury for Lateral Meniscus in the study was noted. Among the 18 patients with lateral meniscal injuries, Anterior horn was involved in 5 patients, body was involved in 7 patients and Posterior horn was involved in 6 patients.

**Table 4:** MRI vs Arthroscopy correlation for MRI findings of Lateral Meniscal injury

MRI	Arthroscopy		
	Yes (Injury present)	NO (Injury absent)	Total
Yes (Injury present)	13	8	21
NO (Injury absent)	5	19	24
	18	27	45

Sensitivity, Specificity, PPV, NPV and Accuracy were calculated for MRI findings with Arthroscopy as the gold standard. They were found to be 72%, 70%, 62%, 80% and 71% respectively.

Kappa statistics = 0.414, Moderate agreement  
P value = 0.005 - significant.

### 5. Discussion

For diagnosing injuries involving the knee joint, clinical examination is the initial choice. But the pain and swelling around the joint does not permit adequate examination. MRI examination of the knee joint is a non-invasive investigation and commonly used for evaluation of internal derangement of the knee joint. But, observer bias and the power of the machine used play a major role in the final diagnosis given out [3]. Arthroscopic examination of the knee is considered as the gold standard for the evaluation of internal derangement. However, the resultant findings largely depend on the facilities available at the institute, experience of the performing surgeon and inherent limitations of the procedure itself. Intra-substance tears are usually missed on an Arthroscopy. Visualisation of posterior horn of Medial Meniscus is missed on arthroscopy giving out false positive results.

At times, A surgeon may describe a free edge abnormality as a tear, and another one might not interpret it as a tear [4]. In the present study of 45 patients, Males were a total of 40. Maximum numbers of patients were in between 20-40 years. 22 of the patients suffered this injury following RTA, the next common cause being trauma suffered during sports. Anterior cruciate ligament was the most frequently injured structure in our study. Multiple structures were injured in 18 cases.

**5.1 Meniscal Injuries**

Chang *et al.* studied findings of 148 patients with figures of

92% for sensitivity and 87% for specificity of MRI findings for meniscal tears [5]. The conclusion was that MRI is a reliable diagnostic tool for displaced meniscal tears. Aydingoz *et al.* found sensitivity and positive predictive values of 90% for MRI findings in a series of 45 meniscal injuries [6].

In our study Medial Meniscus tears were 17 compared to 18 Lateral Meniscal tears.

The results of comparison of MRI and Arthroscopy findings for Lateral meniscal injuries in our study and several other studies are shown below.

**Table 5:** Results of comparison of MRI and Arthroscopy findings for Lateral meniscal injuries in our study compared to other studies.

Name of Study	Sensitivity	Specificity	PPV	NPV	Accuracy
Elevenes <i>et al.</i> [7]	40%	89%	33%	91%	84%
Dutka <i>et al.</i> [8]	44%	93%	50%	91%	86%
Rayan <i>et al.</i> [9]	61%	92%	74%	88%	85%
Navali <i>et al.</i> [10]	56%	93%	65%	70%	86%
Nikolaou <i>et al.</i> [11]	62%	88%	81%	74%	77%
Present Study	72%	70%	62%	80%	71%

Data from various studies shows that the specificity of MRI is higher than sensitivity and NPV is higher than PPV. We however found that, the difference is not significant.

The results of comparison of MRI and Arthroscopy findings for Medial meniscal injuries in our study and several other studies are shown below.

**Table 6:** The results of comparison of MRI and Arthroscopy findings for Medial meniscal injuries in our study compared with other studies.

Name of study	Sensitivity	Specificity	PPV	NPV	Accuracy
Elevenes <i>et al.</i> [7]	100%	77%	71%	100%	84%
Dutka <i>et al.</i> [8]	88%	64%	60%	90%	73%
Rayan <i>et al.</i> [9]	76%	52%	57%	73%	63%
Navali <i>et al.</i> [10]	84%	71%	73%	83%	78%
Nikolaou <i>et al.</i> [11]	83%	69%	83%	69%	81%
Present Study	70%	78%	67%	81%	76%

Data from our study and the other studies shows that the PPV is lesser compared to NPV.

Compared to the other studies, where the sensitivity was higher than specificity, the specificity was better than sensitivity in our study.

**5.2 Anterior Cruciate Ligament**

The results of comparison of MRI and Arthroscopy findings for Anterior Cruciate Ligament injuries in our study and several other studies are shown below.

**Table 7:** The results of comparison of MRI and Arthroscopy findings for Anterior Cruciate Ligament injuries in our study compared with other studies

Name of Study	Sensitivity	Specificity	PPV	NPV	Accuracy
Dutka <i>et al.</i> [8]	80%	86%	90%	72%	82%
Rayan <i>et al.</i> [9]	81%	96%	81%	95%	93%
Navali <i>et al.</i> [10]	99%	83%	90%	98%	93%
Nikolaou <i>et al.</i> [11]	83%	89%	90%	86%	86%
Present Study	100%	90%	93%	100%	95%

The results for sensitivity, specificity, PPV and NPV obtained from our study were equal to or better than the results of other studies.

In a study conducted by Nikolaou *et al.*, [11] they concluded that though MRI is useful, there have been countable numbers of false results. Thus, correlation between clinical, MRI and arthroscopy is very important.

It is essential to note the efficacy of MRI because it will in turn, effect the treatment of the pathology. In a study conducted by MacKenzie *et al.*, [12] only 38% of the patients who were clinically positive for Meniscus pathology finally underwent Arthroscopy based on the presence or absence of injury on MRI. Thus, we must underline a need for MRI before arthroscopy. In our study, 67% of the patients tested

positive by clinical examination, had MRI findings of injury that were eventually confirmed by arthroscopy.

In a study conducted by Navali *et al.*, [10] Clinical examination and MRI had equal efficacy for internal derangements. In our study, we found this to be true with regards to Anterior cruciate ligament injuries. We also found that clinical examination was equal to MRI in single lesion knees when compared to those with more than one structure involved.

In a study conducted by Perera, Joel and Bunola [13], they came to a conclusion that despite having typical mechanism of injury of ACL, the diagnosis of ACL tear may be delayed up to 4-6 months without proper evaluation, with the mean delay in consulting an orthopaedic specialist being 165 days.

In our study, the longest delay had been 3 months.

In a study done by Barile *et al.*,<sup>[14]</sup> it was advocated that weight bearing MRIs showed unstable meniscal lesions which is helpful for diagnostic and therapeutic purposes.

In a study conducted by Muhle, Ahn and Dieke<sup>[15]</sup> they concluded that knee MRIs done at 55° of flexion resulted in better diagnosis of ACL tears when compared to MRIs in knee extension. There was not much of a difference in diagnosis of meniscal injuries. Our hospital didn't have the equipment to perform knee MRIs in flexion. However, the PPV and NPV of ACL were satisfactory in our study. A detailed and longer study needs to be done to know the efficacy of MRIs taken with knee in flexion.

## 6. Conclusion

Although MRI is very useful in detecting injuries of the knee joint, correlation between clinical, MRI and arthroscopy findings is very important. MRI helps in reducing unnecessary arthroscopic interventions in patients who are clinically suspected to have internal derangements of the knee joint by confirming the injuries.

MRI is better than clinical examination in diagnosing multiple knee injuries. MRI examination helps in decreasing the delay between the diagnosis of the internal knee injury and the treatment, thus reducing the suffering of the patient. Sensitivity and NPV of MRI for ACL injuries are 100% proving that if MRI is positive for an ACL tear then the chances of finding the same on Arthroscopy are very high.

The specificity of MRI for MM injuries is higher than sensitivity, which means that the chances of identifying a normal meniscus are higher than chances of identifying a lesion.

NPV for both MM and LM injuries are higher than the corresponding PPV, suggesting again that the chances of identifying a normal meniscus are higher than that of detecting a pathological meniscus.

Kappa statistics showed moderate agreement between MRI and Arthroscopy for Medial and lateral menisci and perfect agreement for Anterior cruciate ligament. The P value was significant (<0.05) for all the 3 structures.

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**8. Competing interest:** The authors have declared that no competing interest exist.

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