



ORIGINAL ARTICLE

MRI EVALUATION OF LIGAMENTOUS AND MENISCAL INJURIES OF THE KNEE JOINT WITH ARTHROSCOPIC CORRELATION

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ABSTRACT

Background: Within a decade of its clinical introduction, magnetic resonance imaging has revolutionized diagnostic imaging of the knee. It has become the imaging test of choice for ligamentous and meniscal pathologies in the knee. **Purpose:** The objective of this study is to correlate the MRI findings with the arthroscopic findings of ligamentous and meniscal injuries of the knee as well as to analyze the type and grade of ligament tears. **Materials and Methods:** MR imaging studies of the knee were performed in 50 clinically suspected patients using a 1.5T MR machine. Various sequences in coronal, sagittal and axial planes were obtained to evaluate the ligaments, menisci, joint effusion and bony contusions. **Results:** All 50 patients had ligament injuries and out of these, anterior cruciate ligament tear was found to be the most common involving 38 cases. Medial meniscal tear were found in 61% of cases, which had complete ACL tear. Next common ligament to be torn was the medial collateral ligament, which was seen in 14 patients. 57% of these patients had grade 2 tear. Out of all the various sequences, PD in sagittal plane was most useful for ACL tear and fat saturated in coronal plane proved to be useful for MCL tear. **Conclusion:** MRI is an accurate, non-invasive technique in detecting the ligamentous and meniscal injuries of the knee. It has great capability in classifying them into types and grades and can also avoid unnecessary arthroscopic examination. Various sequences are used to identify the tears but certain specific sequences proved to be most useful and should be included as a part of standard protocol.

Keywords: MRI Knee, Ligamentous injuries, meniscal injuries, arthroscopic correlation

1. INTRODUCTION

The objective of this study is to correlate the MRI findings with the arthroscopic findings of ligamentous and meniscal injuries of the knee as well as to analyze the type and grade of ligamentous and meniscal tears.

2. MATERIALS AND METHODS:

MR imaging studies of the knee were performed in 50 clinically suspected patients using a 1.5T MR machine. Various sequences in coronal, sagittal and axial planes were obtained to evaluate the ligaments, menisci, joint effusion and bony contusions.

3. DATA ANALYSIS AND RESULTS:

Table – 1: Types of ACL and PCL Tears based on MRI Findings

Type	ACL		PCL	
	N	%	N	%
Acute (Partial)	18	47.37	4	57.14
Chronic	6	15.79	-	-
Acute (Complete)	14	36.84	3	42.86
Total	38	100	07	100

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The MRI findings of ACL and PCL injuries are presented in Table – 5. Partial tear is the common injury (46.37%) of ACL. About 36.84% of ACL injury patients have complete tear and 12% of patient with ACL injury have chronic type.

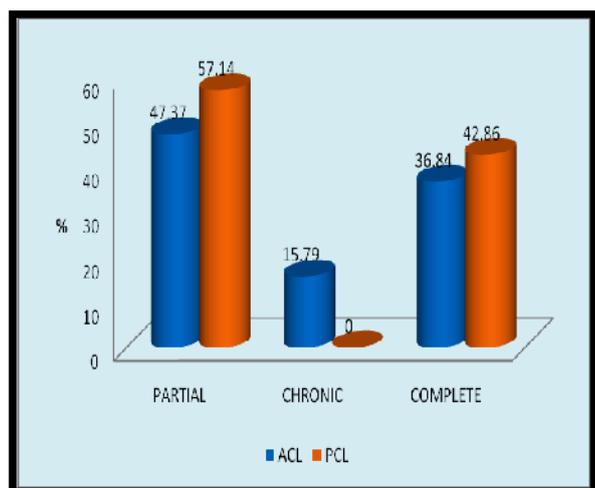


Fig. – 1 : Type of ACL and PCL Tears MRI Findings

Table – 2: Distribution of Grades of Collateral and Meniscus Tears: MRI Findings

Grade	MCL		LCL		MM		LM	
	N	%	N	%	N	%	N	%
G1	2	16.67	3	20	4	17.39	3	15.79
G2	6	50	8	53.33	3	13.04	4	21.05
G3	4	33.33	4	26.67	16	69.56	12	63.16
Total	12	100	15	100	23	100	19	100

The grade distribution of collateral and meniscal tears is presented in Table – 7. The most common grade of MCL tear is grade-2 (50%). About 33.3% of MCL injury patients have grade 3 tear.

The majority of LCL tear have grade-2 (53.3%). About 26.67% of patients with LCL injuries have grade-3 tear.

The most of MM injuries are grade-3 (69.56%) and again most of LM injuries have grade-3 (63.16) tears.

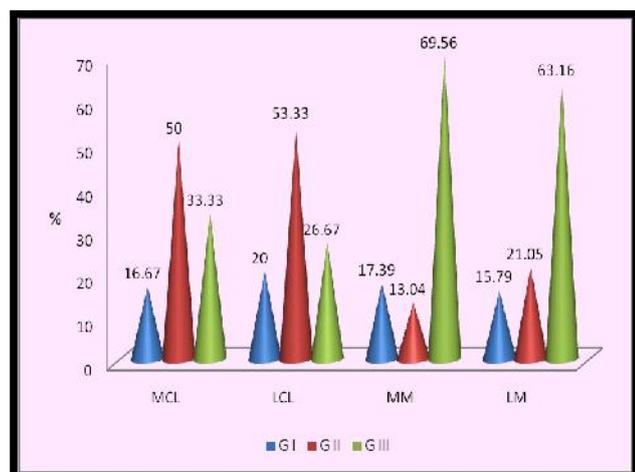


Fig. 2 - Distribution of Grades of Collateral and Meniscus Tears: MRI Findings

Table – 3: Types of ACL and PCL Injuries: Arthroscopy

Type	ACL		PCL	
	N	%	N	%
Partial	17	48.57	4	57.14
Chronic	5	14.29	-	-
Complete	13	37.14	3	42.86
Nil	-	-	-	-
Total	35	100	7	100

The type of ACL and PCL injuries in arthroscopy findings is presented in Table – 9. The majority of ACL tears are partial (48.57%). 37.14% of ACL injuries are complete tear.

The majority of PCL tears are again partial (57.14%). About 42.86% of PCL injuries are complete.

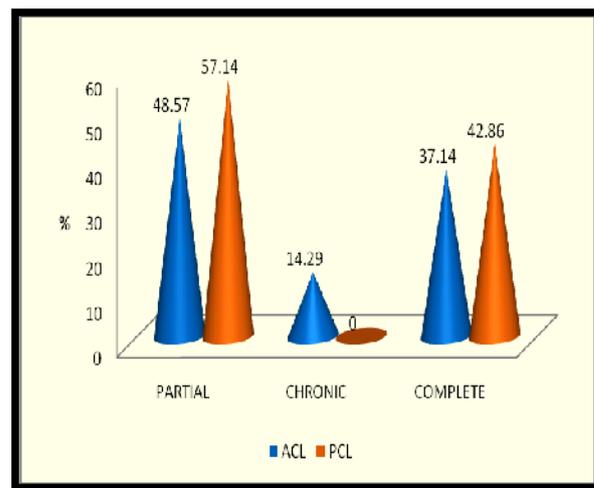


Fig. 3 - Types of ACL and PCL Injuries: Arthroscopy

Table – 4: Grades of MM and LM Injuries: Arthroscopy

Grade	MM		LM	
	N	%	N	%
G3	15	100	12	100
Total	15	100	12	100

All the persons (100%) with MM injuries are grade 3 involvement and again all the patients (100%) with LM injuries are grade – 3 involvements.

Table – 5: Association of MRI Vs Arthroscopy in ACL Injury

MRI ACL	Partial		Chronic		Complete		Nil		Total	
	N	%	N	%	N	%	N	%	N	%
Partial	15	83.3	-	-	-	-	3	16.7	18	100
Chronic	1	16.7	5	83.3	-	-	-	-	6	100
Complete	-	-	-	-	13	92.9	1	7.1	14	100
Total	16	34	5	13.16	13	34.21	4	10.53	38	100

Chi-Square Test

	Value	'P' Value
Chi-square Value	111.111	0.001

The MRI Vs arthroscopy findings are statistically compared for association using Chi-square test. About 83.3% of patients have demonstrated partial tear of ACL in both MRI and arthroscopy findings. Again 83.3% are identified with chronic tears in both MRI and arthroscopy. About 92.9% of findings of complete tears are matched in MRI and arthroscopy findings. The chi-square test of association is significant ($\chi^2 = 111.111$, $P = 0.001$). Hence the findings of ACL injuries of MRI are significantly matched with findings of arthroscopy

Table – 6: Association of MRI Vs Arthroscopy in PCL Injury

PCL	Partial		Complete		Nil		Total	
	N	%	N	%	N	%	N	%
Partial	4	100	-	-	-	-	4	100
Complete	-	-	3	100	-	-	3	100
Nil	-	-	-	-	-	-	-	100
Total	4	47.14	3	42.86	0	0	7	100

Chi-Square Test

	Value	'P' Value
Chi-square Value	100.00	0.001

The association of MRI Vs arthroscopy findings of PCL injuries are analysed by chi-square test of association. It is inferred that the findings are 100% matched in partial, complete and no tears between MRI and arthroscopy. The chi-square test of association is statistically significant ($\chi^2 = 100.00$, $P = 0.001$).

Table – 7: Comparison of MRI Vs Arthroscopy in MM Injuries

MRI	Yes		No		Total	
	N	%	N	%	N	%
Yes	13	86.7	2	13.3	15	100
No	2	5.7	33	94.3	35	100
Total	15	30	35	70	50	100

Chi-Square Test

	Value	'P' Value
Chi-square Value	32.77	0.001

Comparisons	%
Sensitivity	86.67
Specificity	94.29
Positive Predicted Value (PPV)	86.67
Negative Predicted Value (NPV)	94.29
False Positive Rate	5.71
False Negative Rate	13.33

The comparison shows that, 86.7% are demonstrated positive MM injuries in both MRI and Arthroscopy (true positive cases). True negative cases are 94.3%. False positive cases are 13.3% and false negative cases are 5.7%. The chi-square test of association is significant ($\chi^2 = 32.77$, $P = 0.001$). Therefore, the findings of MRI and arthroscopy are significantly matching.

The sensitivity of MRI in detecting MM injury is 86.67 whereas specificity is 94.29%. The PPV is 86.67% and NPV is 94.29%. False positive rate (5.71%) is comparatively less than false negative rate (13.33%).

Table – 8: Comparison of MRI Vs Arthroscopy in LM Injuries

MRI	Yes		No		Total	
	N	%	N	%	N	%
Yes	11	91.7	1	8.3	12	100
No	1	2.6	37	97.4	38	100
Total	12	24	38	76	50	100

Chi-Square Test

	Value	'P' Value
Chi-square Value	36.64	0.001

Comparisons	%
Sensitivity	74.67
Specificity	84.37
Positive Predicted Value (PPV)	69.67
Negative Predicted Value (NPV)	94.37
False Positive Rate	2.63
False Negative Rate	8.33

Table – 17 shows that, true positive cases for LM injuries is 91.7%. False positive cases are 8.3% and false negative cases are 2.6%. The chi-square test of association is significant ($\chi^2 = 36.64$, $P = 0.001$). Hence the findings of MRI and arthroscopy are significantly matching with each other.

The sensitivity of MRI in LM injuries is 81.69% whereas its specificity is 74.37%. The PPV and NPV are 69.67% and 94.37% respectively. False positive rate is 2.63% and false negative rate is 8.33%.

4.DISCUSSION:

The study population consisted patients in the age group of 18 — 61 yrs. Maximum number of patients who underwent MRI of the knee for both cruciate and collateral ligaments belonged to the age group of 18 — 38 years. This study also showed a male preponderance accounting for 78% of the caseload.

ANTERIOR CRUCIATE LIGAMENT:

The percentage of involvement is 56 % for right side and 44% for left side. ACL injuries are very common. About 76% have involvement of ACL. Only 14% have PCL injury.

Of the 38 patients who had anterior cruciate ligament tear, 14 (36.84%) had complete tear, 18 patients (47.37%) had partial tear and 6 patients (15.79%) had chronic tear. Out of these, only 35 patients identified on MRI were confirmed on arthroscopy. Two patients with positive finding on MRI were found negative on arthroscopy. These were partial tears of ACL cases. Discordant appearance of ACL (when one MR sequence shows disrupted or poorly seen ACL fibres and other sequences show intact ACL fibres) was the reason for this false positive case. Crawford et al., (2007) have proved

that when discordant appearance of ACL was seen, they appeared normal on arthroscopy. There are several reasons why the ACL may be abnormal on routine sagittal MR images in absence of ligamentous tear. These include presence of mucoid or eosinophilic degeneration within the ligament, partial volume averaging of the ACL with the lateral femoral condyle or with periligamentous fat and suboptimal selection of the sagittal imaging plane to view the ACL in continuity. In these situations the secondary signs are useful. The various secondary signs, which were seen in ACL injury were, buckled PCL, uncovering of the posterior horn of the lateral meniscus and bone contusions in characteristic location. The most common secondary signs, which were seen in this study, were buckling of PCL and bone contusion.

There was one clinically suspected case of ACL tear, which was missed on MRI but picked up on arthroscopy. This case had partial tear. So the sensitivity (i.e. accurately identifying an ACL tear) of this test is 97.14%, specificity is 91.33% and the positive predictive value (reliability of a positive MRI result) is 89.47%. Mink et al(1998) reported accuracy of MRI for detecting ACL tear as 95% whereas Polly et al⁽⁴¹⁾ found the sensitivity, specificity and accuracy of MRI in detecting ACL tear to be 100%, 96.9% and 97.3% respectively. Sensitivity, specificity and accuracy of MRI in detecting ACL tear was reported to be 98.7%, 98.9% and 98.8% in a study by Singh et al(2004). Hartzman et al(1987) reported the sensitivity, specificity and accuracy of MRI to detect ACL tears to be 96%, 98% and 99% respectively.]

POSTERIOR CRUCIATE LIGAMENT

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. There were 7 patients of PCL tear identified on MRI and confirmed on arthroscopy. Most common type of PCL tear was partial tear (57.14%). The sensitivity, specificity and accuracy of MRI identifying PCL tear is 100%.

MEDIAL COLLATERAL LIGAMENT

Medial collateral ligament tear was seen in 12 patients. Out of these, 2 (16.67%) had grade 1 tear, 6 had (50%) had grade 2 tear and 4 (33.33%) had grade 3 tear. Schweitzer M et al⁽³⁰⁾, on a study population of 76 patients, found that maximum number of patients with knee pain who had MCL tear belonged to grade 2 which was similar to this study. In our institute, the arthroscopic surgeons do not as a routine, study the collateral ligaments and arthroscopic repair of the collateral ligaments is not done. In case MR imaging shows significant strain of collateral ligament and clinical tests for tear are also positive, then the orthopaedic surgeons perform an open surgery for repair of these ligaments. Hence arthroscopic correlation of collateral injuries was not available in this study.

Ancillary findings of MCL tear include joint effusion, bone contusion of femoral and tibial condyles, osteochondral fracture of the medial tibial plateau, haemarthrosis and meniscal tears. Out of 12 cases of MCL tear, 5 cases (41.6%) had medial meniscal tear and only 1 case (8.3%) had lateral meniscal tear. It is also noteworthy to find that 9 cases out of these 12 MCL tears had associated ACL tear.

O'Donoghue's triad (anterior cruciate ligament with medial meniscal and medial collateral ligament tear) was seen in 2 patients.

LATERAL COLLATERAL LIGAMENT

Tears of LCL also known as strains were divided into 3 grades based on MRI appearances. There were 15 cases of LCL strain identified in our study in which 3 cases (20%) were grade 1 tear, 8 cases (53.33%) were grade 2 tear and 4 case (26.67%) were graded 3 tear. However arthroscopic correlation was not obtained as collateral ligament repair is not done arthroscopically in our institute.

Associated findings include joint effusion, bone marrow contusion, haemarthrosis, fracture of medial tibial plateau, osteochondral fracture of lateral tibial plateau and meniscal tears. 4 patients (26.6%) out of 15 total LCL tear cases had lateral meniscal tear while 9 cases (60%) had associated medial meniscal tear.

Different sequences proved to be helpful in diagnosing LCL sprain. These include Tiw coronal, Proton Density coronal and Fat saturated images in coronal plane. In a study done by Rubin et al⁽³⁶⁾, where increased signal within and around the ligament on T2w images proved to be the most useful indicator of a tear. However contrary to that, this study had grade 2 tear more common and disruption of the fibres were more easily picked up on proton density images.

MEDIAL MENISCUS:

A total of 23 patients (46%) showed intra substance signal changes for MM injury. Out of the 23, 4 cases (17.39%) had G-I injury, 3 (13.04%) cases had G – II injury and 16 cases (69.56%) had G – III injury.

Arthroscopy showed 15 cases (30%) tears of MM. Horizontal / oblique tear was seen in 7 cases (43%). Vertical tear was seen in 4 cases (25%). Radial tear was seen in 2 cases (12.5%). Complex tear was seen in 1 case (6.2%). Displaced Bucket handle tear was seen in 2 cases (12.5%).

Most of our patients had tear in the body (10 cases – 62.5%) and posterior horn (7 cases – 43.75%) followed by posterior root (3 cases – 18.75%) and anterior horn (2 cases – 12.5%).

86.7% are demonstrated positive MM injuries in both MRI and Arthroscopy (true positive cases). True negative cases are 94.3%. False positive cases are 13.3% and false negative cases are 5.7%. The chi-square test of association is significant ($\chi^2 = 32.77$, $P = 0.001$). Therefore, the findings of MRI and arthroscopy are significantly matching. The sensitivity of MRI in detecting MM injury is 86.67 whereas specificity is 94.29%. The PPV is 86.67% and NPV is 94.29%. False positive rate (5.71%) is comparatively less than false negative rate (13.33%).

LATERAL MENISCUS:

A total of 19 patients (38%) showed intra substance signal changes for LM injury. Out of the 19, 3 cases (15.79%) had G-I injury, 4 (21.05%) cases had G – II injury and 12 cases (63.16%) had G – III injury.

Arthroscopy showed 12 cases (24%) tears of LM. Horizontal / oblique tear was seen in 5 cases (41.67%). Vertical tear was seen in 2 cases (16.67%). Radial tear was seen in 2 cases (16.67%). Complex tear was seen in 2 cases (16.67%). Displaced Bucket handle tear was seen in 1 case (8.33%).

Ruth Crawford et al⁽⁵²⁾ did a study considering arthroscopy as gold standard. He concluded that results of MRI differ for medial and lateral meniscus with accuracy of around 85%.

Most of our patients had tear in the body (7 cases – 58.33%) and posterior horn (6 cases – 50%) followed by posterior root (1 cases – 8.33%) and anterior horn (3 cases – 25%).

True positive cases for LM injuries are 91.7%. False positive cases are 8.3% and false negative cases are 2.6%. The chi-square test of association is significant ($\chi^2 = 36.64$, $P = 0.001$). Hence the findings of MRI and arthroscopy are significantly matching with each other.

The sensitivity of MRI in LM injuries is 91.69% whereas its specificity is 97.37%. The PPV and NPV are 91.67% and 97.37% respectively. False positive rate is 2.63% and false negative rate is 8.33%.

Ali Akbar Esmaili Jah et al⁽⁵³⁾ compared MRI with arthroscopic findings and calculated the sensitivity (MM – 79%, LM – 66%), specificity (MM – 94.7%, LM – 86.2%), positive predictive value (MM – 92%, LM – 61%) and negative predictive value (MM – 96.7%, LM – 92.6%) for meniscal tears, which is in consistent with our study.

5. CONCLUSION:

The present study was conducted as a prospective study using a Phillips 1.5 T MRI Scanner in the department of Radiodiagnosis, Rajah Muthiah Medical College and Hospital, Chidambaram aimed to evaluate the usefulness of MRI to detect the ligamentous injuries and meniscal injuries of the knee.

In this study, it was found that

1. Ligamentous and meniscal injuries occur frequently in patients with trauma to the knee. It was noted that ACL (76%) and LCL (30%) are the two ligaments, which are most commonly torn when compared to PCL (14%) and MCL (24%).
2. Majority (46%) of patients have medial meniscus injury and the rest 38% of patients have lateral meniscus injury.

3. MRI is highly sensitive and accurate at identification of both anterior cruciate and posterior cruciate ligament tears. A close agreement was obtained between MRI and arthroscopic diagnosis.
4. Both ACL and MCL tears showed predilection towards Medial meniscus tear.
5. To view ACL tear, Proton density sagittal images proved to be most useful. For PCL tear, T2W sagittal images helped the most and for MCL tear, it was Fat saturated coronal sequence. LCL tear was most well depicted on Proton density coronal sequence. Meniscii are best demonstrated on Fat saturated Proton density sagittal sequence.
6. Mistakes 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.
7. Horizontal tears are the most common tear pattern noted in both Medial and lateral meniscal tear predominantly involving the body and posterior horn.

MRI is an accurate, non-invasive technique in detecting the ligamentous and meniscal injuries of the knee. It has great capability in classifying them into types and grades and can also avoid unnecessary arthroscopic examination. Various sequences are used to identify the tears but certain specific sequences proved to be most useful and should be included as a part of standard protocol.

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