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MRI Evaluation of Ligamentous Injuries and Meniscal Injuries of the Knee Joint

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Abstract: ***Aim and Objectives:*** *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 analyse the type and grade of ligament and meniscal 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 who had complete ACL tear. Next common ligament to be torn was the lateral collateral ligament which was seen in 15 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 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.*

1. Introduction

Advantages of MRI over other modalities include lack of radiation, lack of beam hardening artefacts, excellent soft tissue contrast and multiplanar imaging capabilities, non-invasive and do not require manipulation of the knee as in arthrogram.

Advantages of Magnetic Resonance Imaging

Advantage of MRI over other modalities include9-

- Lack of ionizing radiation.
- Non invasiveness
- Multiplanar imaging capabilities
- Excellent soft tissue contrast

Contraindications of Magnetic Resonance Imaging

These include-

- Cardiac Pacemaker
- Cochlear implants
- Tissue expanders
- Ocular prosthesis
- Dental implants
- Neurostimulators
- Bone growth stimulators
- Implantable cardiac defibrillators
- Implantable drug infusion pumps
- Claustrophobia, if severe, may make the examination difficult.

2. Aim and Objectives

1) To know the occurrence of ligament and meniscal tears following knee injury.
2) To analyse the type and grade of ligament tears and meniscal tears with the help of appearances reported in literature.
3) To correlate MRI findings with the arthroscopy findings of these patients.

3. Review of Literature

Anterior Cruciate Ligament (ACL)

The ACL extends from its semicircular attachment at the posterior aspect of the medial surface of the lateral femoral condyle to the anterior intercondylar region of the tibia, just medial to the midline, just lateral and anterior to the anterior tibial spine. The attachment is therefore millimetres posterior to the anterior tibial margin. It is just posterior to the transverse ligament and just anterior to the central attachment of the anterior horn of the lateral meniscus where some fibres mix. The tibial attachment is larger than the femoral and fanlike in shape. The ligament measures approximately 4x1 cm.

Posterior Cruciate Ligament (PCL)

The PCL arises at the lateral surface of the medial femoral condyle and extends to the posterior surface of the intercondylar region, below the level of the articular tibial plateau. It is wider and thicker than ACE. It is arcuate in shape when knee is extended or slightly flexed and becomes taut with increasing flexion. The PCL limits anterior rolling of the femur on the tibial plateau during extension converting it to spin. It also prevents anterior displacement of the tibia on the femur and helps prevent hyperflexion of the knee joint. In the weight bearing flexed knee, the PCL is the main stabilizing factor of the femur (eg- when walking downhill).

MENISCI: The menisci of the knee joint are crescentic plates of fibrocartilage on the articular surface of the tibia. The upper surfaces of both menisci are concave. Both menisci measure approximately 4 to 7 mm in height at the periphery and 1 mm or less at the free edge. The menisci are thicker at their external margins and taper to thin, unattached edges in the interior of the joint. Wedge shaped in transverse section, the menisci are firmly attached at their ends to the intercondylar area of the tibia. Their external margins attach to the joint capsule of the knee. The **coronary ligament**are portions of the joint capsule extending between the margins

of the menisci and most of the periphery of the tibial condyles. A slender fibrous band, **the transverse ligament** of the knee joins the anterior edges of the menisci tethering them to each other during knee movements.

Medial Meniscus

The medial meniscus is c-shaped and broader posteriorly than anteriorly. It is shaped more like a half-circle. Although its posterior horn is attached to the tibia just posterior to the posterior lateral meniscal attachment, its anterior horn attaches far anteriorly approx 10 to 14 mm anterior to the anterior horn of the lateral m eniscus. The width of the medial meniscus, in contrast to the lateral meniscus, gradually tapers from posterior to anterior. The peripheral margin of the medial meniscus is more firmly attached to the joint capsule and to the tibial plateau itself, the latter via a coronary ligament. As on the lateral side, the capsule does not extend anteriorly into the joint near the posterior central attachment site. The menisci serve the important function of shock absorption, distribution of nutrient synovial fluid within the joint, load transmission and stability.

Lateral Meniscus

The lateral meniscus has the same width throughout; approximately 7 to 10mm. It is shaped like three quarter circle, with its anterior and posterior horns attached to the tibia immediately in front of and behind the intercondylaremimence. The central attachment sites are narrower. The peripheral margin of the lateral meniscus is attached to the capsule except posterolaterally, where the popliteal tendon crosses it, and moreposteriorly and centrally near the central attachment site, where the capsule does not extend anteriorly into the joint.

4. Materials and Methods

Source of Data

The study included patients who were clinically diagnosed to haveligamentous injuries and meniscal injuries of the knee, undergoing. MRI scan in the department of Radio Diagnosis and Imaging in GMK Medical College Salem. The MRI was done on the advice of the referring doctor and no patient was made to undergo MRI for the sole purpose of this study.

Equipment for Study: 1.5 TESLA, OPEN MAGNET TYPE

Sample size: Fifty patients

Study Period: November 2016 to September 2018

Study Design: Cross sectional evaluative study

Inclusion Criteria:

Patients of adult population (18-61) willing to undergo MRI scanning with clinically suspected ligamentous injuries of the knee and consenting for the same. Carrino et al[49], in their study found that in the pediatric population between 8 and 15 years, abnormal signal may be seen in more than 60% of the children without tears. This pattern is most prominent in early adolescence and diminishes sometime before skeletal maturity and is believed to reflect the normally prominent vascularity of a developing muscular skeletal system. In elderly there is often severe mucoid, myxoid andhyaline degeneration with extensive signal abnormality, however often without a frank tear.

Exclusion Criteria

- Patients who had previously undergone arthroscopy with repair of the menisci and ligaments
- Patients not consenting for the study
- Patients on cardiac pace maker
- Patients on metal implants
- Patients on Neuro stimulators

Data Acquisition

Once a patient satisfied the inclusion criteria for this study, he or she was administered the study proforma.

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 visualisation of the ACL completely on Sagittal images) and is also flexed 5-10° (to increase the accuracy of assessing the patello-femoral compartment.)

5. Data Analysis and Results

The present work is carried out to study the prevalence of ligament and meniscus tears. Further the findings of MRI are compared with arthroscopy to detect the sensitivity, specificity, PPV, NPV, false positive rate and false negative rate of MRI. A total of 50 patients with ligament and meniscus injuries are selected. Chi-square test of association is computed apart from sensitivity and specificity analysis to compare the MRI and arthroscopy findings. Frequency distribution statistics is computed for all the outcome variables. The entire analysis is performed using statistical packages of social sciences (SPSS-21).

Table 1: Age Distribution

Age	Number	Percentage	Mean	S.D.
18-28	15	30	36.76	11.82
29-38	15	30		
39-48	11	22		
49-58	7	14		
≥ 58	2	4		
Total	50	100		

Age distribution of the patients is presented in Table – 1. 18 to 28 years and 29 to 38 years are the common age group of the patients. 30% are observed in both these age categories. The next common age is 39 to 48 years in which 28% are observed. The mean age of the study patients is 36.76 ± 11.82 years.

Table 2: Gender Distribution

Gender	Number	Percentage
Male	39	78
Female	11	22
Total	50	100

Table – 2 shows gender distribution of the study patients. Most of the study patients (78%) are male participants. Female constitutes 22%.

Table 3: Prevalence of Collateral Ligament and Meniscus Injuries – MRI Findings

Injury	Number	Percentage
MCL	12	24
LCL	15	30
MM	23	46
LM	19	38

The prevalence of collateral ligament and meniscus injuries are presented in Table – 3. It is observed that, 46% of patients have medial meniscus injury and 38% of patients have lateral meniscus injury.

Table 4: Prevalence of MM and LM Injuries: Arthroscopy Findings

Injuries	N	%
MM	15	30
LM	12	24

The prevalence of MM and LM injuries of arthroscopy findings are presented in Table – 4. About 30% of patient has MM injury and 24% of patient has LM injury.

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 (χ^2 = 111.111, P = 0.001). Hence the findings of ACL injuries of MRI are significantly matched with findings of arthroscopy.

The comparisons of MRI and arthroscopy findings of ACL injuries are presented in Table – 5.

The true positive cases (Both MRI and arthroscopy identified ACL Injury) is 34, that is 89.5%. The true negative cases (Both MRI and arthroscopy not identified ACL Injury) are 11 that is 91.7%. The false positive cases (MRI wrongly identifies ACL injury but actually it is absent) is 4 (10.5%). The false negative cases (positive in arthroscopy but absent in MRI) is just 1 (8.3%). The sensitivity of MRI in detecting ACL injury is 97.14%. That is ability of MRI in rightly identifying the ACL injury is 97.14%. The specificity of MRI (rightly identifying absence of ACL injury) is 91.33%. The PPV (if test is positive, the probability of getting ACL injury) is 89.47%. The NPV (it test is negative, the probability of not getting ACL injury) is 91.67%. The false positive rate is quite high (26.67%) when compared to false negative rate (2.86%). The chi-square test of MRI and arthroscopy findings is statistically significant (χ^2 = 28.59, P = 0.001).

6. Summary

The present study was conducted as a prospective study using a 1.5 T MRI Scanner in the department of Radiodiagnosis, 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.

7. Conclusion

MRI is the examination of choice in the evaluation of ligamentous injuries and meniscal injuries of the knee.

The diagnostic accuracy of MR imaging allows it to be a good screening tool and helps targeting of arthroscopy to these patients who are likely to obtain therapeutic benefits obviating an invasive procedure in other patients.

Various sequences currently used to identify ligament and meniscal tears but certain specific sequences like Proton density sagittal, T2W sagittal, Fat saturated coronal and Proton density coronal should be used as a part of standard protocol.

MRI of the knee joint has effectively replaced arthrography and computed tomography as the imaging modality of choice in the evaluation of cruciate collateral and meniscal injuries. Despite its cost, both patients and referring clinicians have readily accepted MR imaging.

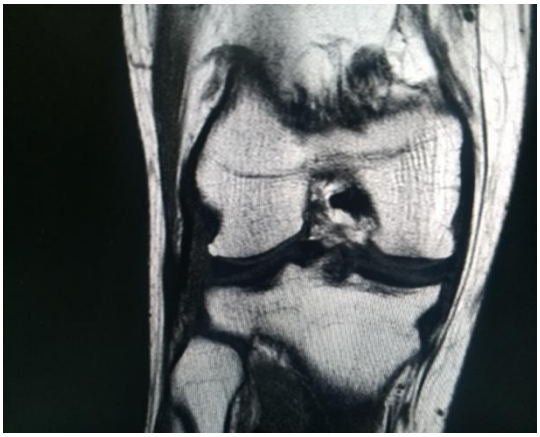

Figure 1: ACL TEAR

Figure 2: ACL TEAR

Figure 3: LM TEAR

Figure 4: MM TEAR

Figure 5: MM TEAR

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