

MRI evaluation of cruciate ligaments and associated injuries in knee joint

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Abstract

The knee joint is one of the most frequently injured joints in the body. Since it is a weight bearing joint, it is consistently exposed to substantial force. The anterior and posterior cruciate ligaments play a vital role in stabilization of the knee joint. Loss of these restraints leads to substantial morbidity and can result in secondary dysfunction of other structures of the knee.

MR imaging of the knee is an excellent modality that detects lesions not always evident on arthroscopy and helps in planning and treatment of meniscal & ligament injuries. The aim of our study is to assess the accuracy of MR imaging in evaluation of cruciate ligament injuries of knee joint. To study and categorize the patterns of cruciate ligament injuries and associated bone and surrounding soft tissues on MRI. Also, to correlate the clinical profile of cruciate and associated ligament injuries with magnetic resonance imaging findings.

Fifty patients were examined on a 1.5 T GE MR system at Mahatma Gandhi Medical College, Jaipur for a time period of eighteen months from December 2019 to May 2021.

Conclusion of our study is that MRI is an excellent modality to detect the lesions in an injured knee. It has great capability in diagnosing meniscal tear and classifying them into grades. According to our study MRI is more sensitive than clinical tests to detect the cruciate ligaments and associated lesions. MRI is unique in its ability to evaluate the internal structure as well as the peripheral meniscal tears, and inferior surface tears. MRI being noninvasive does not involve morbidity associated with other tests like arthroscopy.

Keywords: Knee joint, cruciate ligament injury, ACL, MRI

Introduction

Normal knee joint is essential for everyday life and in many popular sports. The knee joint is one of the most frequently injured joints in the body. Since it is a weight bearing joint, it is consistently exposed to substantial force. Unfortunately, the knee is at the end of two fairly long lever arms, so even a modest amount of force beyond the "design limits" can cause major disruption of the joint. Different modes of clinical presentation in all age groups & both sexes make it a difficult job to ascertain the nature of the lesion causing pain & instability.

The anterior and posterior cruciate ligaments play a vital role in stabilization of the knee joint by preventing anterior translation and internal rotation of tibia (anterior cruciate ligament), and posterior translation and external rotation of the tibia (posterior cruciate ligament). Loss of these restraints leads to substantial morbidity and can result in secondary dysfunction of other structures of the knee. Thus, an early and accurate diagnosis of cruciate ligament and associated injuries is very important.

Since the introduction of MRI to musculoskeletal imaging in the early 1980's, MRI has revolutionized diagnostic imaging of the knee. MR imaging of the knee is an excellent modality that detects lesions not always evident on arthroscopy and helps in planning and treatment of meniscal & ligament injuries. MRI has significant advantages over computed tomography, conventional arthroscopy and radiography because of its excellent, soft tissue contrast, high resolution, reduced artifacts, shorter imaging time and improved accuracy. Multiplanar capability of MRI combined with inherent tissue contrast made available by it, is of immense help in localizing and defining the extent of lesions. MRI has made it possible to look into the injured knee noninvasively, thereby avoiding invasive procedures and further morbidity.

MRI has emerged as a primary imaging tool in assessment of meniscal and ligament injuries. It can show both internal and external meniscal abnormalities. MRI is also of value potentially more difficult to interpret for studying patients who had either partial or complete meniscectomy or primary arthroscopy repairs of meniscus. MRI is well tolerated by patients, widely accepted by evaluating physicians and assists in distinguishing pathologic knee conditions that may have similar clinical signs and symptoms.

Choosing the correct MRI sequence and imaging plane is important, when designing a diagnostic study. The integrity of menisci of the knee is best evaluated with proton density images [long repetition time (TR) & short echo time (TE) whereas ligaments may require more T2 weighting.

To the best of our knowledge there is a lack of age-related knee joint injury research in the existing literature. Besides, most of the injury related work on knee joint is on comparison between MRI and arthroscopy; clinical correlation has been somehow overlooked. Therefore, an age and clinical correlation related study of Cruciate ligaments and associated injuries was undertaken.

Aims and objectives

1. To assess the usefulness/accuracy of MR imaging in evaluation of cruciate ligament injuries of knee joint.
2. To study different appearances/patterns of cruciate ligament injuries on MRI.
3. To categorize the cruciate ligament injuries on the basis of MRI appearance.
4. To study associated injuries of ligaments, bones and surrounding soft tissues.
5. To correlate the clinical profile of cruciate and associated ligament injuries with magnetic resonance imaging findings.

Materials and methods

This study was carried out in the department of radio diagnosis, examined on a 1.5 T GE MR system at Mahatma Gandhi Medical College, Jaipur for a time period of eighteen months from December 2019 to May 2021.

Inclusion criteria

1. All post traumatic patients of knee joint of all age group irrespective of sex.
2. Clinically suspected ligament injury.

Exclusion criteria

Patients who are already diagnosed cases of ACL/PCL injury and patients who are negative for ligament injury on MRI.

Study design

This prospective study was conducted, to study the role of magnetic resonance imaging in diagnosis of cruciate ligaments and associated injuries. In every patient of knee injury examination was done by clinical tests *viz* Anterior drawer test & Lachman test, Posterior drawer test, McMurray's and Apley's grinding test then MRI was performed subsequently. Written, informed consent was taken from each patient in the study group. Such 50 consecutive knee injury patients were examined and investigated according to a predesigned examination proforma.

Research tool

MRI was performed on performed on 1.5 T GE MR system. Following sequences were taken: Sagittal T1, T2 and STIR.

Coronal T1 and STIR, Axial T1 and STIR, and for ACL additional ACL oblique were taken. An FOV of 240 mm and 256x256 matrix was used. Slices were obtained at 5 mm thickness.

Patients were placed in supine position with the knee in closely coupled QD (Quadratus extremity) coils. The knee was externally rotated 15-20 degree, in order to facilitate the visualization of anterior cruciate ligament completely on sagittal images and flexed 5-10 degree, to increase the accuracy of assessing the patello-femoral compartment and patellar ligament.

Results

Fifty patients were examined on a 1.5 T GE MR system at M.G.M. Medical College, Jaipur for a time period of eighteen months from December 2019 to May 2021. All the patients had unilateral knee injury, so that total numbers of knees examined were also fifty.

The study comprised of 33 males (66%) and 17 (34%) female patients.

Among Males, the most commonly affected age group was 21-30 years (39.39%). Among Females, the age groups that were affected most were 11-20, 41-50 and 51-60 years (23.53%)

Table1: Patients profile

Variable	Value	%	
Gender	Male	33	66%
	Female	17	34%
Age	11-20 years	8	16%
	21-30years	15	30%
	31-40years	9	18%
	41-50years	10	20%
	51-60years	8	16%
Site of involvement	Right	22	44%
	Left	28	66%
Causes of knees injuries	Minor trauma	10	20%
	Trauma sports related injuries	18	36%
	Road traffic accidents	20	44%

Frequency of different clinical features	Clinical features pain	50	100%
	Tenderness along the joint line	50	100%
	Instability	15	30%
	Locking	7	14%
	Audible click	12	24%
	Feeling of give away	9	18%
	Joint effusion	42	84%

In most of the patients, left Knee (56%) of the two knees was affected. Percentage in males and females was 66% and 34% respectively.

The most common cause of knee injuries was road traffic accidents (44%) followed by group having sports related injury (36%). The least affected Group was patients with minor trauma (20%).

The clinical profile of the cases presented pain and tenderness along joint line to be the most common presenting clinical features (100%) which were seen in all patients. The prominent clinical features after pain and tenderness, was joint effusion (84%), joint instability being next in order of frequency (30%), and the least common feature was locking (14%).

Table 2: Distribution of the injuries

Ligament/Menisci	No. of cases	Percentage
Anterior Cruciate Ligament (ACL)	45	90%
Posterior Cruciate Ligament	6	10%
Medial Meniscus (mm)	33	68%
Lateral Meniscus (LM)	20	40%
Medial Collateral Ligament (MCL)	6	12%
Lateral Collateral Ligament (LCL)	3	6%

According to our study, the most common lesion found was tear of anterior cruciate ligament (90%) closely followed by medial meniscus (60%). Lateral meniscus (40%), medial collateral ligament (12%) Posterior cruciate ligament and Lateral collateral ligament (10% & 6%) were then found in decreasing order of frequency.

The gender wise distribution, however, showed, more occurrence of anterior cruciate ligament (88.23%) then medial meniscus tears (52.94%) in Females, Males also increased incidence of anterior cruciate ligament tears (90.9%)

Table 3: No. of patient in which tear was suspected by clinical examination (clinical tests)

Ligament/ Meniscuses	No. of patients in which tear was suspected by clinical examination (Clinical tests)	No. of patients of patients in which tear was detected on MRI
ACL	19	45
PCL	3	5
MM	18	34
LM	18	20
MCL	4	6
LCL	2	3

Discussion

This study was conducted at Department of Radiodiagnosis, Mahatma Gandhi Medical College and hospital for a time period of eighteen months. The total number of patients studied were 50, comprising 33 males and 17 females.

In our study the most common age group affected was 21-30 years and men predominated

over women. This correlated with the study of *Shetty et al.* [1]. They reported 21-30 years age group to be the most commonly affected group by knee injuries.

The most common cause of knee injuries in the 21-30 years age group was due to road traffic accidents and sports activities in our study which are more likely to be caused because of the range being of a potentially active group.

In our study we found that positioning knee with 5-10 degrees of flexion and 15-20° of external rotation was optimal. If ACL was incompletely seen repeat oblique images were obtained. T2W images were preferable, as acute lesions were seen as high signal intensity with great degree of accuracy which correlated with study by *Mink et al.* [2]

The most common lesion found in symptomatic knee in our study, was anterior cruciate ligament tear, closely followed by medial meniscus and lateral meniscal tears which was in accordance with the study by *Lakhkur et al.* [3] they also found anterior cruciate ligament tear to be the commonest lesion detected.

In our study ACL tear was the frequent condition accounting for 45 patients and the least common structure to be injured was the posterior cruciate ligament, which is in accordance with the study *Sonnin et al.* [4].

Hyperintensity was the most common MR sign, found in anterior cruciate ligament tears. In our study hyper intensity in the ligament was seen in 33 patients (73.3%) and discontinuity in 9 patients (20%), 3 patients (6.70%) with ACL tear showed non-visualization of ACL which correlated with study by *Gentili et al.* [5] who also found MR features in similar frequency.

Mid substance tear was the most common lesion found in anterior cruciate ligament injuries. In our study anterior cruciate ligament injuries in the form of mid substance hyperintensity was noted in 29 patients (64.4%) *Berquist et al.* [6] also reported in their study mid-substance tear as the most common type.

In our study, Grade- III meniscal tears were found to be the most common type which is in accordance with the study of *Crues et al.* [7]

Posterior horn was the most commonly injured part of the meniscus in our study, which corresponds with the study by *Lukhkar et al.* [8] who also found posterior horn to be commonly injured part of the meniscus, followed by anterior horn tear and tear of body.

In our study three patients showed bucket handle tears of which two were found in the medial meniscus and one in the lateral meniscus, this corresponds with the study by *Wright et al.* [9] who reported bucket handle tears to be more common in the medial meniscus than the lateral meniscus.

The cystic lesions encountered were meniscal cyst and popliteal cyst, Meniscal cyst can be intrameniscal, parameniscal or synovial. We had two cases of MM cyst which was seen to communicate with the horizontal degenerative tear in the meniscus. Similar MR appearance was reported by *Burk et al.* [10]

In our study, Grade-III meniscal tears were found to be most common type which is in accordance with the study of *Crues et al.* [7]

The MR appearance of both ACL and medial meniscal tears served as indirect evidence of MCL injury, with irregular MCL thickening indicative of prior injury. Similar MR appearance was reported by *Staron et al.* [11]

In our study the number of male patient (66%) were more than female patient (34%), thus-the given details are more true for male patients. Slight variation was seen when females were seen as a separate group. Included in this was the fact that knee injuries secondary to road traffic accident occurred mostly in the age group of 11-20 years, which is perhaps the proactive group in women.

In our study Specific clinical features and test suggesting involvement of a particular structure were inferior as compared to the detection of lesions on MRI. In all the cases MR always detected the lesion, wherever clinical suspicion of involvement of particular structure was given. However, MRI showed the lesions even when the lesion was not suspected

primarily on clinical criteria.

Conclusion

1. In our study the most common age group affected was 21-30 years, and men predominated over women.
2. The most common population group affected by knee injuries in males was third decade and in females it was second decade.
3. Left knee was more commonly affected in both males and females.
4. Road traffic accidents and Sports related injuries were the most common causes of knee injuries in the younger population, whereas these were not common cause in older population.
5. Pain and tenderness along joint line were the most common presenting clinical features, which were seen in all patients. Specific signs of particular lesions were seen less commonly.
6. In the overall population, commonest lesion found in a symptomatic knee was tear of ACL followed by MM, LM, MCL, LCL and PCL.
- 7a. Hyper intensity was the most common MR sign observed in anterior cruciate ligament tear.
- 7b. Mid substance was the most common site of anterior cruciate ligament tear.
- 7c. The most common structure injured with anterior cruciate ligament was meniscus. However, the most common associated MRI feature with anterior cruciate ligament tears was increased joint fluid.
- 7d. Sagittal T2-weighted images were preferable, as acute lesions were seen as high signal intensity with great degree of accuracy.
- 7e. An anterior tibial subluxation greater than 5 mm, serves as a helpful adjunctive sign in the diagnosis of complete tears of the anterior cruciate ligament.
- 8a. Medial meniscus was the commoner of the two menisci to be injured in both males and females.
- 8b. Posterior horn was the most commonly injured part of the meniscus, whether medial or lateral.
- 8c. Grade III injuries were the most common type of injury in the meniscus.
- 8d. Bucket handle tears were more commonly seen in medial meniscus than lateral meniscus.
- 8e. Coronal MR Images of the knee allowed better detection and characterization of some meniscal tears than sagittal images alone. Radial meniscal tears, bucket-handle tears, and horizontal tears in the body of the meniscus may be difficult to characterize in the sagittal plane alone. Use of coronal T1- weighted images, rather than coronal T2-weighted or sagittal proton density images alone allows accurate characterization of some additional marrow lesions.
- 9a. Posterior cruciate and lateral collateral ligament were the least common structure to be injured in the knee joint.
- 9b. Most common MRI sign of posterior cruciate ligament was hyper intensity in the ligament.
- 9c. Posterior cruciate ligament tears were most common in midsubstance.
- 9d. Most commonly associated injuries with posterior cruciate ligament tears were meniscal tear.
- 9e. The PCL is usually injured as the result of stretching deformation; on MRI, the

ligament maintains continuity as a single structure with apparent thickening. On sagittal T2-weighted images, an anteroposterior diameter of 7 mm or more is highly suggestive of a torn PCL. Increased intrasubstance signal intensity in the PCL on STIR images with lower signal intensity on T2-weighted images is another common feature.

- 10a. Medial collateral ligament was more commonly affected than lateral collateral ligament.
- 10b. Hyper intensity was the most common MR sign of the collateral ligament tears.
- 10c. Most common affected part of collateral ligaments was mid substance.
- 10d. Coronal T2-weighted images and T1-weighted images were preferable, enabling better detection and characterization of Collateral ligament tear.
11. MRI is an excellent modality to detect the lesions in an injured knee, it has great capability in diagnosing meniscal tear and classifying them into grades.
12. According to our study MRI is more sensitive than clinical tests to detect the cruciate ligaments and associated lesions.
13. MRI is able to detect lesions type more effectively than clinical tests.
14. MRI is unique in its ability to evaluate the internal structure as well as the peripheral meniscal tears, and inferior surface tears.
15. MRI being noninvasive does not involve morbidity associated with other tests like arthroscopy. MRI is an excellent non-invasive modality in imaging of the knee and a noninvasive replacement for Arthrography.

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