

Role of MRI in the evaluation of ligamentous injuries in traumatic knee joint

¹Dr. Bharath Kakileti, ²Dr. Akshay Bhanudas, ³Dr. Datla Ashok Reddy

¹Assistant Professor, Department of Radiology, Konaseema Institute of Medical Sciences and Research Foundation (KIMS RF), Chaitanya Nagar, Amalapuram, East Godavari, Andhra Pradesh, India

²Associate Professor, Department of Radiology, Konaseema Institute of Medical Sciences and Research Foundation (KIMS RF), Chaitanya Nagar, Amalapuram, East Godavari, Andhra Pradesh, India

³Postgraduate, Department of Radiology, Konaseema Institute of Medical Sciences and Research Foundation (KIMS RF), Chaitanya Nagar, Amalapuram, East Godavari, Andhra Pradesh, India

Corresponding Author:

Dr. Bharath Kakileti

Abstract

Introduction: Since its introduction to musculoskeletal imaging in early 1980, MRI has revolutionized diagnostic imaging of the knee. It has, therefore, become the examination of choice in the evaluation of internal joint structures of the knee like menisci, cruciate ligaments and articular cartilage.

Purpose: The objectives of this study is to describe the most commonly injured ligament of knee, MRI features of various Ligament injuries and associations, and most common age group involved in ligament injuries of knee.

Materials and Methods: MR imaging studies of the knee were performed in 120 patients with history of painful knee joint and suspected ligament injury (men, women; mean age 33.86 years) using a 1.5 T MR machine. The sequences included coronal and sagittal PD, sagittal T2 FSE, fat suppressed T2 FSE, STIR axial and coronal. Knee MR studies were obtained to evaluate ligaments and menisci.

Results: Out of 120 cases ACL tears are Present in 92 cases and absent in 28 cases. Among 92 cases 32 are complete ACL tear, 60 are partial ACL tears. Out of total 120 patients meniscal tears are seen in 98 patients and Among 92 patients with ACL tear, 78 patients had associated meniscal tear. Among 120 cases studied only 10 are having posterior cruciate ligament tear

Conclusion: MRI is a non-invasive and accurate technique for examination of the soft tissues and osseous structures of the knee. It has great capability in diagnosing meniscal tears and classifying them into grades and types which would avoid unnecessary arthroscopic examination. It is a very good modality to diagnose complete tears of the ACL. Disadvantages are the limited accuracy in evaluation of hyaline articular cartilage.

Keywords: Anterior cruciate ligament, Posterior cruciate ligament, Medial meniscus, Lateral meniscus

Introduction

1. The knee joint is the most significant joint of the human body with complex articulation characterized by ligamentous and meniscal structures that play an essential role in the stability and mobility.
2. This articulation is subject to high mechanical stresses. The frequency, diversity and severity of ligament and meniscus injuries occur mainly in the young and athletes, associated with significant morbidity, frequently need surgical treatment.
3. The joint injury is a potent risk factor for the onset of osteoarthritis.

4. Although the clinical examination is essential for the diagnosis of ligament and meniscal injuries, in the acute phase of the injury, painful examinations are not always accurate. In cases of trauma to the knee, clinical examination along with radiographs and even CT scans are not enough to diagnose many internal derangements of this joint.
5. MRI, due to its excellent multi-planar imaging and soft-tissue contrast resolution capabilities, provides significant advantages over other imaging techniques in evaluating traumatic & ligament injuries of the knee joint.
6. MRI has revolutionized the diagnostic imaging of the knee. It provides excellent soft-tissue contrast in evaluating the soft tissues and bones in several imaging planes, which provides significant advantages over other imaging techniques.
7. It is a non-invasive and radiation-free technique that provides access to a real "lesional mapping." MRI plays a vital role in the imaging, diagnosis and monitoring of traumatic knee & Ligament injuries. MRI is a cost-effective technique by reducing unnecessary surgical and arthroscopic interventions.
8. MRI is the investigation of choice for nearly all knee joint pathologies for the detection of meniscal and ligamentous injuries.

The current research aimed to study the normal anatomy of the knee joint on MRI, to study the efficacy of MRI in the evaluation of ligament injuries of the knee joint, to study MRI presentations of various ligament injuries of the knee joint and to study the correlation between clinical presentations and radiological findings.

Aims and Objectives

1. To know the occurrence of ligament tears in a traumatic knee.
2. To know which is the most common ligament injured.
3. To analyze the type and grade of ligament tears with the help of appearances reported in the literature.
4. To study the limitations of MRI in detecting the ligament injuries of the knee

Methodology

Source of Data

The study included patients who were clinically diagnosed to have ligamentous injuries of the knee, undergoing an MRI scan in the department of Radio Diagnosis and Imaging KIMS RF Amalapuram. 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

PHILIPS Acheiva1.5 TESLA

Sample size

120 patients

Study Period

December 2020 to April 2022

Study Design

Cross sectional evaluative study.

Inclusion criteria

Patients of the 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.*, in their study, found that in the pediatric population between 8 and 15 years, the 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 musculoskeletal system. In the elderly, there is often severe mucoid, myxoid and hyaline degeneration with an extensive signal abnormality, however often without a frank tear.

Exclusion criteria

- Metallic implants
- Claustrophobia
- Pacemakers
- MR incompatible prosthetic heart valves
- Body weight (MRI tables have specific weight limitations)

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.

Data analysis

The data was processed and arranged into distribution tables and cross tables using statistical package for the social sciences (SPSS) version 21.

Results**ACL tear**

Out of 120 cases ACL tear is present in 92 (76.6%) cases and absent in 28 (23.3%) cases. Among 92 cases 32 (26.6%) are complete ACL tear, 60 (50%) are partial ACL tear and 2 cases are of chronic ACL tear. The data is divided into two age groups <40 and >40 yrs. Among total 92 positive cases 80 (66.6%) cases are below 40 age group and 12(10%) cases are above 40 age group.

Table 1: Distribution based on ACL tear

Age group	ACL tear positive	ACL tear negative
<40 yrs	80 (66.6%)	10 (8.3%)
>40 yrs	12(10%)	18(15%)
All age groups	92 (76.6%)	28(23.3%)

Chi square 30.06; p value 0.000 which is highly significant.

Among 92 ACL tear, it is further classified according to severity as complete or partial tear. Among total complete tear cases i.e 32 (26.6%), 17 (14.1%) cases are below 40 age group and 15 (12.5%) cases are above 40 age group. Among total partial tear cases of 60(50%), 52 (43%) cases are below 40 age group and 8 (6.66%) belong to above 40 age group.

Table 2: Distribution based on Complete/ partial ACL tear

Age group	Complete tear	Partial tear	Total
<40 yrs	17(14.1%)	52 (43.3%)	69(57.5%)
>40 yrs	15 (12.5%)	8 (6.66%)	23(19.1%)
All age groups	32(26.6%)	60 (50%)	92(76.6%)

Meniscal tear with ACL tear

Out of total 120 patients meniscal tears are seen in 78(65%) patients and Among 92 patients with ACL tear, 60 (50%) patients had associated meniscal tear.

Table 3: Distribution based Meniscal tear with ACL tear

	Meniscal tear positive	Meniscal tear negative	Total
ACL tear positive	60(50%)	32 (26.6)	92 (76.6%)
ACL tear negative	18(15%)	10(8.3%)	28(23.3%)
	78(65%)	42(35%)	120(100%)

Chi square 0.01, p-value= 0.928 which is not significant.

PCL tear

Among 120 cases studied only 10 are having posterior cruciate ligament tear. Out of 10 PCL cases 8(6.6%) belong to below 40 age group and 2 (1.6%) cases are of above 40 yrs age group.

Table 4: Distribution based on PCL Tear

Age group	PCL tear positive	PCL tear negative
<40 yrs	8 (6.6%)	80 (66.6%)
>40 yrs	2 (1.6%)	30 (25%)
All age groups	10 (8.3%)	110 (91.6%)

Chi square 0.25, p value = 0.618 which is not significant.

Meniscal tear

Among 120 cases meniscal tear is seen in 78 (65%) patients. Among the 78 cases 65 (54.1%) belong to below 40 yr age group and 13(10.8%) are of above 40 age group.

Table 5: Distribution based on Meniscal Tear

Age group	Meniscal tear positive	Meniscal tear negative	
<40 yrs	65 (54.1%)	11 (9.16%)	76
>40 yrs	13 (10.8%)	31 (25.8%)	44
All age groups	78 (65%)	42 (35%)	120

Chi square 38.39, p value = 0.000 which is highly significant.

MCL Tear

Among 120 cases MCL tear is seen only in 8 (6.6%) cases. Among 8 cases 6 (5%) belong to below 40 yrs age group and 2 cases (1.6%) are above 40 yrs age group.

Table 6: Distribution based on MCL Tear

Age group	MCL tear positive	MCL tear negative
<40 yrs	6 (5%)	75 (62.5%)
>40 yrs	2 (1.6%)	37 (30.8%)
All age groups	8 (6.6%)	12 (10%)

Chi square 0.22, p value = 0.639 which is non-significant

LCL tear

Among 120 cases LCL tear is seen only in 7 (5.7%) cases. Among 7 cases 5 (4.1%) cases belong to below 40 years age group and 2 (1.6%) are of above 40 yrs age group

Table 7: Distribution based on LCL Tear

Age group	LCL tear positive	LCL tear negative
<40 yrs	5 (4.1%)	80 (66.6%)
>40 yrs	2 (1.6%)	33 (27.5%)
All age groups	7 (5.7%)	113 (94.1%)

Chi square 0.00, p value = 0.972 which is non-significant.

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

There are many advantages of MR imaging over other modalities. This study included 120 patients with a traumatic knee injury, complaining knee pain and were clinically suspected ligament injuries, underwent Knee joint MRI. All the scans were done in the department of Radiodiagnosis, KIMS RF using PHILIPS Acheiva1.5 TESLA. It was done during the period from December 2020- April 2022. They were done prospectively using a scan protocol, which included T1W, T2WI, and Proton Density images in coronal, sagittal planes and Fat saturated, T2W images in coronal and axial images. The study population is divided as below 40 yrs age group and above 40 yrs age group. Most of the patients who underwent MRI of the knee for ligament injuries are below 40 years of age group.

Anterior cruciate ligament

Among total 120 cases 92(76%) patients had anterior cruciate ligament tear. Out of 92 cases of ACL tear 32 (34.7%) had a complete tear, and 60(65.2%) patients had a partial tear. Out of 92 patients who had an ACL tear, 78 (84.7%) patients have meniscal tear^[1]. Rajesh umap *et al.*, in his study, found that out of 100 cases, ACL injuries are most common among knee injuries. The MRI findings noted were anterior cruciate ligament injury (76%), followed by medial meniscal injury (38%).The percentage of anterior cruciate ligament injury is exactly matching our study i.e 76%. In 19. Hemangi Balat *et al.* study, 32 out of 50 (64%) patients, had an ACL injury, only eight patients (25%) had a complete tear, and 24 patients (75%) had a partial tear of ACL 20. Singh JP *et al.*, in their study of 173 patients, 78 patients (45.08%) had ACL tears, and among these 52 (66.67%) were partial, 16(20.51%) were complete. The authors concluded that ACL tears were more common than the other ligamentous injuries and partial tears are more common than complete tears, which is coinciding with our study. 21. Anil Madurwar *et al.*, in which authors noted 36 (76%) ACL tears in total 50 knees examined on MRI, which is exactly coinciding with our study. For ACL tear, only some sequences were considered useful, like the sagittal images of T1w and proton density as well as T1w coronal images. Out of these, the most useful sequence was proton density in the sagittal plane posterior cruciate ligament PCL injuries were less common than ACL injuries, and reported rates vary from 3% to 20%. In The PCL is a stronger ligament, has a low incidence of tears. There were 10 (8.3%) patients of PCL tear identified. The sensitivity, specificity, and accuracy of MRI identifying PCL tear is 100%. 1. Rajesh Umap *et al.* found Out of a total of 100 patients, the percentage of PCL injuries detected was 15%. Out of a total of 15 PCL injuries, 6 patients had partial tear, 6 patients had complete tear and 3 patients had grade I sprain. In a study by 22.Grover *et al.*, where they analyzed findings of 510 consecutive MRI of knee joints with an emphasis on PCL tear 11(2%) patients had different grades of tear on MRI, which was confirmed by arthroscopy. Other 202 patients who underwent MRI and arthroscopy for internal derangement of the knee, none of the patients had any PCL injury as predicted by MRI. 21. Anil Madurwar *et al.* in his study out of 50 cases he noted 6% PCL injury cases, 20. Singh JP *et al.* also studied 50 cases and he noted 5.6% positive PCL cases.

and Shetty *et al.* in his 50 cases study noted 4.4% of patients with knee injury having PCL tears. In 19. Hemangi Balat *et al.* study, out of 50 patients, 16% of patients had PCL injury while in 23. Schulz *et al.* study that 20% of patients had PCL tear.

Medial collateral ligament

There were a total of 8 (6.6%) MCL injuries, out of 120 case studies. In 1. Rajesh Umap *et al.* study Out of a total of 100 patients complete MCL tear is noted in 1 patient, a partial tear in 3 patients and grade I sprain noted in 1 patient i.e the total MCL injuries in their studies are about 5%. In 19. Hemangi Balat *et al.* study out of 50 patients, 23 patients (46%) had MCL tear. 25. Schweitzer M *et al.*, In a study population of 76 patients he studied exclusively on medial collateral ligament injuries and he concluded the maximum number of patients with knee pain who had MCL tear belonged to grade 2. Mink JH *et al.* [24] observed on MRI and arthroscopy of 11 patients who had a tear of ACL and among them seven patients had a tear of MCL [21]. Anil Madurwar *et al.* in his study out of 50 cases he noted 14 (28%) having MCL tear.

Lateral collateral ligament (LCL) tear

Among 120 cases LCL tear is seen only in 7 (5.7%) cases. Among 7 cases 5 (4.1%) cases belong to below 40 years age group and 2 (1.6%) are of above 40 yrs age group [1]. Rajesh Umap *et al.* study Out of a total of 100 patients 17 (17%) cases showed tear in lateral collateral ligament. In Hemangi Balat *et al.* [19] study out of 50 patients, 12 patients (24%) having an LCL tear [21]. Anil Madurwar *et al.* in his study out of 50 cases he noted 9 (18%) having MCL tear.

Conclusion

In this study, it was found that

- Ligament injuries and meniscal injuries frequently occur in patients with traumatic knee joints. It is noted that ACL is the most commonly injured ligament and partial tears being more common than complete tears followed by Meniscal tears, PCL tears and collateral ligament tears.
- MRI is highly sensitive and accurate in identifying both anterior cruciate and posterior cruciate ligament tears.
- While ACL and MCL tears showed predilection towards medial meniscus tear, LCL tear showed a strong relationship with a lateral meniscus tear.
- To find 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.
- Mistakes are more likely to happen in partial anterior cruciate ligament tear because they can be missed or can be over-diagnosed on MRI.
- Describing the type ligament tears with image findings of MRI helps the orthopedic surgeons in the treatment of Ligamentous injuries of the knee. A conservative approach indicated in case of partial tears, and reconstructive surgery was indicated in complete tears.

References

1. Rajesh Umap, Bijpuriya Anurag, Sachin Bagale, Navid Shattari. Evaluation of traumatic knee joint injuries with MRI. International Journal of Contemporary Medicine Surgery and Radiology. 2018;3(3):C77-C81.
2. Keith L Moore, Arthur FDalley, Clinically Oriented Anatomy- 5th edition, Churchill Livingstone, Edinburgh. 1999.
3. Agur AMR, Lee MJ. Grants' Atlas of Anatomy, 9th edition. Baltimore: Williams and Wilkins. 1991.
4. DeMaeseneer M, Shahabpour M, Van Roy F, *et al.* MR imaging of medial collateral ligament bursa: Findings in patients and anatomic data derived from cadavers. AJR Am J

- Roentgenol. 2001;177:911-917.
5. Prickett, William D, Ward S, Mathew M. magnetic resonance imaging of the knee. Sports medicine. 2001;31(14):997-1019.
 6. Rothstein CP, Laorr A, Helms CA, *et al.* Semimembranous - tibial collateral ligament bursitis: MR image findings. AJR Am Roentgenology. 1995;155:875-877.
 7. Kean DM, Worthington BS, Preston BJ, *et al.* Nuclear MR imaging of the knee: Examples of normal anatomy and pathology. British J Radiol. 1983;56(666):355-364.
 8. Shaw D. Fundamental principles of nuclear magnetic resonance In: Wehrli FW, Shaw D & Kneeland WW, editors. Biomedical magnetic resonance imaging: principles, methodology & applications. 1988, 1-46.
 9. Young SW. Magnetic resonance imaging: Basic principles, New York: 95 Raven Press, 1988.
 10. Fu FH, Harner CD, Vince KG. Knee Surgery, Baltimore (BM): Williams and Wilkins, 1994.
 11. Crotty JM, Monu JUV, Pope TL Jr. Magnetic Resonance Imaging of the musculoskeletal system: Part 4. The knee. Clinical Orthopedics and related research, 330, 288-303.
 12. Hartzman S, Reicher MA, Basset LW. MR imaging of the knee Part II. Chronic disorders. Radiology. 1987;162:553-557.
 13. Crues JV, Mink J, Levy TL, *et al.* Meniscal tears of the knee: accuracy of MR imaging. Radiology. 1987;164(2):445-448.
 14. Heron CW, Calvert PT. Three-dimensional gradient-echo MR imaging of the knee: Comparison with arthroscopy in 100 patients. Radiology. 1992;183(3):839-844.
 15. Jackson DW, Jennings LD, Maywood RM, *et al.* Magnetic resonance imaging of the knee. Am J Sports Med. 1988;16(1):29-38
 16. Lee JK, Yao L, Phelps CT, *et al.* Anterior cruciate ligament tears: MR imaging compared with arthroscopy and clinical tests. Radiology. 1988;166(3):861-864.
 17. Polly DW, Callaghan JJ, Sikes RA, *et al.* The accuracy of selective magnetic resonance imaging compared with the findings of arthroscopy of the knee. J bone Joint Surg AM. 1988;70(2):192-198.
 18. Champney S Sinnatamby. Lasts Anatomy- Regional and applied 10th edition, Churchill Livingstone, Edinburgh, 130-135.
 19. Hemangi Balat, *et al.* Int J Res Med. 2013;2(4):80-83. e ISSN:2320-2742 p ISSN: 2320-2734
 20. Singh JP, Garg L, Shrimali R, Setia V, Gupta V. MR Imaging of the knee with arthroscopic correlation in twisting injuries. Indian J Radiol Imaging. 2004;14:33-40.
 21. Anil Madurwar, *et al.* Evaluation of Role of MRI in Knee Joint Injuries in Correlation with Arthroscopy. International Journal of Research & Review (www.gkpublication.in) 2017 July, 41(4).
 22. Grover JS, Basset LW, Gross ML, *et al.* Posterior cruciate ligament: MR imaging. Radiology. 1990;174(2):527-530.
 23. Shetty DS, Lakhkar BN, Krishna GK. MR imaging in pathological conditions of knee Indian J Radiol. 2002;2(3):375-381.
 24. Schulz MS, Russe K, Weiler A, *et al.* Epidemiology of posterior cruciate ligament injuries. Arch Orthop Trauma Surg. 2003 May;123(4):186-91.
 25. Mink JH, Reicher MA, Crues JV III. MRI of the knee. New York: Raven Press, 1987.
 26. Schweitzer ME, *et al.* Radiology. 1995 Mar;194(3):825-9.