

MR Imaging Based Diagnosis of Anterior Cruciate Ligament Tears in Patients with Internal Derangement of Knee

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ABSTRACT

Introduction: Internal derangement of knee joint constitutes a major source of morbidity. It includes a group of disorders due to disruption of normal functioning of ligaments and menisci of knee joint leading to persistent or intermittent signs and symptoms such as pain, instability, or abnormal mobility of the knee. Among these Anterior Cruciate Ligament (ACL) tears are the most commonly encountered injury in radiology practice.

Aim: To identify the various MRI imaging findings in clinically suspected cases of ACL injury and to identify, assess indirect signs of ACL tears.

Materials and Methods: This study was performed in the Department of Radiodiagnosis, Mysore Medical College and Research Institute, Mysuru, Karnataka, on patients referred from Orthopedics Department for a period of one year. Fifty patients with clinically suspected ACL tears (37 men, 13 women) were included in this prospective

study. Patients were subsequently subjected to imaging of knee using 1.5 T MRI 8 channel GE Brivo MRI machine. Sequences used were axial, sagittal and coronal PD Fat Sat; sagittal, axial and coronal T2 FSE and sagittal T1 FSE.

Results: Among 50 patients ACL was the commonest ligament to be injured with complete tear being more common than partial tear. Indirect signs of ACL injury were evaluated and helped to corroborate the tears. Certain patterns of associations of injuries were found such as ACL tear with posterolateral corner injury and O'Donoghue's triad.

Conclusion: MR imaging of knee complements therapeutic arthroscopies and would greatly reduce the need of diagnostic arthroscopies. As MR is a non-invasive, painless and morbidity-free modality for accurate preoperative assessment, it is well accepted by patients. Hence, MR is an excellent tool for evaluation of ACL pathologies.

Keywords: Blumensaat's angle, Lachman test, O'Donoghue's triad

INTRODUCTION

Knee being one of the major joints involved in kinesis, also bears the consequences of increased mobility. The price of its mobility is a tendency to instability. With increasing involvement in sports related activities especially in young people, trauma related knee pathologies have increased [1].

MRI has emerged as an excellent modality for imaging of ligaments, cartilage, menisci and other structures around the knee joint. This is due to the combination of multiplanar capability and superior soft tissue characterization. This modality has superseded already available modalities like radiograph and CT, over last two decades.

It is a non-invasive diagnostic modality that lacks the radiation issues associated with radiograph and CT and is non-operator dependent unlike ultrasound.

MATERIALS AND METHODS

This was a prospective study, performed in the Department of Radiodiagnosis, Mysore Medical College and Research Institute, Mysuru, Karnataka, on patients referred from Orthopedics Department for a period of one year (December 2012 to November 2013). Fifty patients with painful or unstable knee joint with or without other associated symptomatology of different age groups and either sex (37 men, 13 women) were included in the study. Those patients with prior history of surgery on the same knee were excluded.

The study was performed with the approval of Institutional ethical committee review board. Written informed consent was obtained from every patient. Patients were evaluated with clinical examinations and were subsequently subjected to imaging of knee using 1.5 T MRI 8 channel GE Brivo MRI machine. Sequences used were axial, sagittal and coronal PD

Fat Sat; sagittal, axial and coronal T2 FSE and sagittal T1 FSE. The Imaging protocol used has been shown in [Table/Fig-1]

Sequence	Field of View (cm)	Slice Thickness (mm)	Matrix	Nex
Axial PD Fat sat	18	4/skip 0.5	320x224	2
Sagittal PD Fat sat	16	4/skip 0.5	320x224	2
Coronal PD Fat sat	16	4/skip 0.5	320x194	4
Axial T2 FSE	18	5/skip 1	320x194	4
Sagittal T2 FSE	16	4/skip 0.5	320x224	2
Coronal T2 FSE	16	4/skip 0.5	320x224	4
Sagittal T1 FSE	16	4/skip 0.5	320x224	2

[Table/Fig-1]: Imaging protocol

ACL tears were identified by primary signs (abnormal signal intensity, abnormal course or discontinuity) and secondary signs (bone contusions, Blumensaat's angle, anterior tibial displacement, PCL line and PCL angle). Blumensaat's angle is the angle created between a line drawn along the edge of the intercondylar roof and anterior most margin of ACL on the sagittal view. Anterior tibial displacement is measured based on position of lateral tibial plateau to lateral femoral condyle on sagittal images. The PCL angle is created between a line connecting the origin site of PCL on the femur to a point placed at the point of directional change of PCL and a line drawn from the same point to the distal most point of PCL insertion on tibia. Posterior cruciate line refers to posterior cruciate line in relation to distal femur. This line is drawn tangent to posterior margin of distal PCL and extended proximally.

STATISTICAL ANALYSIS

Statistical methods were carried out using SPSS for windows (Version 20.0) and Microsoft Excel 2010. Frequencies, Descriptive statistics & Crosstabs were used.

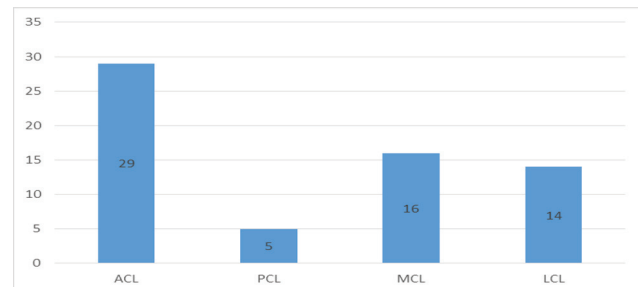
RESULTS

Among 50 patients involved in the present study, 37 (74%) were males and 13 (26%) were females with mean age of 33.2 years. Mostly young adult male underwent MR for clinically suspected ACL tears.

ACL Tears

Among the 50 patients who underwent MRI, ACL tears were identified in 29 cases (58%). Tears of various other ligaments around the knee were also identified: PCL tear in 5 (10%), MCL tear in 16 (32%) and LCL tear in 14 (28%) of cases [Table/Fig-2].

Out of 29 cases, complete tear of ACL was detected in 19 cases (65.5%) and partial tear in 10 (34.5%) [Table/Fig-3]. Associated LCL tears were identified in 13 cases (45%) and



[Table/Fig-2]: Distribution of ligamentous tears around knee joint.

ACL Tear	Number	Percentage (%)
Complete	19	65.5%
Partial	10	34.5%

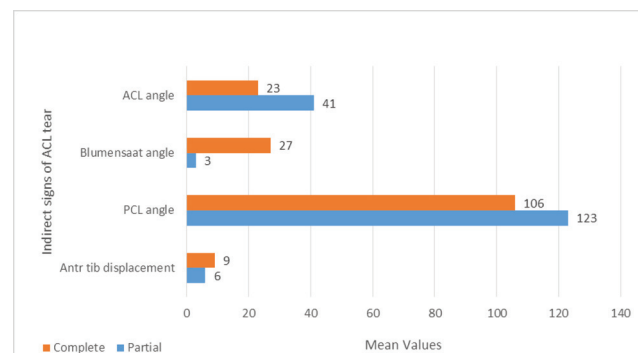
[Table/Fig-3]: Type of ACL tear.

MCL tears in 10 cases (35%). ACL tears were associated with tear of posterior cruciate ligament in 4 cases.

In all 86% cases of complete ACL tears were found positive by both Lachman's test and MR, but 14% of cases, were not suspected clinically on Lachman's test but were detected on MR.

Indirect signs of ACL tear in the form of objective criteria such as sagittal ACL – Tibial angle, Blumensaat's line – ACL angle, PCL angle and anterior tibial displacement were used.

The mean sagittal ACL – Tibial angle was 41° in case of partial ACL tear while the mean was only 23° in complete ACL tears. The mean Blumensaat's line – ACL angle was + 3° in partial ACL tear and was + 27° in complete ACL tears. The mean PCL angle was 123° in partial ACL tear and more acute angled with a mean angle of 106° in complete ACL tears. Mean anterior tibial displacement measured 6 mm in partial ACL tear and 9 mm in complete ACL tears [Table/Fig-4].

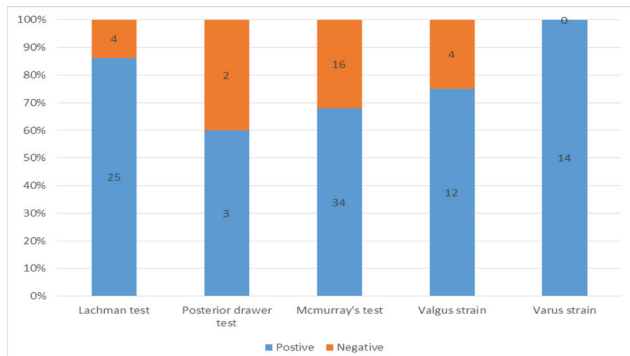


[Table/Fig-4]: Indirect signs of ACL tear.

Clinical Tests

Lachman test was conclusive for ACL tear in 86% of cases, posterior drawer test in 60%, McMurray's test in 68% of medial meniscal tear, 79% of lateral meniscal tear, valgus stress test

in 75% of MCL tear and varus stress in 100% of LCL tears [Table/Fig-5].



[Table/Fig-5]: Clinical examinations for internal derangement of knee.

DISCUSSION

Disruption of various ligaments and cartilage around the knee joint leads to significant morbidity, especially in young adults involved with sporting activities. Therefore, imaging of this complex synovial joint becomes crucial to promptly identify the pathology affecting it. Invention of MR imaging and its increasing use in musculoskeletal imaging has revolutionized the understanding of pathologies around knee joint. It has replaced radiographs and CT in evaluation of ligamentous and meniscal pathologies. It is a non-invasive technique that does not require contrast administration and is not operator dependant.

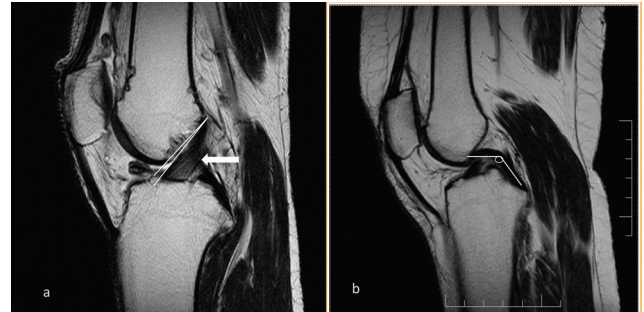
Compression and tension are the two basic loads that act on the knee. MRI findings can reveal the traumatic mechanisms in many acute knee injuries. Impaction causes bone marrow contusion, cortical fractures and meniscal tears. Ligament damage is a common and important distraction injury with numerous MRI manifestations [1].

Many studies have been published on sensitivity and specificity of MRI in identifying ligamentous and meniscal pathologies and imaging features compared with arthroscopy or surgical findings. The overall pooled sensitivities and specificities are approximately 91% and 94% for ACL pathologies [2]. These have suggested MR to be an effective tool for evaluation of knee joint.

This study included 50 patients who were clinically suspected as having some form of internal derangement of knee. According to Majewski et al., [3], acute traumatic injuries of knee were common in age group of 20-29 and 70% of them were male, which was similar to our study (73% male). In this study among 50 cases, 29 (58%) had ACL injury. ACL tear could be recognized by identifying the primary signs on imaging and by identification of secondary and associated findings in equivocal cases [4,5].

Primary Findings

1. Abnormal signal intensity (focal or diffuse increase in signal intensity of the ligament on T2W images) [Table/Fig-6a,b]



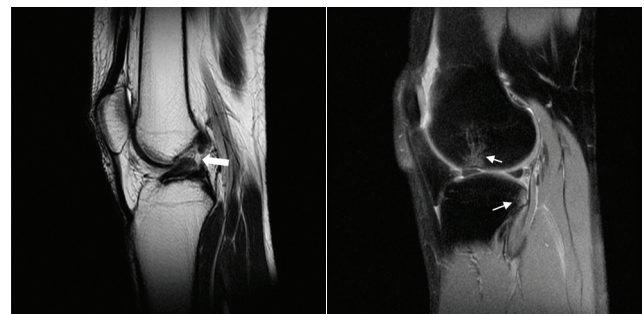
[Table/Fig-6a,b]: ACL Sprain: Bulky ACL with abnormal signal intensity without disruption of its fibres. Blumensaat angle (7.7°) and PCL angle (122.8°) are normal.

2. Abnormal course [6] (represented by increased Blumensaat's angle > 9.5 degrees.)

3. Discontinuity (focal gap in the ligament or visualization of more than one ligament piece) [Table/Fig-7].

Secondary Findings

1. Bone Bruises - Present in lateral femoral condyle, anterior aspect of lateral tibial plateau or both [7] [Table/Fig-8].



[Table/Fig-7]: Complete midsubstance ACL tear with discontinuity of fibres. **[Table/Fig-8]:** Bony contusions in femoral and tibial condyles.

2. Anterior Tibial Displacement - Sub-luxation of more than 5 mm is considered significant in association with complete tear of ACL [8].

3. Uncovered posterior horn of lateral meniscus.

4. PCL angle <114.8 degrees [9].

5. Position of posterior cruciate line - considered positive for ACL tear if it did not cross the medullary cavity of distal 5 cm of femur [9].

Of the 29 cases of ACL tears, 66% was complete tear and 88% of them involved the mid substance. In the study by Wing Ng WHA et al., ACL tears were mostly complete (80%) and mid substance tear was demonstrated in 90% [10].

The mean ACL angle was 23° in complete tear and 41° in partial tears.

Mean Blumensaat's – ACL angle was 27° for complete tear and 3° for partial tear.

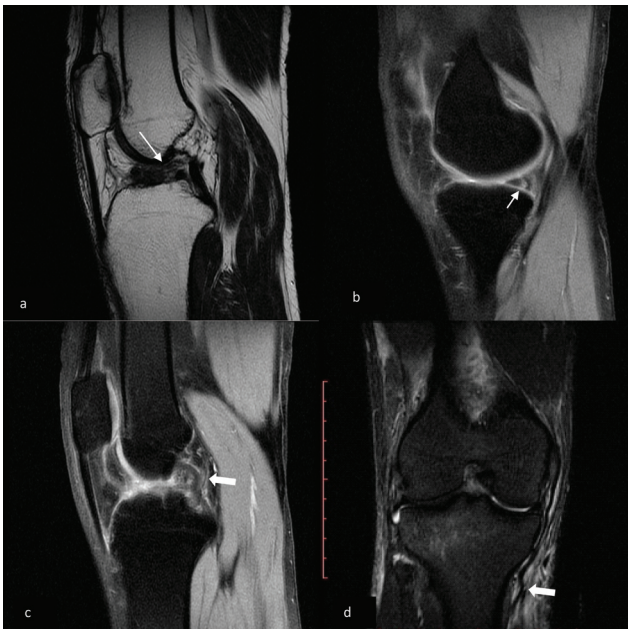
The mean PCL angle was 123° in partial ACL tears and was more acute angled with mean value of 106° in complete tears.

Mean anterior tibial displacement was 9 mm in complete tears and 6 mm in partial tears.

Gentili A et al., performed a retrospective study to establish the sensitivity and specificity of indirect signs of ACL tears on MR [11]. The report of sensitivity and specificity were; 90%, 97% for ACL angle $< 45^\circ$; 89%, 100% for Blumensaat's – ACL angle $> 15^\circ$; 52%, 94% for PCL angle $< 107^\circ$ and 41%, 91% for anterior displacement of tibia > 7 mm. Presence of these indirect signs corroborated the presence of ACL tear in our study.

The indirect signs of ACL tear have high specificity but low sensitivity. These signs are useful when primary signs are equivocal. Anterior tibial displacement of > 5 mm can differentiate complete tear from partial tear.

Associated LCL tears were identified in 13 cases (45%) and MCL tears in 10 cases (35%). O'Donoghue's triad (combination of ACL, MCL and medial meniscus tear) was seen in 6 cases [Table/Fig-9a-d]. ACL tears were associated with tear of posterior cruciate ligament in 4 cases [Table/Fig-10].



[Table/Fig-9a-d]: O'Donoghue's triad: (a) Complete mid substance tear of ACL seen (arrow); (b) Associated oblique tear of posterior horn of medial meniscus noted; (c) Buckling of PCL (arrow) noted along with mild joint effusion; (d) Coronal STIR image showing discontinuity of MCL fibres near its tibial attachment (arrow).



[Table/Fig-10]: Low grade partial ACL tear associated with PCL tear: Bulky ACL with altered signal intensity with avulsion fracture of tibial insertion of PCL (arrow). Note is made of moderate joint effusion.

86% of cases with positive Lachman's test had complete ACL tears on MR. In only 14% of cases, ACL tear were not suspected clinically on Lachman's test but was detected on MR. These were all cases of partial disruption of a bundle of ACL. Complete ACL tears were suspected clinically by positive Lachman's test and confirmed on MR examination. Study done by Malanga GA et al., on physical examination of knee demonstrated that the Lachman's test is sensitive and specific for the detection of anterior cruciate ligament tears [12], which can be supported from our study, as 86% of cases were positive by Lachman's test and had complete ACL tears on MR.

LIMITATIONS

There were few limitations to our study. First the study sample was of limited size. The imaging findings were not correlated with that of arthroscopy.

CONCLUSION

Currently, MR imaging has evolved as the most commonly performed radiologic test in the assessment of intra-articular knee abnormalities especially pathologies involving the ACL. Although, arthroscopy has revolutionized the diagnosis and treatment of knee disorders, most orthopaedists acknowledge the invasiveness of the procedure, limitations in evaluation of extra-articular pathology, cost and uncommon but potential complications associated with the procedure. Hence, clinicians utilize MR imaging to support non-surgical management or to

confirm injuries that benefit from arthroscopic or open surgical treatment.

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