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Medicine

Role of Magnetic Resonance Imaging in Knee Trauma

Dr. Rajesh Kuber[1*], Dr. Vaibhav Aher[2], Dr. Pooja Karanjule[3]

[1]Professor & Head of the department, Department of Radiodiagnosis, Dr. D Y Patil Medical College,Hospital and Research Center, Pimpri, Pune,India
[2]Resident in Department of Radiodiagnosis, Dr. D Y Patil Medical College,Hospital and Research Center, Pimpri, Pune. India
[3]Senior Resident in Department of Radiodiagnosis, Dr. D Y Patil Medical College,Hospital and Research Center. Pimpri, Pune, India

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***Corresponding author:** Dr. Rajesh Kuber

Abstract **Original Research Article**

A descriptive study of 50 patients was conducted on Siemens Avanto 1.5 T magnetic resonance imaging machine for evaluation of traumatic knee injuries using various MRI sequences. Out of 50 patients 36 patients were males and 14 patients were female which accounts for 72% for male and 28% for female respectively. MRI sequences taken were using sagittal (T2 FSE, PDFAT SAT, STIR, T2 FRFSE fatsat), coronal PDFATSAT and axial STIR sequences. The assessment of images was subsequently performed by the use of PACS software together by the radiologist blinded to the final diagnosis. Various traumatic knee pathologies included ACL tear, PCL tear, meniscal tear, collateral ligament tear, bony contusions and various soft tissue injuries etc.

Keywords: Knee trauma, magnetic resonance imaging, ACL tear, PCL tear, meniscal tear, collateral ligament, bony contusions.

INTRODUCTION

Knee injuries are very common and can lead to substantial disability. The young and active individuals are more prone to injuries. Trauma is usually associated with internal derangements of the knee and requires certain investigations as a supplement to clinical examination. Magnetic resonance imaging (MRI) has a numerous impact on musculoskeletal imaging and the knee is most frequently indicated in the injuries of the anterior cruciate ligament (ACL) and menisci.

MRI of the knee joint has often been considered a substitute to arthroscopy because of its noninvasive, radiation free, multiplanar capability and ability to assess soft tissues in knee injuries [1].

ACL is the most commonly injured ligament in the knee joint [2]. With continuous improvement, MRI became an important diagnostic tool. The overall accuracy of MRI of the knee is known to be very high. MRI scan is routinely used to aid in the diagnosis meniscal or cruciate ligament injuries.

The ACL prevents anterior translation and internal rotation of the tibia with respect to femur, resulting in a stable knee joint. It has been found that meniscal injures accompany injuries to the ACL in up to one -third of cases [3]. MRI was first used by Kean et al in 1980's for diagnosis of knee lesions [4]. MRI gives much better soft tissue contrast, takes less imaging time and reduced artifacts. MRI also has better ability to pick intra articular injuries. The overall accuracy of MRI of the knee is known to be very high in the diagnosis of ACL and meniscal tears and has been reported to have a sensitivity of 80% and 100%[5].

MATERIAL AND METHODS

This is a prospective study of 50 consecutive patients of knee injuries coming to Dr D.Y. Patil Medical College and hospital using standard MRI protocol. The patients with history of knee injuries were referred for MRI for further evaluation of clinically suspected tears of ACL, PCL and meniscus.

All patients of knee trauma with suspected ACL, PCL and meniscal injuries were included. Patients with the associated fracture of femoral condyle, tibial plateau and dislocation, patients who were contraindicated for MRI and h/o previous knee surgeries were excluded.

After explaining the procedure of the examination to the patient informed consent is taken. SIEMENS 1.5 TESLA MRI machine was used to carry out the examination. Patient in lying down position on the MRI table with knee surface coil was placed. The

knee was kept in the surface coil with extension and external rotation approximately 10-15 degree. The knee is secured in the coil by centering the joint. MRI scan was done using sagittal (T2 FSE, PDFAT SAT, STIR, T2 FRFSE fatsat), coronal PDFATSAT and axial STIR sequences (Table 1).

Table-1: MRI Knee Protocol

Image Plane	TR	TE	Slice Thickness	Field Of View (FOV)	Echo Train Length	Matrix Acquisition
Coronal T2WI STIR	3200	32	3mm/skip 0.5mm	16	8	320 x 320
Coronal T1WI FSE	400	10	3mm/ skip 0.5mm	14	3	384 x 384
Coronal T2WI GRE	681	15	3mm/ skip 0.5mm	16	1	320 x 320
Sagittal PD FS SE	3000	41	3mm/ skip 0.5mm	14	8	320 x 320
Sagittal T1WI FSE	400	10	3mm/ skip 0.5mm	14	8	448 x 448
Sagittal T2WI FSE	3500	80	3mm/ skip 0.5mm	16	13	448 x 448
Axial PD FS FSE	3410	43	3mm /skip 1 mm	18	10	320 x 320
Axial T2WI FSE	3310	77	3mm/skip 1 mm	14	13	380 x 384
T2* GRE	967	4.7	3mm /skip 1 mm	16	1	256 x 256

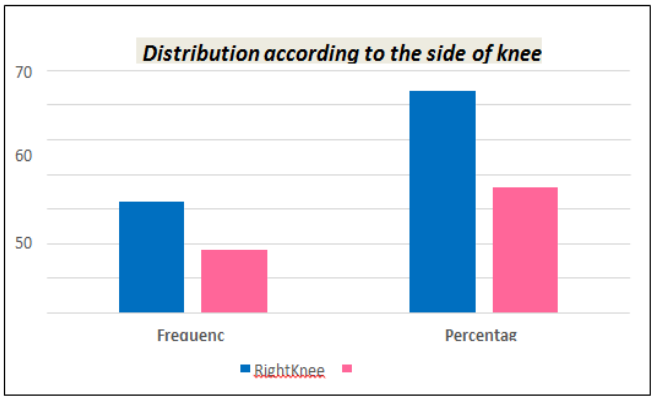
TR: Time to Repeat (milli seconds), TE: Time to Echo (milli seconds)

OBSERVATION & RESULTS

Fifty patients were examined on a 1.5 T MR system at Dr DY Patil Medical College.

Table-1: Showing distribution of the patients according to side of knee injured

Side of Knee	*Frequency*	*Percentage*
Right Knee	*32*	*64*
Left Knee	*18*	*36*
Total	*50*	*100*

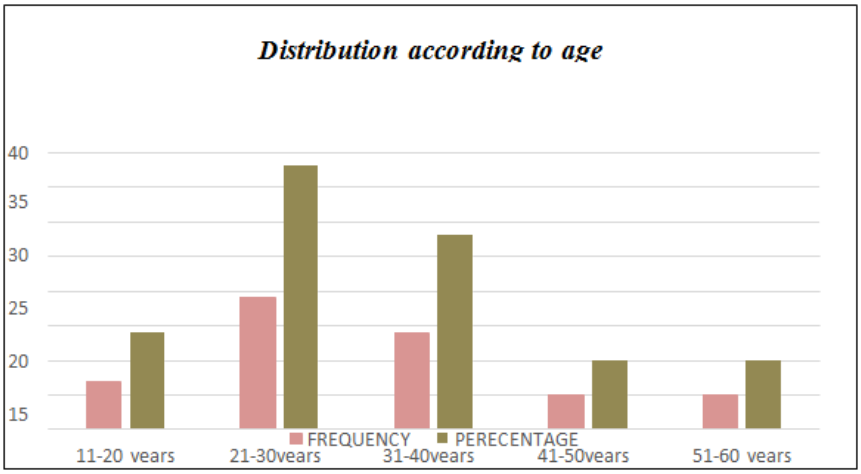


Graph-1: Showing distribution of the patient according to side of knee

Out of 50 patients, right knee was injured in 32 patients and left knee was injured in 18 patients. Hence, right knee was affected more than left knee.

Table-2: Showing distribution of the patient according to age

Age	*Frequency*	*Percentage*
11-20 years	*7*	*14*
21-30 years	*19*	*38*
31-40 years	*14*	*28*
41-50 years	*5*	*10*
51-60 years	*5*	*10*
Total	*50*	*100*

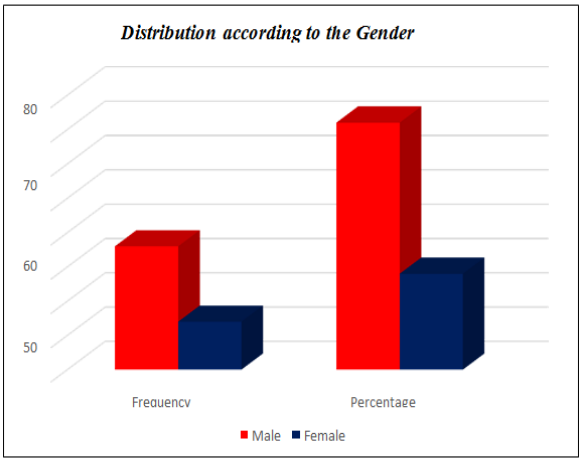


Graph-2: Showing distribution of the patient according to age

In our study the most common group affected were 21-30years.

Table-3: Showing distribution of the patient according to gender

Gender	*Frequency*	*Percentage*
Male	*36*	*72*
Female	*14*	*28*
Total	*50*	*100*

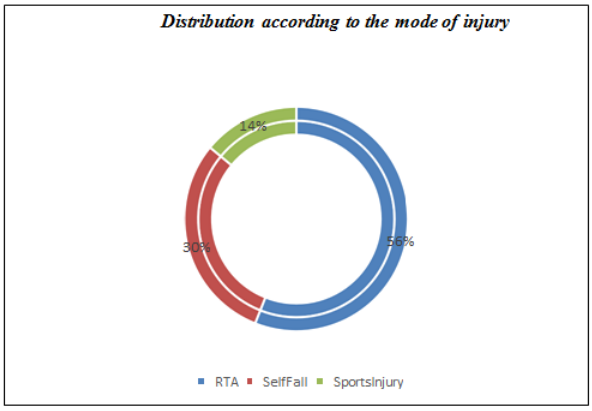


Graph-3: Showing distribution of the patient according to gender

There were 36 males and 14 females in this study. Males comprised 72% and female 28% of the study group and male patients exceeded the number of female patients in all the age groups.

Table-4: Showing mode of injury among the study group

Mode of Injury	Frequency	Percentage
RTA	*28*	*56*
Self-Fall	*15*	*30*
Sports Injury	*7*	*14*
Total	*50*	*100*

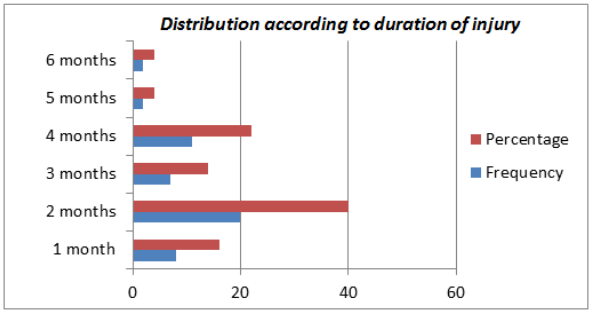


Graph-4: Showing mode of injury among the study group

Road traffic accident was most common mode of injury in our study, accounting for 56%.

Table-5: Showing duration-wise distribution of the patients

Duration of Injury in month	Frequency	Percentage
1 month	*8*	*16*
2 months	*20*	*40*
3 months	*7*	*14*
4 months	*11*	*22*
5 months	*2*	*4*
6 months	*2*	*4*
Total	*50*	*100*

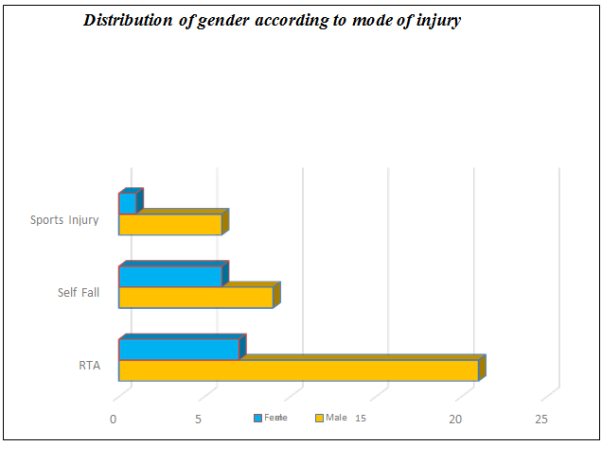


Graph-5: Showing duration-wise distribution of the patients

The duration between the injury & assessment with MRI ranged from 2 to 6 months. Most of the injuries were between 2-4months. 20 patients reported for MRI within 2 months of duration (40%).

Table-6: Showing distribution of mode of injury in male and female

Sex	Mode of injury			Total
	RTA	*Self fall*	*Sports injury*	
Male	*21(42)*	*9(18)*	*6(12)*	*36(72)*
Female	*7(14)*	*6(12)*	*1(2)*	*14(28)*
Total	*28(56)*	*15(30)*	*7(14)*	*50(100)*



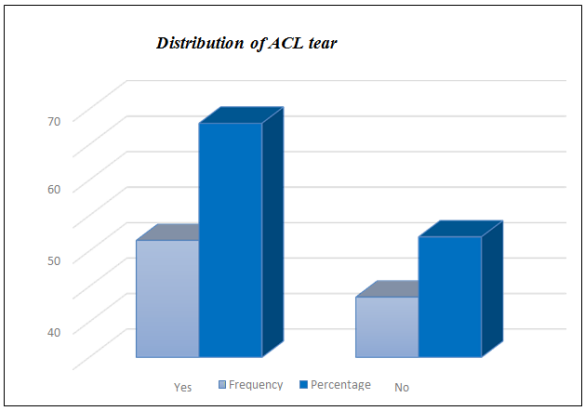
Graph-6: Showing distribution of gender according to mode of injury

When gender of the patients was calculated according to mode of injury, it was found that RTA was more associated with males that are about 42%.

Table-7: Showing frequency of ACL injury in the study group

ACL Tear	Frequency	Percentage
Yes	*33*	*66*
No	*17*	*34*
Total	*50*	*100*

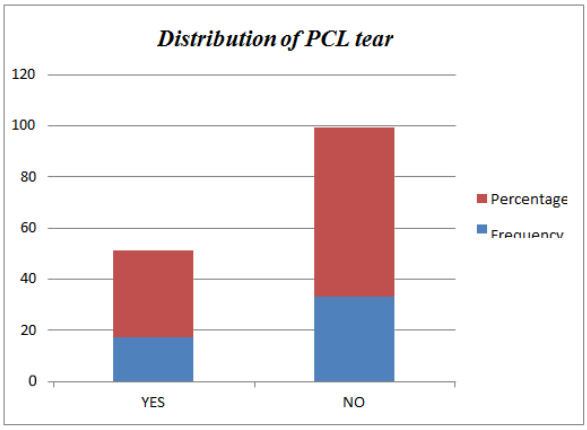
Incidence = New cases of disease/People at risk * 100
33/50*100=6



Graph-7: Showing frequency of ACL injury in the study group

Table-8: Showing frequency of PCL injury in the study group

PCL Tear	Frequency	Percentage
YES	*17*	*34*
NO	*33*	*66*
Total	*50*	*100*

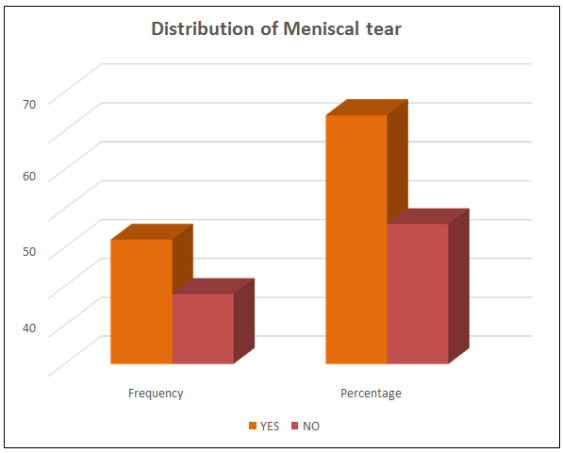


Graph-8: Showing frequency of PCL injury in the study group

In our study PCL injury was seen in 17 patients out of 50 patients

Table 9: Showing frequency of meniscal injury in the study group

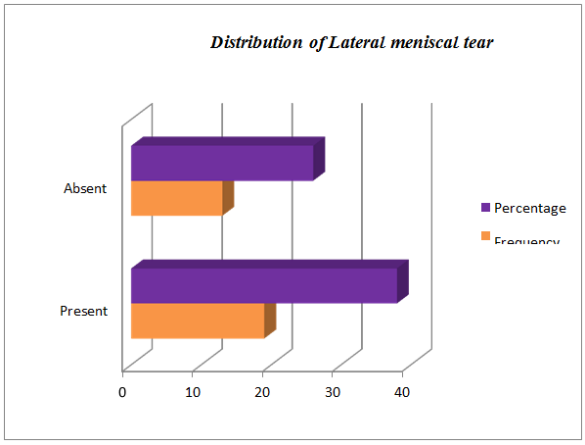
Meniscal tear	Frequency	Percentage
Yes	*32*	*64*
No	*18*	*36*
Total	*50*	*100*



Graph-9: Showing frequency of meniscal injury in the study group

Table-10: Showing frequency of lateral meniscal tear in the study group

Lateral meniscal tear	Frequency	Percentage
Present	*13*	*26*
Absent	*19*	*38*
Total	*32*	*64*

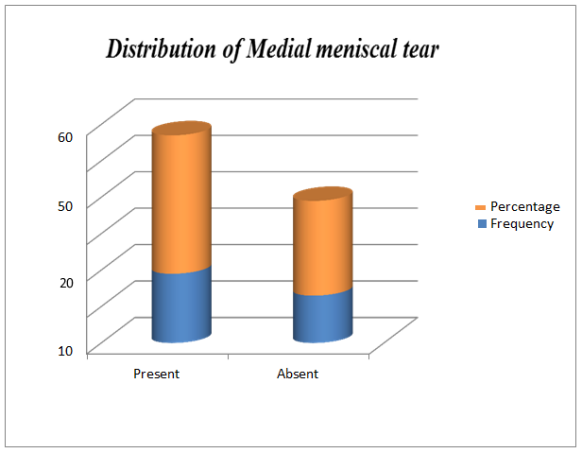


Graph-10: Showing frequency of lateral meniscal injury in the study group

Lateral meniscal tear was seen in 13 patients in our study.

Table-11: Showing frequency of Medial meniscal tear in the study group

Medial meniscal tear	Frequency	Percentage
Present	*19*	*38*
Absent	*13*	*26*
Total	*32*	*64*

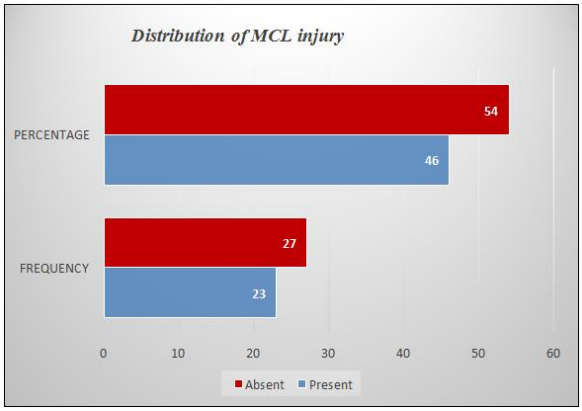


Graph-11: Showing frequency of medial meniscal injury in the study group

Medial meniscal tear was seen in 19 patients in our study.

Table-12: Showing frequency of MCL in the study group

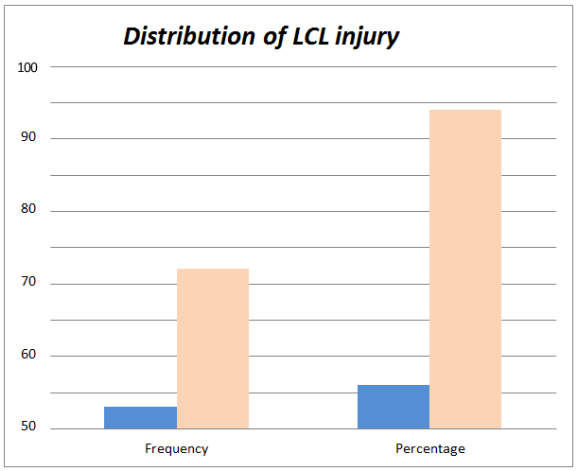
MCL Injury	Frequency	Percentage
Present	*23*	*46*
Absent	*27*	*54*
Total	*50*	*100*



Graph-12: Showing frequency of MCL in the study group

Table-13: Showing frequency of LCL in the study group

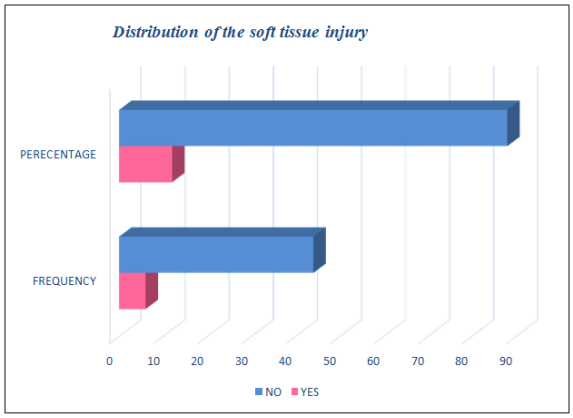
LCL Injury	*Frequency*	*Percentage*
Present	*6*	*12*
Absent	*44*	*88*
Total	*50*	*100*



Graph-13: Showing frequency of LCL in the study group

Table-14: Showing frequency of soft tissue injury in the study group

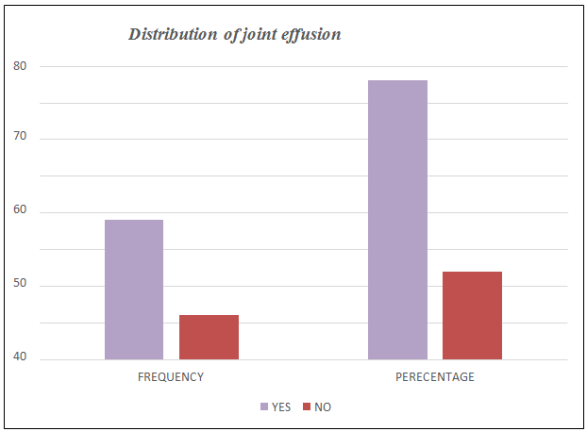
Soft tissue injury	Frequency	Percentage
Yes	*6*	*12*
No	*44*	*88*
Total	*50*	*100*



Graph-14: Showing frequency of soft tissue injury in the studygroup

Table-15: Showing frequency of Joint effusion in the studygroup

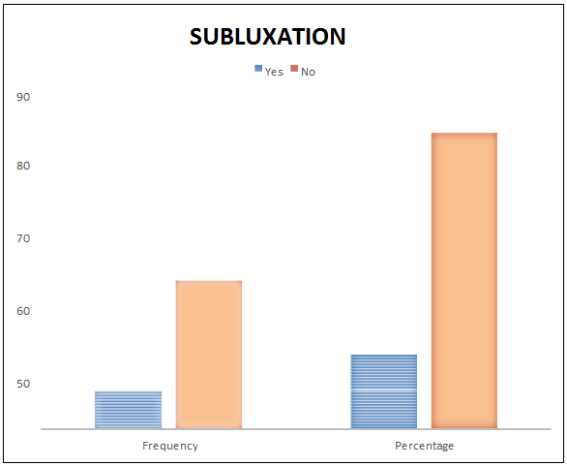
Joint effusion	Frequency	Percentage
YES	*38*	*76*
NO	*12*	*24*
TOTAL	*50*	*100*



Graph-15: Showing frequency of Joint effusion in the study group

Table-16: Distribution according to the subluxation:

Subluxation	Frequency	Percentage
Yes	*10*	*20*
No	*40*	*80*
Total	*50*	*100*



Graph-16: Showing frequency of subluxation in the study group

Example cases

Case1: COMPLETE ACL TEAR

Fig-1(A): Sagittal PDFAT SAT image showing complete non visualization of the ligament (arrow) suggestive of complete ACL tear

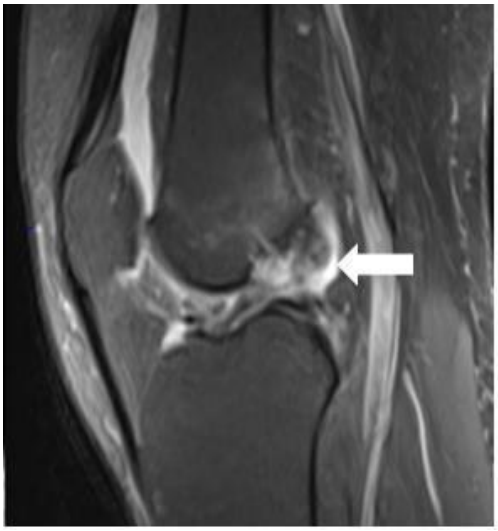


Fig-1(B): Sagittal T2WI showing complete ACL tear (arrow) near its femoral attachment.

Case 2: partial acltear

Fig-2: PDFS sagittal image showing altered signal intensity in the tibial attachment of the ACL (arrow), however as the femoral attachment is normal

Case 3: Sign of acl tears

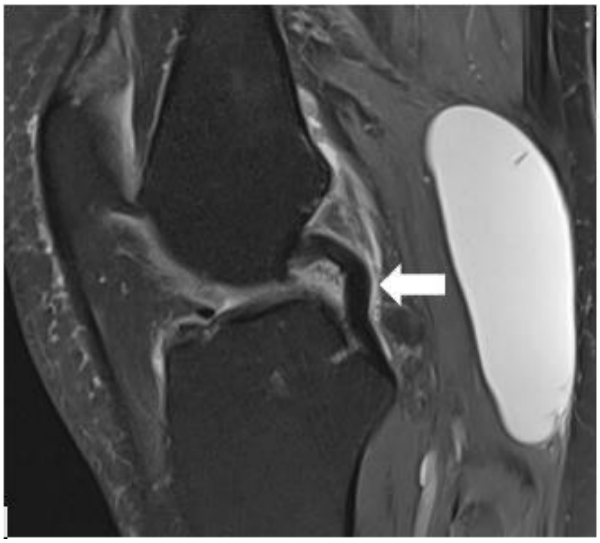


Fig-3(A): T2WI sagittal showing complete ACL tear giving typical "question mark configuration' of PCL (arrow). Baker's cyst was also noted

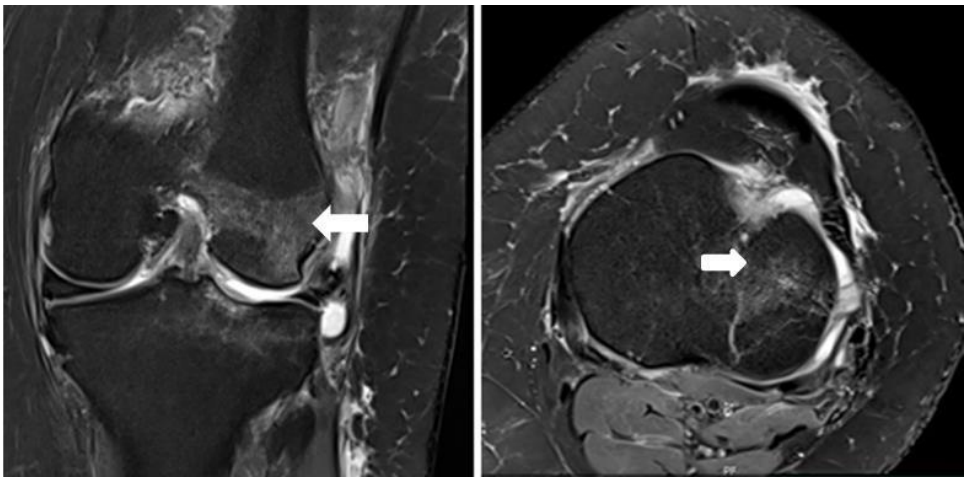


Fig-3 (B) and (C): Coronal and axial PDFAT SAT image showing heterogeneous predominantly increased signal intensity on the lateral condyle of tibia and femur (arrow), a secondary sign of ACL tear

Case 4: Full thickness pcl tear

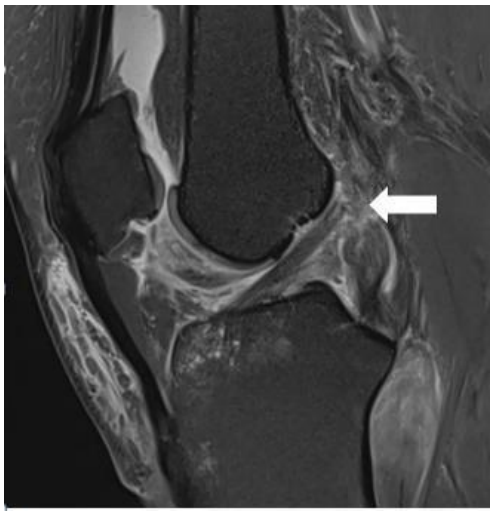


Fig-4: PDFS sagittal image showing bulky PCL with intra-substance PDFS hyperintensity and disruption of fibers at the femoral insertion (arrow) suggestive of full thickness tear

Case-5: Meniscal Tear – Grades Of Meniscal Tear

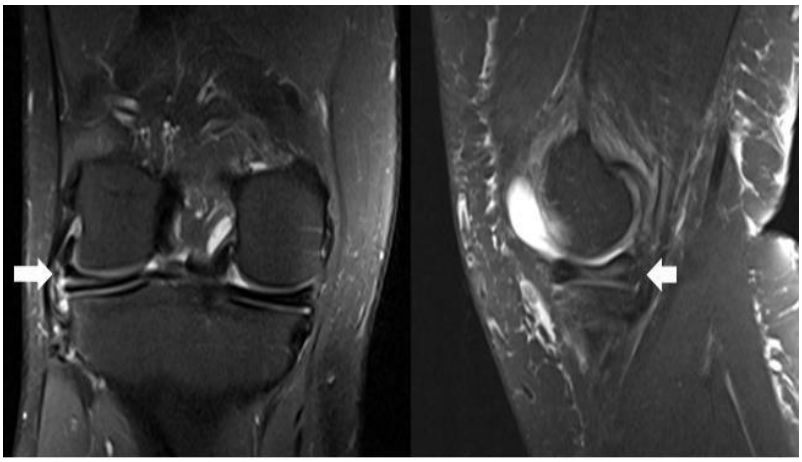


Fig-5(A), Fig-5(B)

Figure 5(A) – PDFS coronal image show linear high signal intensity extending into the meniscus (*arrow*) which is not reaching upto the articular surface suggestive of grade 1 tear.

Figure 5(B) – T2 sagittal image show irregular signal intensity extending through the meniscus (*arrow*) and not touching the articular surface suggestive of grade 2 tear.

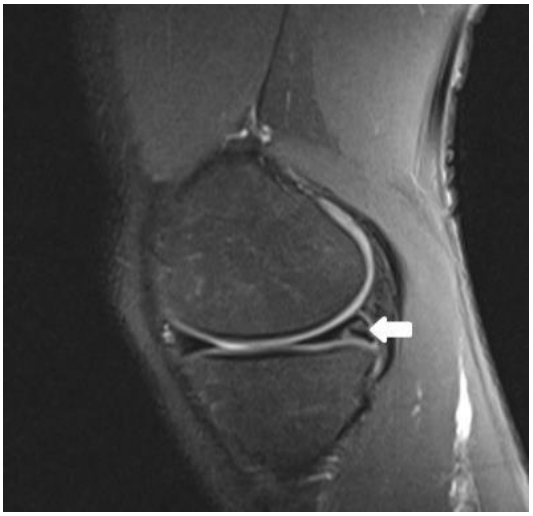


Fig-5(C): PDFS sagittal image showing linear hyper intensity reaching up to the articular surface (arrow) suggestive of grade 3 tear

Case 6: Meniscaltear

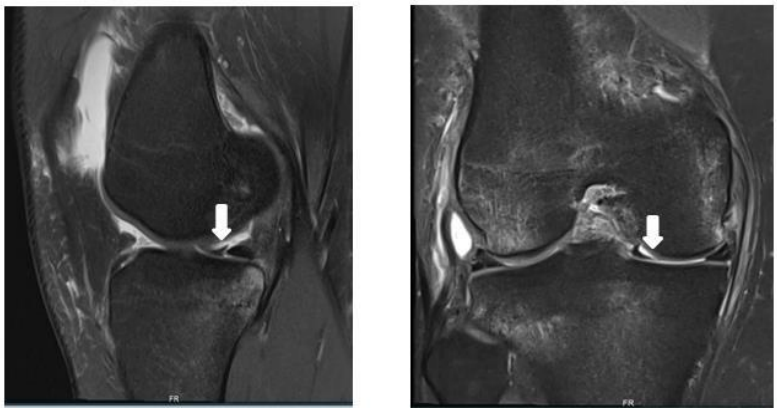


Fig-6(A), Fig-6(B)

Fig-6 (A) (B): PDFS sagittal (A) and coronal (B) Complex tear of posterior horn and body of medial meniscus with displacement of fragment of meniscus (*arrow*) towards the inter-condylar notch.

Case 7: Sign of Meniscal Tear (Double Pcl Sign)

Fig-7: PDFS sagittal image showing tear of the posterior horn of medial meniscus is noted with flipped fragment lying anterior and parallel to PCL (double PCL sign) – bucket handle tear (arrow)

Case 8 - Joint Effusion

Fig-8: PDFS sagittal image showing moderate joint effusion (arrow) with suprapatellar extension with mild synovial thickening

Case 9 - Bone marrow edema/contusions

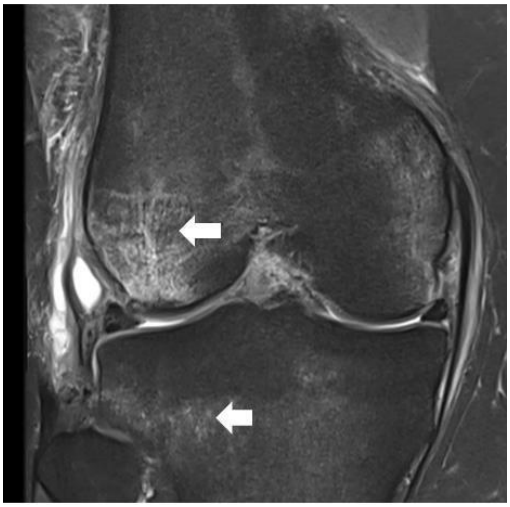


Fig-9: PDFS coronal image showing hyperintensity involving the distal diaphysis, both condyles femur and tibia suggestive of marrow edema/ contusions (*arrow*). No obvious fracture seen

Case 10: Anterior subluxation oftibia

Fig-10: PDFS sagittal image showing Mild anterior subluxation of tibia is seen

Miscellaneous Findings in Knee Trauma
Oblique popliteal ligament sprain

Fig-11: PDFS sagittal image showing few foci of PDFS hyperintensity noted in oblique popliteal ligament (arrow) without discontinuity of its fibers suggestive of sprain

Fibular collateral ligament sprain

Fig-12: PDFS hyperintensity noted in proximal fibers of fibular collateral ligament (*arrow*) suggestive of sprain. No obvious tear seen

Fat pad edema

Fig-13: PDFS hyperintensity noted in Hoffa's fat pad (*arrow*) suggestive of fat pad edema.

Peri-articular subcutaneous and intramuscularedema

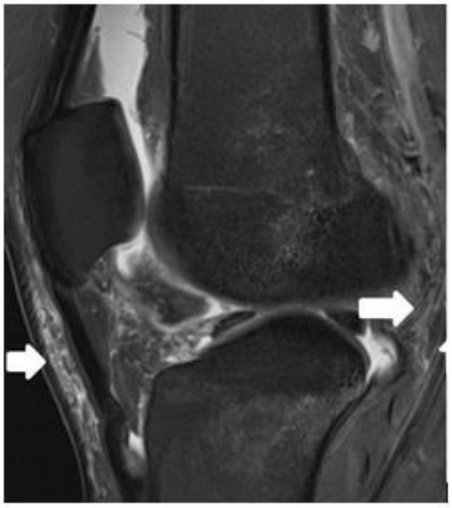


Fig-14: PDFS sagittal image showing hyperintensity seen in peri-particular region (*arrow*) and anterior aspect of knee joint in of subcutaneous plane (*arrow*) suggestive of Mild peri-articular subcutaneous and intramuscular edema

Fluid at insertional site of distal patellar tendon

Fig-15: PDFS sagittal image showing fluid at the insertional site of distal patellar tendon (*arrow*) at anterior tibial tubercle

Peri-articular soft tissue edema

Fig-16: PDFS sagittal image showing hyperintensity in peri-articular soft tissue (*arrow*) suggestive of edema

Grade II tear of medial collateral ligament

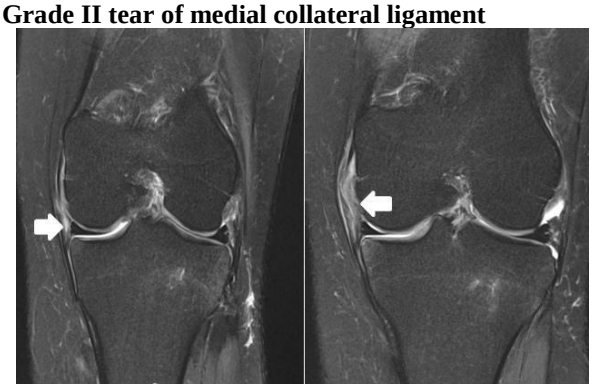


Fig-17: (A) and (B) PDFS coronal images–Edema in image A(*arrow*) and focal thickening in image B (*arrow*) and along the fibers of medial collateral ligament suggestive of Partial/ grade II tear of medial collateral ligament

Post traumatic fracture

Fig-18 :T1 coronal (A) and PDFS coronal (B) imagesshowing Transverse tibial metadiaphyseal fracture(*arrow*), along with medial tibial plateau fracture(*arrow*) appearing hypointense on T1WI and hyperintense on PDFS

DISCUSSION

Age, gender and side of the knee

In our study out of 50 patients, clinically suspected with some form of internal derangement of the knee were included. The right knee was involved in 32(64%) patients, and the left knee was involved in 18 patients (36%) which were comparable with a study done by Ali Akhbar Ismaili Jah, Sohrab Keyhani, Reza Zarei, Ali Kalhor Moghaddam[6] in 70 patients, who showed right knee involvement in 42.9% and left in 57.1%.

In our study maximum numbers of cases were young subjects in the age group of 21-30 years (38%), 72% of cases were males and male outnumbered females in all age groups of this study. In a study done by Majewski M, Susanne H, Klaus S[7] acute traumatic injuries of the knee were common in age group of 20-29 and 70% of them were male.

Acl tears

In our study out of total 50 patients, ACL tear was commonest finding affecting 33 patients (66%), followed by MM tear in 32 patients (64%) and the PCL tear seen in 19 patients (38%).

Findings were in correspondence with Singh JP ,L Garg, R Shrimali, V Setia, V Gupta[8] in which they studied 173 patients, 78 (45.08%) showed ACL tear, among which 52 (66.67%) are partial and 26(21.13%) cases showed non-visualization of ACL suggesting complete tear. The authors interpreted that ACL tears are more common than other injury of ligaments.

Meniscal tears

In our study there was preponderance of Medial meniscus 18(36%)over lateral meniscus 8(16%) which again correlated with the study done by Singh JP , L Garg, R Shrimali, V Setia, V Gupta[8], they found out of 173 ,57(38.23%) patients had MM tear and 28 (29.41%) patients had LM tear.

M.Schurz, J.T. Erdoes, P. Platzer, N. Petras, J.T. Hausmann[9] studied patients with the clinical suspicious of meniscal tears and recommended MRI as a diagnostic tool for the diagnosis of meniscal tears. In our study the meniscal tears were diagnosed by an area of altered signal within the meniscus on at least one image that extended to the meniscal articular surface, or abnormal appearance of the meniscus.

Collateral ligament tear

MCL tear - In our study MCL injuries was seen in 22 patients out of which 13 were partial tear and 9 were complete tear. On MRI study, partial MCL tear showed high signal intensity and disturbances in morphology, and complete MCL tear appeared as discontinuity of the fibers. Our findings were in correspondence with Schweitzer M E, Duc Tran, Diane M. Deely, Eric L. Hume [10].

In our study LCL injury was seen in five patients and appeared as increased in the signal in intensity on MR imaging. Our findings were in correspondence with Lee HN, Ahn SE, Park JS, Ryu KN, Jin W, Park YK, Huh Y [11]. Where they stated that the incidence of LCL injury is low when compared to rest of the knee ligament.

BONY CONTUSIONS

Our study showed 31 bony contusions out of 50 patients. Bony contusions were also seen as a associated finding with ACL tear. On MRI images bony contusions appeared as irregular areas of poorly marginated altered signal intensity (low signal intensity on T1WI, high signal intensity on T2WI, or both) in the cancellous bone and marrow. Our findings were in correspondence with Sanders TG, Medynski MA, Feller JF, Lawhorn KW[12].

Miscellaneous injury (musculotendinous)

Our study showed 6 musculotendinous injuries like muscle contusion, myotendinous strain, and tendon avulsion.

Anterior tibial subluxation (ats)

In our study we have found anterior tibial subluxation in 10 patients. Patients of complete ACL tear showed higher subluxation, thus suggesting that significant ATS is existent with complete ACL tears. Findings were in correspondence with Chan WP, Peterfy C, Fritz RC, Genant[13].

Fluid

We calculated the fluid in the affected knees and the association with internal derangements. Of the 50 knee MRI examinations joint effusion was found in 38patients.

CONCLUSION

Magnetic resonance imaging is excellent imaging and radiation free modality to study the ligaments of the knee joint and surrounding soft tissue. The diagnostic yield is increased with appropriate use of MR sequences and proper interpretations of images in all planes.

Magnetic resonance imaging is able to detect lesions type more effectively than clinical tests. Magnetic resonance imaging is noninvasive and does not involve morbidity associated with other tests. Magnetic resonance imaging is an excellent non-invasive modality in imaging of the knee and a noninvasive replacement for arthrography.

Magnetic resonance imaging is an excellent modality to detect the lesions in an injured knee, it has great capability in diagnosing ACL tear, PCL tear and related pathologies.

According to our study Magnetic resonance imaging is better than clinical tests to detect the cruciate ligaments and associated lesions.

Almost all the ligamentous and meniscal injuries can be diagnosed with high level of confidence. Pathological entities should be carefully differentiated from normal variants, pitfalls and artifacts of imaging. In traumatic setting Magnetic resonance imaging has now been evolved as a most commonly used and best imaging modality for the assessment of ligamentous, meniscal and intra-articular pathologies.

In post-traumatic knee, Magnetic resonance imaging evaluation before arthroscopic examination has been proved as cost-effective.

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