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Magnetic Resonance Imaging of Knee Injuries and It's Correlation with Arthroscopic Findings.

Mihir Kumar Jha[1], Subrat Prasad[2], Utpalendu Das[3], Ashok Kumar Bhadra[3], N D Chatterjee[4], Sukanta Sen[5]

[1]Assistant Professor, Department of Radiodiagnosis, Shri Ramkrishna Institute of Medical Sciences, Kanksha, Durgapur, Malandighi, West Bengal 713212.
[2]Associate Professor, Department of Radiodiagnosis, Mata Gujri Memorial Medical College & LSK Hospital , Purabbali, Dinajpur Road, Kishanganj, Bihar 855108, India.
[3]Professor, Department of Radiodiagnosis, SSKM & IPGMER Hospital, 244 A.J.C. Bose Road, Kolkata 700 020, India.
[4]Professor, Department of Orthopedics, SSKM & IPGMER Hospital, 244 A.J.C. Bose Road, Kolkata 700 020, India.
[5]Professor, Department of Pharmacology, ICARE Institute of Medical Sciences & Research, Banbishnupur, Haldia, West Bengal 721645, India.

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ABSTRACT

Background: The knee joint is one of the most vulnerable and frequently injured joints of the body. X-ray, arthrographic, scintigraphic, ultrasound examinations hold their place in diagnosing knee injuries, but they are loosing precedence to computerised tomography (CT), magnetic resonance imaging (MRI) and arthroscopy. Role of magnetic resonance imaging (MRI) in the diagnosis of knee lesions has now become more evident. To find out the efficacy of MRI in diagnosing various ligamentous and meniscal injuries in terms of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). **Methods:** In this prospective interventional comparative study patients of all age group of either sex attending the orthopaedic OPD of IPGMER & SSKM Hospital with clinical features suggestive of soft tissue around knee were included in the study during the period of Feb 2008 to Aug 2009. MR imaging with GE make of 1.5 tesla (super conductive in nature) was used. The patients was evaluated in sagital, coronal and axial imaging planes. **Results:** In the present study 100 cases of knee evaluated based on the clinical history and examination a provisional diagnosis was made. About 44% of the patients were subjected to MRI within 10 weeks after the onset of their sufferings. Most common structure being injured was medial meniscus in about 64% cases. In our study, arthroscopy had been taken as gold standard but arthroscopy is useful for intraarticular structures and its injuries only. So the correlation of intraarticular structures i.e. meniscus & cruciates can be done only. Out of 100 patients, 48 cases showed ACL tears, 22 patients showed PCL tear arthroscopically. Out of 48 ACL tears confirmed by arthroscopy the diagnosis 5543by MRI was 48. **Conclusions:** MR is highly specific and highly sensitive in detection of cruciate ligament injuries in patients with acute as well as chronic injury. MR is more sensitive in detection of multiple meniscal tear that may be overlooked on sonography or arthroscopy.

Keywords: Soft tissue injuries, Menisci, Ligaments, Knee joint, MR imaging, Arthroscopy, Diagnosis.

INTRODUCTION

Knee joint being a hinge type of synovial joint, the bones have limited contribution to the stability of the joint. The stability of knee joint hence depends upon the supporting soft tissue structures including the joint capsule, the ligaments, the menisci and the myotendinous unit. The knee joint is one of the most frequently injured joint because of its anatomical structure, it's exposure to external forces, and the functional demand placed on it. Apart from injuries involving osseous structure, the understanding of injuries related to extra articular structures (tendons & ligaments) and intra articular structures (menisci and cruciates) are of great importance. These internal derangements of knee, resulting due to trauma, are severely disabling unless diagnosed promptly and treated efficiently.[1-3]

Physical examination is pivotal in making a working diagnosis from different tests available. Now these working diagnoses allow the orthopaedist to contemplate the most effective imaging to reach the definitive diagnosis. Decision making requires the integration of science of physical examination and anatomic diagnosis with socioeconomic factors and the patient's desires. The best decision and best plan for the patient is the ultimate goal of physical examination and physician.[4,5] Apart from clinical examination, there are other important diagnosing modality to soft tissue injury around the knee i.e. USG, MRI and arthroscopy. Now our concern of this study is to find out the modality of investigation of

Name & Address of Corresponding Author
Dr Subrat Prasad,
Associate Professor,
Department of Radiodiagnosis,
Mata Gujri Memorial Medical College & LSK Hospital ,
Purabbali, Dinajpur Road,
Kishanganj, Bihar 855108, India

choice with accuracy, promptness and cost effectiveness.

MRI is the most accurate modality for imaging the soft tissues injuries, but the high cost and less or non-availability is the major disadvantages.6 CT scan is also not very helpful in the evaluation of pathophysiology of tendons.[6]

Soft tissue discrimination with MR imaging is excellent and differentiation can be made among cortex, marrow, ligaments, tendons, muscles, synovium, vascular and cartilage elements. Additional advantages of MR imaging are multiplaner and thin section capabilities and the ability to evaluate subchondral bone and marrow and no radiation exposure.[7]

MRI has a great effect on the amanagement of internal derangement of the knee and is increasingly available to hospital specialists. Access to MRI by specialists for patients with knee problems could result in early diagnosis. Negative result could allow specialists to reassure patients, treat them conservatively and avoid unnecessary hospital referrals and associated costs. Positive results could confirm orthopaedics clinical diagnosis and get urgent cases treated more quickly with reduce average waiting times, increase efficiency, and even improve patient prognosis and quality of life. MRI is safer and less expensive than arthroscopy. MRI is very sensitive for meniscus and cruciate lesions. MRI has decreased the arthroscopy rate following clinical examination.[8]

However MRI too have few limitations[8,9]

Young children usually require deep sedation or anaesthesia for MRI, but none is required for USG. Patients having claustrophobia, any metallic implants or intra orbital foreign body can't undergo MRI examination. In comparison to USG, MRI is costlier and not available frequently in periphery or small scale set up.

In this study, all the selected patients on the basis of suggestive clinical features of soft tissue injury around knee (except for those coming under the criteria for exclusion) will be subjected to sonography and MRI followed by arthroscopy after proper counselling and consent.

MATERIALS & METHODS

In this prospective interventional comparative study patients of all age group of either sex attending the orthopaedic OPD of IPGMER & SSKM Hospital with clinical features suggestive of soft tissue around knee were included in the study during the period of Feb 2008 to Aug 2009.

Inclusion Criteria:

Any patients having history of knee injury with suggestive soft tissue involvement as per clinical evaluation

Exclusion Criteria:

1. Patients having any suggestive infection and sepsis
2. Partial or complete ankylosis of knee
3. Patients with neoplasm and infectious disorder
4. Major capsular disruptions of knee joint

Demographic information, clinical examination, imaging evaluation by MRI, and arthroscopic findings were noted.

MRI: M/S GE make, 1.5 T (super conductive in nature)

Arthroscopy: Specification of instrument not required

MR imaging with GE make of 1.5 tesla (super conductive in nature) was used. Typically patient was placed in the supine position with the knee placed in a closely coupled extremity coil. The knee should be slightly flexed (5-10°) and may be exrernally rotated (15-20°). The patients was subjected to pulse sequences susch as spin echo and fast spin echo technique, gradient echo (TIRM), and both slice selective and 3D Fourier transformation. Short Tau Inversion Recovery (STIR/FS) & FSE STIR was used. The patients was evaluated in sagital, coronal and axial imaging planes. The parameters used were:

1. T1 W images: TR 512.0, TE-11.0, with a slice thickness of 3 mm and a matrix of 512x640.
2. T2 W images-TR-4000, TE-77, with a slice thickness of 5 mm and a matrix of 358x512
3. PD TSE FS images- TR-2140, TE-30.0, with a slice thickness of 3 mm and matrix of 512 x 512
4. 3D Fourier transformation- TR 11, TE-4.8, with a slice thickness of 5 mm and a matrix of 238 x 56
5. 5. T2 STIR image- TR-4500, TE-28, TE-160, with a slice thickness of 5 mm and a matrix of 512 x 512

RESULTS

In the present study 100 cases of knee evaluated based on the clinical history and examination a provisional diagnosis was made. Then these patients were subjected to USG and MRI. If there is indication for arthroscopy (intra-articular injuries) arthroscopy done.

Table 1: Demographic and clinical characteristics of study participants

Characteristics	No. of patients [%]
Age group [Yrs]	
0-10	0
11-20	32 [32]
21-30	38 [38]
31-40	22 [22]
41-50	16 [16]
51-60	0
Male	72 [72]
Female	28 [28]
Side effected	
Right	64 [64]
Left	36 [36]

Their age was ranged from 15 to 49. Maximum number of patients belonged to 20-30 age group, which was comprised 36% of the whole study group. The average age of the study group was 32. Male subjects were showing definite male preponderance.

In 64% of cases right knee joint was involved. This may be due to overuse or overdependence of the right knee joint in sports and daily activities [Table 1].

Table 2: Clinical presentation of various patients

Clinical features	No. of patients
Pain	72
Swelling	64
Locking	28
Muscle wasting	24
Feeling of giving away	28
Others	12

Pain was the most common presenting symptom followed by swelling and locking respectively [Table 2].

Table 3: Duration between onset of symptoms and MRI

Time gap between onset of symptoms & USG (weeks)	No. of Patients [%]
1-10	44 [44]
11-20	32 [32]
21-30	12 [12]
31-40	8 [8]
41-50	4 [4]
Total	100

About 44% of the patients were subjected to MRI within 10 weeks after the onset of their sufferings. The earliest one to get MRI done was after 1 week of onset of symptoms and on the other extreme was by 50 weeks after onset of symptoms. The average delay in MRI after the onset of symptoms was 15 week. This observation gave a clear idea of duration of sufferings of the study group [Table 3].

Table 4: Frequency of potential diagnosis

Injury	No. of Cases [%]
Medial meniscal tear	64 [64]
Lateral meniscal tear	32 [32]
ACL tear	36 [36]
PCL tear	16 [16]
MCL tear	24 [24]
LCL tear	4 [4]

Most common structure being injured was medial meniscus in about 64% cases. Cases following kinematic principal medial meniscal injury were seen associated with medial collateral ligament in all 24 cases of MCL injury. From 36 cases of ACL injury 32 had associated medial meniscal injury whereas only 4 showed associated lateral collateral ligament as well (triad of O'donaghue's) [Table 4, Figure 1-7].

Table 5: Categorization of diagnosis into major groups

Injury	No. of Cases [%]
Ligamentous	52 [52]
Menisci	84 [84]
Bone	60 [60]
Injury	
ACL	36 [36]
PCL	8 [8]
Medial Menisci	36 [36]
Lateral Menisci	24 [24]
Bone	8 [8]

Among major group of injuries meniscal injuries were predominat followed by bony injuries and ligamentous injuries [Table 5, Figure 5-7].

Correlation MRI findings with arthroscopic findings

In our study, arthroscopy had been taken as gold standard but arthroscopy is useful for intraarticular structures and its injuries only. So the correlation of intraarticular structures i.e. meniscus & cruciates can be done only. Out of 100 patients, 48 cases showed ACL tears, 22 patients showed PCL tear arthroscopically. Out of 48 ACL tears confirmed by arthroscopy the diagnosis by MRI was 48 [Table 6, Figure 1-3].

Table 6: Injuries diagnosed by MRI and confirmed by arthroscopy

MRI Findings	Injury to ACL confirmed by arthroscopy		
	Present	Absent	Total
Positive	48	2	50
Negative	0	50	50
Total	48	52	100

Therefore different parameters of correlation of MRI with arthroscopic findings were sensitivity 100%, specificity 96.15%, PPV 96%, NPV 100%, percentage of false negative 0% and percentage of false positive 3.7% [Table 6]. Out of 14 PCL tears confirmed by arthroscopy, the diagnosis by MRI was 14.

Table 7: Injuries to PCL diagnosed by MRI and confirmed by arthroscopy

MRI Findings	Injury to PCL confirmed by arthroscopy		
	Present	Absent	Total
Positive	2	0	2
Negative	12	86	98
Total	14	86	100

Therefore different parameters of correlation of MRI with arthroscopic findings were sensitivity 100%, specificity 90.7%, PPV 63.60%, NPV 100%, percentage of false negative 0% and percentage of false positive 9.3% [Table 7]. Out of 100 patients, 62 cases showed medial meniscus tear, 22 patients showed lateral meniscus tear arthroscopically. Out of 62 medial meniscus tear confirmed by arthroscopy, the diagnosis by MRI was 60.

Table 8: Injuries to medial meniscus diagnosed by MRI and confirmed by arthroscopy

MRI Findings	Injury to medial meniscus confirmed by arthroscopy		
	Present	Absent	Total
Positive	60	1	61
Negative	2	37	39
Total	62	38	100

Therefore different parameters of correlation of MRI with arthroscopic findings were sensitivity 96.7%, specificity 97.4%, PPV 98.4%, NPV 94.9%, percentage of false negative 3.2% and percentage of false positive 2.6% [Table 8]. Out of 22 lateral

meniscus tear confirmed by arthroscopy, the diagnosis by MRI was 21.

Table 9: Injuries to lateral meniscus diagnosed by MRI and confirmed by arthroscopy

MRI Findings	Injury to lateral meniscus confirmed by arthroscopy		
	Present	Absent	Total
Positive	21	1	22
Negative	1	77	78
Total	22	78	100

Therefore different parameters of correlation of MRI with arthroscopic findings were sensitivity 95.45%, specificity 98.7%, PPV 95.45%, NPV 98.7%, percentage of false negative 4.5% and percentage of false positive 1.3% [Table 9].

DISCUSSION

The age group and the average age of study group are comparable to that of other studies. The observations show that patients having soft tissue injuries around the knee joints fall in the reproductive age group. The male-female ratio shows a wide variation with that of some studies, but at the same time it is similar to other studies. The high male-female ratio in our study may be because of the fact that males are more involved in outdoor activities, sports, travelling, industrial works etc, which make them vulnerable to knee injuries and other knee joint problems. Social obligations are more towards the female in this part of the country, which may also contribute to this high male-female ratio. The right/left ratio is not mentioned in other studies, may be due to its less importance in diagnostic point of view. The high incidence of right side may be due to the fact that our study group is small or may be due to overuse or overdependence of right knee joint in sports and daily activities.

Meniscal Injury

Palmer et al described most trauma related medial meniscal tears peripheral in location and longitudinally oriented, whereas lateral meniscal tears involve the free margin and are transverse in orientation.[10]

Smillie IS notied that displaceable meniscal tears usually have longitudinal, radial, or complex configurations, such tears are associated with substantial ipsilateral, collateral ligament lesions and pain.[11] Drosos et al,[12] reported the patients with sport injuries (mean age 33 yrs) accounted for 32.4% of cases. The patients with non-sporting injuries (mean age 41 yrs) accounted for 38.8% of tears. About 71.9% of these happened in activities of daily living (and halp of this group sustained their tear by squatting or ascent from this position. Patients without identifiable injury (mean age 43 yrs) represented 28.8% of cases. Male: female was 4:1. Medial tears accounted for two third of cases.

In our study we found the patients with sports injuries (mean age 29 yrs) accounted for 47.6% of cases. The patients with nonsporting injuries (mean age 38 yrs) accounted for 38.08%. Patients without identifiable injury (mean age 41 yrs) represented 14.2% of cases. Male:female ratio 4:1. Medial tears accounted for two thirds of cases. Our results were slightly different from that reported by Drosos et al,[12] which we attribute to difference in referral pattern.

The statistical parameters of meniscal injuries diagnosis in our study group compared with other studies available is in the following table.

Comparison of MRI findings of our study with others

Study	Results			
	Medial meniscus		Lateral meniscus	
	Sensitivity	Specificity	Sensitivity	Specificity
Fischer et al[13]	97.1%	98.3%	87%	99.2%
Singh et al. 2004 [14]	96.5%	98.28%	99.29%	97.11%
Our study	96.7%	97.4%	95.45%	98.7%

Comparison of MRI findings of our study with others

Study	Results			
	Anterior cruciate ligament tear		Posterior cruciate ligament tear	
	Sensitivity	Specificity	Sensitivity	Specificity
Fischer et al[13]	98%	98%	99%	100%
Singh et al. 2004[14]	98.7%	98.9%	100%	100%
Our study	100%	96.15%	100%	90.7%

In our study the sensitivity and specificity of MRI for detecting meniscal injuries is comparable with other studies available.

In our study the sensitivity and specificity of MRI for detecting cruciate ligament injuries is comparable with other studies available. Locations of meniscal tear, capsuloligamentous sprain, and osseous injury all provide clues about the mechanism of injury. By understanding the most common patterns of knee injury, a biochemical approach can be used in the interpretation of MRI images.15 The identification of abnormality in one structure should lead to a directed search for subtle abnormalities involving anatomically or functionally related structures, their by improving diagnostic confidence.[10]

The deep meniscocapsular and superficial ligamentous fibers simultaneously develop tension during valgus force and, therefore often are injured together during excessive valgus force besides this anatomic synergism, the medial collateral ligament and medial meniscus are functionally related through the posterior oblique ligament at the psoteriomedial corner of the knee. These structures are both stressed by external rotation, with or without valgus force.[16-18]

Hayes CW et al gave mechanism based pattern to classify complex injuries of the knee depicted at MR imaging on the basis of information from the injury patterns. We have classified complex knee injuries into 10 categories, according to the knee position (flexion, extension), direction of force and presence or absence of rotation (a) pure hyperextension; (b) hyperextension with varus; (c) hyperextension with valgus; (d) pure valgus; (e) pure varus; (f) flexion with valgus, external rotation; (g) flexion with varus, internal rotation; (h) flexion with posterior tibial translation; (i) patellar dislocation (flexion, valgus, internal rotation of femur on tibia; and (j) direct trauma. Recognition of these patterns may help assess the full extent of knee injury, particularly at the posterolateral and posteromedial corners of the knee.[19]

In our study we found that medial collateral ligament injury were frequently associated with medial meniscus injury seen in 20 out of 24 cases (83%) of MCL injury, which can be explained on the basis of intimate natomical relation and functional synergism between two. Both are anatomically related through the deep capsular fibres, which attach to meniscus at the meniscocapsular junction. Both simultaneously develop tension during excessive valgus force and, therefore, often are injured together during excessive valgus force besides anatomical functional synergism is seen related through the posterior oblique ligament at the posteromedial corner of the knee. These structures are both stressed by external rotation, with or without valgus force hence often injured together.[20,21]

Significant association was seen between anterior cruciate ligament injury and medial meniscus out of 36 cases of ACL tear 28 had associated medial meniscus tear (77%) and of total 36 ACL tear 24 cases were diagnosed as complete ACL tear associated with significant anterior tibial subluxation explaining that complete tears are more common in ACL as compared to partial tear because fibre failure usually occur simultaneously rather than sequentially. Moreover the associated medial meniscus injury can be explained on the basis of anterior tibial translation associated with medial ACL tear. The anterior cruciate ligament is the primary restraint to anterior tibial displacement when one of these stabilizing structures is disrupted, the other is jeopardized and the quadriceps pull causes the tibia to shift anteriorly the femoral condyle is the physical barrier that prevents the posterior thirds of medial meniscus from moving freely with the tibia.[22-24]

Figure 1: Normal anterior cruciate ligament (ACL) in the sagittal plane. Sagittal T1-weighted MRI shows a ruler-straight hypointense ACL. The normal ACL occasionally demonstrates a mild smoothly convex contour inferiorly, but sharp angulation is abnormal.

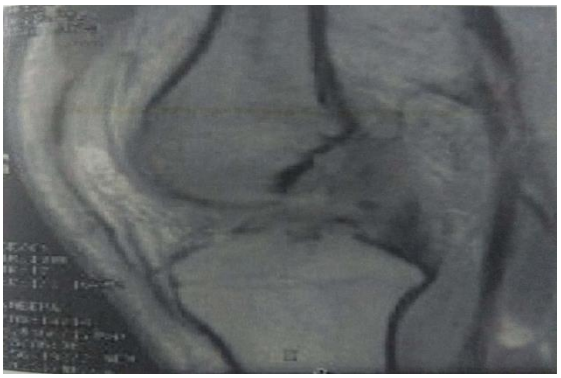

Figure 2: Nonvisualization as primary sign of anterior cruciate ligament (ACL) tear. Sagittal image shows complete (or near complete) nonvisualization of the ACL with ill defined edema and hemorrhage in the usual location of the ACL in the intercondylar notch. This is very common presentation of an acute ACL tear.

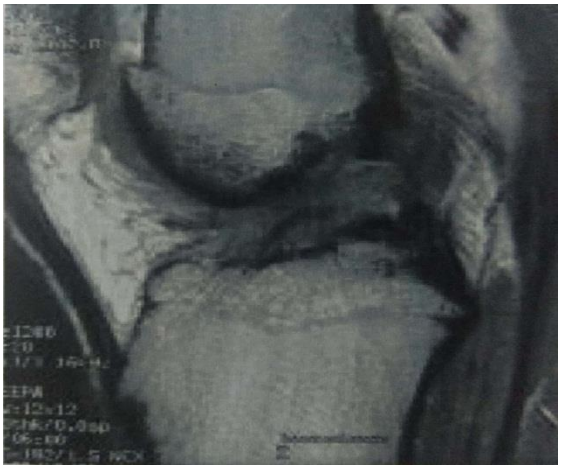

Figure 3: Partial tear of the anterior cruciate ligament. T1-weighted sagittal MRI image shows disrupted ACL fibers proximally compatible with an ACL tear.

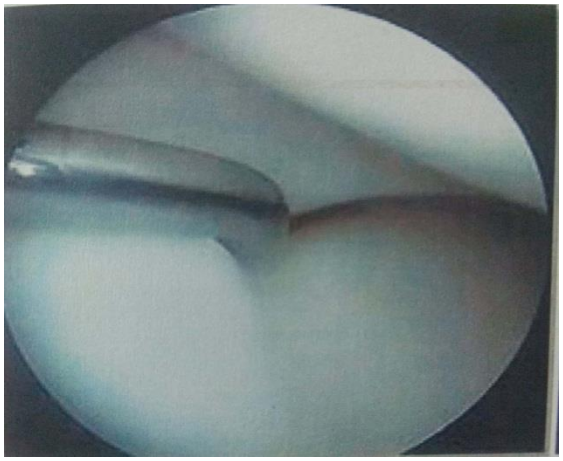

Figure 4: Normal medial meniscus

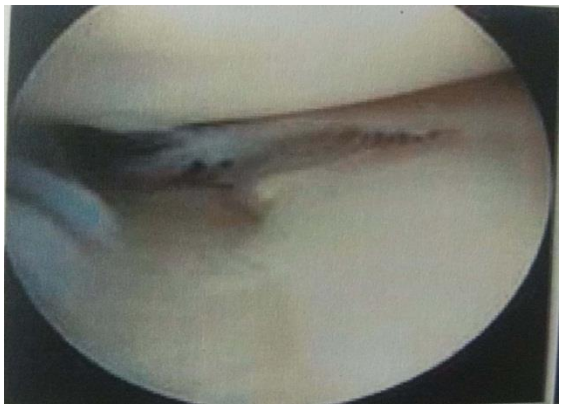

Figure 5: Radial meniscal tear

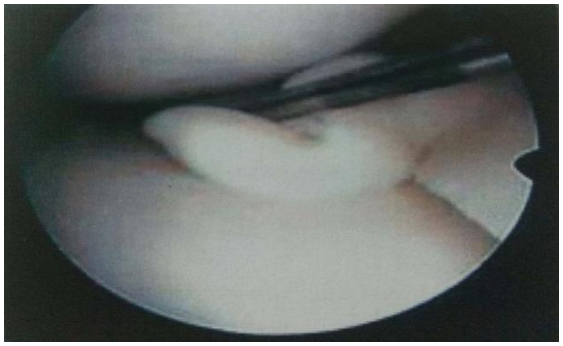

Figure 6: Large meniscal flap tear

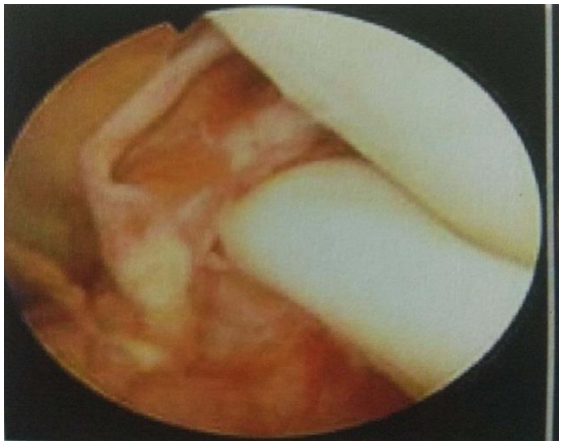

Figure 7: Displaced bucket handle meniscal tear

CONCLUSION

Knee injuries are common in early adolescent and adults (11-40) yrs of population. Knee injuries showed a definitive male preponderance with male to female ratio of 72:28. Right side was seen injured more frequently as compared to left side. Pain was the most common presenting symptom in various knee injuries. Medial menisci was the most common structure being injured seen in about 64 percent of cases.

MR is highly specific and highly sensitive in detection of cruciate ligament injuries in patients with acute as well as chronic injury. MR is more sensitive in detection of multiple meniscal tear that may be overlooked on sonography or arthroscopy. MR as well as sonography is advantageous in conditions where arthroscopy in detection of grade I and II intra-substance tear, precursors to formation of meniscal tears. MR is less sensitive than arthroscopy in detecting partial ACL tears. Bone injuries are a frequent association with various types of knee injuries and occur at predictable site. Clinical and radiological correlation is necessary for accurate diagnosis of most knee injuries. Understanding mechanism of injury and kinematics is crucial for accurate diagnosis.

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