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Mri Evaluation of Anterior Cruciate Ligament Tears with Arthroscopic Correlation

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ABSTRACT

Aim AndObjectives: *1. To evaluate the accuracy and usefulness of MRI in diagnosing ACL tears using arthroscopy as gold standard. 2. To assess the usefulness of primary and secondary signs in diagnosing ACL tear.*
Materials And Methods: Source of data :*Patientswithhistoryofkneetraumaandpain referred to Department of Radiodiagnosisfrom orthopaedic outpatient department in Meenakshi Medical college hospital and research institute were subjected to MRI examination. MRI knee was performed using 1.5TESLA MaganetomEssenza Siemens MRI machine, using quadraturekneecoil.*
Number of patientsfor study*- 57.*
Method of Collection of Data:*A standard proformawill be used to collect patient related data for thestudy. Patientwasplacedinsupinepositionwithkneeplacedin5-10degreeofexternalrotationandextension.*
Study design*: ProspectiveStudy.* ***Study period****:December 2013 – November 2015.*
Onclusion: *High spatial resolution MR imaging with quadrature knee coil is accurate for the detection of complete ACL tears. In this study population, a male patient with knee injury was two times more likely to have torn ACL. Similarly a patient with injury to left knee was 1.4 times more likely to have ACL tear. Primary findings from the essential basis for diagnosis of ACL tears as they are visualized in almost all complete tears. Abnormal axis of the ACL is the single most useful sign in diagnosing complete ACL tear. Medial meniscus tear was the most common associated injury in our study. So pre arthroscopic Finally we conclude that High spatial resolution MR imaging is highly accurate for the detection of complete ACL tears with excellent arthroscopic correlation and is therefore an ideal and more accurate preoperative imaging modality for diagnosing complete ACL tears and associated injuries.*

I. Introduction

Anterior cruciate ligament injury is the most commonly injured of the major knee ligaments. Injuries occur frequently in both athletes and nonathletes. In United States the prevalence of ACL injury is about 1 in 3000, and approximately 2,50,000 injuries occur every year. Prompt assessment of full extent of ligamentous damage is essential for appropriate management. Because of its intraarticular location, the ACL has poor healing potential. The ruptured ACL does not form a bridging scar after complete disruption. The prognosis for a partially torn ACL may be favorable, if the synovial envelope remains intact. Without treatment complete ACL injury can result in progressively increasing symptomatic knee instability and osteoarthritis.Meniscusinjuryoccursinassociationwith50%ofacuteACLtears,and it increases to 90% in chronic ACL deficient knees. The incidence of articular cartilage lesions increases from 30% in acute ACL injuries to approximately 70% of knees with chronic ACL instability. The fundamental rationale for diagnosing and treating ACL injury is to prevent future meniscal tears and associatedjointdamage.

For treating ACL injury the orthopaedician or arthroscopist needs the answer to following questions:

1. Whether ACL is normal or abnormal? If ACL is normal, invasive arthroscopy can be avoided in patients with suspected ACLinjury.

2. If abnormal, whether the tear is complete or partial? If partial conservative management or repair can be done. However in complete tears reconstruction needs to be done in most of cases.
3. What is the status of associated structures such as PCL, menisci, MCL, LCL, posterolateral, posteromedial plateau in ACL injured patients? Because an injury to above structures along with complete tear of ACL needs early reconstruction of ACL.

ACL injury can be diagnosed in majority of patients by history and clinical examination. The clinical diagnosis is fraught with difficulty in acute cases and in large patients. Also partial tears are difficult to diagnose and the associated injuries could not be completely evaluated by clinical examination. Arthroscopy and arthrotomy are the criterion standards for definitive diagnosisbutareinvasiveandcostly.ItcangetunnecessaryifACLturnsoutto benormal.Spiral CT arthrography is more invasive than conventional MR imaging. It uses ionizing radiation and is subject to the potential complications inherent in intraarticular injection of iodinated contrast material.ThecontinuingneedforabetternoninvasiveimagingmodalityforACL injury led to the use of MRI as a diagnostic and pre- operative evaluation modality.MRI is a recently devised modality for evaluation of ACL and knee joint. Imaging is done in sagittal, axial and coronal planes using T1, T2 and STIR sequences using quadrature knee coil.The following study involves detailed evaluation ACL injury and its associated injuries using MRI and comparing with arthroscopic results. MR primary and secondary signs of ACL tear are also analysed and their usefulness assessed in comparison with arthroscopic findings.

Aim

1.To evaluate the accuracy and usefulness of MRI in diagnosing ACL tears using arthroscopy as gold standard.

2.To assess the usefulness of primary and secondary signs in diagnosing ACL tear.

II. Materials And Methods

Aprospectivestudyof57patientswithhistoryofkneetraumaandpain referred from orthopaedic outpatient department was done in Meenakshi Medical college hospital and research institute for the time period of December 2013 – November 2015 . All 57 patients were subjected to MRI examination. MRI knee was performed using 1.5TESLA MaganetomEssenza Siemens MRI machine, using quadraturekneecoil.

III. Method

Patientwasplacedinsupinepositionwithkneeplacedin5-10degreeofexternalrotationandextension.

Mr Technique Used

Ascoutaxialviewwasobtainedtoplanforsagittalandcoronalsections(perpendicular and parallel to posterior femoral condylar line). If needed obliquesagittalsectionsforACLwereperformedusingcoronalslicethatshows theobliquecourseofACL.

The sequences used were

a) T2 weighted sequence

TR–3000ms TE–104msAverages–2

No. of slices–17Slice thickness–4mm

FOV–150mmSagittal –6mins

Axial – 6mins

b) Short tau inversion recovery sequence(STIR) TR–5210ms TE –47

TI-160ms Noofslices–14–16Slice thickness–3mm

FOV –200mmCoronal–5mins

c) Proton density fat sat sequence

TR–3000ms TE –13

Slice thickness–4mm No of slices–19Averages-2

FOV –150mmSagittal–3mins

d) T1 weighted sequence

TR–450ms TE –12ms

Slice thickness–4mm No of slices–19

Averages-2 FOV –150mmSagittal–4mins

e) Optional sequence

i. oblique T2Wsag

Inclusion Criteria
All patients referred from orthopaedic department with history of knee trauma and knee pain with follow up arthroscopy were included in the study.

Exclusion Criteria
i. PriorH/Osurgery,arthroscopy
ii. PatientswithMRincompatibledevicesorimplantsiii. Patients withclaustrophobia
iv. Patientsonlifesupportsystems

The study confines to the ethics and was done with the consent and full cooperation of the patients.

IV. Results And Analysis

TheabilityofMRIandclinicalexaminationtodiagnoseACLinjurywas compared with arthroscopy and the results were analyzed using various statistical tests. Primary and secondary signs for ACL tear in MRI were also studiedindetailincorrelationwitharthroscopy. The final arthroscopic findings after evaluation with MRimagingwereacceptedasreferencestandardagainstwhichtheMRfindingswerecompared. hesensitivity,specificity,positivepredictivevalue,negativepredictivevalue and accuracy were calculated for clinical and MR imaging in diagnosing ACL tears in correlation with arthroscopy. The sensitivity, specificity, positive predictivevalue,negativepredictivevalueandaccuracywerecalculatedforthe primaryandsecondarysignsofACLtearinMRI.

TABLENO1

Gender Distribution OfPatients

	MALE	FEMALE	TOTAL
TEAR	32	6	38
NORMAL	9	10	19
TOTAL	41	16	57

Likelihood ratio for male patient to have ACL tear: 2.081
P < 0.01

Table No 2 Age Distribution Of Patients

SL.NO	AGE GROUP	NUMBER OF PATIENTS
1	< 20	9
2	20 - 30	23
3	30 – 40	11
4	40 – 50	10
5	> 50	4

60% patients were in the age group 20 – 40 years.

TableNo3 Distribution Of Patients According To Involved Knee Joint

	TEAR	NORMAL	TOTAL
Left	20	7	27
Right	18	12	30
Total	38	19	57

Likelihood ratio for Left knee to have ACL tear: 1.4

TableNo4 Distribution Of Patients As Per Clinical Evaluation Of Acl

Clinical Acl Status	Number Of Patients
Tear	32
No Tear	25

TableNo5 Comparison Between Clinical Diagnosis And Arthroscopy For Acl Tear

Clinical Diagnosis	Arthroscopy			Total
	Normal	Partial Tear	Complete Tear	
Tear	2	1	29	32
Normal	17	4	4	25
Total	19	5	33	57

TableNo6: Comparison Between Mri Diagnosis And Arthroscopic Diagnosis For Acl Tear

MRI	ARTHROSCOPY			TOTAL
	NORMAL	PARTIAL TEAR	COMPLETE TEAR	
NORMAL	15	1	0	16
PARTIAL TEAR	3	4	1	8
COMPLETE TEAR	1	0	32	33
TOTAL	19	5	33	57

TableNo7: Location of Acl Tear

	PARTIAL TEAR	COMPLETE TEAR	TOTAL
FEMORAL ATACHMENT	1	1	2
MIDSUBSTANCE	2	23	25
TIBIAL	0	2	2
BOTH FEMORAL & MIDSUBSTANCE	2	7	9
TOTAL	5	33	38

Midsubstance of ACL was the most common site of ACL tear.

TableNo8: Associated Injuries

	PARTIAL TEAR	COMPLETE TEAR
MEDIAL MENISCUS	1	15
LATERAL MENISCUS	0	3
MCL	1	3
PCL	1	3
LCL	0	1

Medial meniscus tear was the most common associated injury with ACL tear.

TableNo9: Comparison Between Clinical Diagnosis Arthroscopic Diagnosis For Acl Tear

CLINICALDIAGNOSIS	ARTHROSCOPY REPORT		TOTAL
	TEAR	NORMAL	
TEAR	30	2	3
NORMAL	8	17	2
TOTAL	38	19	5

		CONFIDENCE LIMIT
SENSITIVITY	78.9%	62.6 – 90.4
SPECIFICITY	89.5%	66.8 – 98.7
POSITIVE PREDICTIVE VALUE	93.7%	79.2 – 99.2
NEGATIVE PREDICTIVE VALUE	68%	46.5 – 85.0
ACCURACY	82.5%	69.8 – 97.9
KAPPA	0.63	

P < 0.001

TableNo10: Comparison Between Clinical Diagnosis And Arthroscopy For Complete Tear

CLINICAL DIAGNOSIS	ARTHROSCOPY		TOTAL
	COMPLETE TEAR	NORMAL	
COMPLETE TEAR	29	2	3

NORMAL	4	17	2
TOTAL	33	19	5

		CONFIDENCE LIMIT
SENSITIVITY	87.8%	71.8 – 96.6
SPECIFICITY	89.5%	66.9 – 98.7
POSITIVE PREDICTIVE VALUE	93.5%	78.6 – 99.2
NEGATIVE PREDICTIVE VALUE	80.9%	58.1 – 94.5
ACCURACY	88.5%	72.5 – 97.4
KAPPA	0.76	

P < 0.001

TableNo11: Comparison Between Mri And Arthroscopy For Acl Tear

MRI	ARTHROSCOPY		TOTAL
	TEAR	NORMAL	
TEAR	37	4	41
NORMAL	1	15	16
TOTAL	38	19	57

		CONFIDENCE LIMIT
SENSITIVITY	97.4%	86.2 – 99.9
SPECIFICITY	78.9%	54.4 – 93.9
POSITIVE PREDICTIVE VALUE	90.2%	76.8 – 97.3
NEGATIVE PREDICTIVE VALUE	93.7%	69.8 – 99.8
ACCURACY	91.2%	78.2 – 99.7
KAPPA	0.80	

P < 0.001

TableNo12: Comparison BetweenMri And Arthroscopy For Complete Acl Tear

MRI	ARTHROSCOPY		TOTAL
	COMPLETE TEAR	NORMAL	
COMPLETE TEAR	32	1	33
NORMAL	0	15	15
TOTAL	32	16	48

		CONFIDENCE LIMIT
SENSITIVITY	100%	89.1 – 100
SPECIFICITY	93.7 %	69.8 – 99.8
POSITIVE PREDICTIVE VALUE	96.9%	84.2 – 99.9
NEGATIVE PREDICTIVE VALUE	100%	78.2 – 99.9
ACCURACY	97.9%	82.9 – 99.6
KAPPA	0.95	

P < 0.001

TableNo13: Distribution Of Primary Signs For Complete Acl Tear

	COMPLETETEAR	NORMAL
INCREASED SIGNAL INTENSITY	27	5
ABNORMAL ANGLE / AXIS	28	1
DISCONTINUITY	17	0
NONVISUALISTION	2	0

Abnormal axis was the most sensitive & specific sign for diagnosing complete ACL tear.

Table No 14: Increased Signal Intensity

INCRESED SIGNAL INTENSITY	ARTHROSCOPY		TOTAL
	COMPLETE TEAR	NORMAL	
PRESENT	27	5	31
ABSENT	6	14	20
TOTAL	33	19	52

		CONFIDENCE LIMIT
SENSITIVITY	81.8%	64.5 – 93.0
SPECIFICITY	73.6%	48.8 – 90.8
POSITIVE PREDICTIVE VALUE	84.4%	67.3 – 97.8
NEGATIVE PREDICTIVE VALUE	70%	45.8 – 88.1
ACCURACY	78.8%	58.9 – 96.9
KAPPA	0.55	

P < 0.001

Table No 15: Abnormal Angle / Axis

ABNORMAL ANGLE/AXIS	ARTHROSCOPY		TOTAL
	COMPLETE TEAR	NORMAL	
PRESENT	28	1	29
ABSENT	5	18	23
TOTAL	33	19	52

		CONFIDENCE LIMIT
SENSITIVITY	84.8%	68.1 – 94.9
SPECIFICITY	94.7 %	73.9 – 99.9
POSITIVE PREDICTIVE VALUE	96.5 %	82.2 – 99.9
NEGATIVE PREDICTIVE VALUE	78.3%	56.3 – 92.5
ACCURACY	88.5%	72.8 – 97
KAPPA	0.76	

P < 0.001

Table No 16 Discontinuity

DISCONTINUITY	ARTHROSCOPY		TOTAL
	COMPLETE TEAR	NORMAL	
PRESENT	17	0	17
ABSENT	16	19	35
TOTAL	33	19	52

		CONFIDENCE LIMIT
SENSITIVITY	51.5%	33.5 – 69.2
SPECIFICITY	100%	82.4 – 100
POSITIVE PREDICTIVE VALUE	100%	80.5 – 100
NEGATIVE PREDICTIVE VALUE	38%	36.6 – 71.2
ACCURACY	40.4%	52.8 – 90.1
KAPPA	0.44	

P < 0.001

TableNo17: Nonvisualistion

NONVISUALISATION	ARTHROSCOPY		TOTAL
	COMPLETE TEAR	NORMAL	
PRESENT	2	0	2
ABSENT	31	19	50
TOTAL	33	19	52

		CONFIDENCE LIMIT
SENSITIVITY	6%	0.7 – 20.2
SPECIFICITY	100%	82.4 – 100
POSITIVE PREDICTIVE VALUE	100%	15.8 – 100
NEGATIVE PREDICTIVE VALUE	38%	24.6 – 52.9
ACCURACY	40.4%	29.9 – 63.1
KAPPA	0.04	

P = 0.527 (Not significant)

Table No 18: Increased Signal Intensity + Abnormal Axis

INCREASED SIGNAL+ ABNORMAL AXIS	ARTHROSCOPY		TOTAL
	COMPLETE TEAR	NORMAL	
PRESENT	24	0	2
ABSENT	9	19	2
TOTAL	33	19	5

		CONFIDENCE LIMIT
SENSITIVITY	72.7%	54.5 – 86.7
SPECIFICITY	100%	82.4 - 100
POSITIVE PREDICTIVE VALUE	100%	85.8 - 100
NEGATIVE PREDICTIVE VALUE	67.9%	47.6 – 84.1
ACCURACY	82.7%	64.5 – 96.7
KAPPA	0.66	

P < 0.00

Abnormal axis combined with abnormal signal were the most useful signs for diagnosing complete ACL tear with 100% specificity and positive predictive value.

TableNo19: Distribution Of Secondary Signs For Acl Tear

	TEAR(38)	NORMAL(19)
BONE CONTUSION	20	3
ANTERIOR TIBIAL TRANSLATION	23	3
UNCOVERED MENISCUS	19	2
PCL BUCKLING	17	3
DEEP LATERAL NOTCH	8	1

Anterior translation of tibia and bone contusion were the most useful secondary signs in predicting ACL status.

TableNo20: Bone Contusion

BONE CONTUSION	ARTHROSCOPY		TOTAL
	TEAR	NORMAL	
PRESENT	20	3	23
ABSENT	18	16	34
TOTAL	38	19	57

		CONFIDENCE LIMIT
SENSITIVITY	52.6%	35.8 – 69
SPECIFICITY	84.2%	60.4 – 96.6
POSITIVE PREDICTIVE VALUE	86.9%	66.4 – 97.2
NEGATIVE PREDICTIVE VALUE	47.1%	29.8 – 64.9
ACCURACY	63.2%	49.5 – 88.4
KAPPA	0.30	

P < 0.01

Table No 21: Anterior TibialTranslation

ANTERIOR TIBIAL TRANSLATION	ARTHROSCOPY		TOTAL
	TEAR	NORMAL	
PRESENT	23	3	2
ABSENT	15	16	3
TOTAL	38	19	5

		CONFIDENCE LIMIT
SENSITIVITY	60.5%	43.4 – 75.9
SPECIFICITY	84.2%	60.4 – 96.6
POSITIVE PREDICTIVE VALUE	88.5%	69.9 – 97.6
NEGATIVE PREDICTIVE VALUE	51.6%	33.0 – 69.8
ACCURACY	68.4%	51.8 – 83.5
KAPPA	0.38	

P< 0.01

Table No 22: Uncovered Posterior Horn Of Lateral Meniscus

UNCOVERED LATERAL MENISCUS	ARTHROSCOPY		TOTAL
	TEAR	NORMAL	
PRESENT	19	2	21
ABSENT	19	17	36
TOTAL	38	19	57

		CONFIDENCE LIMIT
SENSITIVITY	50.0%	33.4 – 63.6
SPECIFICITY	89.5%	66.9 – 98.7
POSITIVE PREDICTIVE VALUE	90.5%	69.6 – 98.8
NEGATIVE PREDICTIVE VALUE	47.2%	30.4 – 64.5
ACCURACY	63.2%	46.5 – 79.8
KAPPA	0.32	

P< 0.01

TableNo23: Pcl Buckling

PCL BUCKLING	ARTHROSCOPY		TOTAL
	TEAR	NORMAL	
PRESENT	17	3	2
ABSENT	21	16	3
TOTAL	38	19	5

		CONFIDENCE LIMIT
SENSITIVITY	44.7%	28.6 – 61.7
SPECIFICITY	84.2%	60.4 – 96.6
POSITIVE PREDICTIVE VALUE	85.0%	62.1 – 96.8
NEGATIVE PREDICTIVE VALUE	43.2%	27.1 – 60.5
ACCURACY	57.9%	39.5 – 72.9
KAPPA	0.23	

Table No 24: Deep Lateral FemoralNotch

DEEP NOTCH	ARTHROSCOPY		TOTAL
	TEAR	NORMAL	
PRESENT	8	1	9
ABSENT	30	18	48
TOTAL	38	19	57

		CONFIDENCE LIMIT
SENSITIVITY	21.1%	9.6 – 37.4
SPECIFICITY	94.7%	73.9 -- 99.9
POSITIVE PREDICTIVE VALUE	88.9%	51.7 – 99.7
NEGATIVE PREDICTIVE VALUE	37.5%	23.6 – 52.6
ACCURACY	45.6%	33.4 – 63.9
KAPPA	0.11	

V. Discussion

MRI knee joint was performed on 57 patients who were referred to Department of Radiology from orthopaedic department with history of knee trauma and knee pain for the evaluation of ACL tear and its associated injuries.

Out of 57 patients, 41 (72%) were male patients and 16(28%) were femalepatients.32(78%)of41malepatientshadtearsand6(37%)of16female patients had tears. The sex of the patient was found to be significantly associated with ACL tears ($p < 0.01$). Male preponderance may be related to more outdoor activity, sports participation and more usage of vehicles. In this study population a male patient with knee injury was two times more likely to haveatornACL

Thesepatientswereintheagegroupranging from14to64years.Outof 57 patients, 34 (60%) were in the age group 20-40 years. Out of 57 knee examined,30(53%)wererightsideand27(47%)left.20patientshadACLtear on left side and 18 on the right side. In our study, patient with left knee injury was1.4timesmorelikelytohaveACLtear.

57 patients underwent clinical examination for ACL tear. Both anterior drawerandLachmantestweredone.Byclinicalexamination32wereclassified asACLtearand25asnormal.

The positive predictive value for detecting complete tear was 93.5%. Out of 25 clinically reported normal ACLS 4 turned out to be complete tear. The sensitivity for detection of ACL tear was 78.9% and for complete tear was 87.8%. 3 patients with clinically missed ACL complete tear had bucket handle medial meniscal tears. Joong Lee et al and his associates showedsensitivitiesof79%foranteriordrawerand87%forLachmantestfor diagnosis of ACL tear. Clinical examination also missed 4 partial tears out of 5 arthroscopicallyconfirmedACLpartialtear.

Patients with knee trauma and knee pain were subjected to MR knee joint. ACL evaluation was done by scrutinizing sagittal, axial and coronal sections. Using sagittal images tibial and midsubstance of ACL was evaluated and also the alignment to femoral intercondylar line noted. Axial and coronal images were used to visualize the femoral attachment of ACL.

A diagnosis of complete tear of ACL was based on the presence of the following primary findings: a) abnormal high signal intensity within ACL b) abnormalaxis/angle(fibresnotparalleltointercondylarlineofBlumensaat)c) discontinuityofthefibresd)nonvisualistionofACL. For the diagnosis of partial tears the direct signs include focal increase in signal intensity, focal angulation, ligament enlargement and partial discontinuity.

The primary signs were evaluated and ACL status classified as normal, partial or complete tear. Of the 38 arthroscopically confirmed ACL tears, 33 were complete and 5 were partial tears. On evaluation according to the site of tear, isolated midsubstance tear was noted in 25 (66%). Isolated femoral and tibial attachment tear were reported in 5% each. In 9arthroscopically confirmed tears the exact location of tear could not be identified as it seems to involve both mid substance and femoral attachment. The results in our study are similar to the study by Remer et al and Resnick who reported 70% tears in midsubstance, 5-20% near femoral attachment and 3-10% at tibial attachment. Lakhar, Rajagopal and Rai et al studied 78 ACL tears and concluded that midsubstance was the most common tear location seen in 66.7% ofpatients.

As shown in table 12, of the 33 arthroscopically proved complete ACL tears, 32 had complete tears proved by MR having 96.9% sensitivity, 29 had positive clinical examination with 87.8% sensitivity compared to sensitivity of 94% for MRI and 89% for clinical examination by Joong K. Lee et al. Mink et al reported an accuracy of 95% for detection of complete ACL tear on MRI with 9.5% false positives and 4.5% false negatives. Our study showed an accuracy of 97.9%, positive predictive value of 96.9% and negative predictive value of 100% for complete tear. A weighted Cohen's Kappa coefficient measure of complete ACL tear diagnosis was found to be 0.76 for clinical evaluation and 0.95 for MRI. Of the 19 arthroscopically proved normal ACLs, 15 had negative MR findings and 3 patients had increased signal intensity and reported as partial tear. As reported by Umans et al, 1995 this may be due to partial volume averaging of intercondylar notch fluid.

Primary findings were present in all the patients with ACL tears. Twenty eight (84%) of 33 complete tear patients had more than one primary finding. 15 patients had two findings and 13 patients had three findings. Abnormal signal intensity of ACL was present in 27 of 33 arthroscopically confirmed complete ACL tears giving a sensitivity of 81.8% and accuracy of 80.4% in our study. The results are similar to 79% sensitivity shown by Lee et al and his associates in their study. Abnormal Blumensaat angle or axis was seen in 28 of 33 complete tears givingasensitivityof84.8andpositivepredictivevalueof96.5%.Theaccuracy fordiagnosingcompleteACLtearwas88.5%andKappavaluewas0.76.Of19 arthroscopically confirmed normal ACLs only one patient had abnormal axis giving a specificity of 94.7%. This is similar to the results obtained by Patricia Robertsonetalsensitivityof84%andaccuracyof84%andkvalueof0.41for thediagnosisofcompleteACLtears.

Complete discontinuity was present in 17 patients out of 33 complete tears. It was not seen any of arthroscopically confirmed normal ACLs giving 100%specificity.Howeverthesensitivitywas51%andtheaccuracywas40.4% fordiagnosingcompleteACLtear.KwanseopLeeetalstudiedpaediatricknees andshowedsensitivityof21%andspecificityof100%fordiagnosingcomplete tear.

Nonvisualisation of ACL was seen in 2 patients of 33 complete ACL tears. Even though specificity was 100%, the sensitivity was 6%, Kappa value 0.04% which means poor correlation. P value was 0.52 and not significant for diagnosing ACL tear. In our study, abnormal axis was the single most useful sign for diagnosing complete ACL tear with kappa value of 0.76. Combination of abnormalaxiswithabnormalsignalintensityhad72.7%sensitivitywith100% positive predictive value and specificity. They were the most useful signs in diagnosing complete ACL tear with combined kappa value 0.66 which means goodagreement. A medullary signal intensity pattern consistent with bone bruise was observed in 23 patients. It was present in 19 of 33 complete tear, 1 of 5 partial tear and 3 of 19 normal ACLs.

The sensitivity of bone bruise for predicting ACL tear was 52.6% and specificity was 84.2% in our study in comparison to sensitivity of 44% and specificity of 93% in the study by Glenn A. Tung et al. He also noted that the sensitivity increased to 73% when MRI was done with in9 weeks of injury. Gentili et al showed sensitivity of 54% and specificity of 100% for bone bruise in lateral compartment for predicting ACL tear. As per table no 21 anterior tibial translation > 5mm showed sensitivity of 60.5%, specificity of 84.2 and p value < 0.01 for diagnosing ACL tear. Comparatively in a study by AmilcareGentili et al, the sensitivity was 63% and the specificity 80%. Vahey et al reported 58% sensitivity, 93% specificity, and 69% accuracy for ACL tears.

Uncovered posterior horn of lateral meniscus in our study showed specificity of 89.5%, positive predictive value of 90.5% but sensitivity of only 50%. Maccauley et al reported sensitivity of 56% and specificity of 97% in his study. Buckled PCL was seen in 17 (44.7%) of 38 ACL tears and 3 of 19 normal ACLs with an accuracy of 57.9%. kappa value for predicting ACL status was 0.23 which means poor agreement. Robertson et al showed an accuracy of 76% and kappa value of 0.41 in his retrospective review of ACL tears.

Deep lateral condylopatellar sulcus >1.5 mm was observed in 8 (21.1%) of 38 ACL tears and 1(5.2%) of 19 normal ACLs in our study. This finding showed 94.7% specificity, 88.9% positive predictive value and only 21.1% sensitivity in our study. Warren et al found that only one (2%) of 47 patients with clinically intact ACLs had deep sulcus. In contrast, two (4%) of 52 patients with acute ACL tears and 13 (13%) of 101 patients with chronic ACL tears had a sulcus greater than or equal to 1.5 mm in depth. Cobby et al in his study showed deep notch in 5(12%) of 41 patients with ACL tears.

In our study only 6 arthroscopically confirmed partial tears were present of which 4 were reported correctly on MRI. Out of 8 MR reported partialtearsthreeturnedouttobenormalonarthroscopy.Thismaybedueto in acute haemarthrosis of knee partial volume averaging of fluid may result in increasedsignal.

Associated injuries included 19 meniscal tears, 16 involving medial menisci, 3 involving lateral menisci, 4 medial collateral ligament and 4 posterior cruciate ligament and one involving lateral collateral ligament. Medial meniscal tears were the most frequently associated injury in our study. In 15 patients, MRI findings of associated meniscal and PCL injuries resulted in early arthroscopic intervention.

VI. Summary

MRI knee joint along with clinical examination was done in 57 patients referred from orthopaedic department for evaluation of ACL tear and its associated injuries. Of 57 patients, 72% were male patients. 32 (78%) of 41 male patients had tears and 6(37%) of 16 female patients had tears. In this study population, a male patient with knee injury was two times more likely to have torn ACL.

The patients were in the age group 14 – 64 years. 60% of them were in theagegroup20–40.years.Inourstudyapatientwithleftkneeinjurywas1.4 moretimeslikelytohaveACLtear. MRI was extremely useful in diagnosing complete tear with 96.9% sensitivity, 97.9% accuracy and 100% negative predictive value whereas clinical examination had 87.8% sensitivity, 88% accuracy and 93.5% positive predictive value. A weighted Cohen's kappa coefficient measure of MRI diagnosis of completetearwasfoundtobe0.95,and0.76forclinicalexamination.Similarly for diagnosis of ACL tear, kappa value of MRI was found to be 0.80 and 0.63 for clinical examination. Values of kappa were classified as bad (less than 0.4), good (0.4-0.75) or excellent (greater than 0.75), following Landis and Koch's criteria.

Primary findings were present in all complete ACL tear patients. Abnormal axis($p<0.001$) was the single most useful sign for diagnosing complete ACL tear with 84.8% sensitivity, 96.5% positive predictive value & specificity of 94.7%. Combiningabnormal signal intensity and axis increased the specificity and positive predictive value to 100% with sensitivity of 72.7%. Of 5 arthroscopically proved partial tears, one tear was missed by MRI and four by clinical examination. MRI showed poor specificity for diagnosing partial tears as three reported in MRI as partial tear found out be normal on arthroscopy.

Regardinglocationoftears,66%wereseeninmidsubstance,5%eachin femoralandtibialattachmentand24%wereseentoinvolvebothmidsubstance andfemoralattachment.

On evaluation of secondary signs to predict ACL status, bone contusion and anterior tibial translation were the most useful with specificities of 84.2%, 84.2% and sensitivities of 52.6% and 60.5% respectively. Because primary signs directly evaluate the ACL and are seen in all patients with complete tears, it is the primary signs that form the basis for diagnosing ACL tear.

MRI also helped in diagnosing associated injuries with ACL tears which helped in planning management. MRI showed 16 medial meniscal tears, 3 lateral meniscal tears, 4 MCL, 4 PCL and 1 LCL tear associated with ACL tears. Medial meniscal tear was the most common associated injury with ACL tear in our study.

VII. Conclusion

High spatial resolution MR imaging with quadrature knee coil is accurate for the detection of complete ACL tears.

In this study population, a male patient with knee injury was two times more likely to have torn ACL. Similarly a patient with injury to left knee was 1.4 times more likely to have ACL tear.

Primary findings from the essential basis for diagnosis of ACL tears as they are visualized in almost all complete tears. Abnormal axis of the ACL is the single most useful sign in diagnosing complete ACL tear. Midsubstance of the ACL is the most common location of tear. MRI showed associated meniscal and other ligament injuries, which helped in early surgical reconstruction of ACL. Medial meniscus tear was the most common associated injury in our study. So pre arthroscopic MRI helped in planning the timing of surgery in a considerable number of patients in our study.

Regarding partial tears, further studies are needed to evaluate the usefulness of MRI as the number of patients with partial tears is low in our study. Finally we conclude that High spatial resolution MR imaging is highly accurate for the detection of complete ACL tears with excellent arthroscopic correlation and is therefore an ideal & more accurate preoperative modality for diagnosing complete ACL tears & associated injuries.

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PLANNING

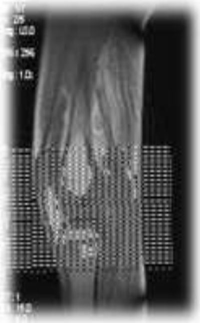
FIG 1 AXIAL PLAN

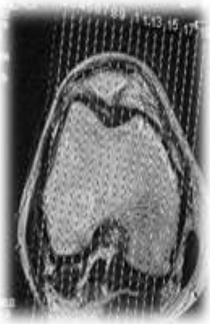
FIG 2 SAGITTAL PLAN


FIG 3 CORONAL PLAN


FIG 4 OBLIQUE SAG

NORMAL MR APPEARANCE OF ACL


FIG 5 T2W SAG


FIG 6 STIR SAG


FIG 7 T2W FS AXIAL


FIG 8 T2W COR

COMPLETE ACL TEAR


FIG 9 T2W SAG

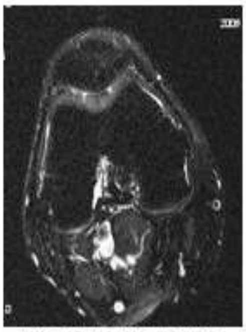
FIG 10 T2W FSAXIAL


FIG 11 STIR CORONAL

PARTIAL ACL TEAR

FIG 12 T2W SAG

FIG 13 GRE SAG

FIG 14 GRE AXIAL

PRIMARY SIGNS

INCREASED SIGNAL

FIG 15 STIR SAG

ABNORMAL AXIS

FIG 16 T2W SAG

DISCONTINUITY

FIG 17 STIR SAG

NONVISUALISATION

FIG 18 PDFS SAG

SECONDARY SIGNS

ARCUATE SIGN

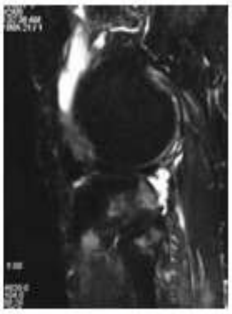

FIG 21 T2W FS SAG

ANTERIOR TIBIAL TRANSLATION

FIG 22 PDFS SAG

<u>LOCATION OF THE TEAR</u>

FEMORAL ATTACHMENT TEAR

FIG 27 T2W SAG

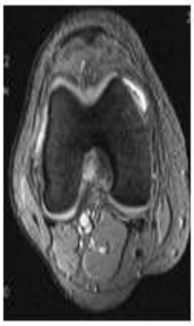

FIG 28 GRE AXIAL

MIDSUBSTANCE TEAR

FIG 29 STIR SAG

FIG 30 T2W FS AXIAL

TIBIAL ATTACHMENT TEAR

FIG 31 PD FS SAG

ASSOCIATED INJURIES

BUCKET HANDLE MEDIAL MENISCUS TEAR

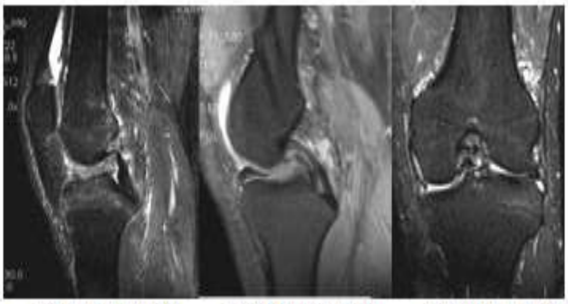

FIG 32 STIR SAG FIG 33 PDFS SAG FIG 34 STIR COR

MCL TEAR

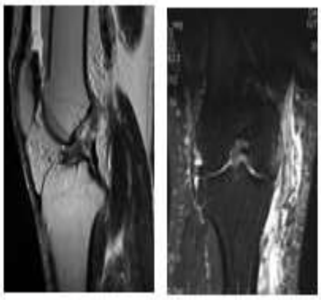

FIG 35 T2W SAG FIG 36 PD SAG

GRADE III TEAR MEDIAL AND LATERAL MENISCUS

FIG 37 STIR COR FIG 38 T2W SAG FIG 39 STIR COR

PCL TEAR

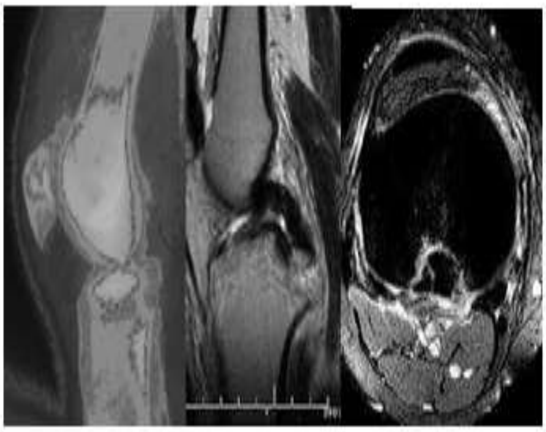

FIG 40 PLAIN RADIOGRAPH FIG 41 T2W SAG FIG 43 GRE AXIAL

ARTICULAR CARTILAGE INJURY

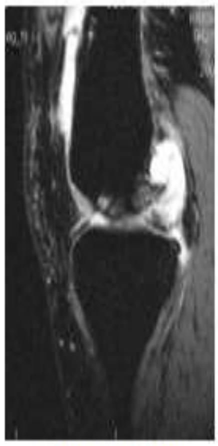

FIG 44 GRE SAG