DISSERTATION ON

MRI EVALUATION OF ANTERIOR CRUCIATE LIGAMENT TEARS WITH ARTHROSCOPIC CORRELATION

Submitted in partial fulfillment of

Requirements for

M.D. DEGREE BRANCH VIII RADIODIAGNOSI

Of

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY, CHENNAI.

MADRAS MEDICAL COLLEGE AND RESEARCH INSTITUTE

CHENNAI - 600 003.

SEPTEMBER 2006

CERTIFICATE

This is to certify that this dissertation titled "MRI EVALUATION OF ANTERIOR CRUCIATE LIGAMENT TEARS WITH ARTHROSCOPIC CORRELATION" submitted by Dr.S.NAKKEERAN, appearing for PART-II MD BRANCH VIII – RADIODIAGNOSIS DEGREE EXAMINATION IN SEPTEMBER 2006 is a bonafide record of work done by him under my direct guidance and supervision in partial fulfillment of regulations of the TAMILNADU Dr.M.G.R.MEDICAL UNIVERSITY, Chennai. I forward this to the Tamilnadu Dr.M.G.R.Medical University, Chennai, Tamilnadu, India.

Signature of the Guide & HOD
PROF.V.CHANDRASEHKAR,
MD., DMRD,
Head of Department,
Barnard Institute of Radiology,
MMC, Chennai.

Signature of the Director
PROF.T.S.SWAMINATHAN,
MD., DMRD., FICR,
Director,
Barnard Institute of Radiology,
MMC, Chennai.

Signature of Dean
PROF. KALAVATHY PONNIRAIVAN, Bsc., M.D.,
Dean, Madras Medical College,
Chennai – 600 003.

DECLARATION

I declare that this dissertation titled " MRI EVALUATION OF ANTERIOR CRUCIATE LIGAMENT TEARS WITH ARTHROSCOPIC CORRELATION " has been conducted by me under the guidance and supervision of PROF. Dr. V. CHANDRASEKAR, M.D., D.M.R.D. It is submitted in part of fulfillment of the requirement for the award of the M.D., Radiodiagnosis, September 2006 examination to be held under Dr.M.G.R. Medical University, Chennai. This has not been submitted previously by me for the award of any degree or diploma from any other University.

Dr.S.NAKKEERAN

ACKNOWLEDGEMENT

I would like to thank Prof. KALAVATHY PONNIRAIVAN, B.Sc., M.D., Dean, Madras Medical College and Research Institute, for giving me permission to conduct the study in this Institution.

I express my sincere and heartfelt gratitude to my teacher and guide Prof. Dr. V. CHANDRASEKAR, M.D., D.M.R.D, H.O.D, Barnard Institute of Radiology, Madras Medical College for having encouraged me to take up this study. But for his guiding spirit, perseverance and wisdom this study would not have been possible.

I am greatly indebted to my Director and other Professors, Prof. Dr. T.S.SWAMINATHAN, M.B., M.D., D.M.R.D., F.I.C.R., Director, Barnard Institute Of Radiology, MMC, Prof. P. KUPPUSWAMY, M.D., D.M.R.D., Prof. N. KULASEKARAN, M.D., D.M.R.D., and Prof. A. P. ANNADURAI., M.D., D.M.R.D., for their support, valuable criticisms and encouragement.

I wish to thank all my Assistant Professors, Dr. P.UMAPATHY, D.M.R.D., Dr. SUNDARESWARAN, D.M.R.D., Dr. NESAM MANIVANNAN, D.M.R.D., Dr. R. RAVI, M.D., and Dr. S. BABU PETER, M.D., for their valuable suggestions and support.

I wish to thank all my fellow postgraduates for their valuable criticism and untiring help.

Last but not least my sincere thanks to all the patients who co-operated for this study without whom this study could not have been possible.

CONTENTS

INTRODUCTION

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.

Meniscus injury occurs in association with 50% of acute ACL tears, 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 associated joint damage.

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 ACL injury.
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 diagnosis but are invasive and costly. It can get unnecessary if ACL turns out to be normal.

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.

The continuing need for a better non invasive imaging modality for ACL 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

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.**

REVIEW OF LITERATURE

<u>REVIEW OF LITERATURE</u>

The anterior cruciate ligament (ACL) is a dense fibrous band composed of collagen fibrils. It is about 3.5cms long and 1cm in transverse diameter. ACL originates from the posteromedial aspect of the lateral femoral condyle and courses through the lateral intercondylar notch in an anterior, inferior, and medial direction. It inserts on the tibia approximately 23-mm posterior to the anterior edge of the tibia, just anterior and lateral to the medial intercondylar eminence (tibial spine). The ACL is not as strong as the PCL and it is less strong at its femoral origin than at its tibial insertion (*Resnick, 1995*).

ACL fascicles are organized into functional anteromedial and posterolateral bundles or bands (*Girgis et al)* that are named for their location relative to each other at tibial insertion (*Resnick, 1995*). The stronger anteromedial bundle tightens with flexion of the knee and probably resists anterior translation of the tibia in flexion. The posterolateral bundle tightens with knee extension and probably resists hyperextension. The physiologic property where part of the spiraled ACL is taut throughout the normal range of motion of the knee is termed isometry. Graft isometry is one goal of reconstructive surgery.

The ACL is an extrasynovial and intracapsular ligament. Bands of mesentery like synovium, arising from the posterior intercondylar region of the tibia, surround the cruciates (This accounts for fluid often seen anterior to the normal ACL and posterior to the PCL) on MRI. The extrasynovial location

also helps to explain why hemarthrosis may be delayed with acute ACL tear. The primary blood supply to the ACL derives from arteries to the surrounding synovial membrane. These in turn derive from branches of the middle geniculate artery piercing the posterior capsule. The central core of the ACL is relatively avascular. This may in part account for the generally ineffective healing of ACL tears. Tibial nerve terminal branches innervate the ACL.

MECHANISM OF INJURY

ACL tears occur with or without contact and with the knee in any position from flexed to fully extended. The most common contact mechanism of injury is the valgus/abduction "clip" injury. These injuries are common in football players and occur with a lateral blow to the partially flexed knee. Coexisting medial and lateral meniscal tears are common, as are medial collateral ligament injury.

Hyperextension or varus-hyperextension from an anterior blow (eg. injury from a motor vehicle accident or contact sports) is the second most common mechanism of ACL injury. The PCL or posterolateral structures are also frequently injured. With more severe hyperextension, the knee may dislocate; the popliteal neurovascular bundle or peroneal nerve may be injured in this setting.

A direct blow to the flexed knee with the ankle plantar flexed, as seen in turf injuries represents the third most common pattern of injury to ACL.

Increasingly, ACL tears are caused by noncontact mechanisms (*Stoller, 1997*). The pivot-shift mechanism is most commonly implicated. This twisting injury typically occurs with rapid simultaneous deceleration and directional maneuvers in skiers, football, basketball, or soccer players. The flexed knee incurs a valgus load, with internal rotation of the tibia or external rotation of the femur. Associated meniscal tears, collateral ligament injuries, and lateral patellar subluxation are common.

Noncontact hyperextension, such as that occurring in a gymnast or cheerleader who misses a landing, is another mechanism of injury that may result in ACL injury.

EVALUATION OF ACL INJURY

Diagnosis of ACL injury can be done by

i. **History and physical examination**
ii. **MRI**
iii. **CT arthrography**
iv. **Arthroscopy**
v. **Arthrotomy**

The skilled clinician can diagnose up to 90% of ACL tears by history and physical examination (*Johnson and Warner; Lee et al, 1998*). Patients typically report an audible "pop" and giving way at the time of injury. A knee effusion usually develops over the next 24 hours. A tear is confirmed at physical examination using primarily the Lachman test (*Swenson et al, 1995*). Anterior

drawer and pivot shift tests are often helpful and arthrometric examination may be contributory. Diagnosis may be difficult in large patients, in patients with strong secondary muscular restraints, and in the acute injury setting where there is soft tissue swelling and guarding. Partial ACL tears are especially difficult to diagnose by physical examination (*Noyes et al, 1989).* MRI may provide pivotal diagnostic information about the ACL in all of these settings (*Otani et al, 2001; Munk et al, 1998).*

Plain radiography of acute ACL injuries may show soft tissue swelling and haemarthrosis. An avulsion off anterior tibial eminence, lateral tibial rim fracture (segond fracture), posterior fracture of lateral tibial plateau and an osteochondral fracture of lateral femoral condyle may be associated with ACL injuries and can be identified in plain radiographs.

***Bernard Stallenberg. Gevenois, A. Sintzoff, Matos, Andrianne and Sruyven et al* studied 25 plain radiographs of ACL tear patients. They concluded that impaction of lateral femoral condyle on the lateral tibial condyle and avulsion of posterior tibial capsular junction represents the most frequent indirect radiographic sign of ACL tear.**

Normal ACL was delineated as hyperechoic images on ultrasound in sagittal and transverse sections. On the other hand, no image of the ligament could be seen when the ligament was ruptured. However it is highly operator dependent and complete evaluation of all knee joint structures could not be possible. In many acute injured patients sonographic window to visualize ACL is poor.

Richter J, David A, Pape HG, Ostermann PA and Muhr G et al **evaluated ACL sonographically in 74 patients and they concluded that ultrasound diagnosis revealed 88% of all complete ACL ruptures.**

Spiral CT arthrography is an accurate method for diagnosing ACL and meniscal tears. The direct signs of ACL tear are discontinuity with intra ligamentous contrast material, discontinuity of ACL with fatty tissue in expected ACL course, abnormal course and abnormal shape. Indirect signs of ACL tears at spiral CT arthrography included anterior translocation of the lateral tibial plateau, abnormal depression of the lateral femoral condyle notch and fracture of the posterior margin of the lateral tibial plateau.

Bruno C.Vanderberg et al **studied 125 patients and compared dual detector CT arthrography findings with arthroscopy findings. The sensitivities and specificities for the detection of ACL tears were 90% and 96%, respectively. The sensitivity and specificity for the detection of meniscal tears in knees with abnormal ACLs were 92% and 88%, respectively. The sensitivity values for the detection of meniscal lesions in knees with abnormal ACLs at spiral CT arthrography could be superior to those obtained at conventional MR imaging, which have been reported to range between 69% and 88% but this observation remains to be assessed in a comparative study. The location and configuration of meniscal lesions observed in knees with abnormal ACLs could partially account for the decreased sensitivity of MR imaging. The meniscal separation and peripheral tears that are associated with ACL tears**

(can be missed at MR imaging) and could be better detected at spiral CT arthrography.

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.

MR APPEARANCE OF NORMAL ACL

Normal ACL shows low to intermediate signal intensity on all pulse sequences slightly higher than that of PCL.

On sagittal images ACL should be ruler straight although mild sagging convex inferiorly may be noted with knee flexion. Normal ACL is parallel to the intercondylar line of Blumensaat. The distal ACL demonstrates relatively increased signal presumably due in part to divergence of fascicles distally. The proximal ACL at its origin is often less well seen on sagittal images than the remainder of the ACL, owing in part to proximity to adjacent intercondylar roof.

The ACL projects laterally in the intercondylar notch in the coronal plane; the PCL projects medially. In the coronal plane, normal ACL fascicles are often few in number and attenuated in appearance.

In the axial plane, the proximal ACL appears as an elliptical low signal intensity band adjacent to the lateral wall of the upper intercondylar notch. It gradually moves away from the wall and splits into a horseshoe (fan-shaped)

array of fascicles as it approaches its tibial insertion (*Roychowdhury et al, 1996*). The distal ACL is thus difficult to evaluate critically on axial images whereas proximal ACL is best evaluated in axial images.

The AMB forms the anterior border of the ACL. The PLB representing the bulk of ACL may display more intermediate signal intensity on T1W images. The axial plane is helpful in spatially identifying sites of tears corresponding to the AMB and the PLB.

The individual low signal intensity fibers may be separated by linear stripes of intermediate to bright signal intensity on T1W images. These stripes are believed to represent fat and synovium and are usually identified at the tibial attachment of ACL.

MRI EVALUATION OF ACL INJURY

The protocol requirements of ACL imaging are sequences in all 3 planes (sagittal, coronal, axial) that include both T1-weighted (or proton-weighted) and T2-weighted sequences in the sagittal plane. When supine, patients are allowed to naturally externally rotate their legs. The sagittal plane usually approximates the optimal imaging plane along the long axis of the ACL.

While the sagittal imaging plane is often most helpful in ACL evaluation, any of the 3 imaging planes may prove pivotal in a given case. Coronal imaging is especially useful for evaluation of proximal tears (*Remer et al, 1992*). Axial sequences are also very useful for evaluating the proximal and middle aspect of the ACL. Axial images provide a unique cross-sectional

viewpoint free of partial volume artifact with the intercondylar roof (*Fitzgerald et al, 1993; Roy chowdhury et al, 1997*).

The ACL is usually seen to greatest advantage on T2-weighted sequences, as opposed to short-TE T1-weighted or gradient-echo images. This is due in part to increased signal seen in ligaments and tendons in short-TE sequences owing to magic-angle effect and other factors. Fast spin echo T2-weighted sequences with fat saturation are obtained faster than conventional T2-weighted sequences.

***Katahira et al* (2001) reported increased diagnostic accuracy prescribing images parallel to the long axis of the ACL off of an oblique- sagittal image (a "double-oblique" sequence). This extra sequence was T2-weighted with 3-mm slice thickness.**

***Joong K Lee, Lawrence Yao, T.Phelps, R.Wirth, John Czajka and Jeffery Lozman et al* studied 79 patients and compared MR findings with the findings of two common clinical tests anterior drawer and Lachman test in arthroscopically proven ACL tears. The sensitivity for MR imaging was 94% compared with 78% for anterior drawer test and 89% for Lachman test with 100% specificity for all three.**

Most ACL tears occur (70-90%) in the midsubstance, 7-20% proximally near its origin. Only 3-10% occurs distally at the tibial attachment *(Remer et al, 1992; Resnick, 1995*). Studies report 92-100% sensitivity and 82-100% specificity of MRI for diagnosis of ACL tears (*Robertson et al, 1994; Mink et*

al, 1988; Fitzgerald et al, 1993; Brandser et al, 1996; Lee et al, 1988; Pope, 1993; Tung et al, 1993).

BN Lakhar, KV Rajagopal and P. Rai et al studied 173 patients of which 78 showed ACL tears. They reported 98.7% sensitivity, 98.9% specificity, 98.1% positive predictive value and 98.8% negative predictive value for MRI in diagnosis of ACL tear in correlation with arthroscopy.

However, sensitivity is significantly decreased if other major ligamentous injuries are present in the knee (*Rubin et al, 1998*). Less data are available on children. Decreased accuracy of MR has been reported in preadolescents *(McDermott et al, 1998*), but a recent study on patients aged 5-16 years demonstrated a sensitivity of 95% and a specificity of 88% (*Lee et al, 1999*).

Definitions of primary and secondary signs for tears of Anterior Cruciate Ligament (ACL)

PRIMARY SIGNS

1) Abnormal signal intensity: Increased signal intensity on T2W images within ACL
2) Abnormal axis/angle>10 deg: when the fibers are not parallel to intercondylar line of Blumensaat in the sagittal images.
3) Discontinuity : when there is discontinuity of fibers of ACL focal or diffuse in sagittal or coronal images
4) Complete nonvisualisation of ACL on all three imaging planes

Primary signs of acute ACL tear (i.e., abnormalities involving the ACL proper) allow high accuracy in the diagnosis of ACL injury, even in the absence of secondary signs (*Brandser et al, 1996; Lee et al, 1998; Mink et al, 1988; Tung et al, 1993; Falchook et al, 1996).*

***Eric Brandser, Riley, Berbaum, El Khoury and Lee Bennet* et al studied the independent value of primary and secondary signs. They concluded that it is the primary signs that form the basis for determining the status of the ACL.**

***BN Lakhar, KV Rajagopal and P. Rai et al* studied 173 patients of which 78 showed ACL tears. They found that hyperintensity was the most common sign seen in 52 (67%) patients.**

***Glenn Tung, Davis, Wiggins and Paul Fadale et al* studied 103 MR examinations in 99 patients and they concluded that abnormal appearance of ACL on sagittal images is the single most sensitive and specific sign of ACL tear.**

***Lee, Siegel, Lau, Hildebolt and Matava et al* studied the accuracy of MR findings of ACL tear in paediatric population aged 5-16 years and they concluded that primary and secondary signs are highly specific and are useful for diagnosis.**

SECONDARY SIGNS

1) **Bone contusion: Medullary bright signal abnormalities seen on STIR images may be due to microfracture, edema or hemorrhage.**

2) Anterior tibial translation: At the level of midlateral femoral condyle draw tangential lines along posterior cortical margin of femur and tibia and measure the distance. >5mm is abnormal.

3) Uncovered posterior horn of lateral meniscus: This sign is present, if on sagittal images tangential line drawn along posterior cortical margin of lateral tibial plateau intersects any part of posterior horn of lateral meniscus.

4) PCL buckling: PCL is said to be hyperbuckled if any portion of its posteriosuperior border is concave. Conversely PCL is normal if this border is straight or convex for its entire length.

5) Deep lateral femoral notch: Draw a tangent across the sulcus on articular surface of lateral femoral condyle and measure from this line to deepest point of sulcus. Depth greater than 1.5mm is abnormal.

6) Posterior PCL line: Draw a line tangent to posterior margin of distal portion of PCL. If this tangent does not intersect posterior cortex of femur within 5 cm of its distal end, this sign is said to be present.

MRI findings of an ACL tear apart from abnormalities of the ACL proper are termed secondary signs. The sensitivity of these signs is limited *(Brandser et al, 1996*), thus the absence of secondary signs in no way excludes ACL disruption. However, certain signs discussed below have substantial (>80%) specificity.

***Thomas vahey, Joseph hunt and Donald Shellbourne et al* evaluated the anterior tibial translocation in relation to femur as a predictor of ACL tear.**

Translocation of 5mm or more had 58% sensitivity, 93% specificity and 69% accuracy for ACL tear. All knees with subluxation of 7mm or more had tore ACL. They also concluded that buckling of ACL is less sensitive and less accurate than anterior translocation as an indicator of ACL disruption.

McCauley et al studied posterior displacement of lateral meniscus in relation to tibia on sagittal images as a predictor of ACL tear. A vertical line constructed through posterior cortical margin of tibia intersecting lateral meniscus had 97% specificity 56% sensitivity for ACL tear.

***Mark Cobby, Schweitzer and Resnick et al* studied 103 patients and concluded that lateral femoral condylopatellar sulcus deeper than 1.5mm was a reliable indirect sign of ACL tear. No patient with a normal ACL had a sulcus greater than 1.2mm in depth.**

***Brian J Murphy et al* and his associates studied MRI bone signal abnormalities in the posterolateral tibial plateau and lateral femoral condyle and they concluded that bone impaction at the above areas suggest a diagnosis of complete ACL tear.**

***Glenn A. Tung, Lawrence M. Davis Michael E. Wiggins, Paul D. Fadale et al* noted 73% prevalence of bone bruise in patients with ACL tear who underwent imaging within 9 weeks of knee injury and, in 91% of cases, the lateral compartment was involved. None of the patients with ACL tear had bone bruises when MR imaging was performed 9 weeks or longer after knee**

injury. In children, ligament laxity may allow a bone bruise to occur while the ACL is still intact.

Avulsion fracture of the proximal fibula (termed the "arcuate sign") was associated with ACL tear in 13 of 18 patients in one study *(Juhng et al, 2002*). This fracture is a marker for varus and hyperextension injury to the posterolateral structures. The "arcuate" sign or fracture is an avulsion fracture of the fibular head and styloid at the attachment of the lateral collateral ligament and biceps femoris tendon. Although the avulsion fracture may occasionally not be visualized on conventional radiographs, the presence of edema in the proximal fibula can be a helpful sign of this injury.

The Segond fracture is an elliptical, vertically oriented, 3 x 10 mm bone fragment paralleling the lateral tibial cortex, about 4-mm distal to the plateau. It has a 75-100% association with ACL tear (*Resnick, 1995*). In the acute setting, MRI often shows a bone bruise of the adjacent edge of lateral tibial plateau secondary to meniscotibial ligament avulsion. The adjacent Segond fragment maybe difficult to visualize *(Weber et al, 1991*). If observed, the bone fragment demonstrates a marrow-edema pattern.

***Karence Chan and Resnick et al* studied ten patients with posteromedial tibial plateu injuries retrospectively. All ten patients had ACL tears at MR imaging. Five patients had posteromedial tibial plateu fractures and five had posteromedial tibial plaeteu bruises. They concluded that fracture of posteromedial tibial plateu is predictive of an associated ACL tear.**

Buckling or redundancy of the PCL (Boeree and Ackroyd, 1992) occurs frequently with ACL tear but also occurs with hyperextension of the normal knee (*Gentili et al 1994*) and with quadriceps dysfunction.

The angle of PCL can also be used to evaluate ACL tears. *McCauley et al* reported PCL angle less than 105 degree was 72% sensitive and 86% specific for predicting ACL tears. The normal PCL angle is 113 to 114 degrees.

PARTIAL ACL TEAR

Partial tears of the ACL are common, accounting for 10-43% of all ACL tears (*Lee et al, 1998*). A tear involving less than 25% of the ACL has a favorable prognosis; a tear involving 50-75% of the ACL has a 50-86% probability of progressing to a complete tear (*Noyes et al, 1989*).

Partial tears are typically underdiagnosed on physical examination. It has been shown in cadavers that laxity is absent by physical examination and arthrometric testing when the anteromedial band of the ACL is transected (*Lintner et al, 1995*).

Several studies have documented suboptimal accuracy of MRI in the diagnosis of partial ACL tears (*Umans et al, 1995; Gentili et al, 1994; Lawrance et al, 1996*). Direct signs may include abnormal focal high signal intensity, focal angulation and ligament enlargement. However, focal increased signal intensity in the ACL is nonspecific (*Umans et al, 1995)* and may be difficult to differentiate from partial-volume averaging of adjacent intercondylar notch fluid. These limitations notwithstanding, MRI does allow

diagnosis of some partial tears missed on physical examination. Secondary signs of ACL injury are not useful in distinguishing partial from complete tear *(McCauley, et al, 1994*).

***Roy chowdhury et al* studied the usefulness of axial MR imaging for diagnosing and characterizing partial ACL tears as stable or unstable. Stable ACL include normal ligaments and stable partial tears. Unstable ACL include unstable partial tear and complete tear. On axial MR images stable ACLs were elliptical, attenuated or increased intrasubstance signal intensity whereas unstable ACLs were isolated ACL bundle, nonvisualisation and cloud like mass. They concluded that axial MR offers prognostic potential to distinguish which patients will have unstable ligaments and require ACL reconstruction.**

***Thomas N. Vahey, Dale R. Broome, Kossmas J. Kayes, Donald Shelbourne et al* studied the MR differential features of acute and chronic tears of ACL. Acute ACL tears can be accurately distinguished from intact ligaments as they are usually characterized by the presence of edema. The findings of acute tear include discrete edematous mass or smaller well defined edematous foci with disrupted ligament. All acute tears over 4 weeks of age had edematous foci. Chronic tears can have potentially confusing appearance due to presence of bridging fibrous scars that can mimic an intact ligament so correlation with history and clinical examination should help in these patients. The findings of chronic tear include nonvisualisation of the ligament, continuous band with focal angulation and visualization of ACL fragments but all without edema.**

An acute tear manifest by enlargement of the ACL and increased internal signal but with visible intact fascicles has been termed an interstitial tear". This should be differentiated from intraligamentous mucinous degeneration.

ARTHROSCOPY

The appearance of normal ACL varies from patient to patient, depending on its anatomy, the presence or absence of injury and the synovial covering.

In a normal ACL the synovial covering is usually thin with small capillaries coursing on the surface. If considerable synovitis is present retraction of ligamentum mucosum and other synovial tissues may be required to observe the underlying ACL. With complete rupture of ACL considerable hemorrhage within synovial tissues is evident. Careful probing and opening of its synovial sheath often demonstrate disrupted ACL bundles not evident during initial inspection.

A normal ACL feels taut or hard when hooked with a probing instrument. A torn ACL feels mushy without tension. A drawer or Lachman test can be performed by the assistant while ACL is directly viewed.

The tear is complete if there is marked pivotal shift, minimal resistance to probing and disruption of more than 90% of fascicles. The tear is classified as partial if there is mild pivotal shift, substantial resistance to probing and disruption less than 90% of fascicles.

Before the use of MR all patients underwent diagnostic arthroscopy. Diagnostic arthroscopy is invasive and considerably more expensive than MR and the accuracy is similar. The wide range of accuracy reports may be due to number of factors such as equipment, imaging technique and expertise of radiologist and arthroscopic surgeon. Arthroscopy should be viewed as an imperfect or relative gold standard for the diagnosis of these disorders, because stretching or intrasubstance injuries to ACL may go undetected despite positive MR findings.

MR imaging affected patient management by enabling selection of patients with a surgical lesion and obviating an invasive procedure in other patients. In addition to guiding treatment it helps in planning and timing of therapeutic arthroscopy before surgery.

MANAGEMENT OF ACL TEAR

Patient activity level (and expectations for activity in the future) is the most important factor guiding treatment choice (*Swenson et al, 1995*). Associated meniscal and ligamentous injuries, degree of laxity, age, and willingness to pursue vigorous postoperative physical therapy are other major determinants.

Primary repair is most successful when avulsion occurs at either femoral or tibial attachment. Patients with midsubstance tears are not good candidates for ACL repair. Primary ACL repair and intraarticular augmentation produce better results than primary ACL repair alone.

The surgical treatment that is strongly recommended in young athletes is either arthroscopic or open reconstruction of the ligament (followed by meniscal repair or partial meniscectomy of the meniscal tears). This should be performed right after the relief of the acute symptoms (usually three weeks later). Acute repair might be considered only when the tibial insertion of the ligament has been avulsed with a fragment of bone.

Patients with injuries to the posterolateral structures and ACL have significantly greater instability and usually require early reconstructions of both areas. Unrepaired posterolateral knee injuries predispose to early ACL graft failure (*Hughston et al, 1985).* If both PCL and ACL tears are present, reconstructive surgery is usually necessary. Meniscal repairs have a higher rate of failure in ACL-deficient knees than in ACL-reconstructed knees

Evidence exists that "late" ACL reconstruction decreases post-procedural stiffness. Surgery is delayed until most of the swelling has subsided and range of motion is restored (*Swenson et al, 1995*). However, MRI enables the diagnosis of coexisting injuries that may preclude a delayed approach. Bucket-handle meniscal tears and posterolateral knee injuries are examples of injuries that respond best to earlier intervention (*Veltri et al, 1994*).

MATERIALS AND METHODS

MATERIALS AND METHODS

A prospective study of 57 patients with history of knee trauma and pain referred from orthopaedic outpatient department was done in Barnard Institute of Radiology, Madras Medical College between March 2004 to Feb 2006. All 57 patients were subjected to MRI examination. MRI knee was performed using Siemens 1.5 Tesla superconducting MAGNETOM, using quadrature knee coil.

METHOD

Patient was placed in supine position with knee placed in 5-10 degree of external rotation and extension.

MR TECHNIQUE USED

A scout axial view was obtained to plan for sagittal and coronal sections (perpendicular and parallel to posterior femoral condylar line). If needed oblique sagittal sections for ACL were performed using coronal slice that shows the oblique course of ACL.

The sequences used were

a) **T2 weighted sequence**

TR – 3000ms	**TE – 104ms**
Averages – 2	**No. of slices – 17**
Slice thickness – 4mm	**FOV –150 mm**
Sagittal – 6 mins	**Axial – 6 mins**

b) **Short tau inversion recovery sequence(STIR)**

TR – 5210ms	**TE – 47**

TI - 160ms | **No of slices – 14 – 16**

Slice thickness – 3mm | **FOV – 200 mm**

Coronal – 5 mins

c) **Proton density fat sat sequence**

TR – 3000ms | **TE – 13**

Slice thickness – 4mm | **No of slices – 19**

Averages -2 | **FOV – 150 mm**

Sagittal – 3 mins

d) **T1 weighted sequence**

TR – 450ms | **TE – 12ms**

Slice thickness – 4mm | **No of slices – 19**

Averages - 2 | **FOV – 150 mm**

Sagittal – 4 mins

e) **Optional sequence**

i. **oblique T2W sag**

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. **Prior H/O surgery, arthroscopy**
ii. **Patients with MR incompatible devices or implants**
iii. **Patients with claustrophobia**
iv. **Patients on life support systems**

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

REPRESENTATIVE CASES

PLANNING

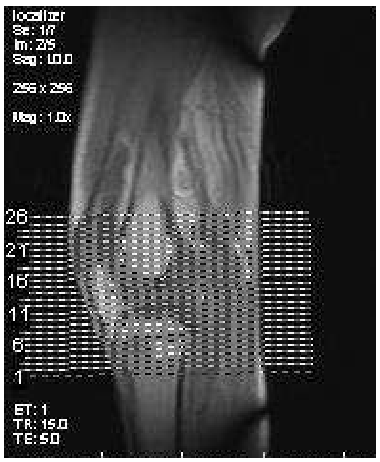


FIG 1 AXIAL PLAN

FIG 2 SAGITTAL PLAN

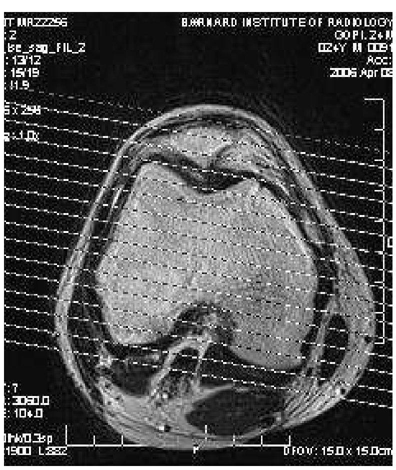


FIG 3 CORONAL PLAN

FIG 4 OBLIQUE SAG

NORMAL MR APPEARANCE OF ACL

FIG 5 T2W SAG

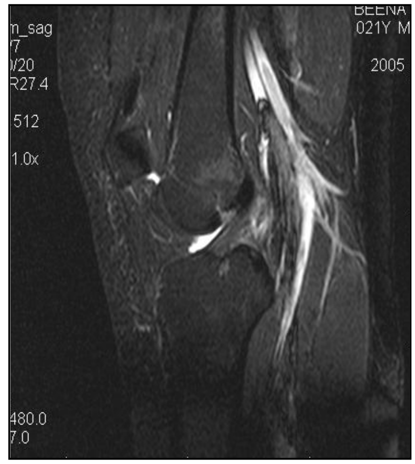


FIG 6 STIR SAG

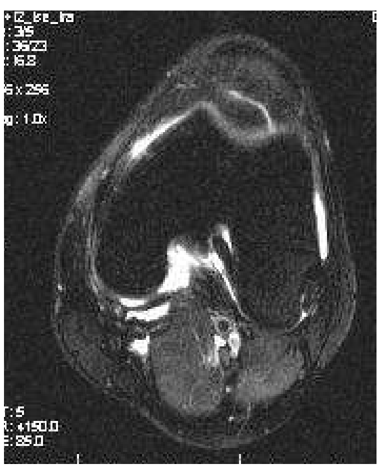


FIG 7 T2W FS AXIAL

FIG 8 T2W COR

COMPLETE ACL TEAR

FIG 9 T2W SAG

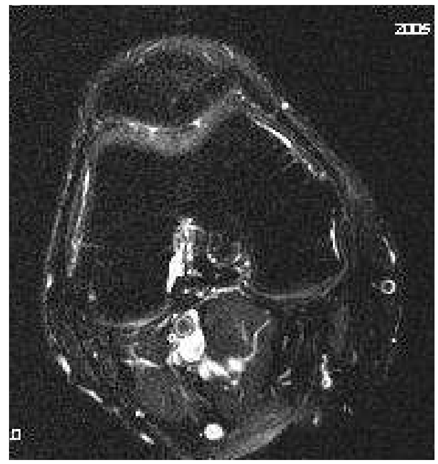


FIG 10 T2W FSAXIAL

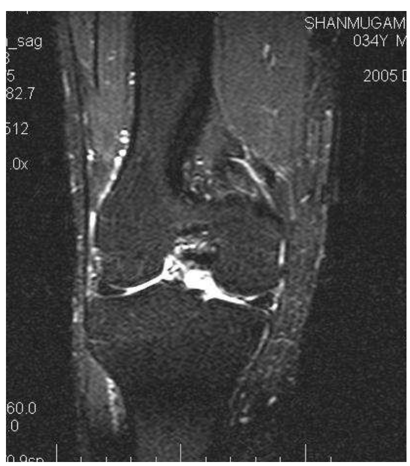


FIG 11 STIR CORONAL

PARTIAL ACL TEAR

FIG 12 T2W SAG

FIG 13 GRE SAG

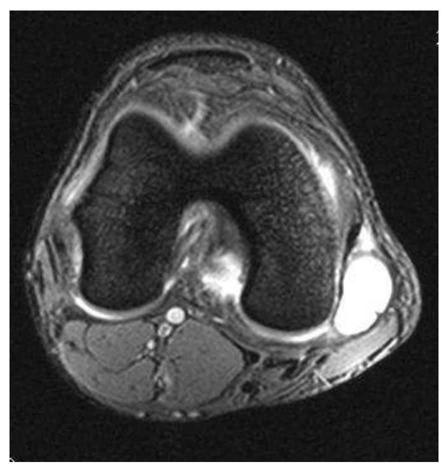


FIG 14 GRE AXIAL

PRIMARY SIGNS

INCREASED SIGNAL

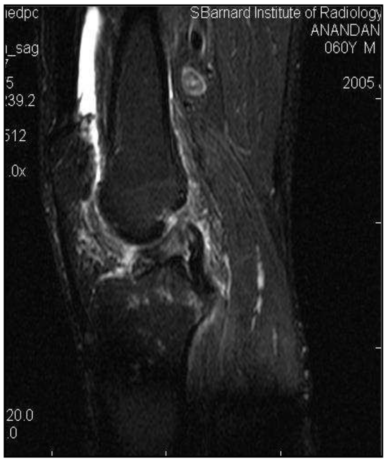


FIG 15 STIR SAG

ABNORMAL AXIS

FIG 16 T2W SAG

DISCONTINUITY

FIG 17 STIR SAG

NONVISUALISATION

FIG 18 PDFS SAG

SECONDARY SIGNS

BONE CONTUSION

POSTEROLATERAL TIBIAL PLATAEU INJURY

FIG 19 STIR SAG

POSTEROMEDIAL TIBIAL PLATAEU INJURY

FIG 20 STIR SAG

ARCUATE SIGN

FIG 21 T2W FS SAG

ANTERIOR TIBIAL TRANSLATION

FIG 22 PDFS SAG

SECONDARY SIGNS

UNCOVERED LATERAL MENISCUS

FIG23 PD FS SAG

PCL BUCKLING

FIG 24 STIR SAG

DEEP LATERAL FEMORAL NOTCH

FIG 25 PLAIN RADIOGRAPH

FIG 26 PD FS SAG

LOCATION OF TEAR

FEMORAL ATTACHMENT TEAR

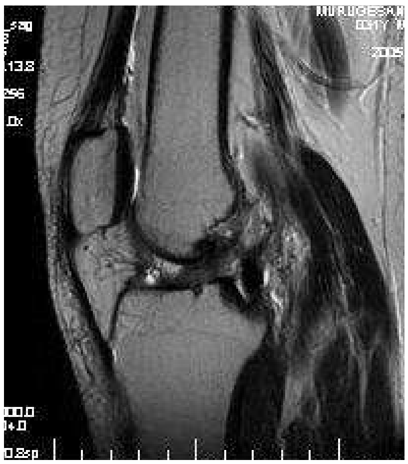


FIG 27 T2W SAG

FIG 28 GRE AXIAL

MIDSUBSTANCE TEAR

FIG 29 STIR SAG

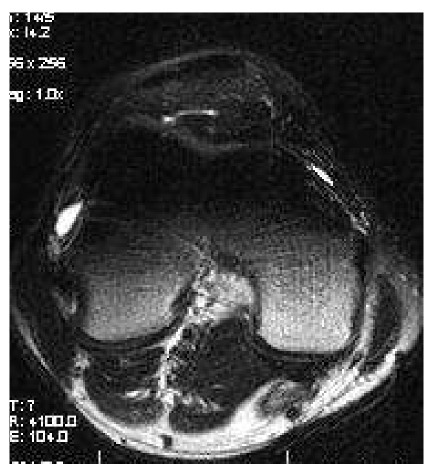


FIG 30 T2W FS AXIAL

TIBIAL ATTACHMENT TEAR

FIG 31 PD FS SAG

ASSOCIATED INJURIES

BUCKET HANDLE MEDIAL MENISCUS TEAR

FIG 32 STIR SAG

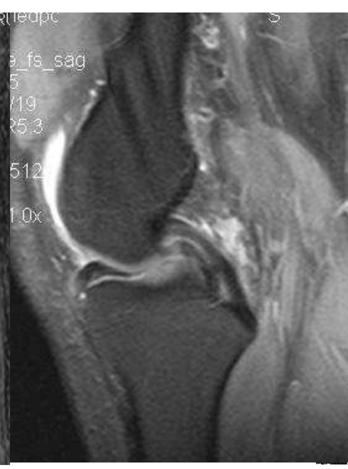


FIG 33 PDFS SAG

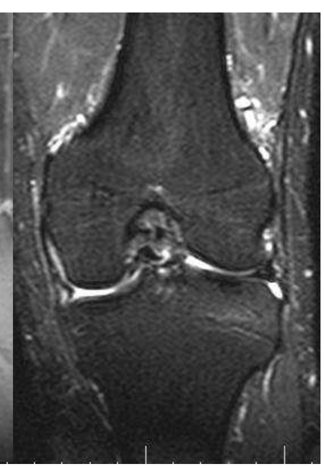


FIG 34 STIR COR

GRADE III TEAR MEDIAL AND LATERAL MENISCUS



FIG 35 T2W SAG **FIG 36 PD SAG** **FIG 37 STIR COR**

MCL TEAR

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

RESULTS AND ANALYSIS

RESULTS AND ANALYSIS

The ability of MRI and clinical examination to diagnose ACL injury was compared with arthroscopy and the results were analyzed using various statistical tests. Primary and secondary signs for ACL tear in MRI were also studied in detail in correlation with arthroscopy.

The final arthroscopic findings after evaluation with MR imaging were accepted as reference standard against which the MR findings were compared.

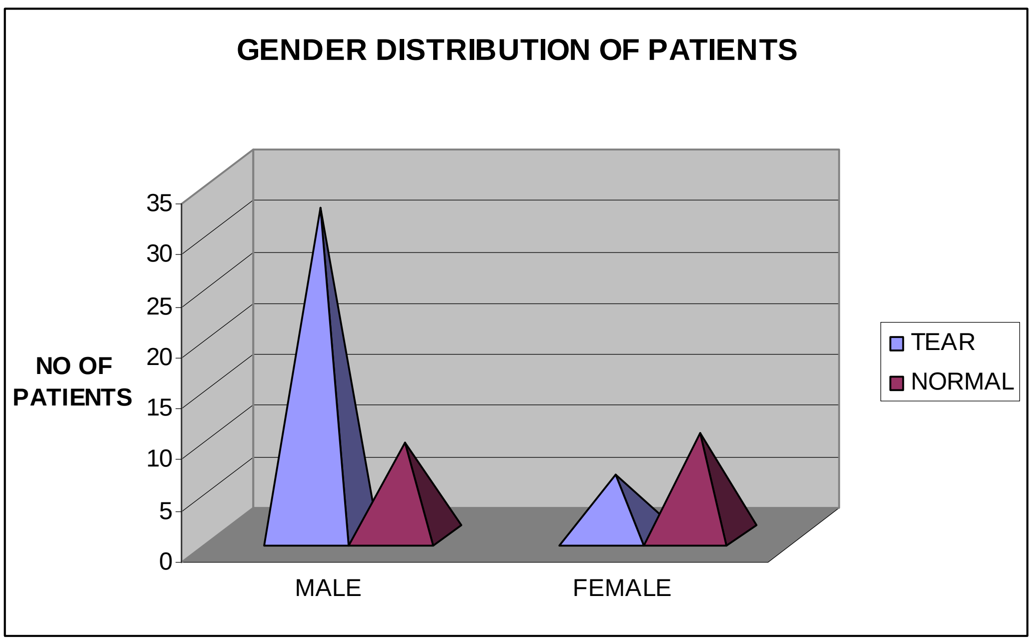
The sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated for clinical and MR imaging in diagnosing ACL tears in correlation with arthroscopy. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated for the primary and secondary signs of ACL tear in MRI.

Cohen's kappa is used to compare the correlation between the modalities. Values of kappa were classified as bad (less than 0.4), good (0.4 – 0.75), excellent (greater than 0.75) following Landis and Koch's criteria.

TABLE NO 1

GENDER DISTRIBUTION OF PATIENTS

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

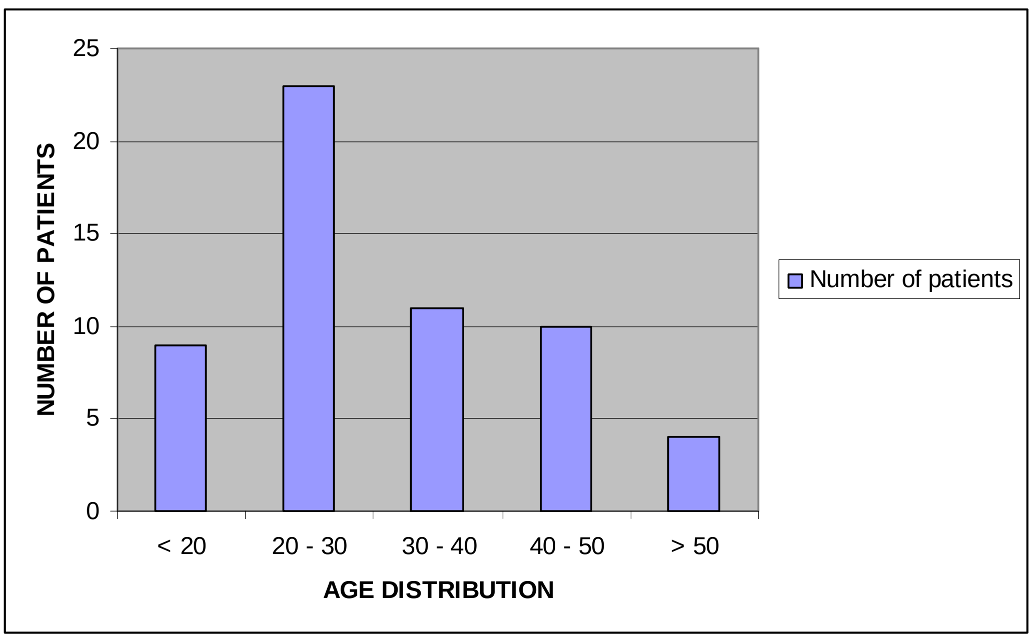


Likelihood ratio for male patient to have ACL tear: 2.081
P < 0.01

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

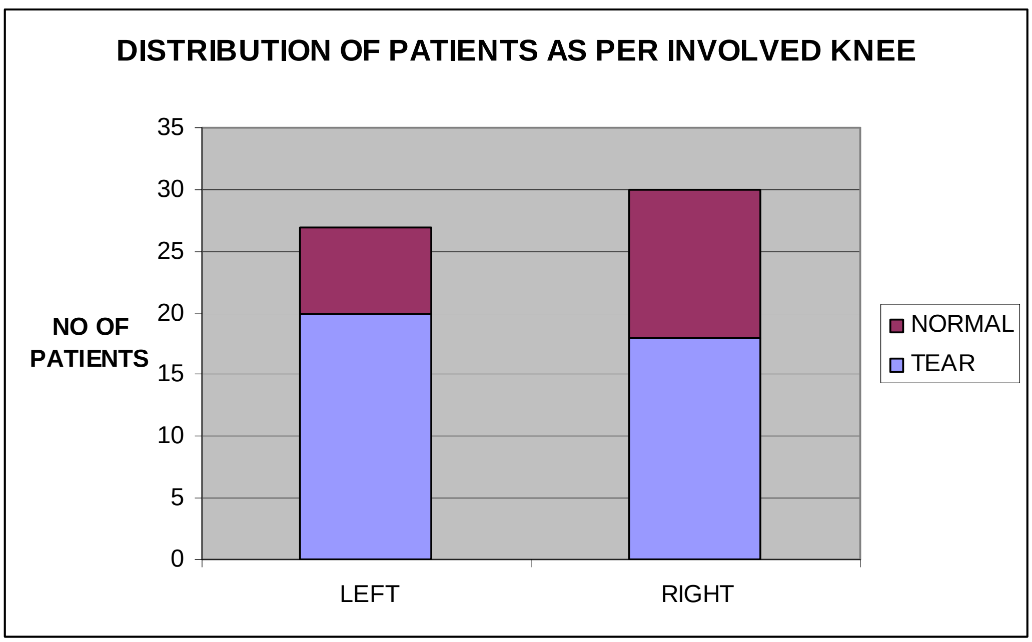


60% patients were in the age group 20 – 40 years.

TABLE NO 3

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

TABLE NO 4

DISTRIBUTION OF PATIENTS AS PER CLINICAL EVALUATION OF ACL

CLINICAL ACL STATUS	NUMBER OF PATIENTS
TEAR	32
NO TEAR	25

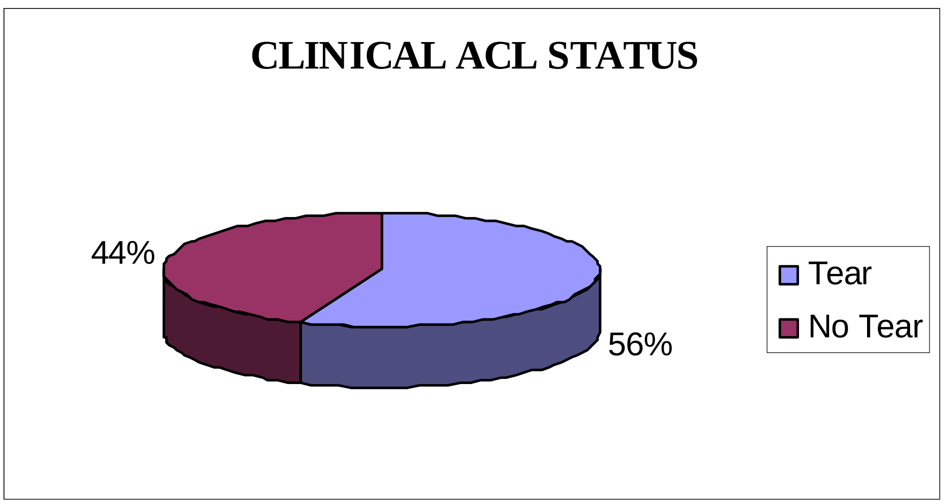


TABLE NO 5

COMPARISON BETWEEN CLINICAL DIAGNOSIS AND ARTHROSCOPIC DIAGNOSIS 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

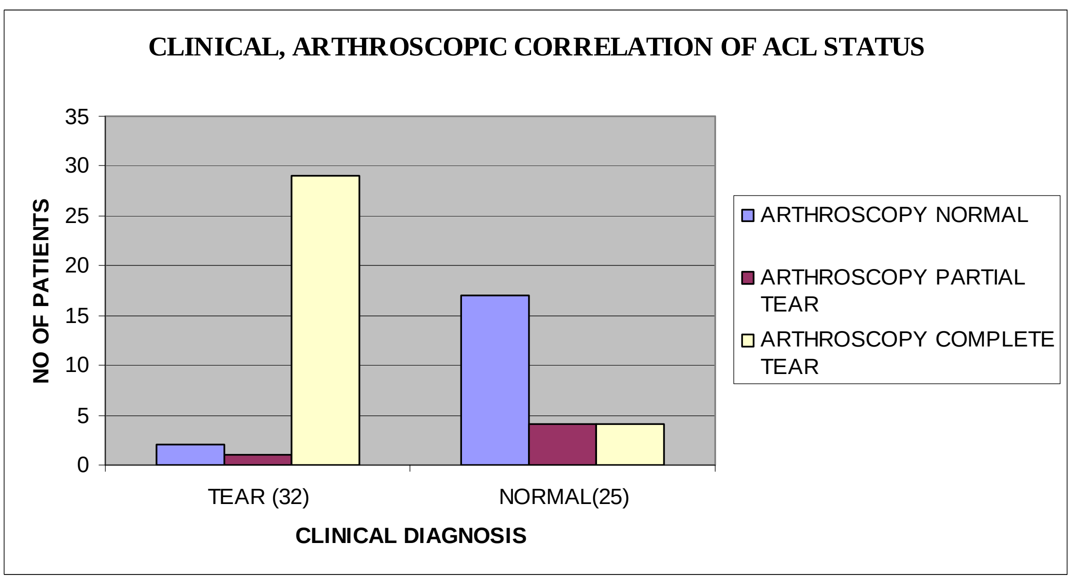


TABLE NO 6

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

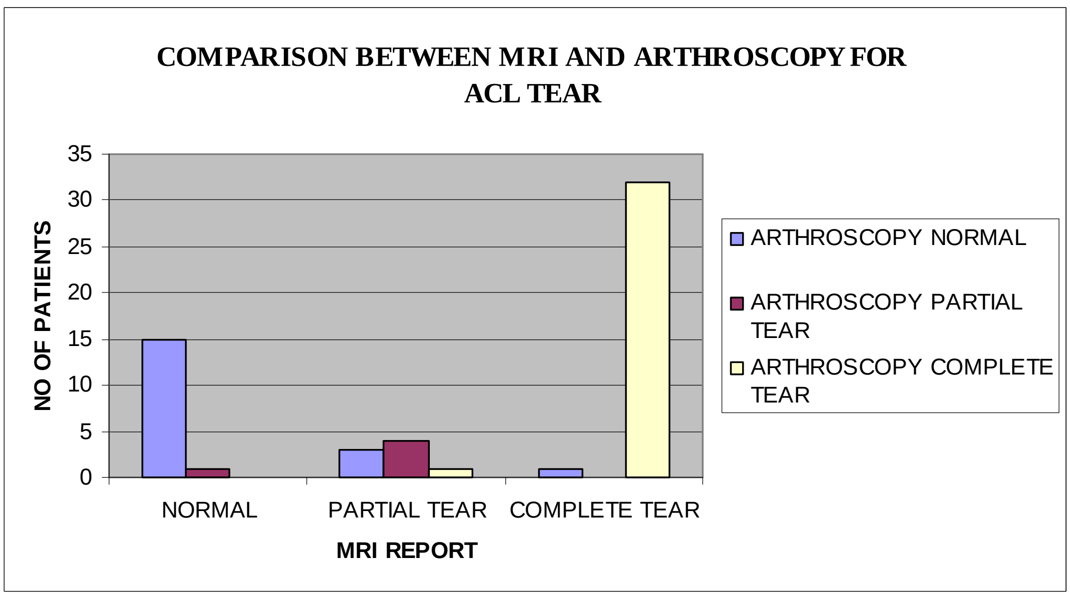
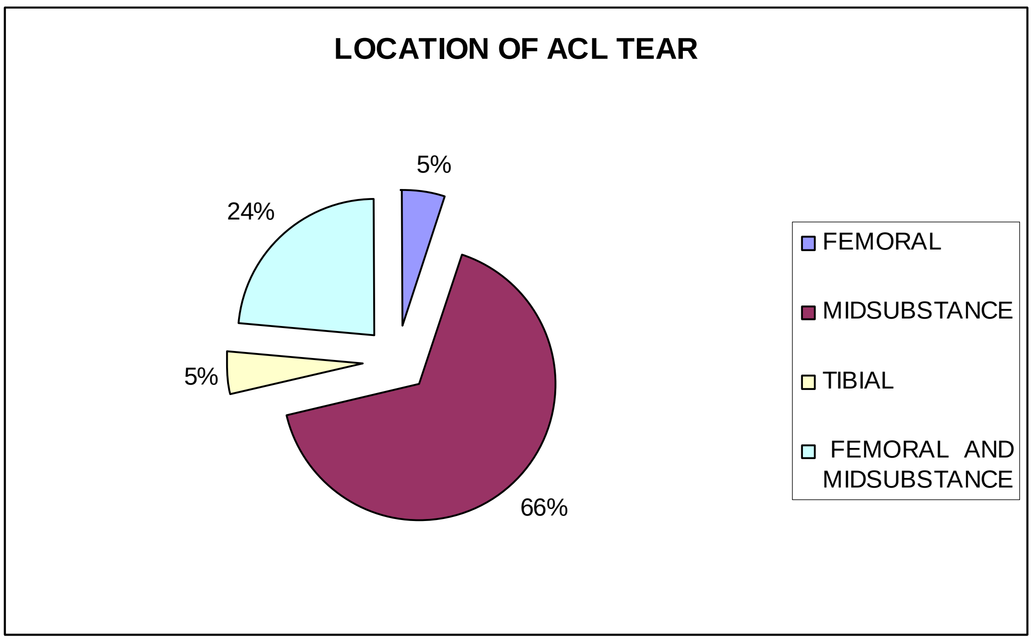


TABLE NO 7

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**

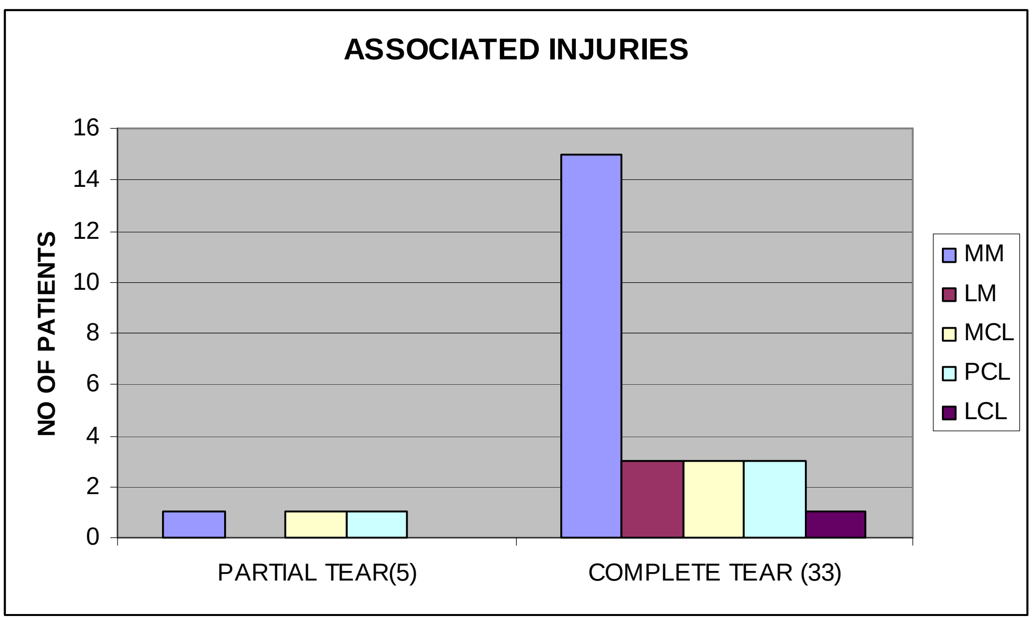


Midsubstance of ACL was the most common site of ACL tear.

TABLE NO 8

ASSOCIATED INJURIES

	PARTIAL TEAR(5)	COMPLETE TEAR(33)
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.

TABLE NO 9

COMPARISON BETWEEN CLINICAL DIAGNOSIS ARTHROSCOPIC DIAGNOSIS FOR ACL TEAR

CLINICAL DIAGNOSIS	ARTHROSCOPY REPORT		TOTAL
	TEAR	NORMAL	
TEAR	30	2	32
NORMAL	8	17	25
TOTAL	38	19	57

		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

TABLE NO 10

COMPARISON BETWEEN CLINICAL DIAGNOSIS AND ARTHROSCOPY FOR COMPLETE TEAR

CLINICAL DIAGNOSIS	ARTHROSCOPY		TOTAL
	COMPLETE TEAR	NORMAL	
COMPLETE TEAR	29	2	31
NORMAL	4	17	21
TOTAL	33	19	52

		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

TABLE NO 11

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	

$P < 0.001$

TABLE NO 12

COMPARISON BETWEEN MRI 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

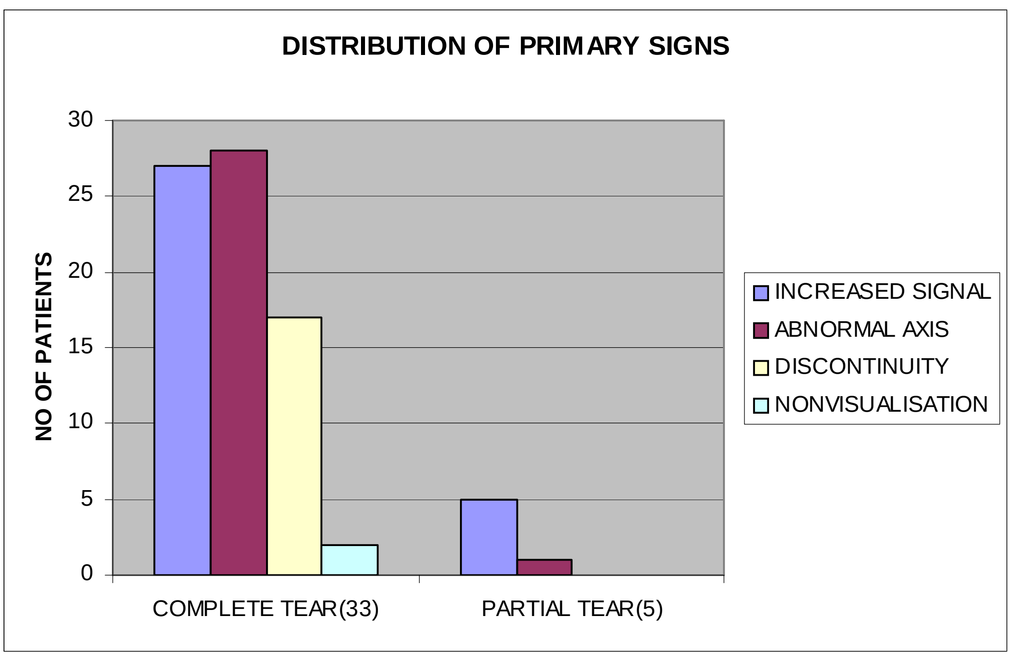
		CONFIDENCE LIMIT
SENSITIVITY	100%	89.1 – 100
SPECIFICITY	93.7 %	69.8 – 99.8
POSITIVE PREDICTIVE VALUE	96.9%	84.2 – 99.9
NEGATIVE PREDICTIVE VALUE	100%	78.2 – 99.9
ACCURACY	97.9%	82.9 – 99.6
KAPPA	0.95	

$P < 0.001$

TABLE NO 13

DISTRIBUTION OF PRIMARY SIGNS FOR COMPLETE ACL TEAR

	COMPLETE TEAR(33)	NORMAL(19)
INCREASED SIGNAL INTENSITY	**27**	**5**
ABNORMAL ANGLE / AXIS	**28**	**1**
DISCONTINUITY	**17**	**0**
NONVISUALISTION	**2**	**0**



Abnormal axis was the most sensitive and 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	

$P < 0.001$

TABLE NO 17

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	24
ABSENT	9	19	28
TOTAL	33	19	52

		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	

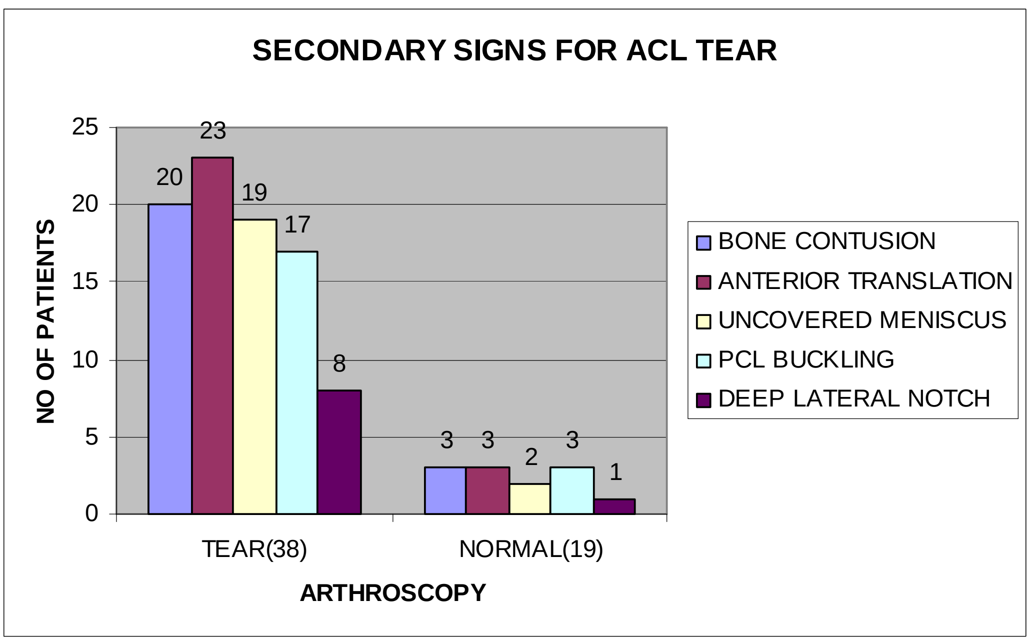
$P < 0.00$

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

TABLE NO 19

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.

TABLE NO 20

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 TIBIAL TRANSLATION

ANTERIOR TIBIAL TRANSLATION	ARTHROSCOPY		TOTAL
	TEAR	NORMAL	
PRESENT	23	3	26
ABSENT	15	16	31
TOTAL	38	19	57

		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

TABLE NO 23

PCL BUCKLING

PCL BUCKLING	ARTHROSCOPY		TOTAL
	TEAR	NORMAL	
PRESENT	17	3	20
ABSENT	21	16	37
TOTAL	38	19	57

		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 FEMORAL NOTCH

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	

DISCUSSION

DISCUSSION

MRI knee joint was performed on 57 patients who were referred 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 female patients. 32(78%) of 41 male patients had tears and 6(37%) of 16 female 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 have a torn ACL

These patients were in the age group ranging from 14 to 64 years. Out of 57 patients, 34 (60%) were in the age group 20-40 years. Out of 57 knee examined, 30(53%) were right side and 27(47%) left. 20 patients had ACL tear on left side and 18 on the right side. In our study, patient with left knee injury was 1.4 times more likely to have ACL tear.

57 patients underwent clinical examination for ACL tear. Both anterior drawer and Lachman test were done. By clinical examination 32 were classified as ACL tear and 25 as normal.

The positive predictive value for detecting complete tear was 93.5%. However 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 showed sensitivities of 79% for anterior drawer and 87% for Lachman test for diagnosis of ACL tear. Clinical examination also missed 4 partial tears out of 5 arthroscopically confirmed ACL partial tear.

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) abnormal axis/ angle (fibres not parallel to intercondylar line of Blumensaat) c) discontinuity of the fibres d) nonvisualistion of ACL.

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 9 arthroscopically

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% of patients.

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 giving a sensitivity of 84.8 and positive predictive value of 96.5%. The accuracy for diagnosing complete ACL tear was 88.5% and Kappa value was 0.76. Of 19 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 Robertson et al* sensitivity of 84% and accuracy of 84% and k value of 0.41 for the diagnosis of complete ACL tears.

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. However the sensitivity was 51% and the accuracy was 40.4% for diagnosing complete ACL tear. *Kwanseop Lee et al* studied paediatric knees and showed sensitivity of 21% and specificity of 100% for diagnosing complete 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 abnormal axis with abnormal signal intensity had 72.7% sensitivity with 100% positive predictive value and specificity. They were the most useful signs in diagnosing complete ACL tear with combined kappa value 0.66 which means good agreement.

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 in 9 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 *Amilcare Gentili 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 partial tears three turned out to be normal on arthroscopy. This may be due to in acute haemarthrosis of knee partial volume averaging of fluid may result in increased signal.

Bone contusion and anterior tibial translation more than 5 mm were the most useful secondary signs for predicting ACL status in our study.

.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.

SUMMARY

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 the age group 20 – 40.years. In our study a patient with left knee injury was 1.4 more times likely to have ACL tear.

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 complete tear was found to be 0.95, and 0.76 for clinical examination. 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 and specificity of 94.7%. Combination of abnormal signal intensity and abnormal 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.

Regarding location of tears, 66% were seen in midsubstance, 5% each in femoral and tibial attachment and 24% were seen to involve both midsubstance and femoral attachment.

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.

CONCLUSION

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 form 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 and more accurate preoperative imaging modality for diagnosing complete ACL tears and associated injuries.

BIBLIOGRAPHY

BIBLIOGRAPHY

1) **Joong K Lee, Lawrence Yao, Carlton T. Phelps, Carl R. Wirth, John Cjzaka and Jeffrey Lozman et al : Anterior cruciate ligament tears : MR imaging compared with arthroscopy and clinical tests ; Radiology 1998; 166; 861-864.**

2) **Glenn Tung, Lawrence Davis, Michael Wiggins, Paul Fadale et al: Tears of Anterior cruciate ligament; Primary and Secondary signs at MR imaging; Radiology 1993; 188; 661-667.**

3) **EA Brandser, MA Riley, KS Berbaum, GY el-Khoury, and DL Bennett et al: MR imaging of anterior cruciate ligament injury: independent value of primary and secondary signs; Am. J. Roentgenol., Jul 1996; 167: 121 - 126.**

4) **DK Smith, DA May, and P Phillips et al: MR imaging of the anterior cruciate ligament: frequency of discordant findings on sagittal-oblique images and correlation with arthroscopic findings; Am. J. Roentgenol., Feb 1996; 166: 411 - 413.**

5) **Timothy G. Saunders, Mark D. Miller et al: A systematic approach to Magnetic Resonance Imaging interpretation of Sports medicine injuries of the Knee; The Americal Journal of Sports Medicine, 2005, Vol 33, No 1.**

6) **S Roy chowdhury, SW Fitzerald, AH Sonin et al: Using MR imaging to diagnose partial tears of anterior cruciate ligament: value of axial images; Am. J. Roentology., Jun 1997; 168: 1487.**

7) **PL Robertson, ME Schweitzer, AR Bartolozzi, and A Ugoni et al: Anterior cruciate ligament tears: evaluation of multiple signs with MR imaging; Radiology, Dec 1994; 193: 829.**

8) **AA De Smet and BK Graf et al: Meniscal tears missed on MR imaging: relationship to meniscal tear patterns and anterior cruciate ligament tears; Am. J. Roentgenol., Apr 1994; 162: 905 - 911.**

9) **Whal Lee, Ho Sung Kim, Seok Jung Kim et al: CT Arthrography and Virtual Arthroscopy in the Diagnosis of the Anterior Cruciate Ligament and Meniscal Abnormalities of the Knee Joint; Korean J Radiol 2004;5:47-54.**

10) **Cross, M.J. (1998). Anterior cruciate ligament injuries: treatment and rehabilitation. In: Encyclopedia of Sports Medicine and Science, T.D.Fahey (Editor). Internet Society for Sport Science: http://sportsci.org. 26 Feb 1998.**

11) **A Gentili, LL Seeger, L Yao, and HM Do Anterior cruciate ligament tear: indirect signs at MR imaging et al: Radiology, Dec 1994; 193: 835.**

12) **TP Ha, KC Li, CF Beaulieu, G Bergman, IY Ch'en, DJ Eller, LP Cheung, and RJ Herfkens et al: Anterior cruciate ligament injury:**

fast spin-echo MR imaging with arthroscopic correlation in 217 examinations; Am. J. Roentgenol., May 1998; 170: 1215 - 1219.

13)F Cerabona, MF Sherman, JR Bonamo, and J Sklar et al: Patterns of meniscal injury with acute anterior cruciate ligament tears; Am. J. Sports Med., Nov 1988; 16: 603.

14)BN Lakhkar, KV Rajagopal, P Rai et al : MR Imaging Of Knee With Arthroscopic Correlation In Twisting Injuries; Ind J Radiol Imag 2004 14:1:33-40.

15)Umans H, Wimphfeimer O, Haramati N, et al. Diagnosis of partial tear of the anterior cruciate ligament of the knee: Value of MR imaging. AJR 1995; 165: 893-897.

16)David W. Stoller. Magnetic Resonance Imaging in Orthopaedics & Sports Medicine 2nd edition, chapter 7, pages 203 – 360.

17)Kai-Jow Tsai, Hongsen Chiang and Chiang Chuan Jiang et al: Magnetic resonance imaging of anterior cruciate ligament rupture; BMC musculoskeletal disorders 2004.

18)Kwanseop Lee, Marilyn J. Siegel, Debra M. Lau, Charles F. Hildebolt, and Matthew J. Matava et al: Anterior Cruciate Ligament Tears: MR Imaging-based Diagnosis in a Pediatric Population; Radiology, Dec 1999; 213: 697.

19)TN Vahey, DR Broome, KJ Kayes, and KD Shelbourne et al: Acute and chronic tears of the anterior cruciate ligament: differential features at MR imaging; Radiology, Oct 1991; 181: 251.

20)Thomas Berquist. MRI of the musculoskeletal system, 4th edition, chapter 7, pages 292 – 381.

21)BJ Murphy, RL Smith, JW Uribe, CJ Janecki, KS Hechtman, and RA Mangasarian et al: Bone signal abnormalities in the posterolateral tibia and lateral femoral condyle in complete tears of the anterior cruciate ligament: a specific sign? Radiology, Jan 1992; 182: 221.

22)RL Barrack, SL Buckley, JD Bruckner, JS Kneisl, and AH Alexander et al: Partial versus complete acute anterior cruciate ligament tears. The results of nonoperative treatment; J Bone Joint Surg Br, Jul 1990; 72-B: 622 - 624.

23)H Mizuta, K Kubota, M Shiraishi, Y Otsuka, N Nagamoto, and K Takagi et al: The conservative treatment of complete tears of the anterior cruciate ligament in skeletally immature patients; J Bone Joint Surg Br, Nov 1995; 77-B: 890 - 894.

24)KD Shelbourne and PA Nitz et al: The O'Donoghue triad revisited. Combined knee injuries involving anterior cruciate and medial collateral ligament tears; Am. J. Sports Med., Sep 1991; 19: 474.

25)PA Kaplan, CW Walker, RF Kilcoyne, DE Brown, D Tusek, and RG Dussault et al: Occult fracture patterns of the knee associated with anterior cruciate ligament tears: assessment with MR imaging; Radiology, Jun 1992; 183: 835.

26) **C. Stanitski et al: Conservative treatment of complete ACL tears; J Bone Joint Surg Br, Jul 1996; 78-B: 681.**

27) **AD Vellet, DH Lee, PL Munk, L Hewe et al: Anterior cruciate ligament tear: prospective evaluation of diagnostic accuracy of middle and high-field-strength MR imaging at 1.5 and 0.5 T; Radiology, Dec 1995; 197: 826.**

28) **DM Daniel, ML Stone, BE Dobson, DC Fithian, DJ Rossman, and KR Kaufman et al: Fate of the ACL-injured patient. A prospective outcome study; Am. J. Sports Med., Sep 1994; 22: 632.**

29) **B Stallenberg, PA Gevenois, SA Sintzoff, Jr, C Matos et al: Fracture of the posterior aspect of the lateral tibial plateau: radiographic sign of anterior cruciate ligament tear; Radiology, Jun 1993; 187: 821.**

30) **SW Houseworth, VJ Mauro, BA Mellon, and DA Kieffer et al: The intercondylar notch in acute tears of the anterior cruciate ligament: a computer graphics study; Am. J. Sports Med., May 1987; 15: 221.**

31) **TN Vahey, JE Hunt, and KD Shelbourne et al: Anterior translocation of the tibia at MR imaging: a secondary sign of anterior cruciate ligament tear; Radiology, Jun 1993; 187: 817.**

32) **FR Noyes, LA Mooar, CT Moorman, 3rd, and GH McGinniss et al: Partial tears of the anterior cruciate ligament. Progression to complete ligament deficiency**

33)Suzuki S, Kasahara K, Futami T, Iwasksi R, Yamamuro et al: Ultrasound diagnosis of pathology of the anterior and posterior cruciate ligaments of the knee joint; Arch Orthop Trauma Surg. 1991; 110(4):200-3.

34)Duke G Pao et al: The lateral femoral notch sign Radiology 2001; 219:800–801.

35)Richter J David, Pape HG, Ostermann PA, Muhr G et al: Diagnosis of acute rupture of the anterior cruciate ligament. Value of ultrasonic in addition to clinical examination; Unfallchirurg. 1996 Feb; 99(2):124-9.

36)R Ptasznik, J Feller, J Bartlett, G Fitt, A Mitchell, and O Hennessy: The value of sonography in the diagnosis of traumatic rupture of anterior cruciate ligament of the knee; Am. J. Roentgenol., Jun 1995; 164: 1461 - 1463.

37) WP Chan, C Peterfy, RC Fritz, and HK Genant et al: MR diagnosis of complete tears of the anterior cruciate ligament of the knee: importance of anterior subluxation of the tibia; Am. J. Roentgenol., Feb 1994; 162: 355 – 360.

38)TT Miller, P Gladden, RB Staron, JH Henry, and F Feldman et al: Posterolateral stabilizers of the knee: anatomy and injuries assessed with MR imaging; Am. J. Roentgenol., Dec 1997; 169: 1641 - 1647.

39) SW Fitzgerald et al: MR imaging of knee ligament injuries: potential role of axial MR images; Am. J. Roentgenol., Jan 1999; 172: 239 - 240.

40) Karence K. Chan, Donald Resnick, Douglas Goodwin, and Leanne L. Seeger Posteromedial Tibial Plateau Injury including Avulsion Fracture of the Semimembranous Tendon Insertion Site: Ancillary Sign of Anterior Cruciate Ligament Tear at MR Imaging Radiology 1999; 211: 754

ANNEXURE

ABBREVIATIONS

MRI	**-**	**Magnetic Resonance Imaging**
ACL	**-**	**Anterior cruciate ligament**
PCL	**-**	**Posterior cruciate ligament**
MCL	**-**	**Medial collateral ligament**
LCL	**-**	**Lateral collateral ligament**
CT	**-**	**Computed Tomography**
AMB	**-**	**Anteromedial Bundle**
PLB	**-**	**posterolateral Bundle**
FS	**-**	**Fat Saturation**

PROFORMA

PROFORMA

Name: **Age:** **Sex:**

Occupation: **Sl.No:** **IP/OP No:**

Address: **Ph.No:** **Date:**

Ref Dr: **Ph.No:**

\Clinical complaints:

Swelling, Instability, Locking, Pain

Past History:

H/O Trauma, Surgery

Clinical examination:

Positive clinical tests:

Clinical diagnosis:

MRI Evaluation:

1) **ACL**
   a) **Primary findings**

Increased signal intensity	
Abnormal axis	
Discontinuity	
nonvisualisation	

b) Secondary findings

Bone contusion	
Anterior tibial translation	
Uncovered posterior horn of lateral meniscus	
PCL buckling	
Deep lateral femoral notch	

Status of ACL: Normal / partial tear / complete tear

Location of tear: midsubstance / femoral attachment / tibial attachment

2) ASSOCIATED INJURIES

Medial meniscus	
Lateral meniscus	
PCL	
MCL	
LCL	

3) Joint effusion

4) Bursa

5) Articular cartilage

6) Adjacent muscles and tendons

MR Report:

Arthroscopic findings:

MR with arthroscopic correlation:

MASTER CHART

								A	B	C	D	A+B	B+C	A+C	a	b	c	d	e	a+b	a+c	b+d	a+d	MM	LM	MCL	LCL	PCL	
1	HEMA	21	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	
2	SURESHKUMAR	20	1	1	1	2	2	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3	YOGENDRASINGH	23	1	2	1	2	2	1	1	1	0	1	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2
4	LOKESH	24	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
5	RAJA	27	1	2	1	2	2	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	2
6	RAJANGAM	56	1	2	1	2	2	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	1	2
7	RAMACHANDRAN	38	1	1	0	2	2	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0	0	1	0	0	1	0	2
8	VENKATRAMAN	39	1	2	1	2	2	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
9	VEERAPPAN	20	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1+2
10	KRISHNA	42	1	2	1	2	2	1	1	1	0	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	1	2
11	GAYATRI	14	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	
12	DEEPALAKSHMI	28	2	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
13	VEERAMANI	40	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
14	SASIKUMAR	29	1	2	1	2	2	1	1	1	0	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	2
15	SIVAKUMAR	28	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
16	TAMILKUMARAN	13	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	
17	BEENA	21	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	
18	ANANDHAN	60	1	2	1	2	2	1	1	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	2
19	SARAVANAN	21	1	1	1	2	2	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	0	1	0	0	0	0	1+2
20	PRADEEPKUMAR	35	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
21	SANJAY	28	1	2	1	2	2	1	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1+2
22	MURUGESAN	31	1	1	1	2	2	1	1	1	0	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	2
23	MIRUNALINI	21	2	2	0	1	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	
24	GNAPRAKASAM	48	1	1	0	1	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
25	KARTHIK	18	1	1	1	2	2	1	1	0	0	1	0	0	0	1	1	1	1	0	0	1	0	1	0	0	0	0	1+2
26	PRABHAKARAN	24	1	2	1	2	2	1	1	1	0	1	1	1	0	1	1	1	0	0	0	1	0	0	1	0	0	0	2
27	KARUNAKARAN	48	1	2	1	2	2	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	2

28	PREMAKUMARI	53	2	1	1	2	2	1	1	0	0	1	0	0	1	1	1	1	0	1	0	0	1	0	0	0	0	0	2
29	MOHAMMED IBRAHIM	45	1	1	1	2	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
30	MURUGAN	27	1	2	0	2	2	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2
31	FAZIL	16	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
32	SRILEKHA	25	2	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1+ 2
33	DANIEL	27	1	2	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	2
34	MALA	34	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	
35	SHANMUGAM	34	1	1	1	2	2	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1+ 2
36	SATHYAMURUGA N	20	1	2	1	2	2	1	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	2
37	MANIMARAN	21	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
38	SHYAMALA NATARAJ	44	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
39	DINESH	17	2	2	1	2	2	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	2
40	POONGOTHAI	45	2	1	1	2	2	1	1	0	0	1	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	1+ 2
41	RAMAKRISHNAN	26	1	2	1	2	2	1	1	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	1	3
42	SUGUNA	42	2	1	0	2	2	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	2
43	TAMILARASI	43	2	1	1	2	2	1	1	0	0	1	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	1+ 2
44	AROKIADOSS	33	1	1	1	2	2	1	1	1	0	1	1	1	0	1	1	1	0	0	0	1	1	0	0	0	0	0	1+ 2
45	ILAMBARITHI	22	1	2	1	2	2	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0	0	1	1	0	0	0	2
46	KALA	16	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
47	NIRMALA	44	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
48	KABALI	45	1	1	1	2	2	0	1	1	0	0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	2
49	HASSAN MOHAMMED	64	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
50	VASUDEVAN	33	1	2	1	2	2	1	1	0	0	1	0	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	2
51	LAKSHMI	22	2	2	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
52	BALAKUMAR	22	1	1	1	2	2	0	0	0	1	0	0	0	0	1	1	1	0	0	0	1	0	1	0	1	0	0	2
53	SUNDARAMOORT HY	29	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

54	UDAYAKUMAR	38	1	2	1	2	2	1	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	2
55	THOTHDRI	36	1	2	1	2	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	3
56	DURGA	27	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
57	HARIHARAN	21	1	2	1	2	2	1	1	0	0	1	0	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	2

KEY TO MASTER CHART

KEY TO MASTERCHART

1.	Sex	Male	-	1
		Female	-	2
2.	Side of involvement	Right	-	1
		Left	-	2
3.	Clinical diagnosis	ACL tear	-	1
		Normal	-	0
4.	MRI report/	Normal	-	0
	Arthroscopy	Partial tear	-	1
		Complete tear	-	2
5.	Primary Signs	Increased signal	-	A
		Abnormal Axis	-	B
		Discontinuity	-	C
		Nonvisualisation	-	D
		Present	-	1
		Absent	-	0
6.	Secondary Signs	Bone contusion	-	a
		Anterior tibial Translation	-	b
		Uncovered posterior horn of lateral meniscus	-	c
		PCL buckling	-	d
		Deep lateral notch	-	e
		Present	-	1

		Absent	**-**	**0**
7.	**Associated Injuries**	**Medial Meniscus**	**-**	**MM**
		Lateral Meniscus	**-**	**LM**
		Medial Collateral ligament-		**MCL**
		Lateral collateral ligament-		**LCL**
		Posterior cruciate ligament-		**PCL**
		Present	**-**	**1**
		Absent	**-**	**0**
8.	**Site of ACL tear**	**Femoral attachment**	**-**	**1**
		Mid substance	**-**	**2**
		Tibial attachment	**-**	**3**