"ROLE OF MAGNETIC RESONANCE IMAGING IN EVALUATING TRAUMATIC KNEE INJURY AND ASSESSING ITS VARIOUS PATTERNS WITH ARTHROSCOPIC CORRELATION"

By

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In partial fulfilment of the requirements for the degree of

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IN
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ROLE OF MAGNETIC RESONANCE IMAGING IN EVALUATING TRAUMATIC KNEE INJURY AND ASSESSING ITS VARIOUS PATTERNS WITH ARTHROSCOPIC CORRELATION

LIST OF ABBREVIATIONS

MRI	Magnetic Resonance Imaging
ACL	Anterior Cruciate Ligament
PCL	Posterior Cruciate Ligament
LCL	Lateral Collateral Ligament
MCL	Medial Collateral Ligament
PLC	Posterior lateral Corner
MM	Medial meniscus
LM	Lateral meniscus
RTA	Road Traffic Accident
AMB	Anteromedial bundle
PLB	posterolateral bundle
ALB	Anterolateral bundle
PMB	posteromedial bundle
BC	Bone contusions
JE	Joint effusion
PD	Proton density
PDFS	Proton density fat saturated
SI	Signal intensity
CT	Computed tomography
FS	Fat saturated
IDK	Internal derangement of knee
PPV	Positive predictive value
NPV	Negative predictive value
N	Frequency
TP	True positive
FP	False positive
FN	False negative
TN	True negative

ABSTRACT

BACKGROUND: Magnetic resonance imaging (MRI) is a completely non-invasive diagnostic modality with no ionizing radiation and plays a vital role in assessment of a wide spectrum of inter derangement of knee. Arthroscopy is highly sensitive and specific procedure in both diagnostic and therapeutic, but is invasive and can cause various complications. This study focus on assessing the role of MRI in evaluating traumatic injuries of knee joint and to compare and correlate MRI findings with arthroscopy findings in ligament and meniscal injuries of the knee.

METHODOLOGY: This was a hospital based prospective observational study involving 52 patients with knee injuries, carried out over a period of 18 months who underwent, MRI and arthroscopy of the knee. Patients fulfilling the inclusions criteria underwent MRI performed on SIEMENS® Magnetom Avanto, 1.5 Tesla, 18 channel MRI machine after the MRI scan, findings of the same and diagnosis were recorded. MRI findings of the patients were correlated with arthroscopic findings. Statistical analysis was performed for anterior cruciate and posterior cruciate ligaments, medial meniscus, lateral meniscus and medial & lateral collateral ligaments. MRI results were analysed with Chi-Square test. Sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) of MRI is evaluated considering arthroscopy as gold standard of reference.

RESULTS: Out of the total 52 cases with knee injury35 were males and 17 were females. Most of the patients were within age group of 36-45 years, road traffic accidents (RTA) and twisting injuries were the most common causes. Anterior cruciate ligament (ACL) tears identified by MRI being the most common at 78.4%, followed by medial meniscus (MM) in 33.3 % cases. Posterior cruciate ligament (PCL) injuries in 17.6%, medial collateral ligament

(MCL) injuries occurred in 29.4% of cases, while lateral collateral ligament (LCL) injuries were less common at 11.8%.

The ACL has 97.5% sensitivity and 91.7% specificity, while the PCL has 100% sensitivity and high specificity (97.7%). Medial and lateral meniscus injuries have moderate sensitivity (66.7% and 69.2%, respectively) but high specificity (90.3% and 89.7%). Cruciate ligaments (medial and lateral) showed lower sensitivity (66.7% and 60%, respectively) and variable specificity (82.5% and 93.6%, respectively).

CONCLUSION: MRI was highly sensitive and accurate at the identification of both ACL and PCL tears as evidenced by close agreement with arthroscopic diagnosis. The diagnostic agreement for the menisci and cruciate ligaments was moderate. Diagnosing articular fractures and specific pattern of bone contusions can guide us to narrow our diagnosis.

Keywords: MRI, traumatic knee, arthroscopy, correlation, knee injuries.

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INTRODUCTION

INTRODUCTION

The knee is the hinge type synovial joint and is the biggest joint in the human body. Knee is the most commonly injured joint because of its anatomical structure, its exposure to external forces, and its functional demands. The knee contain cartilage, muscles, ligaments, and nerves and helps support your weight. Injuries of the knee joint are increasing, as a result of trauma and sports injury, more commonly seen in young active individuals.[1]

An accurate diagnosis is therefore essential for early operative as well as non-operative treatment to prevent degenerative changes from setting in. Internal derangement of the knee *(traumatic or degenerative)* is a very common entity and may require certain studies for the establishment of diagnosis, in addition to clinical history and a thorough physical examination. Clinical examination, performed by an experienced examiner, can have equal diagnostic accuracy compared to Magnetic Resonance Imaging (MRI) to evaluate ligament & meniscal injuries.[1,2]

MRI examination is now routinely used to assess a wide spectrum of internal knee derangements and articular disorders and has virtually replaced conventional arthroscopy in the evaluation of the menisci and the cruciate ligaments, decreasing both morbidity and costs associated with negative arthroscopic examinations. MRI is a popular tool to diagnose musculoskeletal disorders, with an accuracy of around 85% and is most appropriate for screening before therapeutic arthroscopy. The accuracy of MRI ranges from 77% to 96% in few studies. And according to few studies MRI correctly detects meniscal tears in 85 % of cases and Anterior cruciate ligament (ACL) & Posterior cruciate ligament (PCL) injuries in 85 –100 % of cases.[3]

The use of arthroscopy improves the accuracy of the diagnosis, but it's invasive and can cause complications.[2] Diagnostic arthroscopy is an important advance, improving diagnostic accuracy from 64% to 94%. However, it is an invasive procedure, with the possible complications of infection, hemarthrosis, adhesions, and reflex sympathetic dystrophy.[4]

MRI provides information that can be used to grade pathology, guide therapy, prognosticate conditions, and evaluate treatment for a wide variety of orthopedic conditions in the knee. Thus, MRI is a very useful non-invasive diagnostic modality with high sensitivity, specificity, and accuracy in the identification of meniscal and cruciate ligament injuries.[3]

The comparison of MRI diagnosis and surgical/clinical findings has always been a challenge for the health professions. A review of the available literature suggests that only a few studies have looked at for these two diagnostic tools *(MRI scan and arthroscopy).* Larger studies to find the correlation of MRI with arthroscopy are lacking. Hence, the present study was designed to compare effectiveness of MRI and arthroscopy findings in the diagnosis of knee injuries with latter considered as gold standard.

AIMS & OBJECTIVES

AIMS & OBJECTIVES

Primary Objectives:

1. To perform MRI knee and evaluate various pattern of knee injuries.

2. To correlate MRI with arthroscopic findings.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

ANATOMY OF KNEE

The knee is the largest joint in the body. Is a hinge type synovial joint, which mainly allows for flexion and extension (and a small degree of medial and lateral rotation). During propulsion, the knee is able to withstand impressive weight-bearing loads while conducting precision movements, providing a stable yet fluid mechanism for relatively efficient bipedal locomotion.[5,6]

Knee motion is dependent on the action of muscles around the knee, shape of the articular surfaces and ligaments in and around the knee. Bones are covered by articular *(also known as hyaline)* cartilage which minimizes friction on movement the lubricant inside the joint is called synovial fluid. The bones that form the knee joint are: Femur *(thigh bone):* Strongest and longest bone in the human body. Tibia *(shin bone*): Primary weight bearing bone of the lower leg. Patella *(knee cap):* Sits at the front of the knee connecting the quadriceps muscle to the tibia. The fibula is a smaller bone that runs parallel on the outside part of the tibia: while it does not form part of the articulation of the knee joint, it provides attachment to essential soft tissue elements of the knee joint such as the lateral collateral ligaments.[6,7]

Tibiofemoral and patellofemoral articulations make the knee a compound synovial joint. Muscular support is this joint's most important stabilizing factor, and proper conditioning and training can help prevent sports injuries. Understanding its structure helps optimize lower limb rehabilitative strategies.[8]

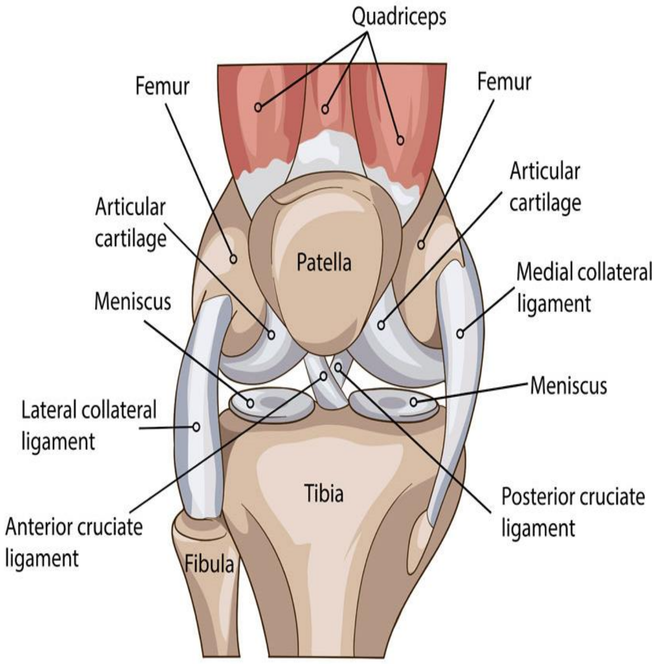


Figure 1: Anatomy of knee.

The knee joint connects the thigh bone (femur) to the shin bone (tibia). It also contains cartilage like meniscus and ligaments, including Lateral collateral ligament (LCL), Medial collateral ligament (MCL), ACL and PCL.

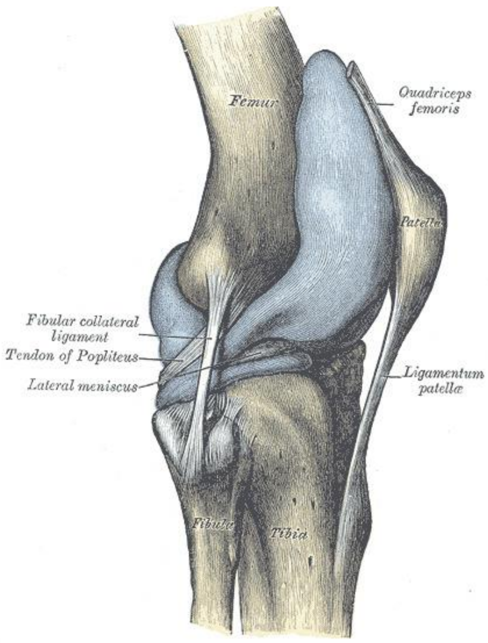


Figure 2: Lateral View of the Right Knee

Image showing fibular (lateral) collateral ligament, tendon of popliteus, lateral meniscus, patellar ligament (ligamentum patellae), quadriceps femoris tendon, patella, femur, fibula, and tibia.

ARTICULATING SURFACES

The knee joint consists of two articulations – Tibiofemoral and Patellofemoral. The joint surfaces are lined with hyaline cartilage and are enclosed within a single joint cavity.[9]

- **Patellofemoral** – Anterior aspect of the distal femur articulates with the patella. It allows the tendon of the quadriceps femoris *(knee extensor)* to be inserted directly over the knee; increasing the efficiency of the muscle. *(Figure 3)*

- **Tibiofemoral** – Medial and lateral condyles of the femur articulate with the tibial condyles. It is the weight-bearing component of the knee joint. *(Figure 3)*

As the patella is both formed and resides within the quadriceps femoris tendon, it provides a fulcrum to increase power of the knee extensor and serves as a stabilising structure that reduces frictional forces placed on femoral condyles. [9,10]

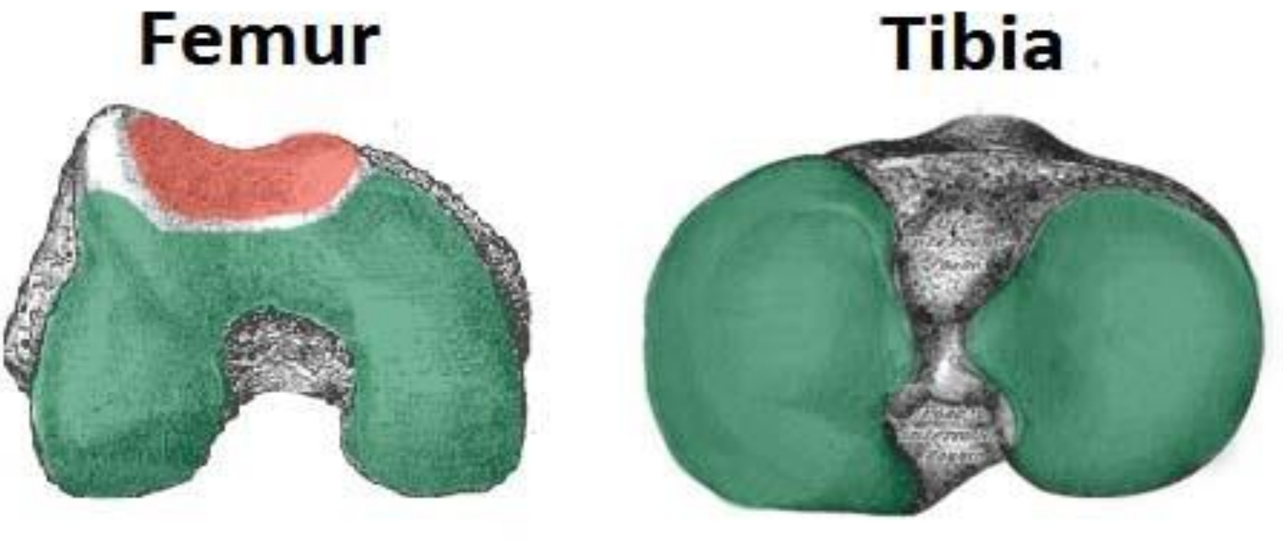


Figure 3: Tibiofemoral (Green) and Patellofemoral surfaces (Red).
Inferior surface of femur and superior surface of tibia showing the articulating surface. Tibiofemoral shown in green colour and Patellofemoral surfaces shown in red.

JOINT CAPSULE & BURSA

The joint capsule of the knee joint is of a composite nature, mainly formed by muscle tendons and their expansions, forming a thick ligamentous sheath around the joint. The capsule is formed from an outer fibrous layer and an inner synovial membrane that lubricates the articular surfaces, reducing friction in addition to providing nourishment to the cartilage. The joint capsule forms several fluid filled pouches called bursae, which reduce friction within the knee joint.[11,12]

Suprapatellar bursa - located superior to the patella between the femur and the tendon of the quadriceps muscle.

Pre-patellar bursa- lies in front of the patella between the patella and the skin

Infrapatellar bursa - located under the patella between the patellar ligament and the tibia.

Semimembranosus bursa – located posterior to the knee joint, between the semimembranosus muscle and the medial head of the gastrocnemius.

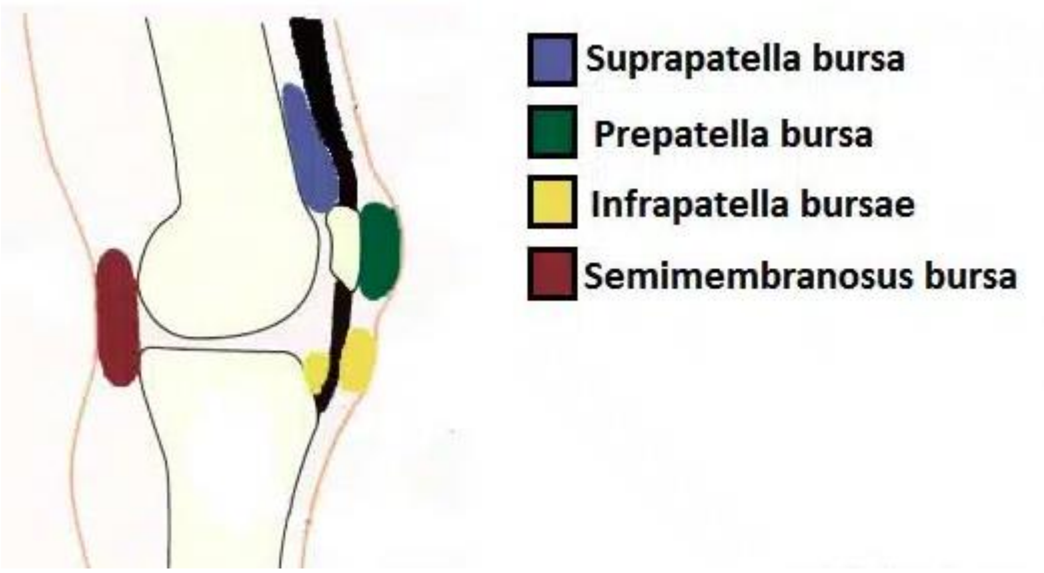


Figure 4: Sagittal section of the knee joint

The image shows suprapatellar bursa, pre-patellar bursa, infrapatellar bursa and semimembranosus bursa marked with the black outlining.

LIGAMNETS OF THE KNEE JOINT

CRUCIATE LIGAMENTS:

The cruciate ligaments cross each other, are very strong, richly innervated intra-capsular structures. Crossing point is located a little posterior to the articular centre. They are named anterior and posterior with reference to their tibial attachments. A synovial membrane almost surrounds the ligaments but is reflected posteriorly from posterior cruciate ligament to adjoining parts of the capsule; the intercondylar part of posterior region of fibrous capsule therefore has no synovial covering.[13]

Anterior Cruciate Ligament (ACL):

ACL is a key structure in the knee joint, as it resists anterior tibial translation and rotational loads. It is one of the most frequently injured structures during high impact or sporting activities. ACL is attached to anterior intercondylar area, just anterior and lateral to the medial tibial eminence in tibia and posteromedial part of lateral femoral condyle.[13,14]

The size of the bony attachment can vary from 11 to 24 mm across. From its femoral attachment, the ACL runs anteriorly, medially, and distally to the tibia. Its length ranges from 22 to 41 mm (mean, 32 mm) and its width from 7 to 12 mm. The ACL fibers fan out as they approach their tibial attachment. They attach to a fossa located anterior and lateral to the medial tibial spine. This fossa is a wide, depressed area approximately 11 mm wide (range, 8–12 mm) and 17 mm (range, 14–21 mm) in the antero-posterior direction.[15]

ACL is formed of two main bundles, anteromedial bundle (AMB) and posterolateral bundle (PLB) *(Fig. 5)*, On MRI, it can occasionally be possible to differentiate these two bundles *(Fig. 5, a)*.[13,14] AMB forms the anterior portion of the ACL, while the PLB forms the posterior portion. Overall, ACL is subject to the maximum tension at the maximum extension and 90-

degree flexion, and the tension mainly acts on the AMB, resulting in frequent injury of AMB (Fig. 5, b). These bundles spread out at the tibial attachment site, but the fibres run in a spiral fashion and may appear as one bundle at the femoral attachment.[15,16]

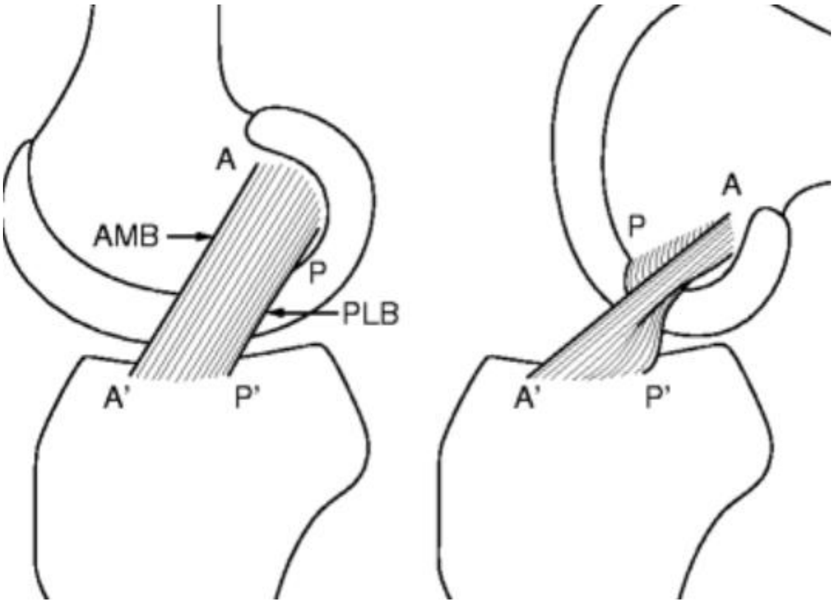


Figure 5: Sagittal images showing two fibers bundles of ACL

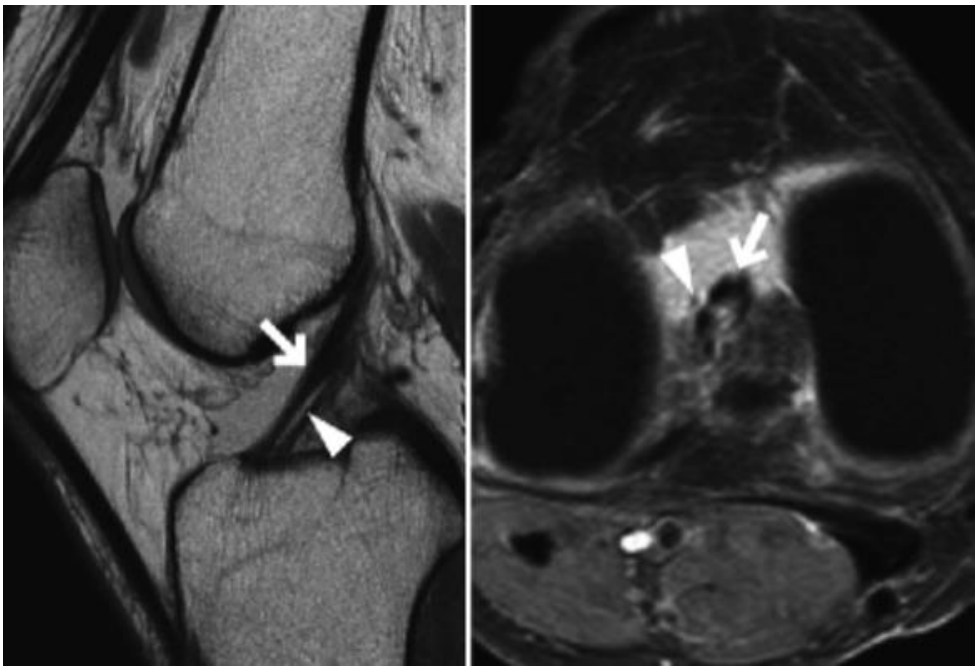


Figure 6: Sagittal and axial section of MRI Knee

Images showing normal appearance of ACL and anteromedial bundle *(arrow)* & posterolateral bundle *(arrowhead)* in Sagittal and axial sections on MRI

Based on flexion angle, tension in bundles varies, with antero-medial bundle being tighter in extension and posterolateral tighter in flexion. In full extension, the anterior surface of ACL lies against intercondylar shelf assisting the ligament in preventing hyperextension. Primary function of ACL is to resist anterior translation. Blood supply of the ACL arises from anastomosis of lateral and medial inferior geniculate arteries through the fat pad and middle geniculate artery branching off the posterior capsule.[17,18]

In any substance tear of ACL, the blood supply gets usually permanently disrupted, which affects it's healing potential thus, reconstruction rather than repair is the preferred surgical tactic. An absent anterior cruciate ligament is rare where in such cases, the condition is usually associated with lower limb dysplasia, and can cause instability of the knee.[18]

Posterior Cruciate Ligament (PCL):

The posterior cruciate ligament (PCL) is the strongest ligament of the knee. It is intra-articular and extra synovial. The PCL arises from the anterolateral surface of the medial femoral condyle and reaches the posterior intercondylar area of the tibia. The femoral origin is more anterior than ACL, and in contrast to the ACL, the PCL is larger at its femoral origin than at its tibial insertion.[19]

The tibial attachment is extra-articular, and it is approximately 1 cm distal to the plane of the articular surface. The PCL is the primary restraint to posterior tibial translation relative to the femur and becomes more important in preventing distraction of the joint as the knee reaches higher degrees of flexion. In addition, the PCL acts as a secondary restraint to resist varus, valgus, and external rotation moments about the knee.[19]

The PCL consists of two functional bundles: The Anterolateral bundle (ALB) and the posteromedial bundle (PMB). The ALB (65 %) is usually thicker and stronger than the PMB (35 %). Most PCL fibers are not isometric and the bundles have different functions that enable the PCL to resist posterior translation. Average length and width of an adult posterior cruciate ligament is 38 and 13mm respectively.[21] The ALB femoral footprint has been described in many studies with average range anywhere from 112 to 118 mm^2 in cross-sectional area and PMB the average length and diameter is 32.42 mm and 5.62 mm^2. The two bundles of the PCL insert onto the tibia as a conjoined structure approximately 1.0 to 1.5 cm distal to the joint line, on a facet of the posterior tibia respectively. Ligaments of Weisberg and Humphry originating in posterior capsular attachment of lateral meniscus courses forward to attach posteriorly and anteriorly respectively with the PCL on femur.[20,21]

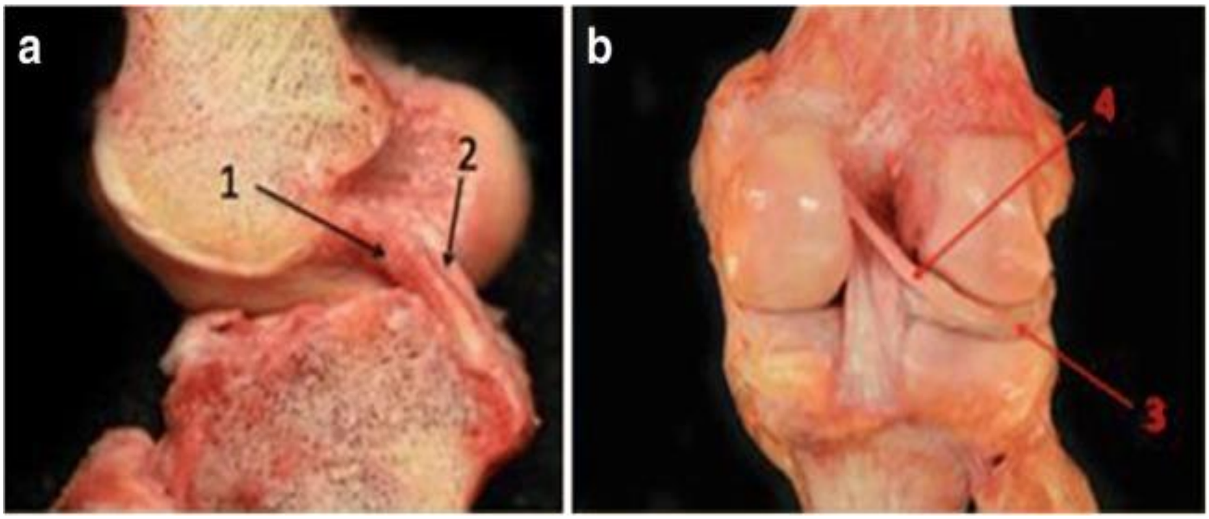


Figure 7: (a) Anatomy of the PCL with the knee extended showing the anterolateral (1) and posteromedial (2) bundles, including the femoral and tibial footprints and (b) anterolateral and posteromedial bundles of the PCL relative to the lateral meniscus (3) and meniscofemoral ligament of Wrisberg (4)

The posterior horn of the medial meniscus serves as the anterior border of this PCL facet. The PCL is innervated by branches of the tibial nerve while its vascular supply comes from the middle geniculate artery.[23] Posterior cruciate ligament ruptures less commonly than anterior cruciate; PCL can occur from a posterior force directed on the tibia, most common with the knee in a flexed position rupture is usually better tolerated by patients than that of anterior cruciate ligament. Unlike ACL, because of its association with posterior capsule, blood supply is not permanently lost with a substance tear of PCL. Thus, primary repair of these injuries is possible.[21,22]

The PCL is seen as band of low signal intensity in MR sequences and is usually visualized in its entire length on one or two consecutive sagittal images. The two-bundle anatomy is often well visualized on sagittal & axial planes. To assess the intact attachments of the PCL, axial, sagittal, and coronal images should be evaluated. The axial images are helpful for the femoral attachment, whereas the sagittal images are helpful for assessing the tibial attachment.[23]

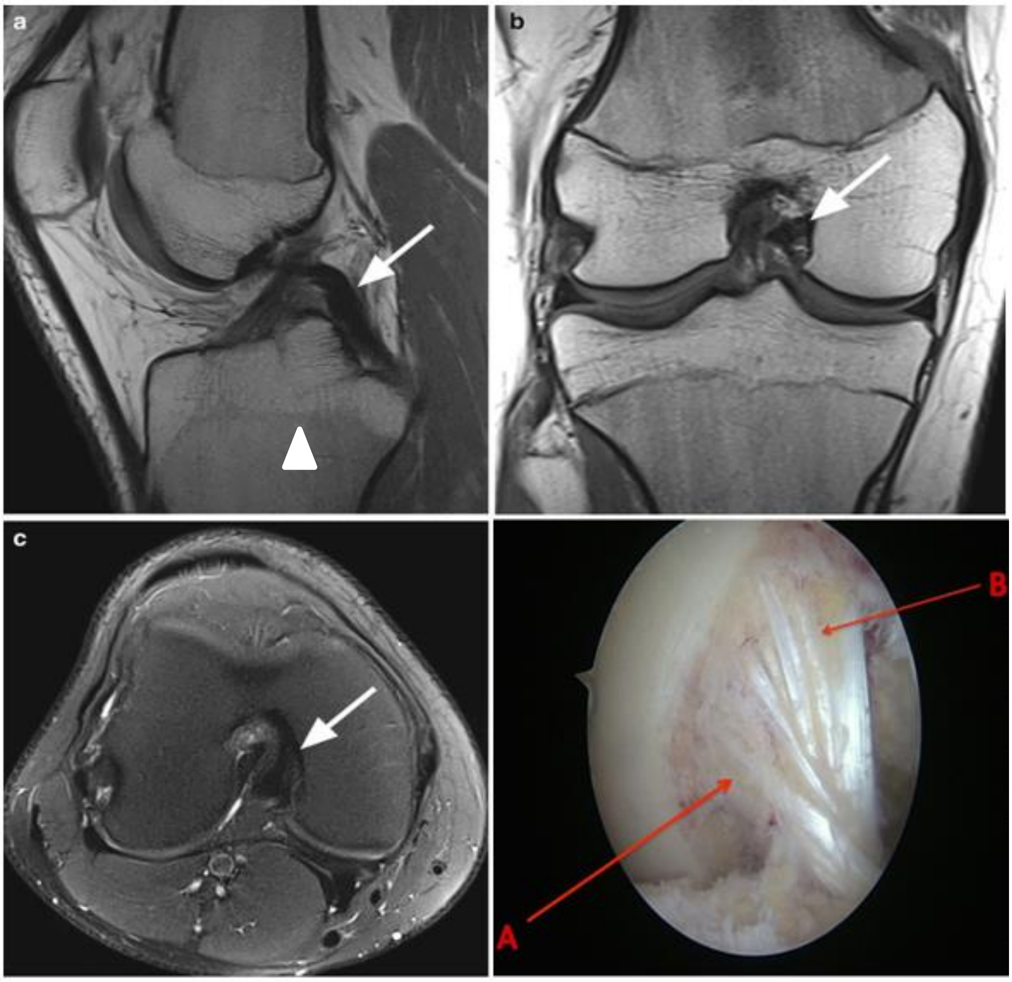


Figure 8: Normal posterior cruciate ligament (PCL) Sagittal image (a) shows the PCL as a band of low signal intensity, anterolateral bundle *(arrow)* & posteromedial bundle *(arrowhead).* Coronal (b) and axial images (c) should always be assessed especially for the femoral attachment *(arrow in b)* and tibial attachments *(arrow in c).* Arthroscopy image of left knee (d) showing PCL with ALB *(A- red arrow)* & PMB *(B- red arrow)*

COLLATERAL LIGAMENTS

These are found on the sides of your knee. The medial or *"inside"* collateral ligament (MCL) connects the femur to the tibia. The lateral or "outside" collateral ligament (LCL) connects the femur to the smaller bone in the lower leg *(fibula).* The collateral ligaments control the sideways motion of your knee and brace it against unusual movement.[24]

Medial collateral ligament:

Medial or tibial collateral ligament is a strong flat band that extends from medial epicondyle of femur to tibial medial condyle and to medial surface of shaft of tibia. It is a primary restraint to valgus angulation at knee, which has a superficial and deep part of it.[24]

The superficial layer *(tibial collateral ligament)* and the deep layer *(medial capsular ligament).* Superficial layer of MCL attaches to the tibia at 7–8 cm below the joint space. The deep layer firmly attaches to the medial meniscus and is also known as meniscofemoral and meniscotibial ligament.[24,25]

Superficial Medial Collateral ligament:

Superficial medial collateral ligament is the largest structure of medial side of knee joint which has got one femoral and two tibial attachments. The femoral attachment of the superficial medial collateral ligament is round to slightly oval in shape and is located in a depression proximal and posterior to the medial epicondyle. As the superficial medial collateral ligament coursed distally, it has two separate tibial attachments, the proximal tibial attachment to the anterior arm of semi membranous tendon and distal tibial attachment to the anterior aspect to the posteromedial crest of tibia.[25]

Deep medial collateral ligament:

Deep medial collateral ligament is a thickening of medial joint capsule that is most distinct along its anterior border, where it roughly parallels anterior aspect of superficial medial collateral ligament. Deep medial collateral ligament consists of distinct meniscofemoral and meniscotibial ligament components. The ligament blends with the central arm of posterior oblique ligament and become inseparable.[26]

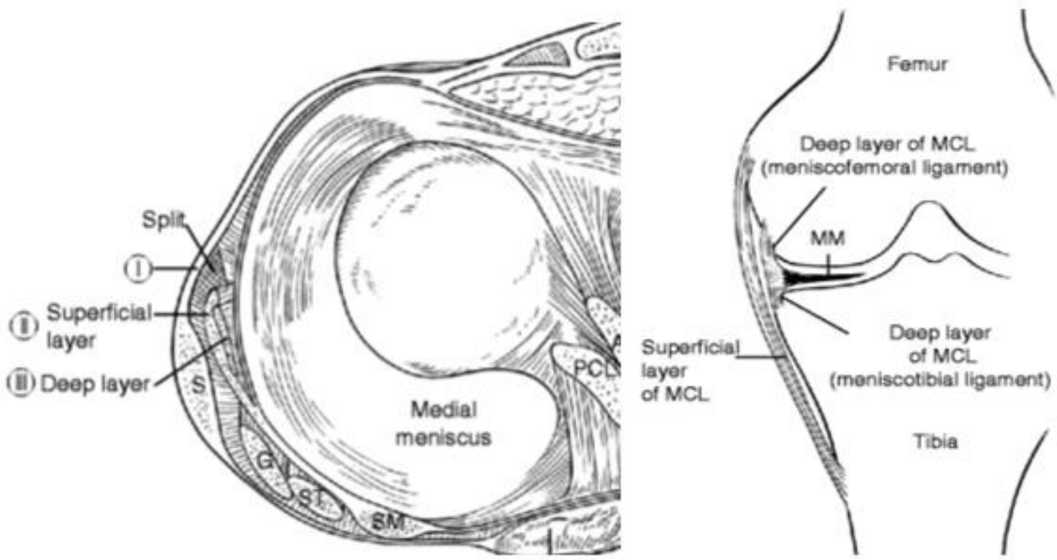


Figure 9: Three layers of the MCL in axial & coronal plane. *Layer I:* Thin sheet that overlies the two heads of the gastrocnemius and the structures of the popliteal fossa. *Layer II:* superficial layer of MCL. *Layer III:* medial joint capsule including the deep layer of MCL.

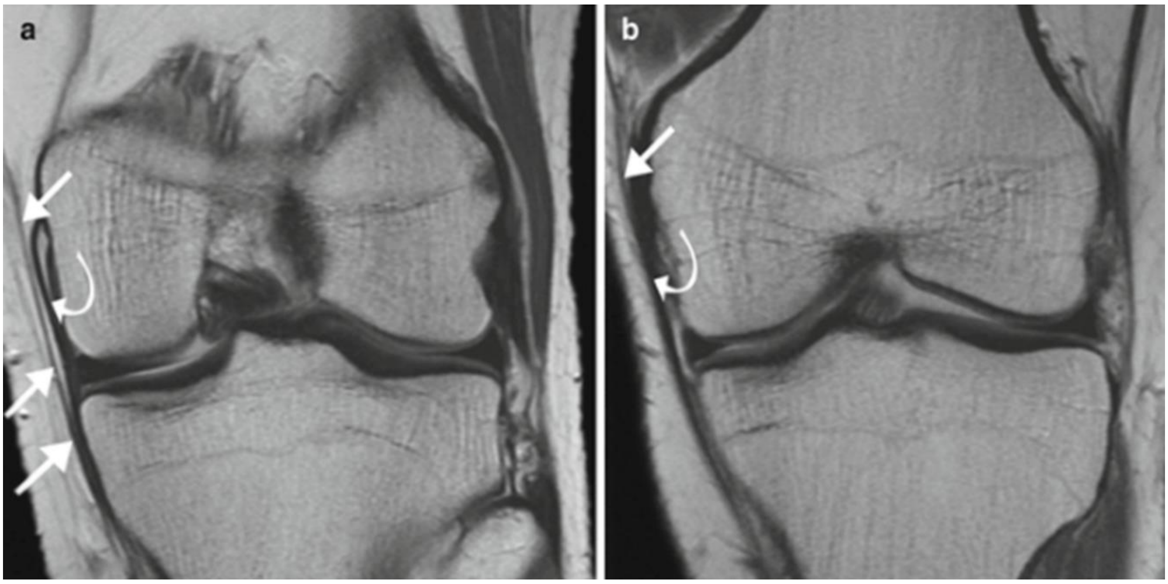


Figure 10: MRI coronal images showing MCL. (a) Deep fascia that is seen on MR images as a thin low-intensity structure *(arrows)* separated by a variable amount of fat from the superficial layer of medial collateral ligament known also as the vertical part of the ligament *(curved arrow).* (b) The deep fascia *(arrow)* joins the medial collateral ligament *(curved arrow in b).*

Lateral collateral ligament (LCL):

Lateral or fibular collateral ligament originates from the external tuberosity of the lateral femoral condyle, directly anterior to the origin of the lateral head of the gastrocnemius muscle. LCL and biceps femoris tendon end by inserting on head of the fibula as a conjoined tendon. The LCL is approximately 6 cm long and 3–5 mm thick. The ligament is superficially located and is a static stabilizer during varus angulation. LCL extends from the lateral femoral condyle, posterior to the lateral epicondyle and 2 cm above the joint line to the fibular head.[27]

Figure 11: Images showing LCL or fibular collateral ligament. Lateral aspect of knee showing attachment of LCL from external tuberosity of the lateral femoral condyle to head of the fibula.

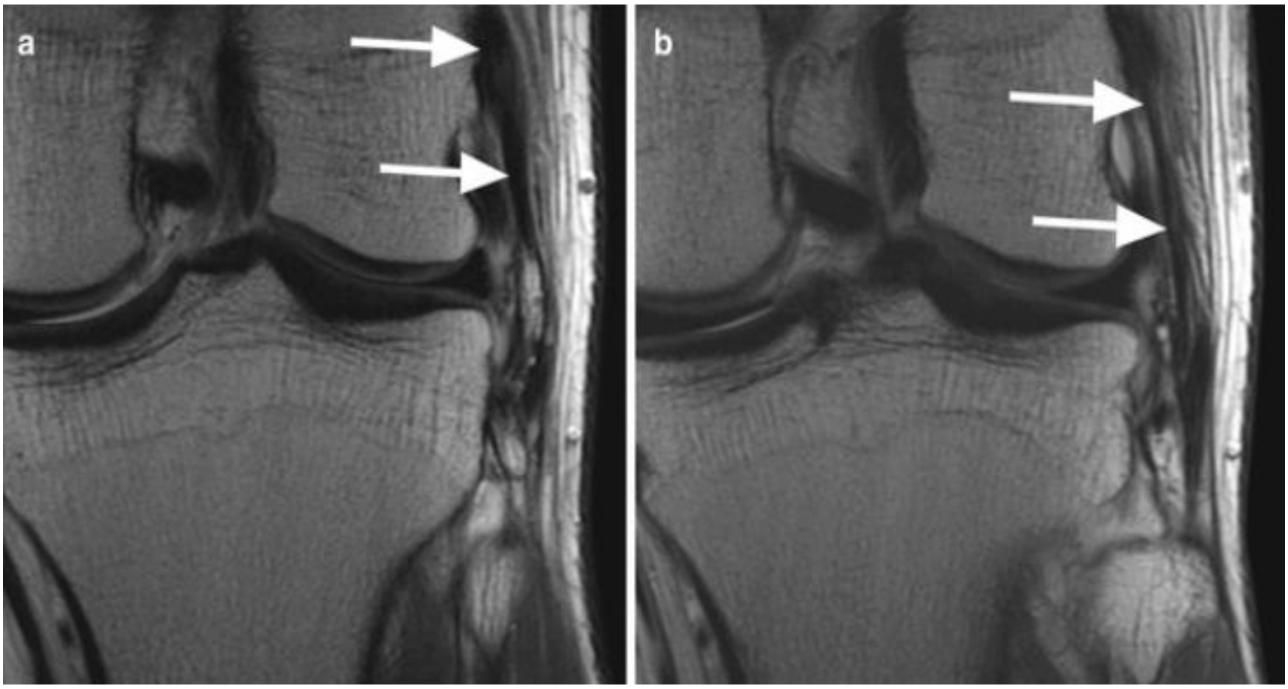


Figure 12: Normal lateral collateral ligament (LCL). Coronal proton-density fat sat MRI images show the normal LCL extending from the lateral femoral condyle to the fibular head *(large arrows in a & b).*

MENISCI *(MEDIAL & LATERAL)*

Menisci are made up of hyaline cartilage, which covers the articulating surfaces of the bones forming the knee joint, and it creates a smooth surface that protects the underlying bone from damage due to repeated friction.[28] There are two meniscal cartilages in the knee that act as shock-absorbers: one on the inner and one on the outer side. Their job is to evenly distribute the load from the thigh bone to shin bone when walking and to provide knee stability. If the menisci are damaged, this can cause the cartilage beneath to become damaged and develop arthritis.[28,29]

There are two menisci in the knee joint: medial and lateral menisci. They are made up of thick collages fibers, which are arranged circumferentially with radial extensions from the joint capsule. They consist of thick and convex peripheral border, which is vascularized by capillaries from the vessels supplying the joint capsule and synovial membrane.[29]

Medial meniscus

The medial meniscus is semicircular, more crescent shaped, measures approximately 35 mm in diameter *(anterior to posterior)* and is significantly broader posteriorly than it is anteriorly.[42] Covers (~ 60%) portion of the underlying tibial plateau. The anterior horn is attached to the tibia plateau near the intercondylar fossa anterior to ACL. There is significant variability in the attachment location of the anterior horn of the medial meniscus. The posterior horn is attached to the posterior intercondylar fossa of the tibia between the lateral meniscus and the posterior cruciate ligament.[29,30]

The area of the anterior horn insertion site of the medial meniscus was the largest overall, measuring 61.4 mm^2, whereas the posterior horn of the lateral meniscus was the smallest, at 28.5 mm. [30]

The tibial portion of the capsular attachment is the coronary ligament. At its midpoint, the medial meniscus is more firmly attached to the femur through a condensation in the joint capsule known as the deep medial collateral ligament as a result more prone for injury.[30]

Lateral meniscus

The lateral meniscus is almost circular, with an approximately uniform width from anterior to posterior. It occupies a larger portion (~ 80%) of the articular surface. Both horns of the lateral meniscus are attached to the tibia. The insertion of the anterior horn of the lateral meniscus lies anterior to the intercondylar eminence and adjacent to the broad attachment site of the ACL.[16] The posterior horn of the lateral meniscus inserts posterior to the lateral tibial spine and just anterior to the insertion of the posterior horn of the medial meniscus. The lateral meniscus is loosely attached to the capsular ligament; however, these fibers do not attach to the lateral collateral ligament. The posterior horn of the lateral meniscus attaches to the inner aspect of the medial femoral condyle via the anterior and posterior meniscofemoral ligaments of Humphrey and Weisberg, respectively, which originate near the origin of the PCL.[22,31]

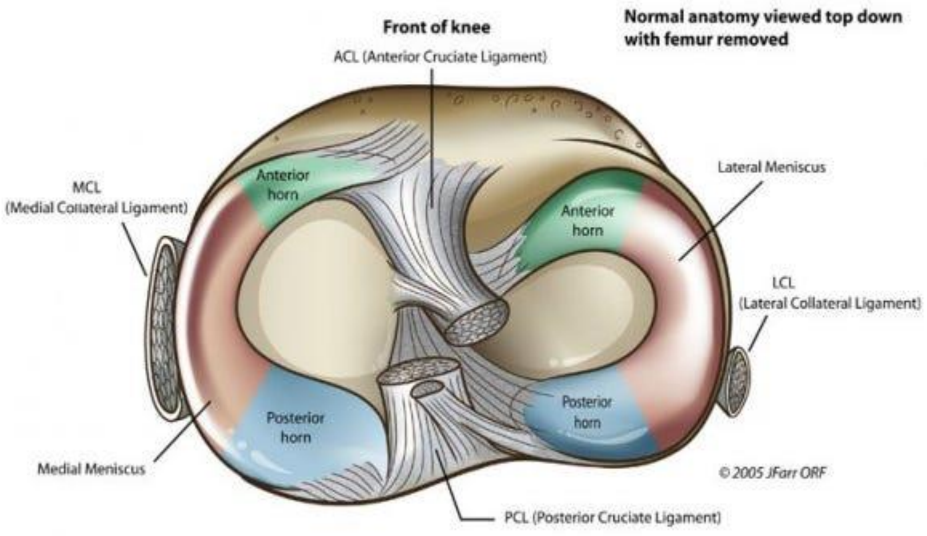


Figure 13: Top view of the tibia showing anterior & posterior horn of both medial & lateral meniscus and their respective attachments.

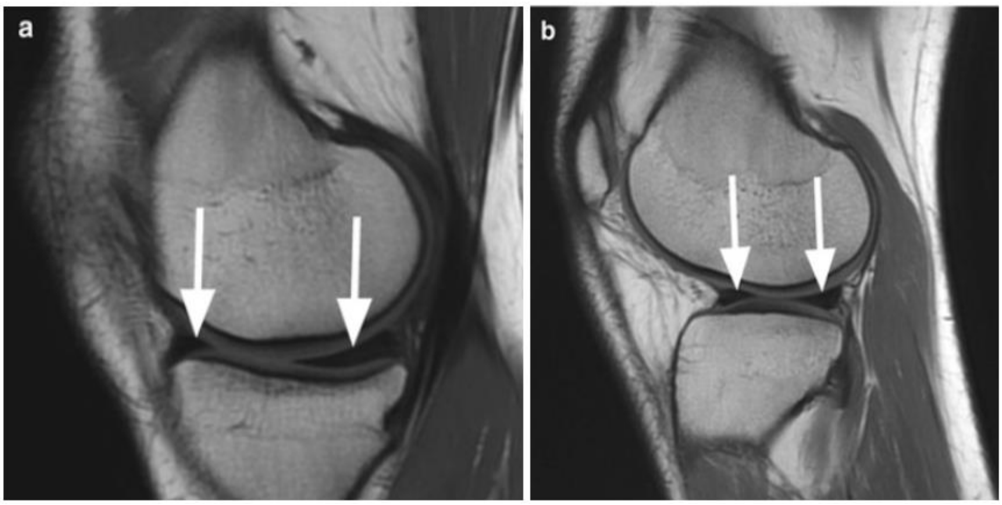


Figure 14: Sagittal MRI images of normal menisci (a) Image through the medial compartment showing medial meniscus which is wider posteriorly than anteriorly *(arrows)* (b) Image through the lateral compartment shows the normal homogeneous hypointense anterior and posterior horn of the lateral meniscus *(arrows).*

KNEE INJURIES

CRUCIATE LIGAMENT INJURIES:

Anterior cruciate ligament (ACL):

The ACL is the most commonly disrupted ligament of the knee, especially in athletes who participate in sports that involve rapid starting, stopping, and pivoting *(e.g. soccer, basketball, tennis, netball, and snow skiing).* Most injuries occur from a non-contact mechanism 70–80% of the time. There are two distinct mechanisms by which the ACL is ruptured in a non-contact manner. The first is deceleration during pivoting, common movement used in sports like football or basketball. Women are about three times at higher risk of having their ACL injured than men.[32,33]

The second non-contact mechanism is that of landing on one leg and then falling with a twisting, valgus force while maintaining quadriceps contraction. Again, with this mechanism, the quadriceps contraction leads to anterior tibial translation with minimal resistance from the secondary stabilizers, ultimately resulting in ACL rupture. Most common mechanism of contact-mediated ACL rupture involves an outside force that results in a valgus collapse of the knee.[33]

ACL is not imaged entirely on a single sagittal image and must be evaluated on two or three contiguous images. While the ACL is best visualized on sagittal images, the coronal and axial images are often helpful for thorough assessment of integrity of its structure.[34]
The normal ACL is relatively low in signal intensity, primarily at its femoral attachment. However, a striated appearance of the distal portion of the ACL on sagittal images is a common appearance and should not be mistaken for a tear.[33]

MRI Imaging: Imaging of ACL tears can be divided into primary and secondary signs.

Primary signs

Includes swelling, increased signal on T2 or fat-saturated proton density (PD) results due to haemorrhage and oedema associated with injury and fiber discontinuity. ACL tears typically occur in the middle portion of the ligament *(mid-substance tears)* and appear as discontinuity of the ligament or abnormal contour. The signal of the ACL can be more hyperintense on T2. If the angle is still normal and there is a hyperintense signal, a partial rupture is more likely than a complete rupture.[35]

Abnormal anterior cruciate ligament orientation relative to intercondylar *(Blumensaat)* line. ACL angle (angle between the intercondylar line and ACL) >15° with the apex of the angle located anteriorly, indicating a less steep ACL line - this indicates a ruptured and collapsed ligament. A fluid signal at the site of femoral attachment at the intercondylar notch, denotes avulsion at the femoral attachment.[35]

ACL tear may only involve one bundle. Imaging of isolated posterolateral bundle tear include: Fluid signal and/or a gap between the medial aspect of the lateral femoral condyle and the lateral aspect of the mid-ACL, can be seen on either axial or coronal MRI images. Incomplete coverage of the lateral aspect of the tibial spine of the tibia by the distal ACL attachment, seen only on coronal MRI images.[35,36]

Secondary signs

Bone contusion in lateral femoral condyle and posterolateral tibial plateau, >7 mm of anterior tibial translation, Segond fracture, Bowing of PCL: reduced PCL angle <107^{o}, Medial or lateral collateral ligament injury, Lateral femoral sulcus deeper than 1.5 mm.

Findings of Chronic ACL tear: Reduced width/Non visualization of ligament *(owing to atrophy of its fibres).* Abnormal orientation of the ACL.[36]

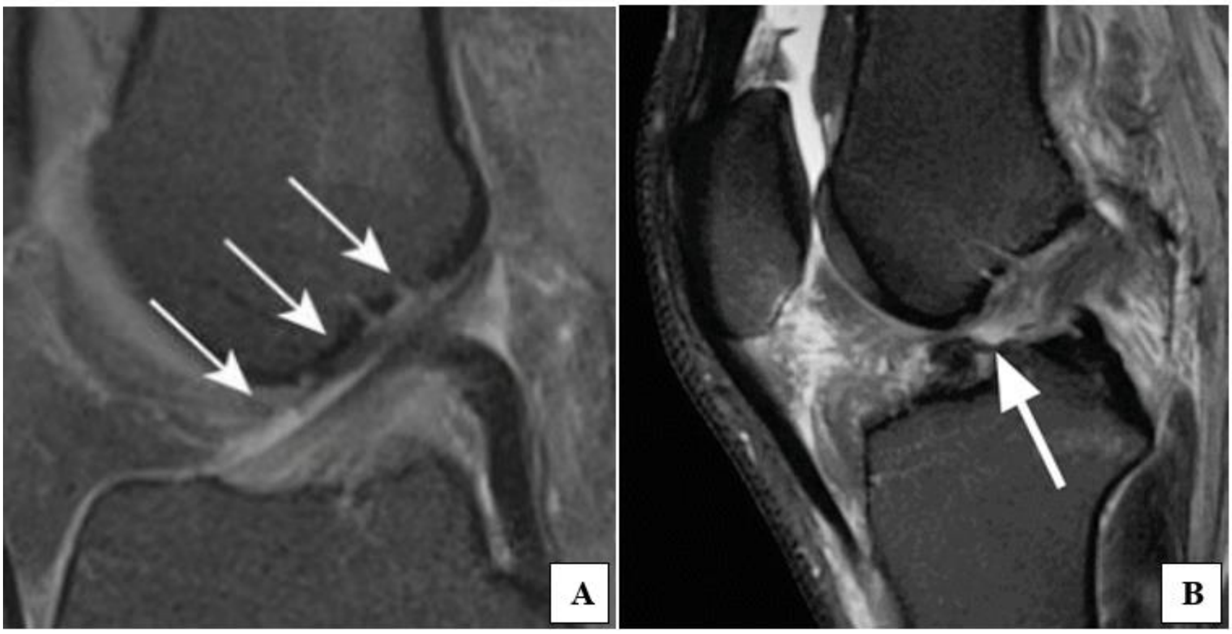


Figure 15: (A) Sagittal proton density weighted fat saturated (PDFS) image showing subtle inter-substance hyperintensities (arrows) *S/o Sprain.* (B) Sagittal T2-weighted fat-suppressed image shows complete discontinuity of the ligament adjacent to the tibial insertion *(arrow) suggesting complete tear*.

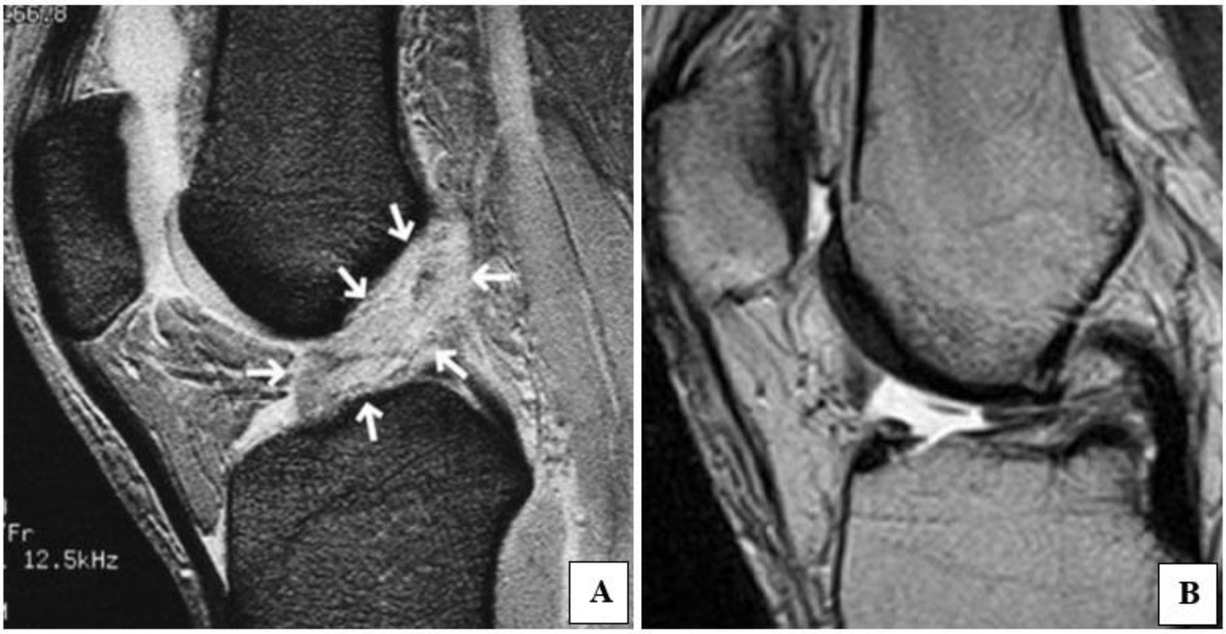


Figure 16: (A) Sagittal T2WI showing discontinuous and swollen ACL for its entire length *(arrows),* intraligamentous linear hyperintensity represents interstitial tear. (B) Sagittal PDFS image demonstrating near complete absence of ACL fibers *suggesting chronic tear*.

Posterior cruciate ligament (PCL):

The PCL arises from posterolateral part of medial femoral condyle and inserts into the posterior intercondylar portion of tibia. PCL is thicker than the ACL. The PCL is diffusely low in signal intensity and has a hockey stick configuration normally. PCL tears are less common than anterior cruciate ligament tears and accounts for ~10 *(range 2-23%)* of all knee injuries. During flexion, the anterolateral band becomes tight, whereas the posteromedial bundle tightens during extension and the posterior cruciate ligament acts to resist anterior translation of the femur on the tibia. While in flexion and weight-bearing *(such as walking downhill).*[37]

PCL injuries are isolated in only 30% of cases and thus commonly associated with other injuries. PCL is the stabilizer for the femur Sports injuries and car accidents *(dashboard injury)* are equally responsible for these injuries. Even if PCL is damaged and its function impaired or lost, the knee instability upon weight-bearing is less commonly seen than in ACL tear, and patients may not be aware of any symptoms, so many patients will be asymptomatic and their clinical examination is unremarkable. Damages to menisci and cartilage secondary to PCL tear is less commonly seen than in ACL tear.[37,38]

MRI Imaging: PCL usually remains contiguous *(~ 60 % of cases)* although there may be complete or partial ligamentous disruption, absent PCL replaced by hyperintense T1 and T2 signal. Enlarged and swollen PCL *(> 8-10 mm)* AP diameter of the vertical portion on sagittal imaging is indicative of a tear. Posterior tibial translation of >2-3 mm can also be measured in the mid medial compartment which indicates PCL tear/sprain. Chronic tears of PCL can result in thinning or non-visualization of the ligament or abnormal angulation (buckling) of this structure can also be seen with other associated knee injuries.[39]

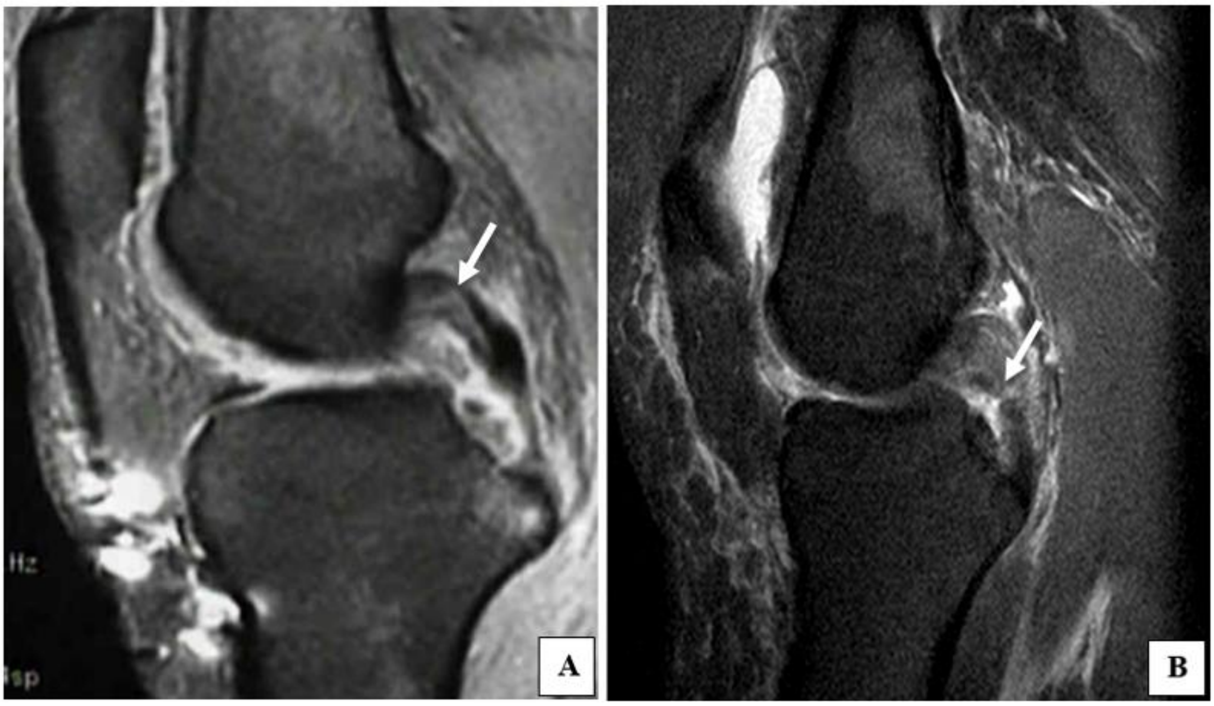


Figure 17: (A) Sagittal PDFS image showing hyperintensities within the PCL with no obvious discontinuity – ***S/o Sprain/edema.*** (B) Sagittal PDFS image demonstrating swollen PCL with focal discontinuity (arrows) – ***S/o Complete PCL tear.***

Figure 18: (A) Sagittal PDFS image showing bulky PCL with intraligamentous linear hyperintensity represents interstitial tear – ***S/o Partial tear.*** (B) Sagittal PDFS image demonstrating abnormal angulation *(buckling)* of PCL.

MENISCI INJURY:

Medial meniscus is larger, more oblong, and normally has a larger posterior horn than anterior horn in cross section. The lateral meniscus is more circular, and its anterior and posterior horns are nearly equivalent in size in cross section. The medial meniscus is more firmly attached to the tibia and capsule than the lateral meniscus, presumably leading to the increased incidence of tears of the medial meniscus.[40]

Normal meniscus is low signal on all sequences. In children, sometimes an increased signal is seen within meniscus due to increased vascularity, but usually the signal does not contact articular surface similarly mucinous degeneration of meniscus can also produce abnormal signal within a meniscus which does not contact an articular surface and should not be mistaken for a tear. Sagittal proton density (PD) images through normal medial and lateral menisci in cross section demonstrate the normal appearance of the anterior and posterior horns as low signal *(black)* triangles.[41]

Mid-coronal fat-suppressed T2 image demonstrates the normal triangular appearance of the bodies of both menisci. Fat sagittal image of the lateral meniscus cuts through the edge shows the bow tie appearance. Most common criterion for diagnosing meniscus tear on MRI is an increased signal extending in a line or band to the articular surface. Another finding is the abnormal size or shape of the meniscus, which would indicate damaged surfaces, abnormal signal must unequivocally contact the surface of the meniscus. Although it may seem easy to read a meniscus as torn from an MRI, it is actually sometimes difficult to interpret whether the abnormal signal comes close to or actually touches the surface.[42,43]

To provide a greater degree of accuracy one should see increased signal contacting the articular surface of the menisci on at least two images *(sagittal or coronal).* Most meniscal tears are visible and best seen on sagittal images because most tears occur in the posterior horns. Increased signal to the surface on only one slice should be considered as a *"possible tear."*[44,45]

Table No. 1: Depicting types and Patterns of meniscal tears

MENISCAL TEAR MORPHOOGY	**DESCRIPTION**	**APPEARANCE ON MRI**
HORIZONTAL	Separates meniscus into superior *(femoral)* and inferior *(tibial)* fragments	Primarily horizontal signal on sagittal images
VERTICAL RADIAL	Splits central margin of meniscus	Vertical signal oriented perpendicular to the curvature of the meniscus
VERTICAL LONGITUDINAL	Extends along length of meniscus, separates it into inner and outer fragments	Vertical signal oriented parallel to the curvature of the meniscus
BUCKET HANDLE	Subtype of longitudinal tear in which the displaced central fragment resembles a bucket handle	"Double PCL" sign, displaced fragment often seen parallel to PCL in intercondylar notch on sagittal images
COMPLEX	Combination of multiple planes, commonly horizontal and radial	Characteristics of each tear type or fragmented/macerated
MENISCOCAPSULAR SEPARATION	Rupture of meniscus-capsule junction	Increased signal between edge of meniscus and capsule

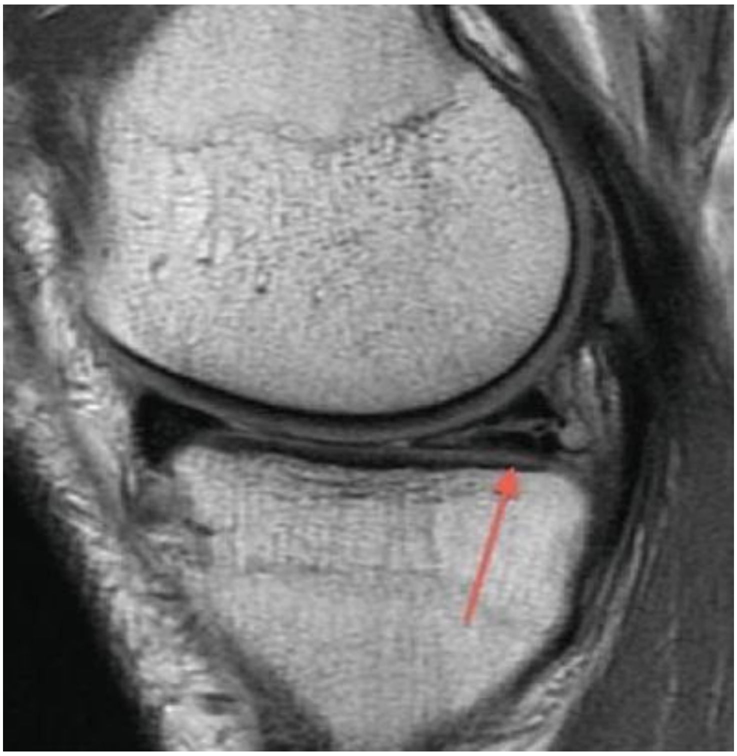
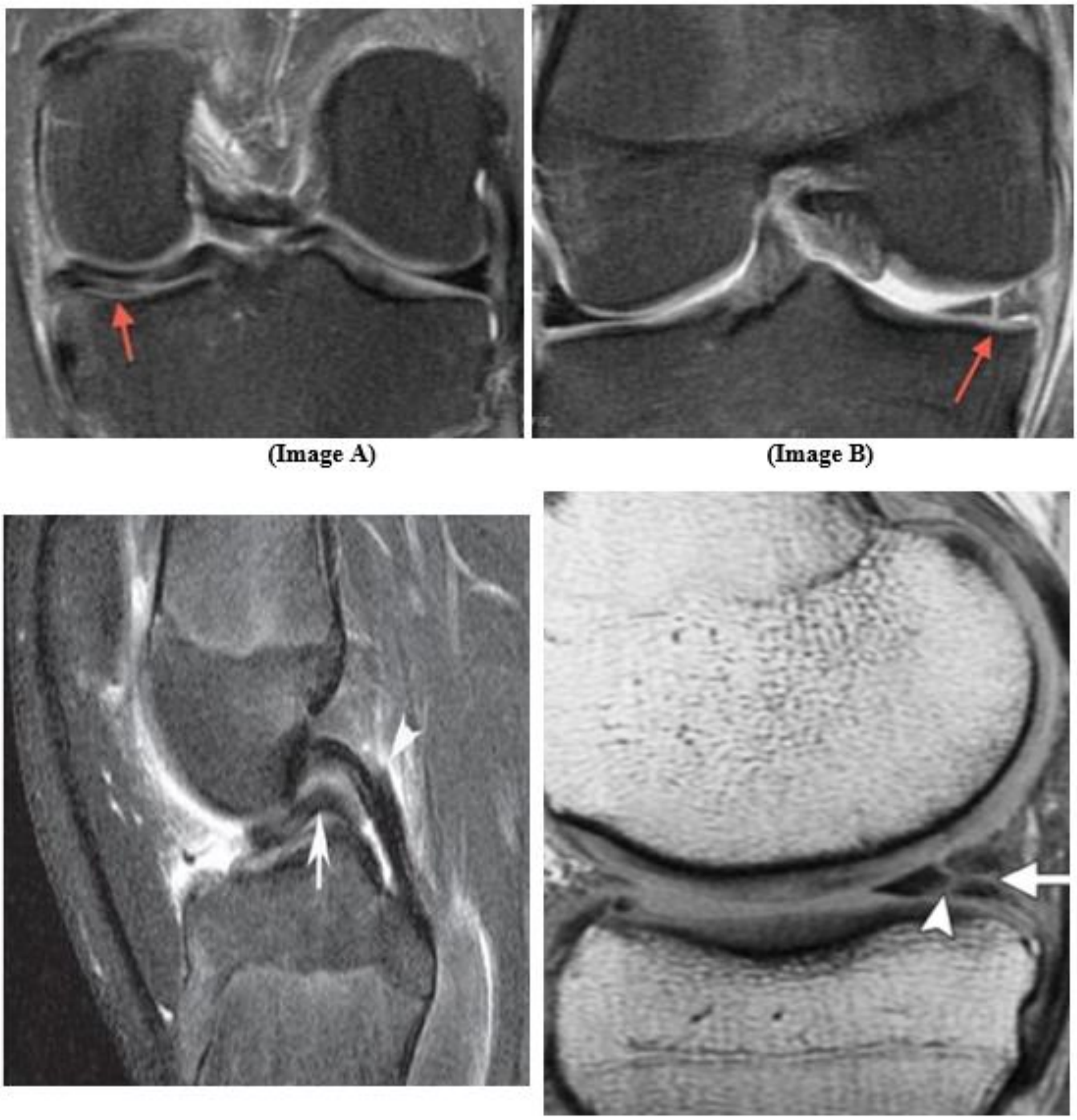


Figure 19: Sagittal PD images show a horizontal tear *(seen separating the meniscus into two parts)* seen in the posterior horn of medial meniscus.

Figure 20: (A) Coronal fat-suppressed T2 image shows radial component of the tear *(seen*



(Image A) (Image B)

(Image C) (Image D)

along the margin of meniscus) in the medial meniscus. (B) Coronal fat-suppressed T2 image showing the longitudinal tear *(oriented perpendicular to the meniscus).* (C) A sagittal PDFS image shows a meniscal flap (arrow), arising from medial meniscus and displaced inferior to the PCL (arrowhead), exhibiting the double-PCL sign**.** (D) PDFS image both horiz. & vertical components are seen crossing through each other involving multiple areas – *S/o complex tear*.

Table No. 2: MRI grading system for meniscal signal intensity.

GRADE	DESCRIPTION
1	Small area of hyper intensity, no extension to the articular surface
2	Linear areas of hyper intensity, no extension to the articular surface
2A	Linear abnormal hyper intensity with no extension to the articular surface
2B	Abnormal hyper intensity, reaches the articular surface on single image
2C	Globular wedge shaped abnormal hyper intensity with no extension to the articular surface
3	Abnormal hyper intensity extends to atleast one articular surface (superior or inferior) and is referred as a definite meniscal tear

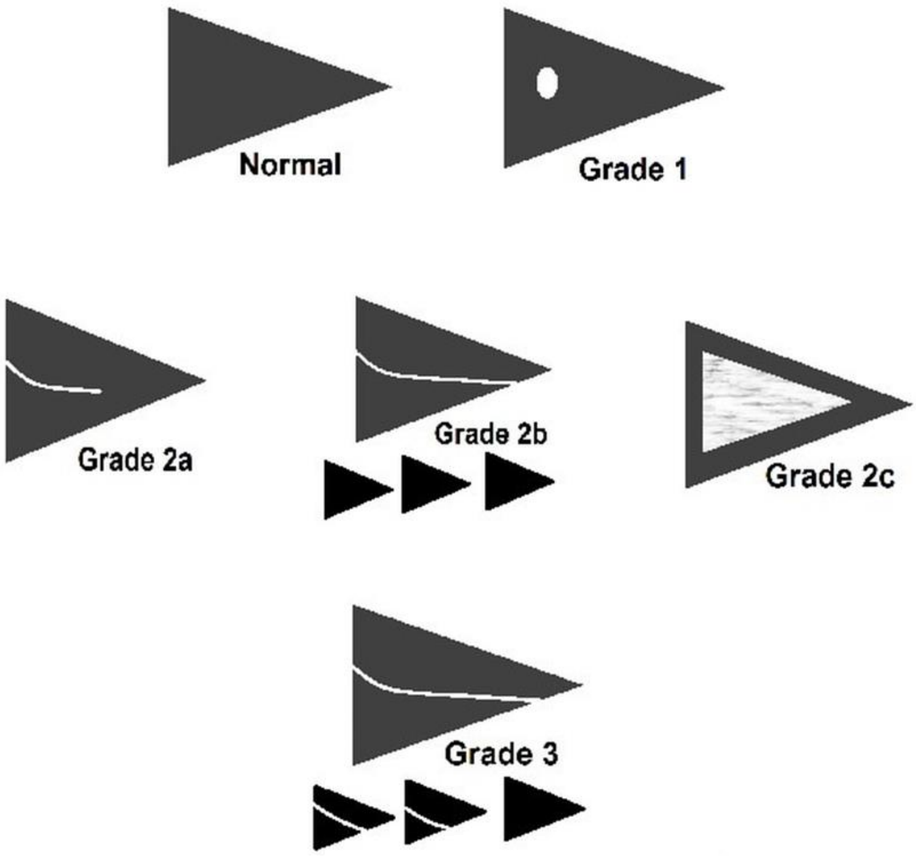


Figure 21: Diagrammatic representation of the meniscus showing different grades of different type of hyperintensities seen during the tear of meniscus injury.

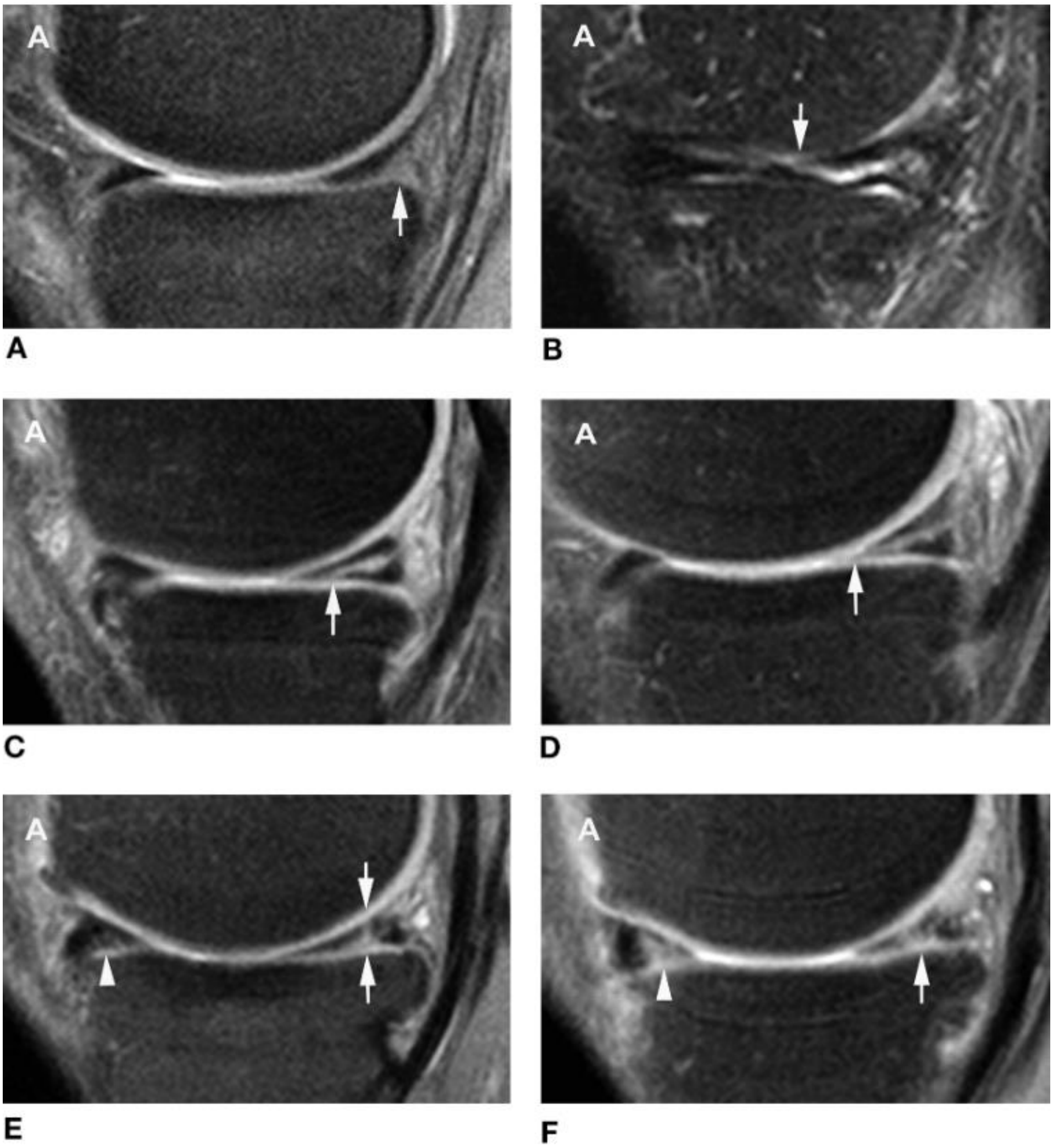


Figure 22: Sagittal MRI of the anterior and posterior one-third of the with type 1 to 6 signal intensities contacting one or both articular surfaces. (A) Type 1, broad intermediate SI in peripheral 1/5 of posterior third in contact with tibial surface *(arrow).* (b), (c) & (d) Type 2a & 2b intermediate SI contacting tibial surface with some not the extending to the posterior articular surface *(arrow).* (e) Type 2c, intrameniscal intermediate SI contacting both femoral and tibial surfaces *(arrows);* one definite and 2 possible SI in contact with tibial surface of anterior third *(arrowhead).* (f) Type 3, comminuted lesions in contact with both surfaces of anterior *(arrowhead)* and posterior third *(arrow).*

COLLATERAL LIGAMENTS INJURY

Medial collateral ligament (MCL)

Medial collateral ligament injuries of the knee comprise of sprains, partial and complete tears. MCL injuries are one of the most common ligamentous injuries of the knee. Medial collateral ligament injuries are very common in athletes and it is likely that many low-grade medial collateral ligament injuries are unreported. Common risk factors for medial collateral ligament injury include both contact and non-contact sports such as: football, martial arts, skiing.[46]

Medial collateral ligament injury or tears are usually the results of valgus stress, but different mechanisms can result in characteristic associated injury patterns. Direct impact on the lateral knee can cause isolated medial collateral ligament injury. High impact valgus force causes medial collateral ligament, posterior oblique ligament and anterior cruciate ligament injury. Valgus force and external rotation causes medial collateral ligament and posteromedial corner injury.[47]

MRI Imaging: The most obvious sign of medial collateral ligament injury is its discontinuity in case of a partial or complete tear. Other signs include a wavy form of the ligament. Injury of the deep portions of the medial collateral ligament is evident as high-signal intensity, swelling and discontinuity of the medial meniscofemoral and meniscotibial ligaments or an avulsion injury of the meniscotibial ligament *(reverse Segond fracture).* Medial collateral ligament injuries can be graded on MRI according to the following grading as shown:[47]

Grade 1: *(Minor sprain)* high signal is seen medial (superficial) to the ligament, which looks normal. **Grade 2**: *(Severe sprain or partial tear)* high signal is seen medial to the ligament, with high signal or partial disruption of the ligament. **Grade 3:** complete disruption of the ligament.

In addition, MRI allows the depiction of associated injuries as bone bruises, posterior oblique ligament and anterior cruciate ligament injuries as well as meniscal tears.

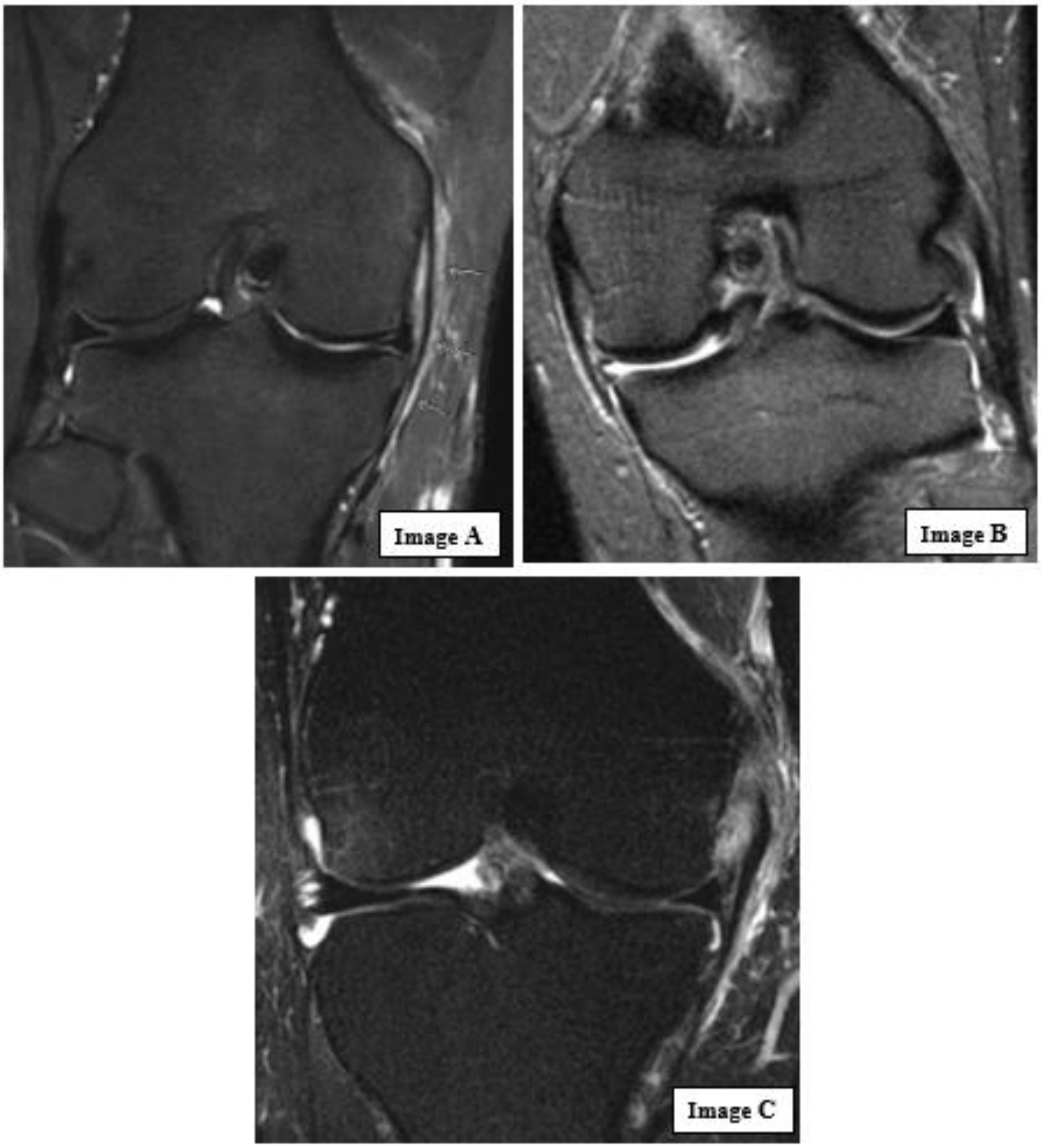


Figure 23: Coronal STIR images demonstrating MCL injury. (A) MCL is seen surrounded by edema, with normal thickness and signal intensity of its fibers and no loss of continuity *(Grade I).* (B) MCL sprain *(grade II)* hyperintense signal along the superficial aspect of the MCL as well as within the ligament. (C) High T2 signal is seen surrounding the MCL which demonstrates loss of continuity in – *S/o complete tear (Grade III).*

Lateral collateral ligament (LCL)

Lateral collateral ligament injuries of the knee are rare in isolation and usually occur in the context of a posterolateral corner injury or in association with other ligamentous or meniscal injuries. LCL injuries usually occur in conjunction with other knee ligament injuries, but are rare in isolation and comprise < 5 % of all knee injuries. History often reveals a varus stress injury or an anteromedial blow. Complaints are lateral knee pain and swelling after acute trauma, instability of the knee near knee extension and difficulties climbing stairs.[48]

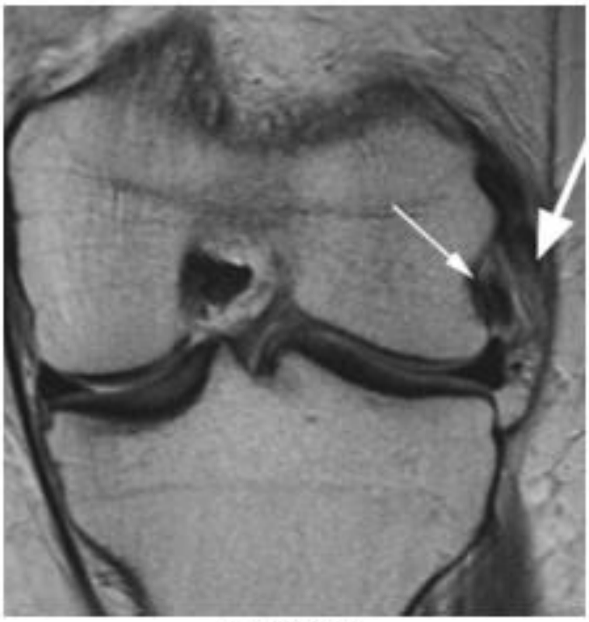
Isolated lateral collateral ligament injury is usually due to a lower velocity injury mechanism, external rotation stress in full extension, varus force in extension or mild to moderate flexion, posterolaterally directed blow to the anteromedial aspect of the tibia in knee extension.[46] Higher varus impact injuries such as a dashboard injury usually result in a concomitant injury of other posterolateral corner structures and/or cruciate ligament injury.[48]

MRI Imaging:

MRI allows for the localization of the injury and injury grading. Fibular collateral ligament injuries can be best depicted in coronal and axial views. Furthermore, it is the modality of choice for the workup of concomitant ligamentous and meniscal injuries. Lateral collateral ligament injuries will display different findings depending on the extent of the injury: Fluid surrounding the lateral collateral ligament *(Grade 1).* Partial discontinuity of the ligament fibers *(Grade 2).* Complete disruption of the fibers *(Grade 3).*[49]

(Image A)

(Image B)



(Image C)

Figure 24: Coronal PDFS images showing grades of Lateral collateral ligament (LCL) **(A)** shows intrasubstance signal changes (arrow) at the proximal insertion of LCL without complete discontinuity of the ligament *(Grade I).* **(B)** Image at the level of the femoral insertion show intrasubstance signal changes and mildly bulky LCL *(Grade II).* **(C)** Shows discontinuity of the ligament (large arrow) with intrinsic hyperintensities *(Grade III)* Note the normal popliteal tendon (small arrow)

Bone contusions

Bone contusions *(also known as bone bruises)* are frequently identified at MRI after an injury to the musculoskeletal system. These osseous injuries may result from a direct blow, load to a subchondral surface to the bone, from compressive forces of adjacent bones impacting one another, or from traction forces that occur during an avulsion injury. They typically appear within 48 hours of injury and can persist for up to six months. The distribution of bone marrow edema is like a footprint left behind at injury, providing valuable clues to the associated soft-tissue injuries.[50]

Patterns of bone bruise in knee injury:[50,51]

Pivot-shift contusions: Posterolateral tibial plateau and mid part of lateral femoral condyle are involved, seen because of valgus stress to flexed and externally rotated knee and usually associated with tears

Dashboard injury contusions: Anterior tibia with or without posterior patella are involved, seen because of anterior force to tibia in a flexed knee *(e.g. knees against dashboard in motor vehicle collision, or fall onto flexed knee)* usually associated with PCL tear.

Clip injury pattern: Lateral femoral condyle and lateral tibial plateau with or without medial femoral condyle from medial collateral ligament (MCL) seen because of valgus stress to flexed knee usually associated with MCL injuries.

Kissing contusions: Anterior tibial plateau and anterior femoral condyle are involved and seen due to direct force to anterior tibia with foot planted can be associated with ACL, PCL, meniscal injuries, and in severe cases knee dislocation.

Lateral patellar dislocation: Anterolateral lateral femoral condyle and inferomedial patella because of twisting injury to flexed knee.

Fracture in knee injury

Bony articular fractures can be identified on MRI after different type of injuries to the knee. They are usually associated with other ligaments injuries and bony contusions. The common types of fractures seen after knee injuries are: Stress fractures (Liner & globular fractures), Displaced, Impacted, tibial plateau and bony shaft fractures. MRI can be effective for the early diagnosis of fractures however few articular/subchondral fracture can be missed on MRI and should be correlated with Computed tomography (CT). The characteristic findings on MRI are bone marrow edema-like signal intensity and articular/subchondral hypointense line of the affected epiphysis, diaphysis or condyles.[52]

Other associated fractures include: ACL avulsion fracture or tibial eminence avulsion fracture. Typically involves separation of the tibial attachment of the ACL to variable degrees PCL avulsion fractures represent the most common isolated PCL lesion, typically involves the separation of the posterior tibial insertion of the PCL to variable degrees. Avulsion fracture of the knee that involves the lateral aspect of the tibial plateau and is frequently associated with disruption of the ACL *(Segond fracture).* Origin of MCL avulsion fracture (*Stieda fracture)*, insertion of deep MCL fibers: (Reverse Segond fracture). Avulsion of the lateral collateral ligament at the origin usually seen above popliteal groove.[52]

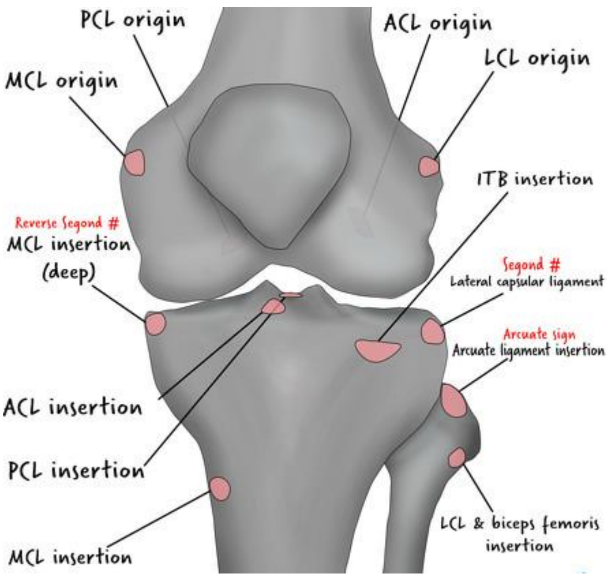


Figure 25: Image showing review areas of the knee that include insertion and origin points of ligaments, tendons and capsular attachments. Each is an important region to look for subtle avulsion fracture.

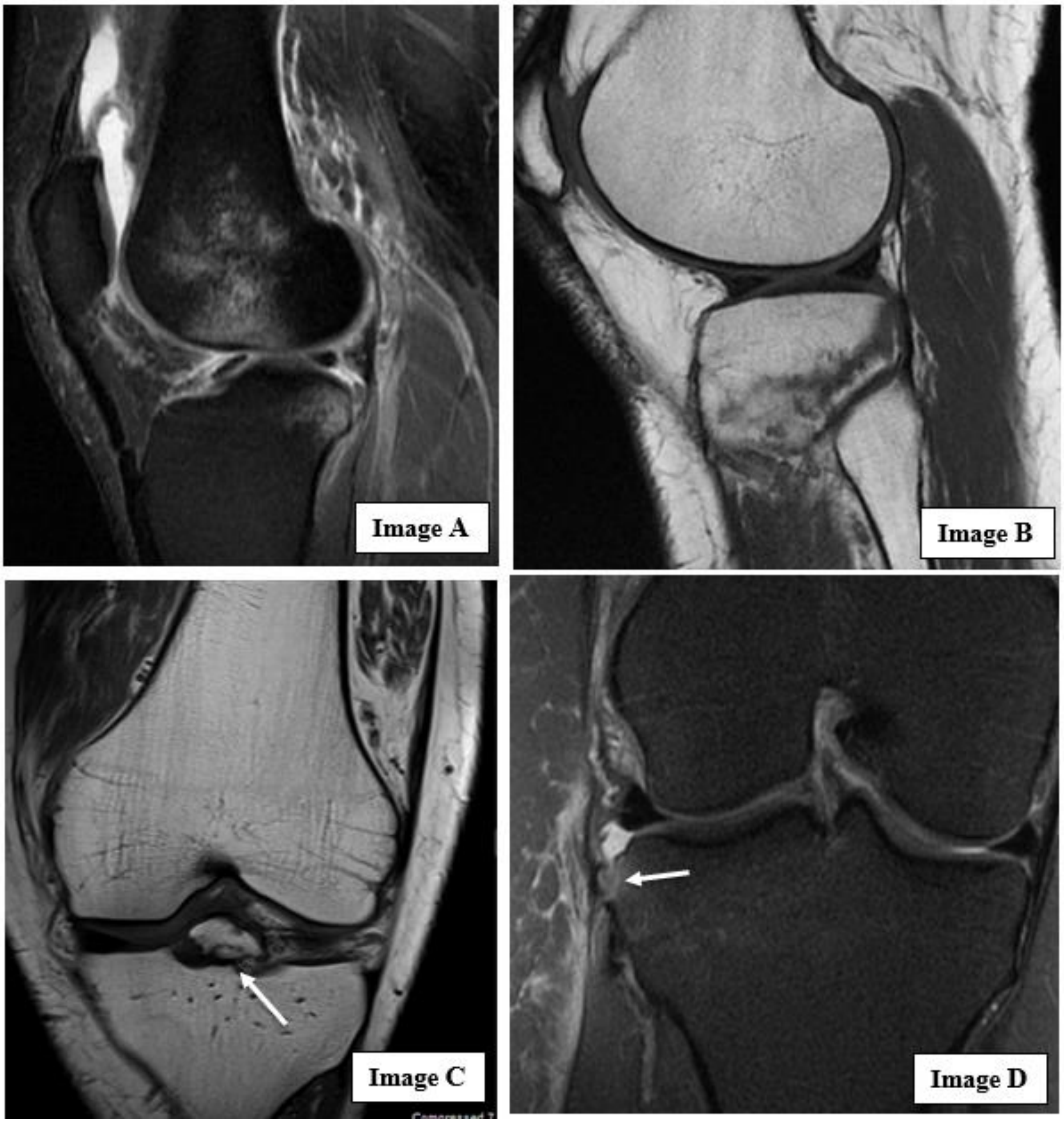


Figure 26: (A) Sagittal T2 fat sat image demsoteraing pivot shift contusion in a patient with sports injury. **(B)** T1 Sagittal section showing step-like transverse fractures through proximal tibial metaphysis with marked surrounding bone marrow edema. **(C)** T1 coronal section there is evidence of an avulsion fracture of the tibial attachment of ACL. **(D)** Coronal T2 FS images showing subtle avulsed cortical bone fragment along the lateral border of the lateral tibial plateau *(Segond fracture)*

JOINT EFFUSION & SOFT TISSUE

Joint effusion is defined as an increased amount of fluid within the synovial compartment of a joint. There is normally only a small amount of physiological intra-articular fluid. Abnormal fluid accumulation can result from inflammation, infection or trauma and might be exudate, transudate, blood and/or fat. Fluid intensities in the subcutaneous fat is a common finding anterior to the knee on MRI. This may be caused by low-grade shearing injuries.[53,54]

On MRI: Reticular fluid intensities or diffuse ill-defined edematous signal changes on the fat-suppressed PD-weighted sequence at the anterior subcutaneous adipose tissue, affecting the pre-patellar and superficial infrapatellar regions can be seen, encapsulated fluid intensity collection at the pre-patellar or superficial infrapatellar regions are the common location.[54]

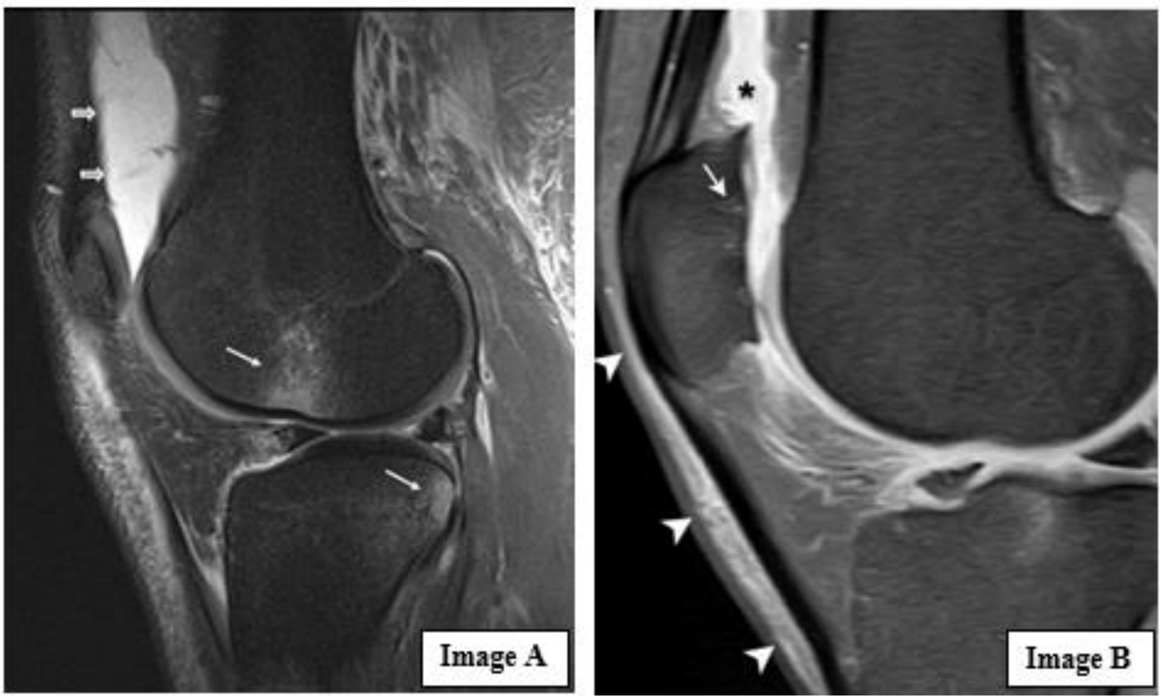


Figure 27: (A) Sagittal PDFS image shows mild Hoffa’s fat pad apex edema, pivot shift bony contusion *(external femoral condyle and of the posterior tibial plateau)* shown by thin arrows and with joint effusion *(wide arrows).* (B) Sagittal PDFS images in a patient with RTA show anterior soft tissue edema *(arrowheads)* and mild joint effusion (*)

KNEE STABILITY AND ITS MOVEMENTS

The overall stability of the knee depends on the interaction of the capsule, menisci, ligaments and muscles, the geometry of the articular surfaces and the femoro-tibial modifications during loading. These are all interdependent between them, thus allowing a normal motility and, at the same time, an effective stability.[55]

The knee is a modified hinge joint where the lack of congruence between the bone surfaces permits six degrees of movement, three translational (anterior-posterior, medial-lateral, and inferior-superior) and three rotational (flexion-extension, intra- external rotation, adduction-abduction). The movements are determined by the sliding of the articular surfaces of the tibia and femur and the orientation of the four major ligaments of the knee. In particular, the movement of flexion and extension is the broadest and more important. The first is defined as a posterior approaching movement of the leg to the thigh, which can be active or passive and dependent on the hip position. During the active flexion, the knee can reach 120°-140° with the hip flexed, while passively reach up to 160°.[55,56]

The medial compartment has a contact 1.6 times greater than the lateral. Flexion is ensured by a combination of rotation (“roll-back”) and sliding of the femur over the tibia. The movements of the articular surfaces mainly depend on the conformation and orientation of the articular surfaces and of ACL, PCL, MCL and LCL.[56]

The lateral femoral condyle rotates more than medial in the first 15°-20° of flexion, because of its greater radius of curvature. This different parameter of the two condyles, determines a movement of tibial internal rotation during flexion. Beyond 20° of flexion, slippage on both condyles becomes predominant. On the contrary extension is associated to an external rotation of the tibia relative to the femur; this rotation has been called “the screw-home movement” and is purely passive and dependent on the articular geometry. The menisci, crushed between the articular surfaces in extension, move posteriorly together with the femur in flexion.[55,56]

INTERNAL DERANGEMENT OF THE KNEE *(IDK)*

IDK is an inclusive term used to indicate *(alone or in combination)* certain disorders of the joint including *(alone or in combination)* torn meniscus, loose bodies in the knee, and damaged collateral or cruciate ligaments. Injuries of knee joint range from isolated single element injuries to combined multiple element injuries because of complex arrangements of ligaments, fascial layers, and tendon insertions. In addition, injuries can range from strains or partial tears to complete disruptions.[57]

Conditions Causing Internal Derangement of Knee: Medial collateral ligament injury/ Lateral collateral ligament injury/ anterior cruciate ligament injury/ Posterior cruciate ligament injury/ Meniscal injury/ Meniscal cysts.[57]

ROLE OF MRI IN KNEE INJURY

Magnetic resonance imaging (MRI) of the knee is a common diagnostic examination that is performed for the detection and assessment of acute and chronic internal derangement injuries of the knee and serves as an important guide to patient management. MRI improves the evaluation of the bones and soft tissues. MRI is useful in the characterisation of meniscal, cruciate ligament, collateral ligament, and extensor mechanism injuries, as well as articular cartilage, synovial, and tendon disorders.[58]

There is wide variation of MRI systems, including open and closed bore magnet systems, various field strengths, and coil technologies, and MRI protocols such as pulse sequences and field-of-view are commonly customised for specific indications. These factors lead to great variability of pulse sequences utilised from institution to institution. Although knee MRI can be performed on lower field strength systems, including open bore magnets, it is most commonly performed with either 1.5 or 3 Tesla (T) closed bore magnets. [59,60]

MRI protocols of the knee commonly consist of three orthogonal imaging planes of section (axial, coronal, and sagittal), with a combination of fluid-sensitive sequences, either T2-weighted, (T2W) fat-saturated (FS) or proton density-weighted (PDW) FS sequences, and T1-weighted (T1W) non-fat-saturated (NFS) imaging. T2W sequences may make bone and soft tissue edema-like signal changes more conspicuous. Furthermore, they may be helpful to better characterise the postoperative meniscus. T1W images are usually performed without fat saturation and should be obtained to evaluate the bone marrow fat for marrow replacing processes or to detect fracture lines, while T1W FS images are obtained to detect gadolinium following intravenous or intra-articular contrast administration.[58,62]

ROLE OF ARTHROSCOPY IN KNEE INJURY

Knee arthroscopy simply means looking ('scopy') into a knee joint ('arthro') with a camera. It is nothing more than simply just a method for looking into a knee. The term *'knee arthroscopy'* says nothing about why you might be doing the procedure, nothing about what might actually find inside the knee and nothing about what the actual surgical procedure might be to fix the problem.[63]

A list of things that one might find inside a knee joint at the time of an arthroscopy includes: Meniscal tears/ fissures, flaps or defects in the articular cartilage on the joint surfaces/ ACL tears (partial or total)/ PCL tears (partial/complete) Osteochondral loose bodies/ Osteochondritis dissecans lesions, Thickening / inflammation of the fat pad and Medial and/or lateral and/or supra patellar plicae.[64]

Looking just at ‘meniscal tears’: there are many various different types of meniscal tear, ranging from vertical peripheral circumferential tears to radial tears, to horizontal cleavage tears, to flap tears, to ragged degenerate tears, to complex tears and to bucket handle tears *(which may be stable, unstable or displaced and locked).*

Each of these tears has different characteristics and tends to be treated in different ways, with a number of various different surgical techniques. So, a meniscal tear is not ‘just a meniscal tear.’ The same applies for pretty much every other potential pathology that one might find inside a knee: each one needs to be considered carefully and with thought, on a case-by-case basis, according to the exact pathology in the specific context of that particular individual patient (in terms of their physiological age, their health, their job, their exercise/sport activities, their circumstances and their expectations and aspirations).[64,65]

In terms of the technicalities of what potential surgical procedures might be undertaken in a knee joint at the time of an arthroscopy, the list (which again, is certainly not exhaustive) includes: Meniscal trimming/ meniscal repair/ meniscal replacement (e.g. meniscal transplantation)/ arthroscopic articular cartilage grafting/ arthroscopic ACL repair, arthroscopic ACL reconstruction/ washout of debris, osteochondral loose bodies, trimming of the fat pad, excision of place, lateral release and synovectomy.[64] These are the actual procedures that can be performed, which can be performed either minimally-invasively through keyhole surgery or, potentially, through larger open incisions.[65]

DIAGNOSTIC ARTHROSCOPY

Knee arthroscopy is an important diagnostic and therapeutic tool in management of disorders of the knee. A complete diagnostic arthroscopy includes visualization of the supra-patellar pouch, medial gutter, lateral gutter, medial and lateral compartments, intercondylar notch, postero-medial and postero-lateral compartments. Diagnostic arthroscopy is a crucial skill for diagnosing intra-articular disorders of knee including meniscal, synovial, ligamentous, and articular cartilage pathology.[66]

Patient is positioned and knee marking are done for portal entry standard anterolateral and anteromedial portals are used for the diagnostic procedure. The arthroscope is placed into the supra-patellar pouch through the anterolateral portal. The light cord is rotated downward to look up at the patella, and then the light cord is raised to look down at the trochlear groove to evaluate for cartilage injury. The arthroscope is then moved medially into the medial gutter, and the hand is raised to follow the floor down to the tibia, checking for loose bodies.

Next, the medial compartment is opened by straightening knee and placing a valgus force on leg. The arthroscope is brought into the medial compartment. At this point, the anteromedial compartment is seen. Medial meniscus is inspected and probed for tears.[66,67] Cartilage on tibial plateau and medial femoral condyle are evaluated. Knee flexion angle can be changed to inspect entire weight-bearing portion of medial femoral condyle. Knee is then bent to 90°, and arthroscope is brought into intercondylar notch to examine anterior cruciate ligament, posterior cruciate ligament and to check for loose bodies. To enter lateral compartment, a triangle between lateral meniscus, lateral femur, and anterior cruciate ligament is identified.[67]

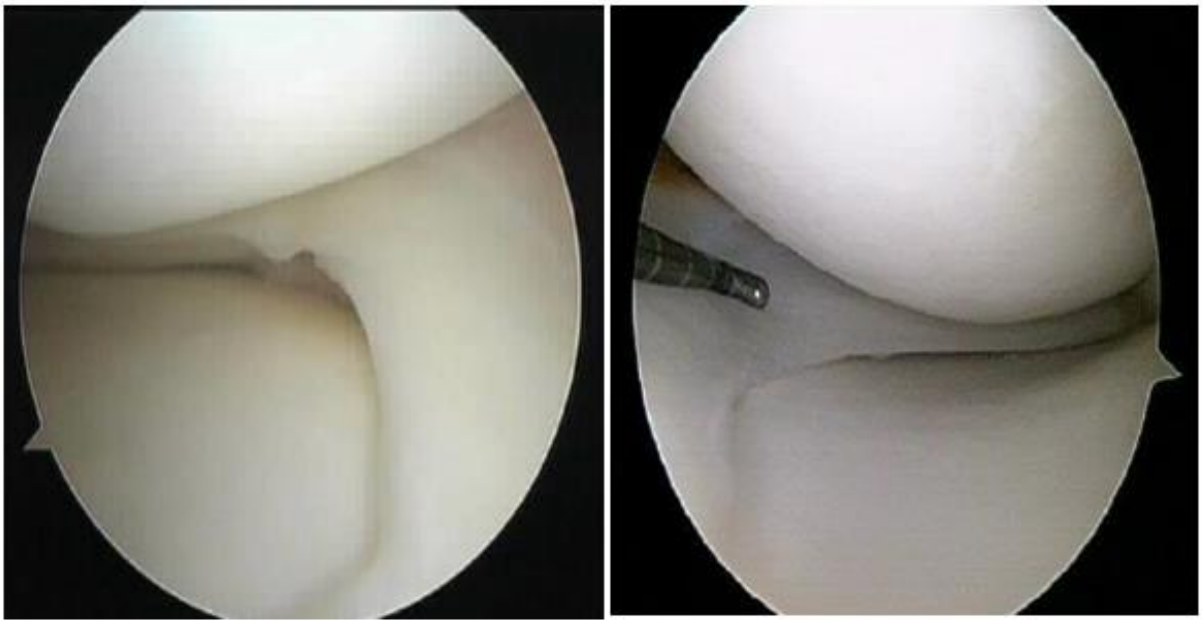


Figure 28: Arthroscopic view of normal meniscus with normal femoral and tibial cartilage

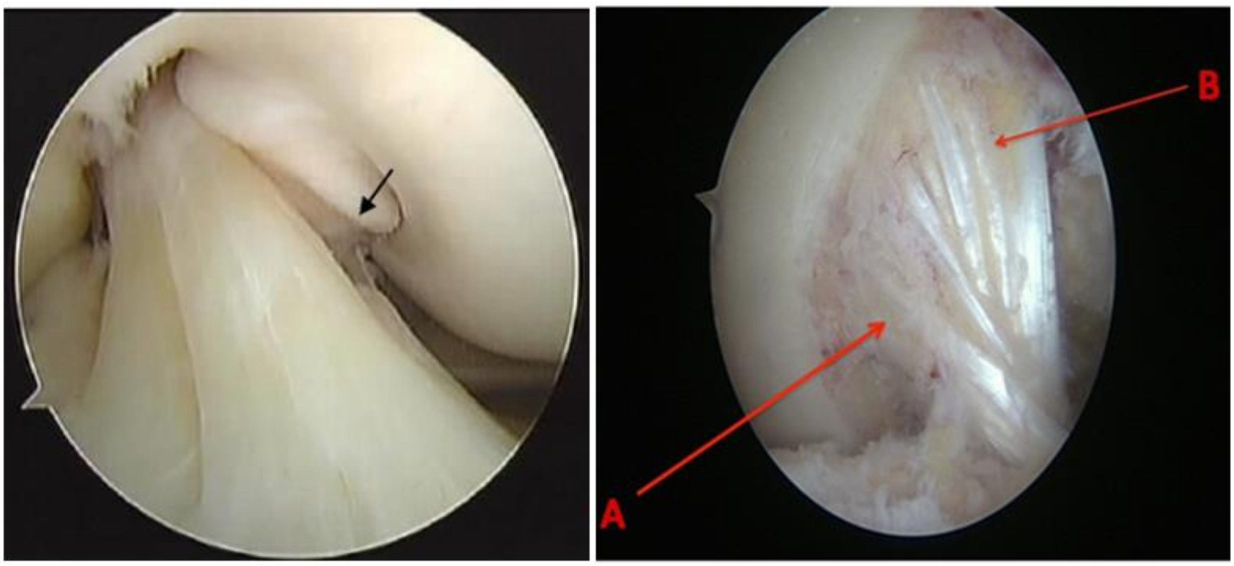


Figure 29: Arthroscopic view showing normal anterior cruciate ligament (ACL) & normal posterior cruciate ligament (PCL), Red arrow showing anterior lateral bundle (ALB) (A- red arrow) & posterior-medial bundle (PMB) (B- red arrow).

Clinical studies on correlation of MRI with arthroscopy in traumatic knee injury:

Chien et al. in a review article summarized on the current clinical practice of MRI evaluation and interpretation of meniscal, ligamentous, cartilaginous, and synovial disorders within the knee that are commonly encountered. The authors concluded that MRI plays a significant role in diagnosis of internal derangements of the knee, detection of the bone marrow oedema-like signal pattern, and radiographically occult factures. MRI enables superb evaluation of the bones, ligaments, menisci, articular cartilage, tendons, synovium, and periarticular soft tissues of the knee joint, and guides orthopaedic treatment planning.[68]

Prospective study conducted by **Ishani et al**. compare and correlated the clinical, MRI, and arthroscopy findings in (ACL) and meniscal injuries of the knee. This study includes 30 cases of ACL and meniscal injuries of the knee admitted between, who underwent clinical examination, MRI, and arthroscopy of the knee. The study results revealed that out of 30 cases, there were 26 male and four female patients with age ranging from 18 years to 60 years, with most patients in between 21 years and 30 years. Clinical examination had sensitivity of 90.91%, specificity of 100%, and accuracy of 93.33% for ACL, sensitivity of 83.33%, specificity of 77.78%, and accuracy of 80% for medial meniscus, and sensitivity of 75%, specificity of 77.27%, and accuracy of 76.67% for lateral meniscus. MRI had sensitivity of 95.45%, specificity of 87.5%, and accuracy of 93.33% for ACL, sensitivity of 91.67%, specificity of 55.56%, and accuracy of 70% for medial meniscus, and sensitivity of 62.5%, specificity of 72.73%, and accuracy of 70% for lateral meniscus. The study concluded that clinical diagnosis is of primary necessity, as the positive predictive value is high for all the lesions.[69]

Umap et al. studied the role of MRI in the evaluation of traumatic injuries of knee joint. A total number of 100 patients referred with history of knee injury. The results of the study showed that the commonest injuries detected in the study are ACL tear, tear of posterior horn of medial meniscus, bone contusions and joint effusions. Clinical presentation and radiographs of the patient did not help in diagnosis in most of the cases of acute knee injury, especially in multiple ligament and bone injuries. MRI detected soft tissue injuries very well in addition to the bony injuries.[1]

Khandelwal et al. conducted a study with a aim to find the accuracy of MRI knee against arthroscopy, in cases of meniscus and Anterior Cruciate Ligament (ACL) injuries. To the best of our knowledge, this is the largest Indian study comparing MRI knee with arthroscopy comprehensively. In 210 patients MRI findings were correlated with arthroscopic findings, considering arthroscopy as the gold standard. ***The results*** demonstrated that the sensitivity, specificity and accuracy of MRI in reference to arthroscopy for ACL tear was 97.46%, 90.38% and 95.71%, respectively; for Medial Meniscus (MM) tear was 95.69%, 94.87% and 95.23%, respectively; and for Lateral Meniscus (LM) tear was 86.04%, 97.01%, 88.09%, 96.42% and 94.76%, respectively. In ACL tear, mid substance tear was the most common site (66.03%) and discontinuity of ACL fibres was the most common pattern (42.8%). In meniscal tears, posterior horn was the most common site and vertical tears was the most common pattern and concluded that the MRI is an excellent non-invasive imaging modality which can accurately detect and characterize various ligament tears of the knee joint.[70]

Study conducted by **Sahni et al.** compared the diagnostic capabilities of MRI and diagnostic arthroscopy in the evaluation of ACL, PCL, MM, and LM injuries etc., seek correlation among both MRI and arthroscopy knee and find the better modality. This prospective study involved 50 patients with knee joint injuries. Keeping arthroscopy as reference, MRI was compared on parameters such as sensitivity and specificity, positive and negative predictive value plus accuracy. ***Results***: MRI had a high accuracy i.e. 91.1%, 94%, 86%, and 92% for ACL, PCL, MM, and LM, respectively. Furthermore, it had low positive predictive value (PPV) and High PPV for meniscal and cruciate injuries. The study inferred that MRI is commonly used to evaluate various structures of the knee. [71]

Sasnur et al. assessed the impact of MRI in selecting or excluding cases which genuinely require an arthroscopic surgery to know whether routine MRI is required pre-operatively.60 cases underwent clinical examination of affected knee and a preliminary diagnosis was made. Further they were subjected to MRI. Results of arthroscopy were considered as definitive diagnosis and results of clinical examination and MRI were judged accordingly. ***Result***: The study found that of 60 patients, examination revealed 85% accuracy, 82% sensitivity, 89% specificity for ACL injuries. For medial meniscus 58% accuracy, 66% sensitivity, 48% specificity. For lateral meniscus 55% accuracy, 58% sensitivity, 50% specificity. MRI revealed 73% accuracy, 82% sensitivity, 63% specificity for ACL injuries. For medial meniscus 63% accuracy, 90% sensitivity, 39% specificity. For lateral meniscus 62% accuracy, 79% sensitivity, 50% specificity. Sasnur et al, concluded that the clinical examination is more sensitive, specific and accurate in diagnosis of ACL. MRI is more sensitive but less specific for meniscal injuries. Clinical examination for cruciate injuries can surpass the MRI findings. Arthroscopy can be performed without MRI in single lesion injuries. However, MRI will play a role in meniscal injuries or doubtful cases.[72]

Study conducted by **Pawal et al.** aimed to demonstrate MRI findings in various types of traumatic knee injuries, their patterns, to correlate them with the arthroscopic findings, and to establish the accuracy of MRI. MRI of knee followed by arthroscopy was performed in 36 patients; Arthroscopy was done within two months of MRI. The study ***results*** that the various types of lesions seen on MRI were as follows: ACL tears-36

(55.38%), MM tears-29 (44.61%) followed by LM tears and PCL tears, each six (9.23%). MCL tear- three (4.61%) and LCL tear- one (1.53%). In detecting the cruciate and meniscal injuries on MRI, the sensitivity, specificity and accuracy were calculated and were as follows: for ACL: 100, 94.1, 97.2; for PCL: 100, 97. 97.2; for MM: 90.4, 86.7, 88.9 and for LM: 100, 96.9, 97.2 respectively. The study concludes that MRI is an accurate, non-invasive and cost-effective means to evaluate knee injuries. It is noted that ACL, MM and MCL tears are more common than PCL, LM and LCL tears.[73]

MATERIALS & METHODS

MATERIALS AND METHODS

Study design & population: This was a prospective hospital based observational study conducted in the Department of Radio-Diagnostic at R.L. Jalappa Hospital and Research Center attached to Sri Devaraj Urs Medical College.

Duration of study: Conducted for a period 18 months *(September 2022 to February 2024).* The study included patients referred for MRI knee for diagnostic evaluation and arthroscopy, who fulfilled the inclusion and exclusion criteria.

SAMPLE SIZE: Assuming alpha error of 0.05 (95% Confidence limit), Hence a maximum sample size of **52 subjects** was enrolled for the study.

The sample size was derived from the following formula: Sample size (n) = $\frac{Z^2(P*Q)}{d^2}$where;

Z is the value for Confidence Interval, d is the absolute precision, p is the expected proportion and q=1-p

The sample size was calculated using the software Open-Epi version 3.01. (Open-Source Epidemiologic Statistics for Public Health**.**

SOURCE OF DATA: The patients were included for the study based on the inclusion and exclusion criteria mentioned as follows: -

Inclusion criteria:

- Patients refereed for MRI knee scanning following traumatic knee injury

Exclusion criteria:

- Patients with previous history of knee surgery.
- Patients with claustrophobia, ferromagnetic implants, pacemakers and aneurysm clips

Method of data collection and protocol:

The patients were briefed about the procedure. Informed written consent was taken from every patient. MRI scan was performed on SIEMENS® MAGNETOM AVANTO, 1.5 Tesla, 18 channel MRI machine in the department of Radiodiagnosis. Patient is placed in supine position with the knee in a closely coupled extremity coil. The knee is externally rotated 15-20° (to facilitate visualization of the ACL completely on sagittal images) and is also flexed 5-10° (to increase the accuracy of assessing the patella femoral compartment). Patients are advised to restrict the movements during the scan to avoid motion artefacts.

Following Imaging sequences were used as follows:

- T1- weighted Axial, Coronal.
- T2- weighted Axial, Coronal, and Sagittal.
- PDFS- Sagittal, Axial.
- STIR- Coronal
- 3D DESS- Coronal/ Sagittal.

After the MRI scan the patient went under arthroscopy, findings of the both were recorded in the Proforma. MRI findings of the patients were correlated with arthroscopy.

Figure 30: Siemens Magnetom Avanto® 1.5 T MRI scanner used in the study.

Figure 31: MRI knee coil used in the study.

Figure 32: Arthroscopic monitor, instruments and portals used in this study

Ethical consideration:

This study was submitted to and approved by the institutional ethical committee. **EC No. SDUMC/KLR/IEC/264/2022-23.**

Informed written consent was obtained from all the study participants, and only those patients willing to sign the informed consent were included in the study. The risk and benefits involved in the study were explained to the patients before taking the obtaining consent. The confidentially of the study participants was maintained.

STATISTICAL ANALYSIS:

Data was collected and entered in the predesigned Microsoft excel spreadsheet and analysed using the Statistical Package for Social Science (SPSS) standard version 20. All socio-demographic and clinical characteristics of the patient were summarized using Mean (SD) for continuous variables and proportions (%) for categorical variables. Comparison of continuous variable across the subgroups were performed using the student's t test.

Comparison of categorical variables (sex, type of injury, mode of injury, etc.) across study groups were done using Chi square test. P-value of <0.05 was considered statistically significant.

Statistical analysis was performed for medial meniscus, lateral meniscus, anterior cruciate and posterior cruciate ligaments, and cartilage surfaces considering arthroscopy as gold standard. MRI results were analysed with Chi-Square test. Sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) were evaluated considering arthroscopy as standard of reference.

RESULTS

RESULTS

The study included mainly qualitative variables for the distribution of patients, patterns of contusions on MRI, frequency of different injuries. The qualitative variables represented as frequency and percentage. For diagnostic accuracy sensitivity, specificity, PPV and NPV calculated for MRI in comparison of arthroscopy as gold standard.

DEMOGRAPHIC FEATURES OF THE PATIENTS:

Out of 52 patients injuries on the right side are more frequent, accounting for 60.8% (31) of cases, while left side injuries represent 41.2% (21). This indicates a higher occurrence of injuries on the right side compared to the left.

GENDER INCIDENCE:

Table No. 3 Gender-wise Distribution of Patients.

Gender	**Frequency (N)**	**Percentage (%)**
Male	35	67.30%
Female	17	32.69%

Table 3 & Figure 33 Gender wise distribution of 52 participants, among which 17 (32.69%) were females and 35 (37.30%) were males.

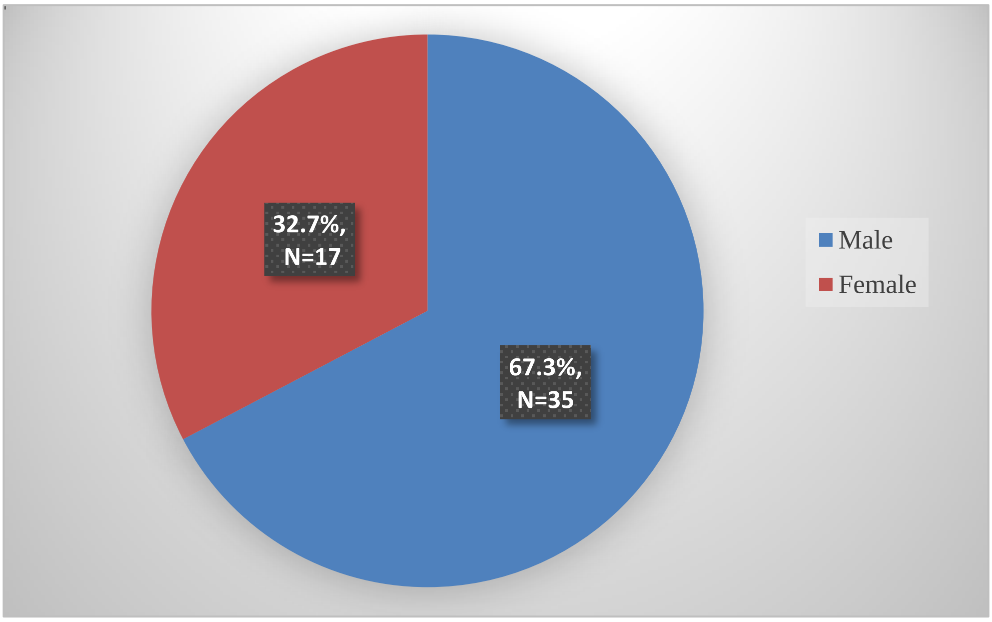


Figure: 33 Gender-wise distribution of Patients

AGE INCIDENCE: The average age in our study population was 30 years. The youngest patient being 19 years and oldest patient being 58 years. Most of the patients were within age group of 36-45 years.

Table No. 4 Age wise distribution of Patients

Age Group	Frequency (N)	Percentage (%)
16-25	15	29%
26-35	10	19%
36-45	17	33%
46-55	7	13%
56-65	3	6%
Total	**52**	100%

The data shows the distribution of 52 individuals across different age groups. The largest group being 36-45 years (33%), followed by 16-25 years (29%) and 26-35 years (19%). The 46-55 age group constitutes 13%, and the smallest group is 56-65 years (6%).

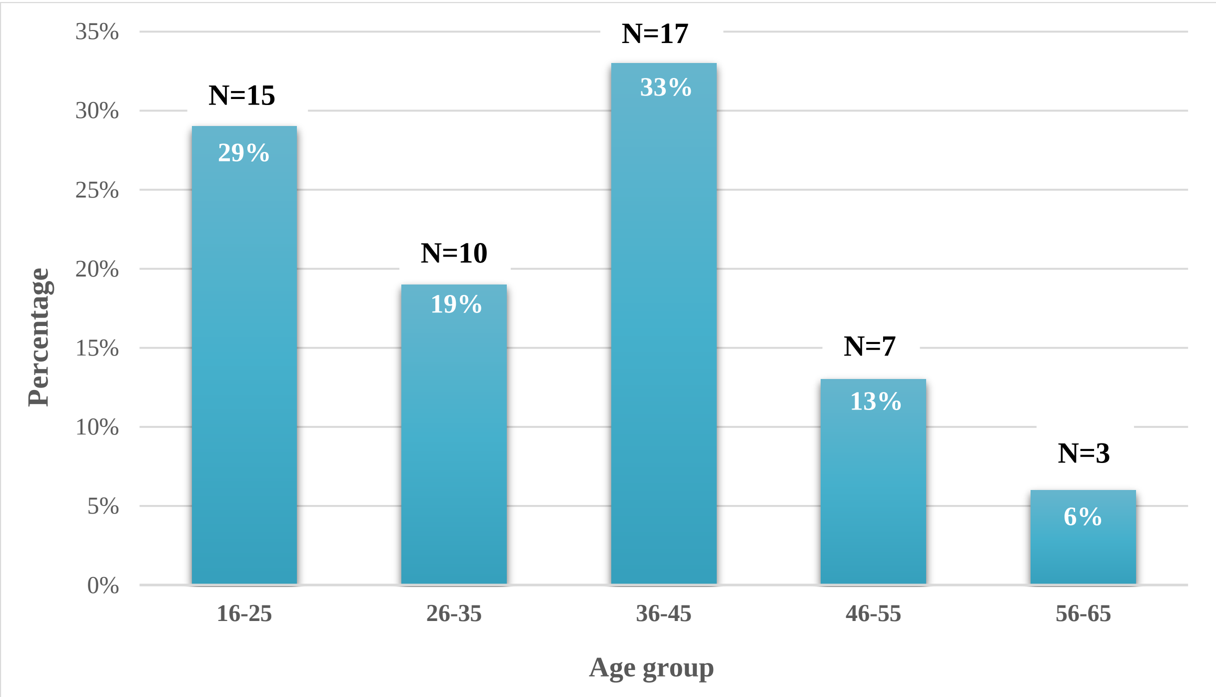


Figure: 34 Graphical presentation of age wise distribution of patients.

MODE OF INJURY:

Table No. 5 Distribution of mechanism of injury.

Mode of injury	Frequency (N)	Percentage (%)
Twisting injury	14	27%
RTA	14	27%
Fall	10	20%
sports injury	8	16%
Direct trauma	6	12%

Table no.5 & figure no. 35 represents the modes of injury among 52 cases. Road traffic accidents (RTA) and twisting injuries being the most common, each accounting for 27%. Falls account for 20% of injuries, while sports injuries make up 16%. Direct trauma is the least common mode, comprising 12% of cases.

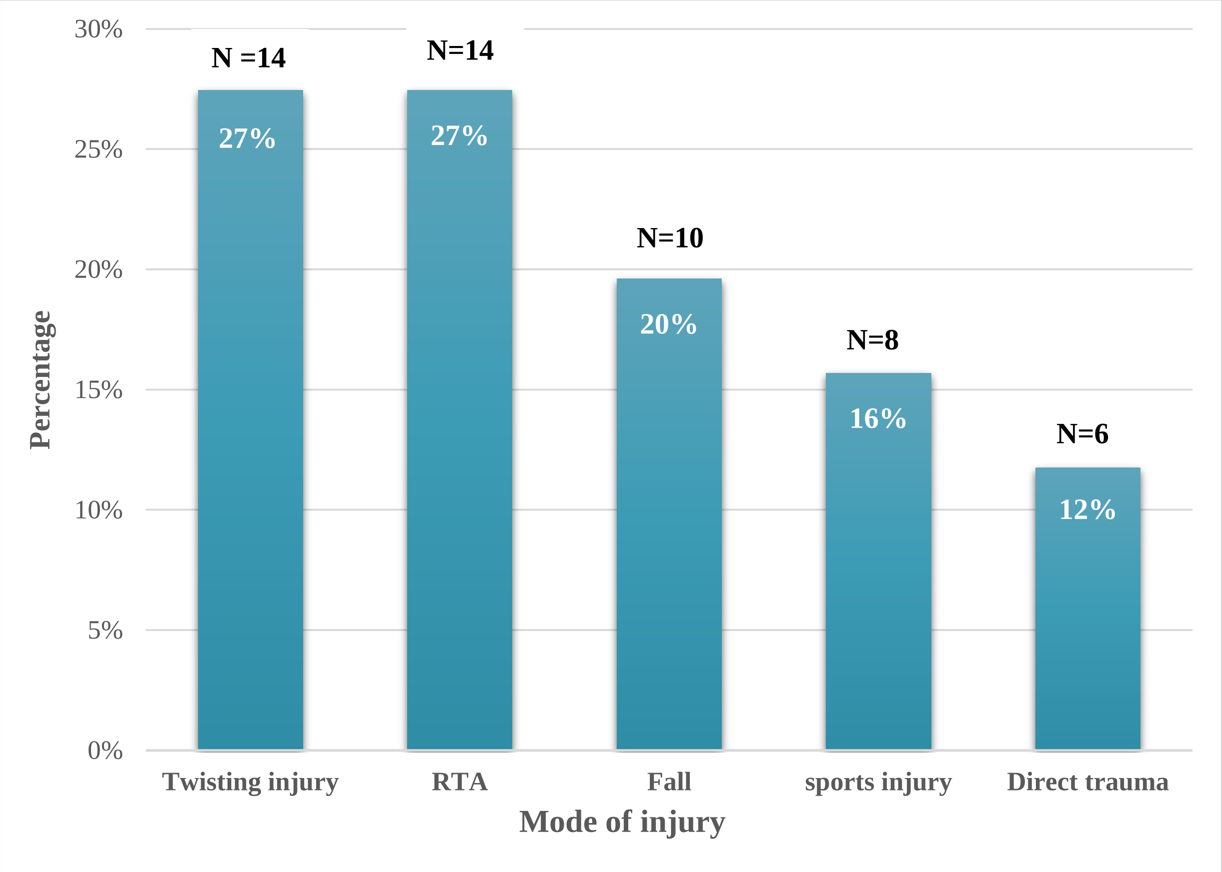


Figure: 35 Graphical presentation of the mode of injury.

TYPE OF INJURY:

Table No. 6 Distribution of various injuries in knee joint on MRI

	Frequency (N)	Percentage (%)
ACL	40	76.9%
PCL	9	17.3%
MM	17	32.6%
LM	13	25.0%
MCL	15	28.8%
LCL	6	11.5%
BC	24	46.1%
Fractures	7	13.4%
Joint Effusion	41	78.8%

The data represents the prevalence of various injuries among the study population, with anterior cruciate ligament (ACL) tears identified by MRI being the most common at 78.4%, followed by medial meniscus (MM) in 33.3 % cases. Joint effusions were observed in 80.4% of cases. Posterior cruciate ligament (PCL) injuries in 17.6%, medial collateral ligament (MCL) injuries occurred in 29.4% of cases, while lateral collateral ligament (LCL) injuries were less common at 11.8%. Bone contusions (BC) were noted in 46.1% and lateral meniscus (LM) tears in 25.5%. Fractures were present in 13.4 % of cases.

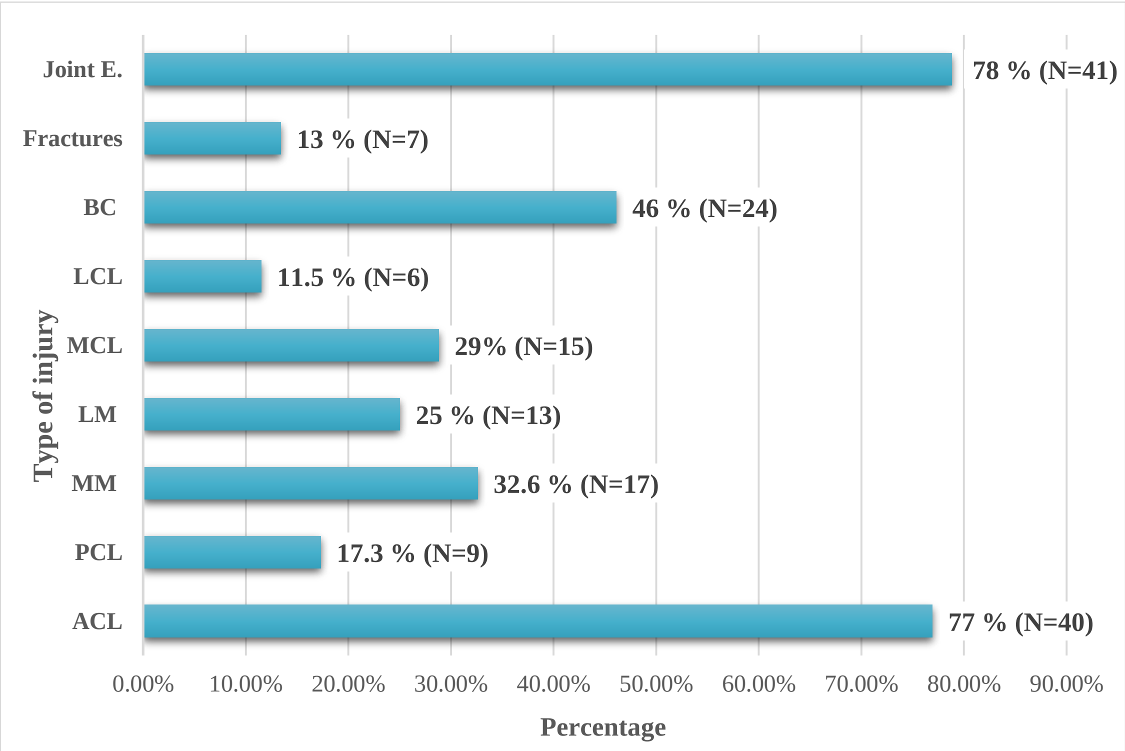


Figure: 36 Distribution of various injuries on MRI

BONY CONTUSIONS: Out of 52 cases, 24 cases (46.1 %) had bony contusion and out of 24 cases with bony contusions 19 (79.1 %) cases were associated with PCL & ACL injury and shows showed some common bony patterns as described below

Table No. 7 Distribution of common bony contusions with ACL and PCL injury

Types of bony contusions/bruises	ALC Injury		PCL Injury	
	Complete	Partial	Complete	Partial
Lateral femoral condyle and Tibial plateau *(posterolateral)*	5	2	1	-
Anterior tibial plateau and anterior femoral condyle	1	2	1	1
Lateral femoral condyle and lateral tibial plateau and/or medial femoral condyle	2	1	1	-
Anterior tibia and/or Posterior patella	2	-	-	-
TOTAL	**15**		**4**	

Table. No. 7 demonstrating the details of bone contusions in relation to ACL and PCL injuries among 19 cases. Total incidence of bony contusions with ACL injury are 15 (78.8 %) and PCL injury are 4 (21.0 %). The Lateral femoral condyle and posterolateral tibial plateau *(pivot-shift)* contusions are seen in 8 cases (42.1 %) out of which the association with ACL injuries, with 5 (26.3%) complete and 2(10.5%) partial tears, and with PCL injuries only 1 case that too with complete tear.

Anterior tibial plateau and anterior femoral condyle *(Kissing)* contusions are seen in 5 (26.3%) cases with association of 1 (5.2%) complete 2 (10.5%) partial ACL tears, and 1 (5.2%) complete and 1 (5.2%) partial PCL tear.

Bruises on the lateral femoral condyle, lateral tibial plateau, and/or medial femoral condyle are seen in 4 (21.0 %) cases with association of 2 (10.5 %) complete and 1 (5.2%) partial ACL tear, and 1(5.2%) complete PCL tears.

Anterior tibia and/or posterior patella bruises are seen in 2 (10.5%), both associated with complete ACL tear.

INJURIES:

Table No. 8 Types of anterior cruciate ligament injury *(Total cases 40).*

Type of ACL injury	No. of cases (N)	Percentage (%)
Sprain/edema	9	22.5%
Partial tear	19	47.5%
Complete tear	12	30.0%

Table no. 8 and figure 37 represents distribution of ACL injuries among 40 cases. Partial tears are the most common, making up 47.5% of cases. Complete tears account for 30%, while sprains or edema constitute 22.5%. This indicates that nearly half of the ACL injuries are partial tears.

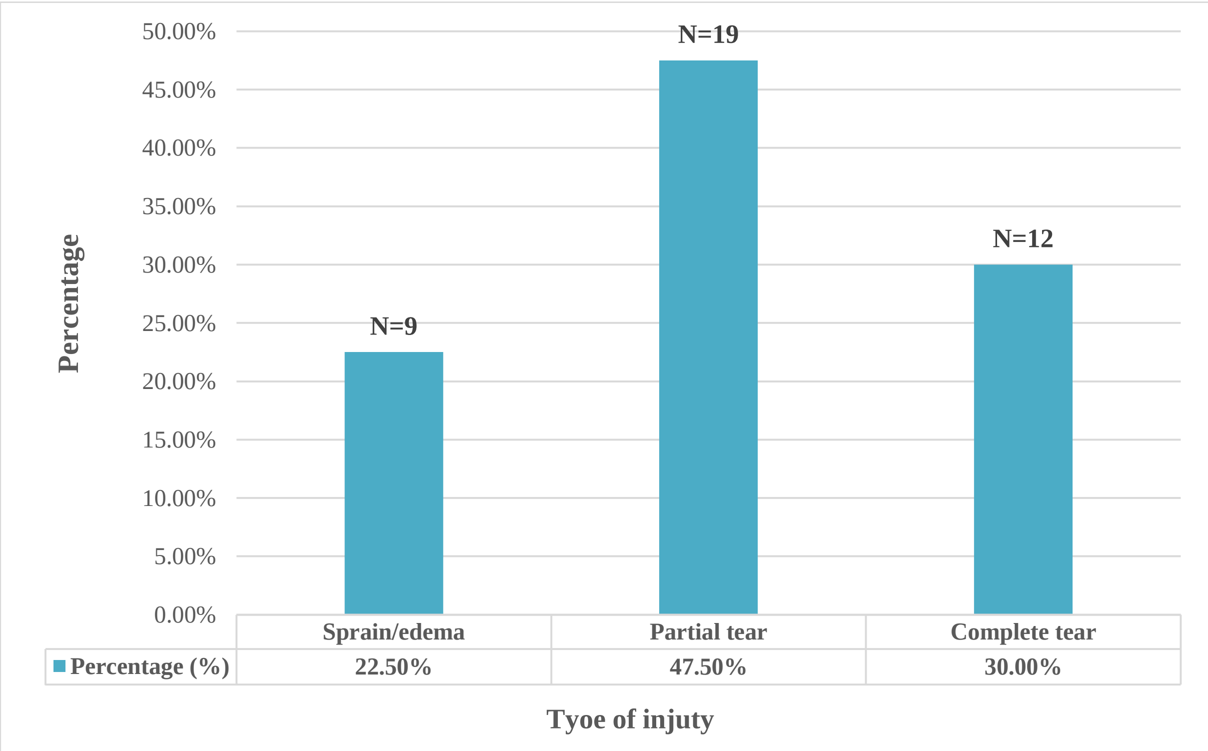


Figure: 37 Distribution of different type of ACL injury.

Table No. 9 Types of posterior cruciate ligament injury *(Total cases 9)*

Type of PCL injury	No. of cases (N)	Percentage (%)
Sprain/edema	2	22.2%
Partial tear	5	55.6%
Complete tear	2	22.2%

Table No. 9 and figure 38 represents the distribution of PCL injuries among 9 cases. Partial tears being the most common, making up 55.6 % of cases. Complete tears and Sprain/edema each constituted 22.5%. Buckling of PCL was seen of 8 patients with other knee injuries.

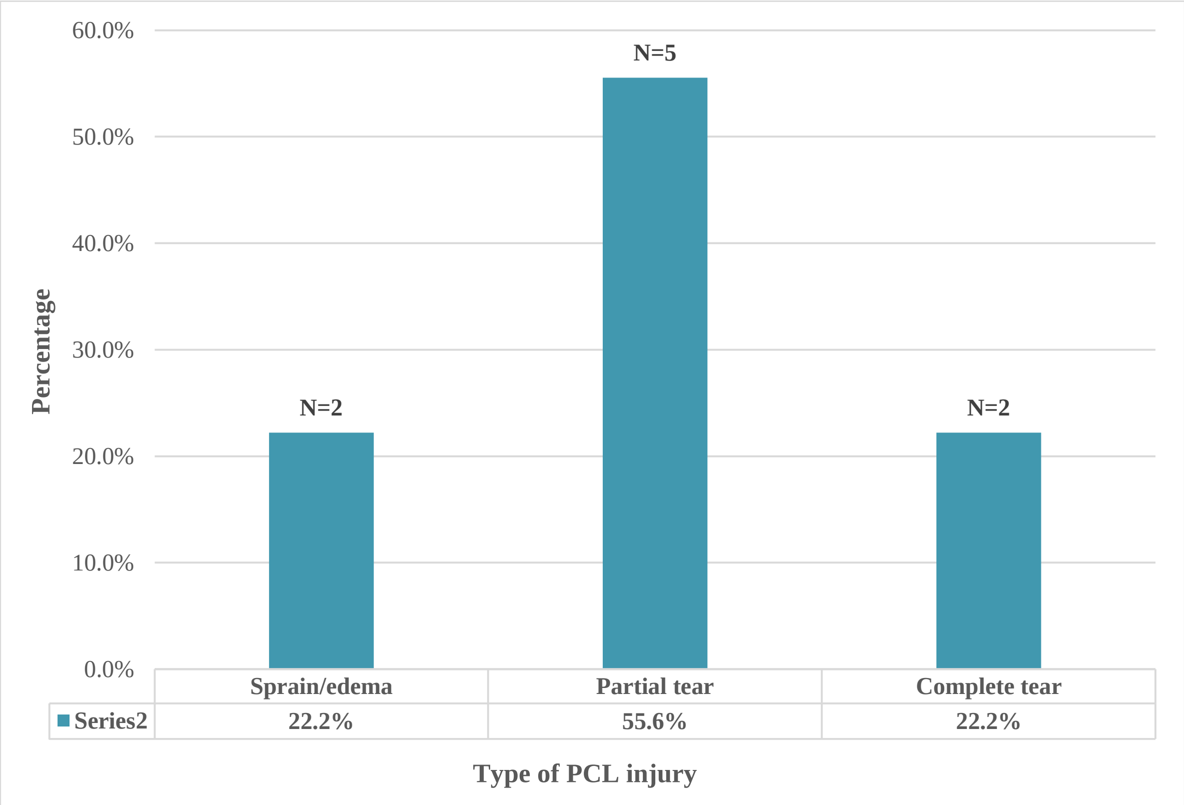


Figure: 38 Distribution of types of PCL Injury

Table No. 10 Distribution of types of medial meniscus injury *(Total cases 17)*

Grade of injury	No. of cases (N)	Percentage (%)
Grade I	5	29.4%
Grade II *(2a,2b&2c)*	7	41.2%
Grade III	3	17.6%
Complex tear	2	11.8%

Table no. 10 and figure 39 outlines the severity of MM injuries among 17 cases. Grade II injuries are most prevalent, accounting for 41.2%. Grade I injuries follow at 29.4%. Grade III injury accounts for 17.6 % and least were complex tear 11.8% of the total. Out of all 17 cases 14 had injury in posterior horn and 7 had in anterior horn.

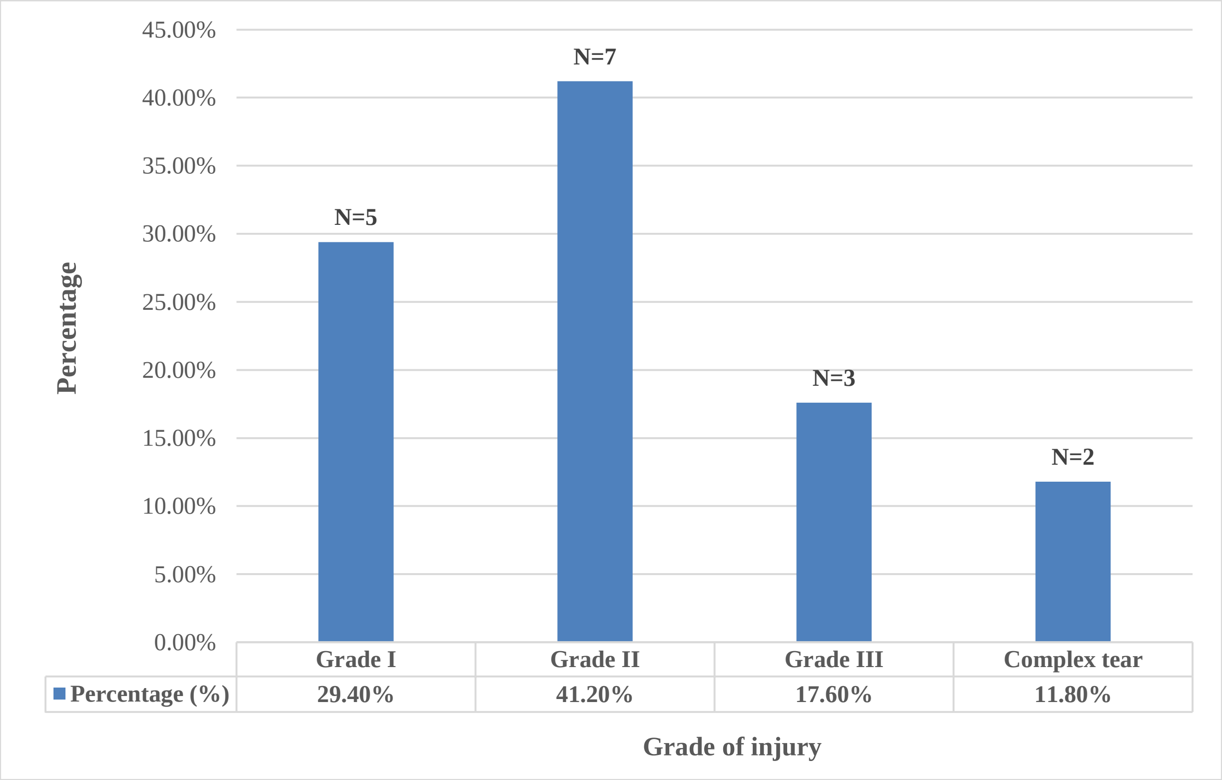


Figure: 39 Distribution of types of medial meniscus injury

Table No. 11 Distribution of Lateral meniscus injury *(Total cases 13)*

Grade of injury	No. of cases (N)	Percentage (%)
Grade I	4	30.8%
Grade II *(2a+2b+2c)*	6	46.2%
Grade III	2	15.4%
Complex tear	1	7.7%

Table no. 11 and figure 40 summarizes the distribution of LM injury grades: Grade I (30.8%) with 4 cases, Grade II (2a+2b+2c) (46.2%), Grade III (15.4%), and one case of complex tear (7.7%). It shows a predominance of Grade II injuries, encompassing various subtypes, highlighting the diverse nature of knee ligament tears in clinical presentation. Out of all 13 cases 9 had injury in posterior horn and 7 had in anterior horn.

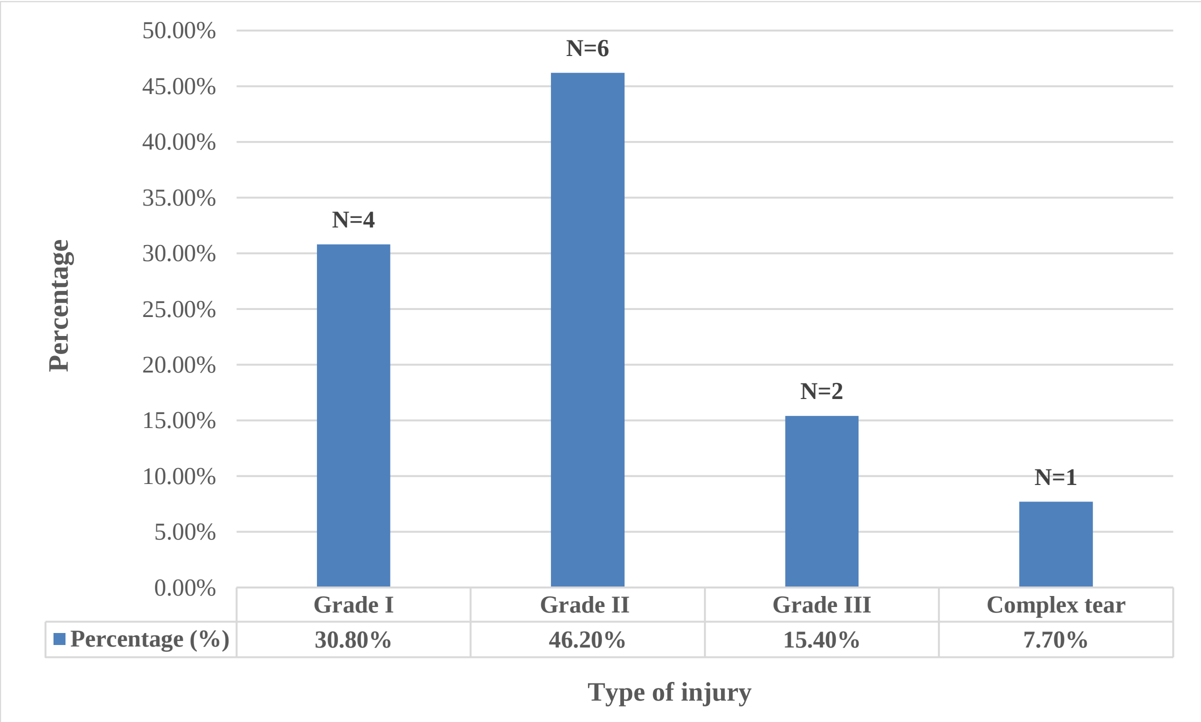


Figure: 40 Distribution of types of Lateral meniscus Injury

Table No. 12 Types of medial collateral ligament (MCL) & lateral collateral ligament (LCL) injury: *(Total cases 15 for MCL & 6 for LCL).*

Type of injury	MCL		LCL	
	No. of cases (N)	Percentage (%)	No. of cases (N)	Percentage (%)
Minor sprain	7	46.7%	3	50.0%
Severe sprain/Partial tear	5	33.3%	2	33.3%
Complete	3	20.0%	1	16.7%

Table no.12 and figure 41 represents types of MCL & LCL Injury among 15 & 6 cases respectively. In MCL injuries minor sprain injuries was the most common 46.7% (7 cases). Severe sprain/partial tear were observed in 33.3% (5 cases).The lowest injury was observed complete 20% (3 cases). In LCL Injury among 6 cases. Minor spine injuries was the most common 50% (3 cases). Severe spine/partial tear were observed in 33.3% (52 cases).The lowest injury was observed complete 16.7 % (1 cases).

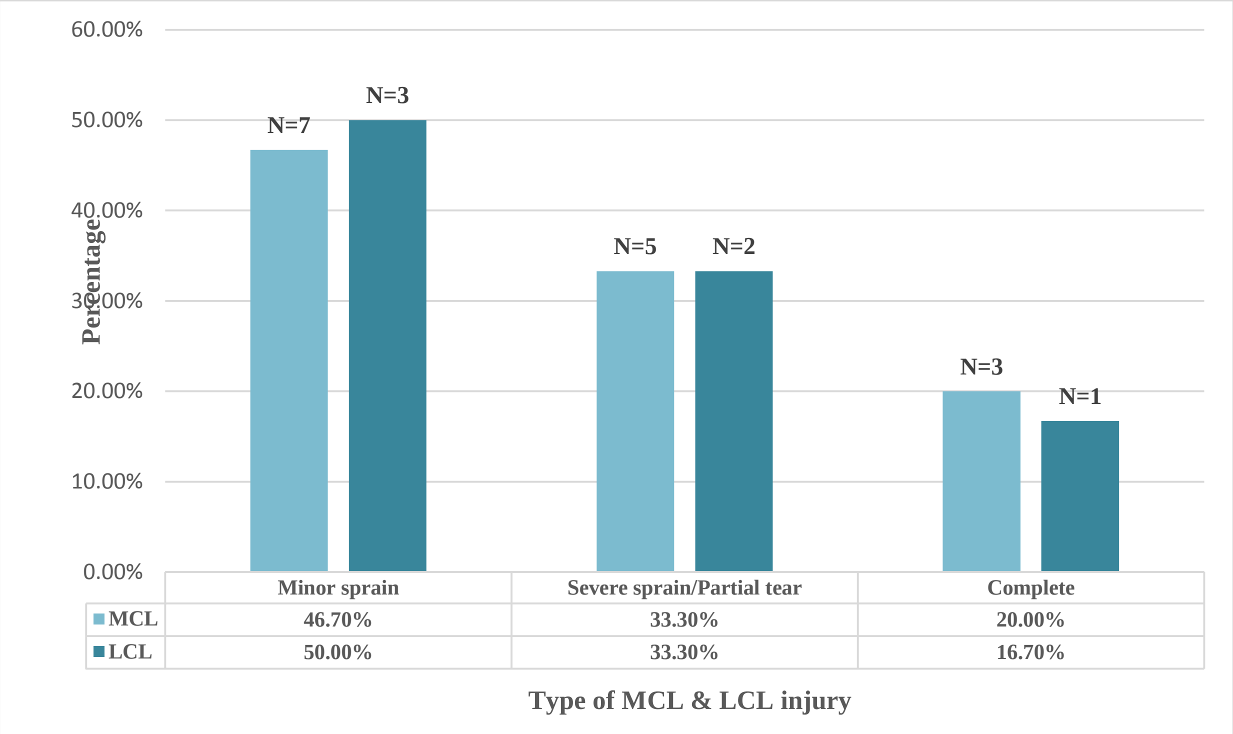


Figure: 41 Distribution of types of MCL & LCL Injury

Table No. 13 Most common patterns of injury seen among the cases with at least 3 structure injured.

ACL	PCL	MM	LM	MCL	LCL	Frequency
Tear (Complete & partial)	No tear +/- Buckling	Tear		Injury		7
Sprain	Tear (Complete & partial)	Tear				4
Sprain		Tear	Tear	Sprain		3
Complete tear	Tear	Tear		Sprain	Sprain	2

The table summarizes injuries in cases with damage to various knee ligaments and menisci*(at least involving three structures)*.7 (13.4 %) cases had complete or partial tears of the ACL, medial meniscus injury with MCL injury*(Out of 7 cases 3 were associated with buckling of PCL)*. 4 (7.6 %) cases had ACL sprains, PCL tears with MM injury. 3 (5.7 %)cases showed ACL sprains, medial & lateral meniscus tears with MCL sprains. 2 (3.8 %) cases had complete ACL tears, PCL tear, MM tear with MCL & LCL sprain/tear. This indicates a high incidence of combined ligament and meniscus injuries, with the ACL most frequently affected, often alongside other structural damage.

Table No. 14 Comparison of joint effusion and articular fracture on MRI and Arthroscopy *(Total number of cases 52).*

Effusion & Fracture	**MRI** Frequency (N)	**Percentage**	**Arthroscopy** Frequency (N)	**Percentage**	**Accuracy of MRI**
Joint effusion	41	78 %	36	69 %	**90.3 %**
Articular fractures	7	13 %	9	17 %	**96.1 %**

Table no. 14 and figure 42 summarizes comparison of joint effusion & articular fractures seen out of 52 cases. Total number of cases to have joint effusion on MRI were 41 (78 %) out of which 36 (69 %) cases had joint effusion on arthroscopy. False positive cases being 5 (9.6 %), predicting that joint effusion was over diagnosed on MRI. Similarly, total number of cases diagnosed with articular fracture on MRI were 7 (13 %), cases diagnosed on arthroscopy were 9 (17 %). False negative cases being 2 (3.8 %), predicting that articular surface was under diagnosed on MRI. Taking arthroscopy as gold standard accuracy of MRI for diagnosing Joint effusion was calculated to be (90.3 %), while the accuracy of MRI for diagnosing articular fractures was calculated to be (96.1 %).

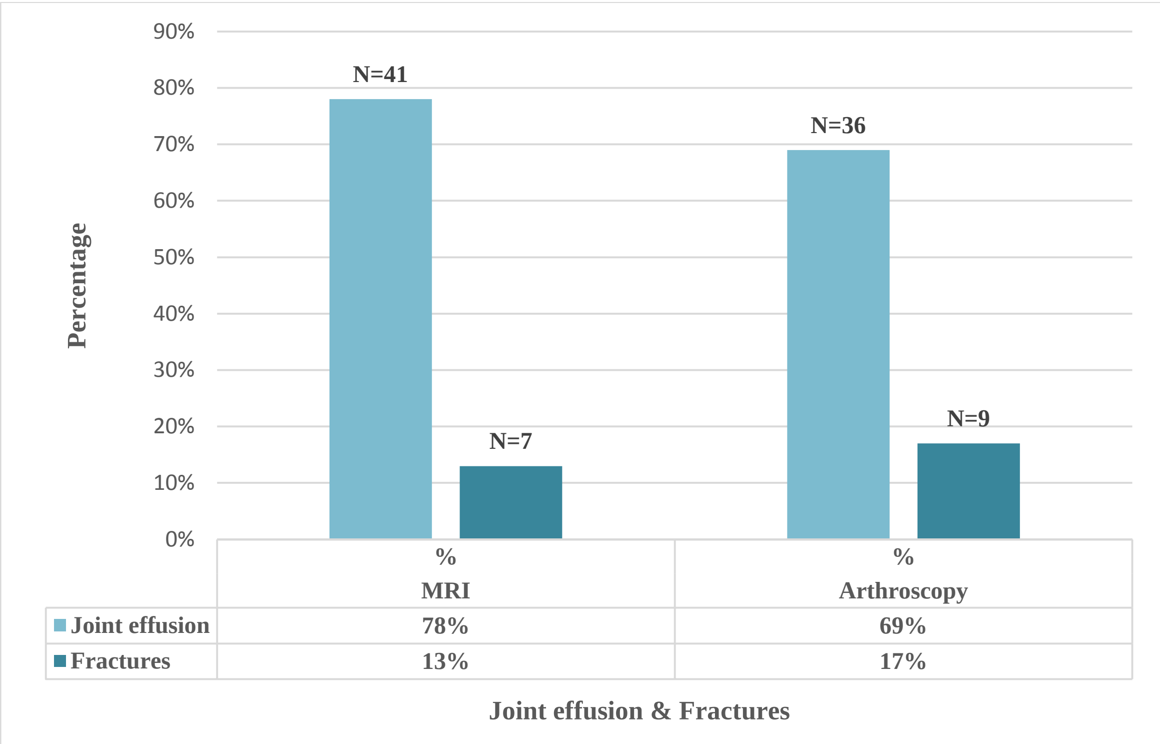


Figure: 42 Comparison of Joint effusion and fractures an MRI and Arthroscopy

Table No. 15 Validity of different type of tears on MRI with arthroscopy as gold standard. Calculated value of True positive (TP), False positive (FP), False negative (FN) and True negative (TN).

	TP	FP	FN	TN
Anterior cruciate ligament	39	1	1	10
Posterior cruciate ligament	8	1	0	42
Medial meniscus	14	3	7	27
Lateral meniscus	9	4	4	34
Medial collateral ligament	8	7	4	32
Lateral collateral ligament	3	3	2	43

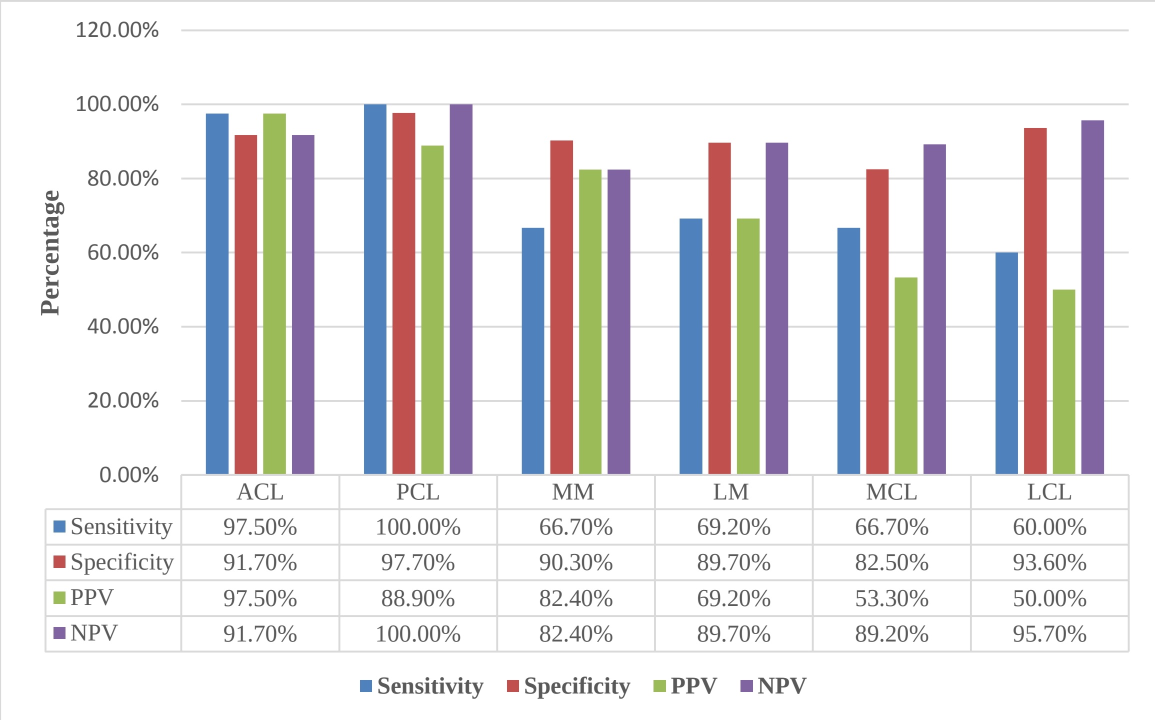
The data indicates diagnostic performance for various knee injuries. For the anterior cruciate ligament (ACL), high true positives (TP = 39) and low false negatives (FN = 1) suggest high sensitivity, with few false positives (FP = 1), indicating high specificity. The posterior cruciate ligament (PCL) has excellent performance (TP = 8, FP = 1, FN = 0, TN = 42). The medial and lateral meniscus show moderate diagnostic challenge with higher false positives and negatives, impacting reliability. The medial collateral ligament (MCL) shows significant false positives indicating moderate accuracy. The lateral collateral ligament (LCL) also has few errors, reflecting reliable diagnostics. Overall, ACL and PCL diagnostics are highly accurate, while meniscus and collateral ligaments show room for improvement.

Table No. 16 Diagnostic accuracy of MRI and demonstrating Sensitivity, Specificity, Positive predictive value and Negative predictive value (NPV) for different injuries.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Anterior cruciate ligament	97.5%	91.7%	97.5%	91.7%	98.0%
Posterior cruciate ligament	100.0%	97.7%	88.9%	100.0%	100.0%
Medial meniscus	66.7%	90.3%	82.4%	82.4%	82.4%
Lateral meniscus	69.2%	89.7%	69.2%	89.7%	86.3%
Medial collateral ligament	66.7%	82.5%	53.3%	89.2%	80.4%
Lateral collateral ligament	60.0%	93.6%	50.0%	95.7%	92.2%

The table shows that the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) have high sensitivity and specificity, reflecting excellent diagnostic accuracy. The ACL has 97.5% sensitivity and 91.7% specificity, while the PCL has perfect sensitivity (100%) and high specificity (97.7%). Medial and lateral meniscus injuries have moderate sensitivity (66.7% and 69.2%, respectively) but high specificity (90.3% and 89.7%). Cruciate ligaments (medial and lateral) show lower sensitivity (66.7% and 60%, respectively) and high specificity (82.5% and 93.6%). PPV and NPV follow similar trends, with higher values for

ACL and PCL, and moderate values for meniscus and cruciate ligaments, indicating varying predictive reliability.



	ACL	PCL	MM	LM	MCL	LCL
Sensitivity	97.50%	100.00%	66.70%	69.20%	66.70%	60.00%
Specificity	91.70%	97.70%	90.30%	89.70%	82.50%	93.60%
PPV	97.50%	88.90%	82.40%	69.20%	53.30%	50.00%
NPV	91.70%	100.00%	82.40%	89.70%	89.20%	95.70%

Figure No. 43 Diagnostic Sensitivity, Specificity, Positive predictive value and Negative predictive value (NPV) of MRI for different knee injuries.

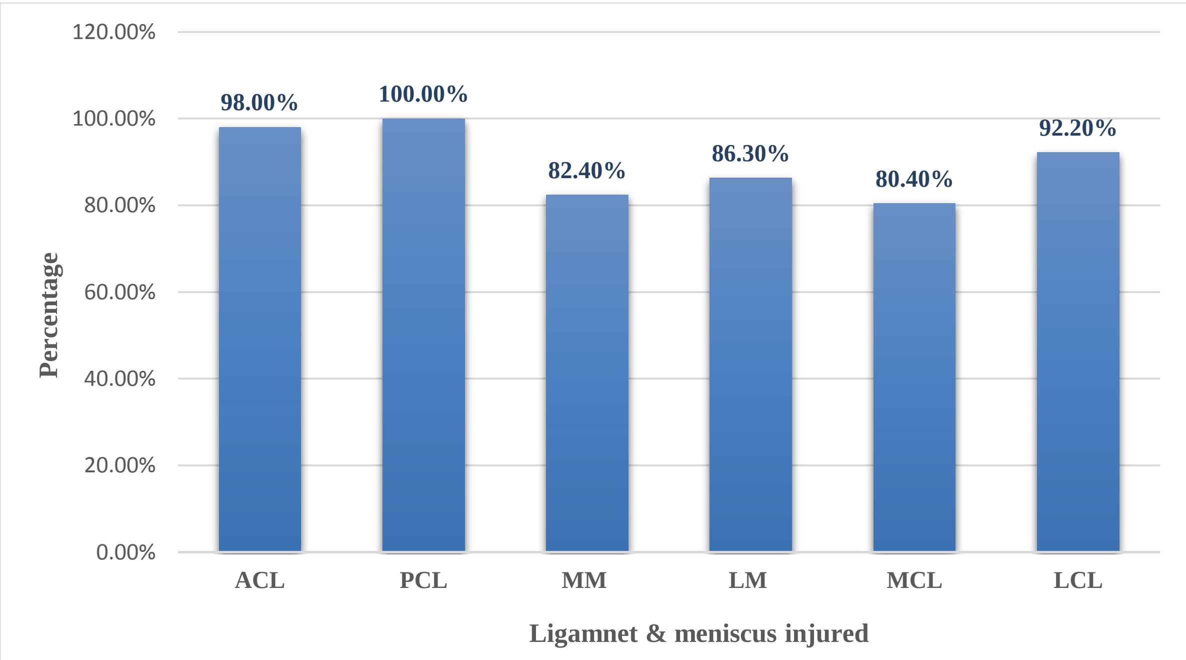


Figure No. 44 Diagnostic accuracy of MRI for various knee injuries.

MRI images showing normal ligaments & menisci

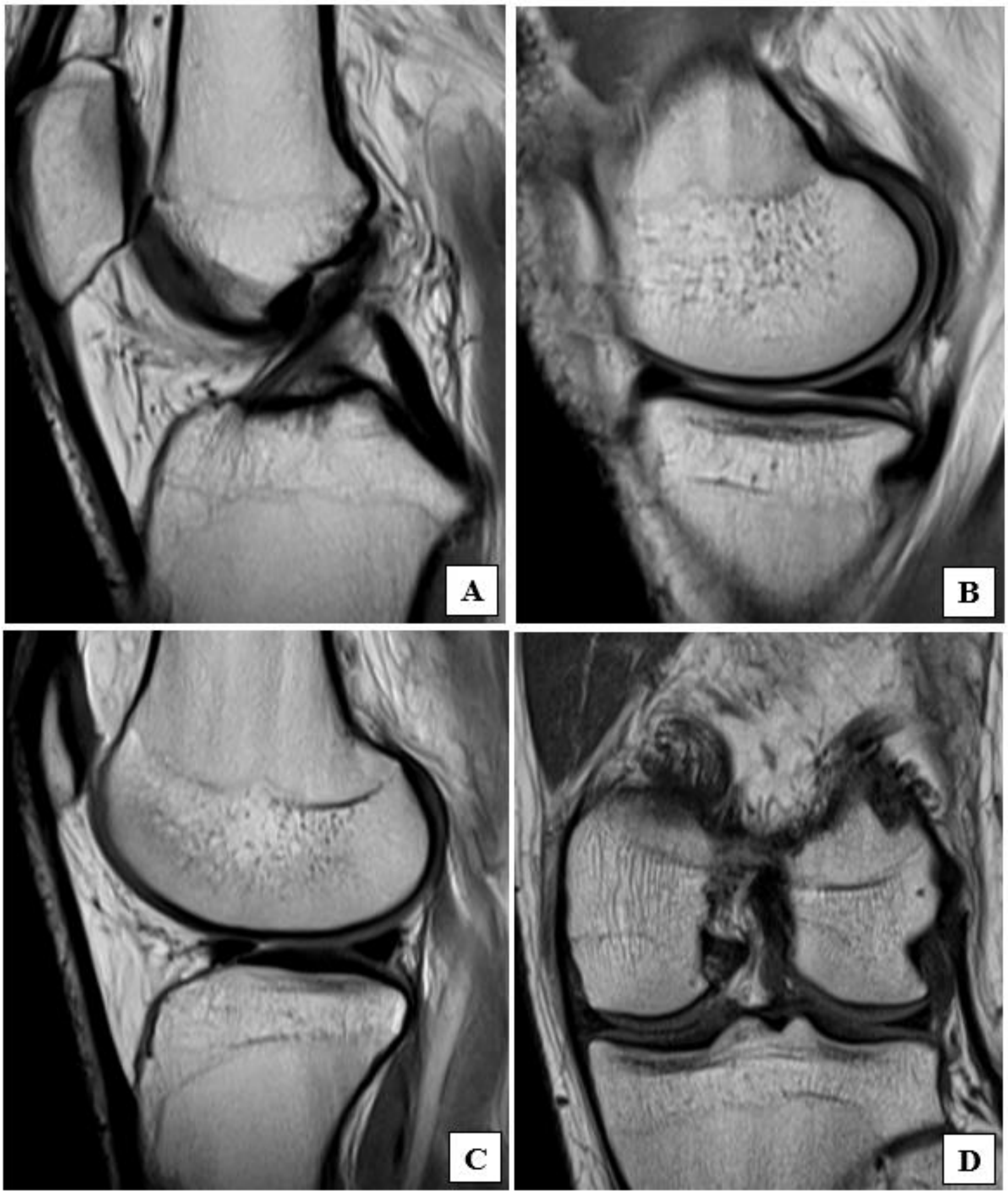


Figure 45: Sagittal (A, B, C) & coronal (D) PDFS MRI images. (A) Normal intensity ACL & PCL. (B) Medial compartment shows the medial meniscus which is wider posteriorly than anteriorly. (C) Image through the lateral compartment shows the normal hypointense anterior and posterior horn of the lateral meniscus. (D) Normal intensity MCL & LCL.

MRI & Arthroscopy: Case of ACL sprain & medial meniscus tear.

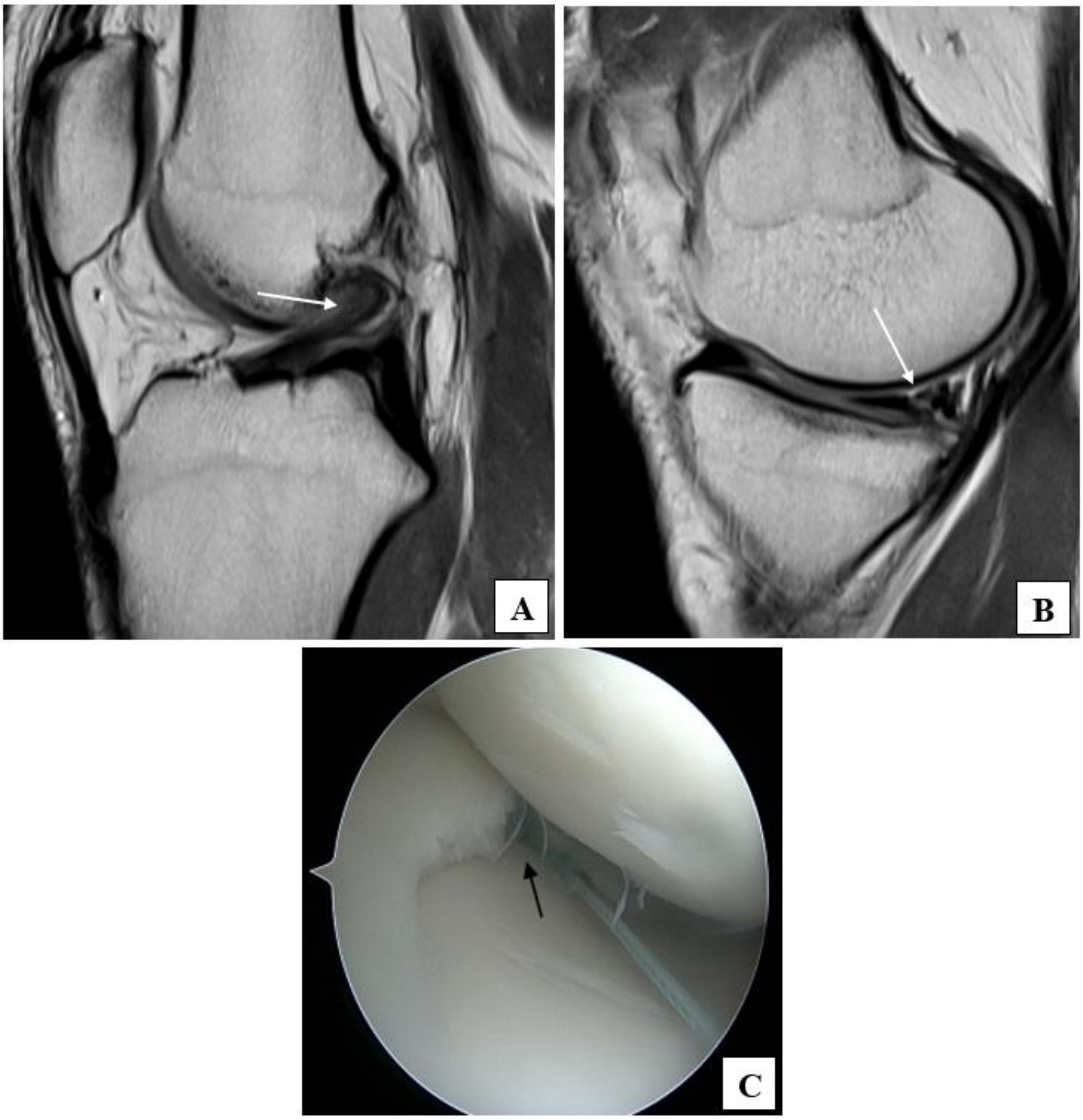


Figure 46: Sagittal PDFS images (A & B). (A) Intrinsic PDFS hyperintensity with no obvious fibers discontinuity noted – *Likely sprain (white arrow).* (B) Complex tear involving posterior horn of medial meniscus *(white arrow).* (C) Arthroscopy confirmed medial meniscus tear *(black arrow).*

MRI & Arthroscopy: Case of Partial ACL tear and medial meniscus tear.

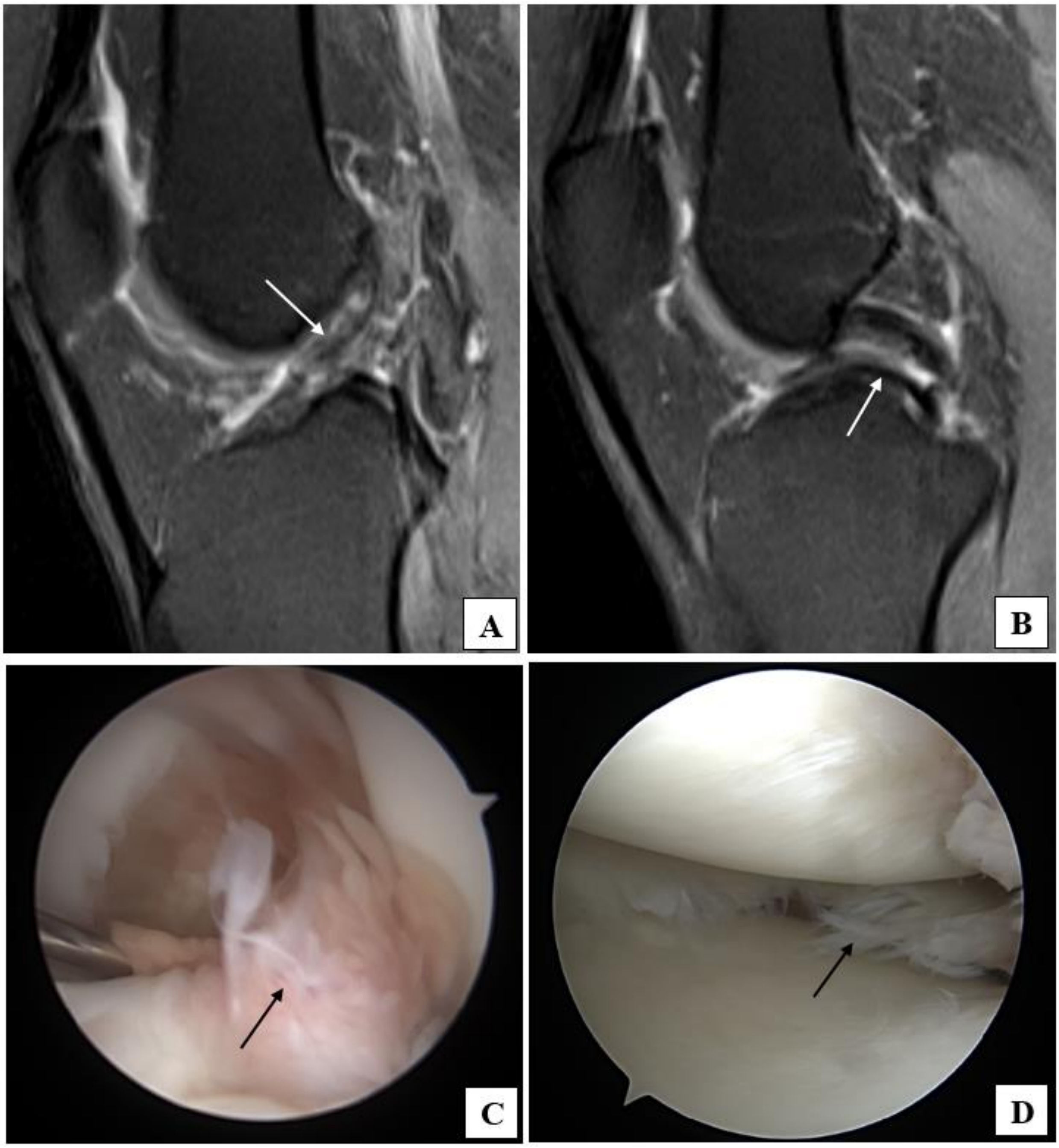


Figure 47: Sagittal PDFS images (A & B). (A) Intrinsic PDFS hyperintensity with partial disruption of fibres - *S/o high grade partial tear (white arrow)*. (B) Double PCL sign – *S/o bucket handle tear of medial meniscus (white arrow).* (C) Arthroscopy confirmed partial ACL tear *(black arrow)*. (D) Arthroscopy showing medial meniscus tear *(Black arrow).*

MRI & Arthroscopy: Case of complete ACL tear, PCL & LCL Sprain.

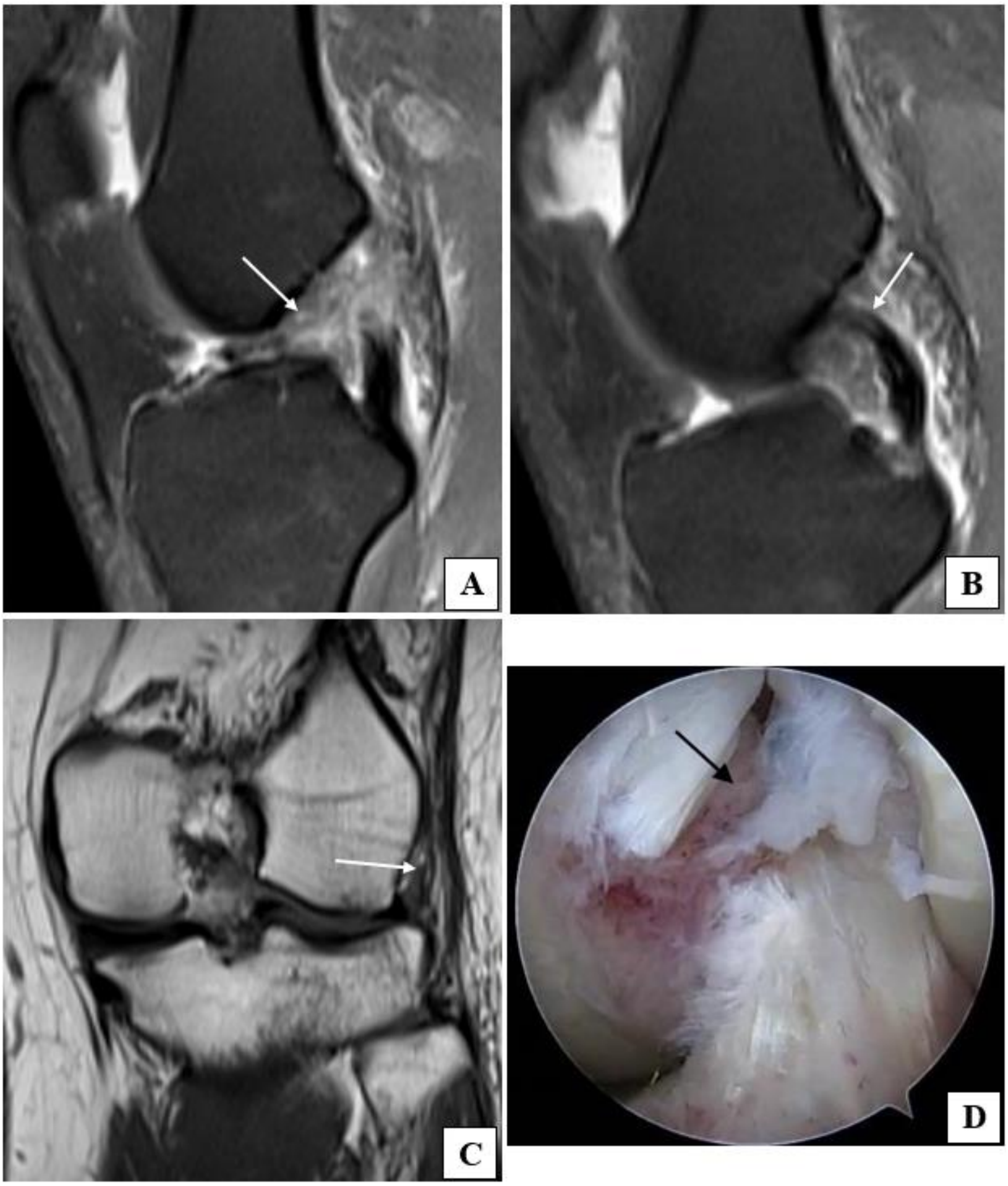


Figure 48: (A & B) FDFS sagittal images showing complete ACL tear and PCL subtle hyperintensity with no obvious fibers discontinuity – Likely PCL sprain. *(White arrow)* and mild joint effusion. (C) T1coronal image shows sprain predominantly at its femoral attachment and peri-ligamentous edema *(white arrow)*. (D) Arthroscopy showing complete ACL tear *(Black arrow)*.

<u>MRI & Arthroscopy</u>: Case of partial ACL tear and medial meniscus tear.

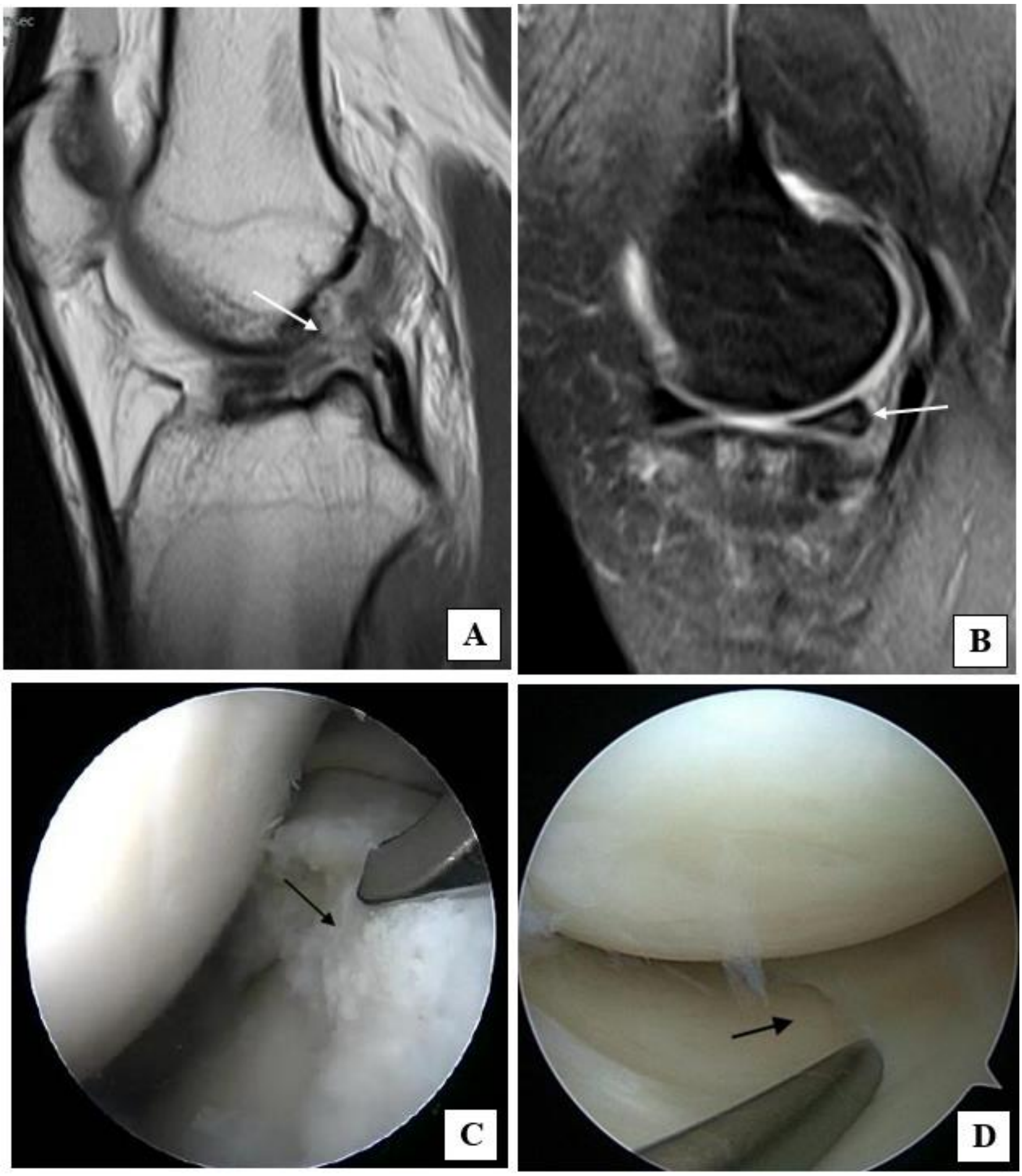


Figure 49: (A & B) FDFS sagittal images, (A) shows bulky ACL with intrinsic hyperintensity (edema) and focal discontinuity – S/o partial tear *(white arrow)*. (B) Shows liner abnormal hyperintensity involving the posterior horn of medial meniscus – *S/o Tear (white arrow). (C)* Arthroscopy image showing ACL tear *(black arrow)*. (D) Arthroscopy image through medial compartment showing normal medial meniscus *(black arrow)*.

Figure 50: (A) PDFS sagittal and (B) T1 coronal images, demonstrating hyperintensities noted along lateral tibial plateau and lateral femoral condyle – *Suggestive of kissing contusion.*

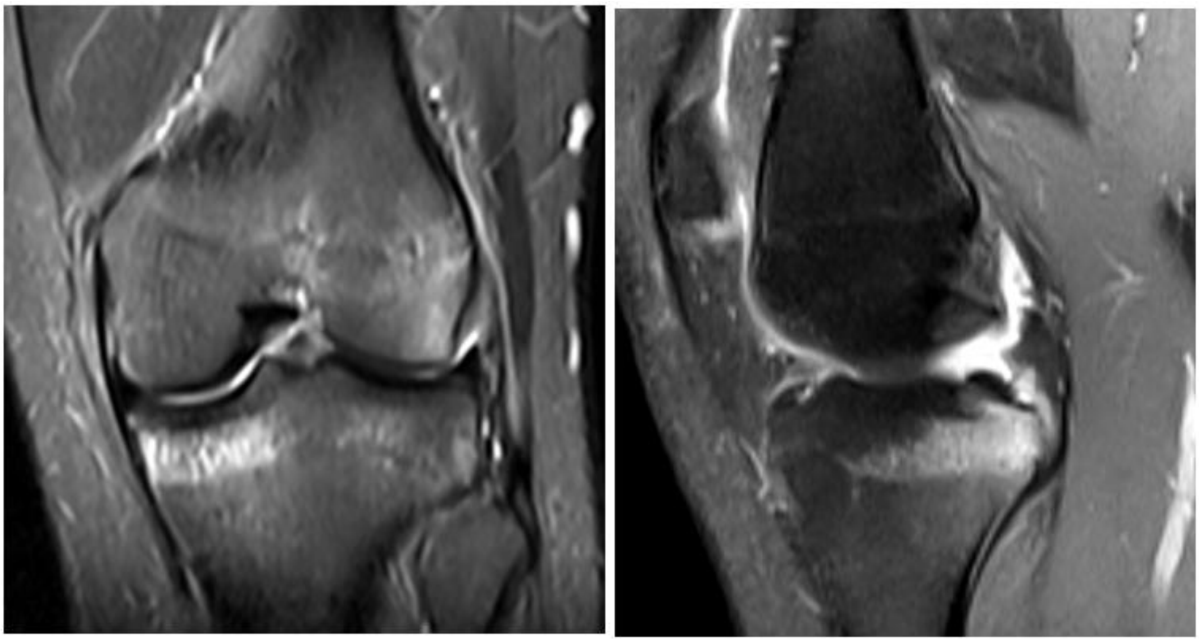


Figure 51: PDFS coronal & sagittal images, showing mild joint effusion and hyperintense signal changes along the lateral femoral condyle and posterior aspect of proximal end of tibia *(medial > lateral) – Suggestive of pivot shift marrow contusion.*

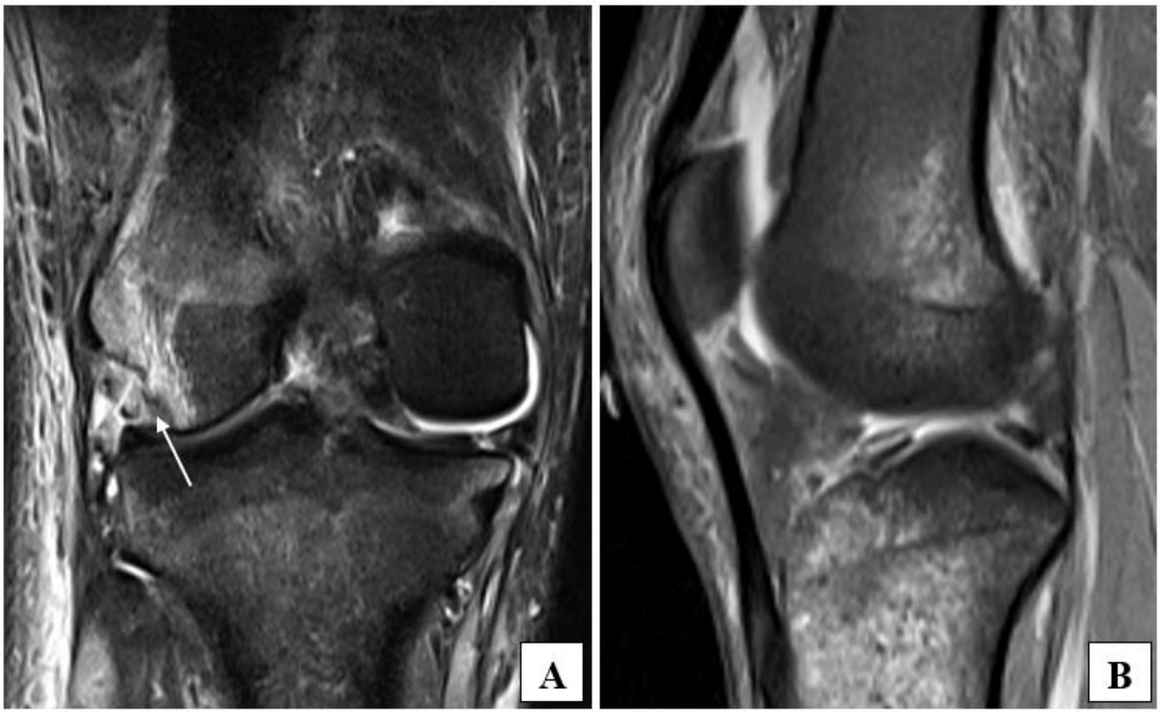


Figure 52: (A) T1 coronal section, showing hypointense line *(white arrow)* in the lateral condyle of femur with adjacent hyperintensities - *S/o Chip fracture with adjacent edema***.** Medial collateral sprain is also seen. (B) PDFS sagittal: Hyperintensities in lateral condyle of femur, proximal tibia **-** *S/o bone marrow contusion.* Mild joint effusion.

Figure 53: (A) Sagittal & (B) axial PDFS section, shows hyperintensity in the posterior intercondylar tibial plateau with associated marrow contusions – *s/o avulsion fracture with adjacent bone edema.*

DISCUSSION

DISCUSSION

Joint injury has been recognized as a potent risk factor for the early onset of osteoarthritic changes. Although clinical examination is essential for the diagnosis of ligament and meniscal injury, painful stress examinations are not always accurate in the acute phase of the injury. In cases of knee joint trauma, clinical examination along with radiographs and even CT scan is not enough to diagnose many internal derangements of this joint. MRI, due to its excellent soft tissue contrast resolution and multiplanar imaging capabilities provides significant advantages over other imaging techniques in the evaluation of traumatic injuries of knee joint.

The use of MRI and arthroscopy of the knee has evolved substantially over the last several decades, and the advancement in surgical treatment for pathological conditions of the knee has been improved because of both technologies. MRI offers excellent visualization of both the intraarticular and extra articular structures of the knee, whereas arthroscopy focuses mainly on the evaluation of intraarticular structures [74]. MRI is highly sensitive and specific in the diagnosis of complete cruciate ligament tears and high grade meniscus tears [74]. The purpose of this study is to reveal the importance of MRI in the assessment of the patients with knee injuries and to compare accuracy of MRI results and arthroscopy findings in diagnosis of various ligament injuries during internal derangement of knee. This prospective study was done on 52 patients. MRI findings in cases were correlated and compared with arthroscopy findings, as arthroscopy is gold standard.

Demographic features:

In our study, out of 52 patients males were more commonly affected, accounting for 35 cases (67.3 %) and right side was also more commonly involved, accounting for 60.8% (31 cases) and left side in 41.2% (21 cases). Similar study conducted by **Rajasekhar et al** [75] and **Umap et al** [1] showed males are more commonly affected by knee injuries with right more commonly involved than left. Also in the study by **Shetty et al** [76] and **Anil Madurwar et al** [77] found that out of 50 patients of knee trauma examined, 42 patients (76%) were males and 8 of them were females, which is similar to our study.

Our study showed, the average age of study population was 30 years. The youngest patient being 19 years and eldest patient being 59 years. The largest group being 36-45 years **(**33%), followed by 16-25 years (29%) and 26-35 years (19%). The 46-55 age group constitutes 13%, and the smallest group was 56-65 years (6%). Study by **Thapa M et al** [2] shows maximum patients were between 30-50 years and another study by **Ishani et al** [69] maximum number of patients belonged to the age group of 30-46 years with eldest patient being 57 years, which was similar to the finding in our study.

In the study conducted by **Thapa M et al** [2], sport injuries was the most common mode of knee injury. The second common mode of injury being fall injury. Another study by **Jah et al.**[78] Sports injury was the most common mode of injury followed by fall injury and road traffic accident. In our study, road traffic accidents (RTA) and twisting injuries are the most common, each accounting for 27%. Falls account for 20% of injuries, while sports injuries make up 16%. Direct trauma is the least common mode, comprising 12% of cases which is in concordance with above studies.

In our study, ACL tears identified by MRI are most common accounting for 78.4%, followed by medial meniscus (MM) in 33.3 % cases, lateral meniscus (LM) tears in 25.5%. Joint effusions were observed in 80.4% of cases. Posterior cruciate ligament (PCL) injuries in 17.6%, medial collateral ligament (MCL) injuries occurred in 29.4% of cases, while lateral collateral ligament (LCL) injuries were less common at 11.8%. Bone contusions (BC) were seen in 46.1% and articular fractures were present in 13.4 % of cases which was similar to the study conducted by **Thapa M et al** [2] in which 59 (90.8%) had joint effusion, 37 (56.9%) had

ACL tear, 8 (12.3%) had PCL tear, 17 (26.2%) had medial meniscus tear, 8 (12.6%) had lateral meniscus tear, 22 (33.8%) had MCL tear, 5 (7.7%) had LCL tear, 33 (50.7%) had bone bruise; 7 (10.8%) had osseous fracture. Almost similar incidence was found by **Rajan & Mohamed AJ**. [79]

Type of ACL injury:

In our study 40 cases (76.9 %) have ACL tear. Out of which partial ACL tears are the most common, making up 47.5% (19 cases). Complete tears account for 30% (12 cases), while sprains or edema constitute 22.5% (9 cases), indicating sprains are nearly half of the partial ACL tear. Similar study conducted by **Nenezic et al**. [80] among 149 patients showed higher incidence of ACL tear 134 (89.9%) with partial tear being most common. Other similar studies conducted by **Bollen et al**. [81] , **Gupta et al**. [82] and **Singh et al.** [83] showed highest incidence of ACL tear and among ACL tear, partial tear was most common than the full-thickness tear.

Type of PCL injury:

Out of 52 cases, in our study PCL tear was observed in 9 cases (17.3%). Of these 9 cases partial tear was observed in 5 cases (55.6 %), complete tear in 2 cases (22.2%) and 2 cases (22.5%) had Sprain. A study done by **Esmailiet al**. [84] also found almost similar percentage of incidence of PCL tear i.e. 11 cases (15.4%) among 71 cases with knee injury. Study by **Thapa M et al**. [2] found that out of 65 patients with knee injury, 8 (12.3%) had PCL tear. Of these 8 patients 7 cases (87.5%) had partial tear and 1 case (12.5%) had complete tear which is similar to our study. PCL is less injured than that of ACL because of the fact that PCL is stronger than ACL.

Medial Meniscus injury:

In our study, 17 cases (32.6 %) had medial meniscus tear out of which Grade II injuries were most prevalent, accounting for 41.2% (7 cases), followed by grade I injuries 29.4% (5 cases), grade III injury 17.6 % (3 cases) and least were complex tear 11.8% (2 cases). Out of all 9 cases had injury in posterior horn and 5 had in anterior horn. Similar study was conducted by **Manoj et al**.[85] found almost similar incidence of medial meniscus injury (29%). Study conducted by **Singh et al**.[83] also found similar incidence of MM (34 %) and posterior horn injury to be more common than anterior horn.

Lateral Meniscus injury:

Out of 52 cases with knee injury in or study, 13 cases (25.0%) had LML injury. Grade I injury was seen in 4 cases (30.8%), grade II in 6 cases (46.2%), grade III in 2 cases (15.4%) and complex tear in1 case (7.7%). It shows a predominance of Grade II injuries, various subtypes, highlighting the diverse nature of knee ligament tears in clinical presentation. Out of all 13 cases 9 had injury in posterior horn and 7 had in anterior horn which was again quite similar to the study conducted by **Manoj et al.** [85] and **Astur et al.** [86]

Jeevika et al [87] found that among meniscal injuries medial meniscal tears (46.5%) were more common than lateral meniscus (37.2%) and the posterior horn of medial meniscus (55%) is commonest site of involvement. There was a preponderance of MM over LM in **Rajan and Mohamed** [79] study which correlated with study by **Singh et al** [83]. Out of 173 they found, 57 (32.9%) patients showed MM tear, and 28 (16.1%) patients showed LM tear. The study done by **Pozo et al** [88] reported that medial meniscal tears were more common than lateral meniscal tears. Our study also showed similar outcome with medial meniscus injury accounting for (32.6 %, 17 cases) and lateral meniscus for (25%, 13 cases) and posterior horn being most commonly effected among both.

Medial Collateral Ligament injury:

In our study, 15 cases (28.8 %) out of 52 had MCL injury, out of which minor sprain injuries (grade I) was the most common, seen in 7 cases (46.7%). Severe sprain/partial tear (grade II) were observed in 5 cases (33.3%).The lowest incidence of injury was observed in complete tears, i.e.3 cases (20%). This was in concordance with a study conducted by **Bollen et al.** [81] had 29% cases of MCL tear, **Thapa M et al.** [2] showed highest incidence of grade I injuries which is similar to our study.

Lateral Collateral Ligament injury:

Out of 52 cases in our study, 6 cases (11.5 %) had LCL tear where sprain injuries (grade- I) minor was the most common, observed in 3 cases (50%). Severe sprain/partial tears were observed in 2 cases (33.3%) and complete tear was observed in 1 case (16.7 %). MCL injury was more common than LCL which is due to the fact that LCL is superficially located and is not attached to lateral meniscus. A study conducted by **Manoj et al.**[85] , **Bollen et al**. [81] and **Uppin et al**. [89] also found decreased incidence of LCL tear as compared to that of MCL which is similar to our study with grade I injury predominance in LCL.

Bone contusions in knee injury:

In our study, 24 cases (46.1%) out of 52 cases had bony contusions. Out of 24 cases, 19 cases had variable contusion patterns associated with ACL and PCL injury. The Lateral femoral condyle and posterolateral tibial plateau *(pivot-shift)* contusions were seen in 8 cases (42.1 %), out of which 7 cases (87 %) were associated with ACL injuries and 1 case (12 %) with PCL injuries. Anterior tibial plateau and anterior femoral condyle *(Kissing)* contusions are seen in 5 (26.3%) cases out of which 3 (60 %) were associated with ACL injuries and 2 (40 %) with PCL injuries. Contusion on the lateral femoral condyle, lateral tibial plateau, and/or medial femoral condyle are seen in 4 (21.0 %) cases, out of which 3 (75 %) were associated with ACL injuries and 1 case (25 %) with PCL injuries. Anterior tibia and/or posterior patella contusions are seen in 2 (10.5%), both associated with complete ACL tear. The results were partly similar to a study done by **Thapa M et al**. [2] in which out of 33 bone contusion cases , lateral femoral condyle and tibial plateau bruise was the commonest 12 (36.3%), followed by medial tibial bruise 11 (33.33%). Most of the patients ACL tear (54.05%) were 8 (43%) lateral femoral condyle/ tibial plateau bruise followed by 6 (30%) medial tibial plateau bruise. This showed that cases with ACL tear had lateral tibial/femoral condyle bruise which is the result of pivot shift injury or the medial tibial plateau bruise as a result of dashboard injury.

Table No.17 Comparison of incidence of ligament and meniscal tears in our study with other referred studies.

Type of Injury	**Present study *(N= 52) (%)***	Rajan & Mohamed AJ[79] *(**N=50**) (%)*	Thapa M et al.[2] ***(N= 65)*** *(%)*
ACL	40 (76.9)	38 (76)	37 (56.9)
PCL	9 (17.3)	3 (6)	8 (12.3)
MM	17 (32.6)	18 (35)	17 (26.2)
LM	13 (25.0)	11 (22)	8 (12.6)
MCL	15 (28.8)	14 (28)	22 (33.8)
LCL	6 (11.5)	9 (18)	5 (7.7)
BC	24 (46.1)	21 (42)	33 (50.7)
Fractures	7 (13.4)	7 (14)	7 (10.8)
Joint E.	41(78.8)	25 (50)	59 (90.8)

In our study, for anterior cruciate ligament (ACL), high true positives (TP = 39) and low false negatives (FN = 1) suggest high sensitivity, with few false positives (FP = 1), indicating high specificity. For posterior cruciate ligament (PCL) our observations were TP = 8, FP = 1, FN = 0, TN = 42. The medial and lateral meniscus (MM & LM) injuries pose diagnostic challenges with higher false positives and negatives, impacting reliability. For

Medial Collateral Ligament (MCL) we found moderate accuracy, with significant false positives but lateral collateral ligament (LCL) have less false positive as compared to MCL and hence has better accuracy than MCL. ACL had 97.5% sensitivity and 91.7% specificity, while PCL has 100% sensitivity and high specificity (97.7%). Medial and lateral meniscus injuries had moderate sensitivity (66.7% and 69.2%, respectively) but high specificity (90.3% and 89.7%).

In study conducted by **Ishani et al.** [69], MRI detected 22 (73.3%) ACL injuries, one of which was false positive. The sensitivity and specificity of MRI with respect to arthroscopy were 95.45% and 87.5% respectively *(fair correlation with arthroscopy in diagnosing ACL tears).* The PPV was 95.45% and the NPV of MRI was 87.5%. In our study MRI had a higher sensitivity (95.45%) and NPV (87.5%). The accuracy, sensitivity, and specificity values for knee injury vary widely in literature**. Rubin et al** [90] reported 93% accuracy for diagnosing isolated ACL tears. Similarly, several prospective studies have shown a sensitivity of 92 to 100% and specificity of 93-100% for MRI diagnosis of ACL tears. [18, 19]

In a study done by **Rajan and Mohamed et al** [79] sensitivity, specificity, and accuracy of MRI in detecting ACL tear were reported to be 94.5%, 80.0%, and 94.0%, respectively, in a study by **Singh et al** [83] showed ACL tears accuracy to be 98.8 %., **Taryn et al**.[91] reported the sensitivity, specificity, and accuracy of MRI in detecting ACL tear to be 91.6%, 95.2%, and 94.4%, respectively. A study by **Yaqoob et al**.[92] **Mink et al.** [93] reported accuracy of MRI for detecting ACL tear as 95 % whereas Polly et al. [22] found the accuracy of MRI in detecting ACL tear to be 97.3 %.

Table No.18 Results between MRI and arthroscopy findings for ACL tears of our study compared with other studies

Name of study	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Our Study	**97.5**	**91.7**	**97.5**	**91.7**	**98**
Ishani Patel et al. [69]	95.4	87.5	95.4	87.5	93.3
Rajan and Mohamed [79]	94.59	80.00	94.50	80.00	94
Bidur Gyawali et al.[94]	89.5	96.9	94.4	94.1	94
Khandelwal et al. [70]	97.4	90.4	96.8	92.2	95.71

PCL injuries are much less common compared to ACL injuries as PCL being the stronger ligament have low incidence of tear. In our study, PCL has 100% sensitivity & NPV, high specificity (97.7%) & PPV (88.9 %) of MRI with accuracy of 100% which is similar to the study conducted by **Manoj et al** [85] in which the accuracy of MRI in detecting PCL tear is 100%. Most of the studies sensitivity, specificity, and accuracy of PCL tears varies from 93-98 %, 96-99 %, and 95-100 % respectively [95,96] and few studies showed sensitivity, specificity, PPV and NPV for PCL as 100%.

Table No.19 Results between MRI and arthroscopy findings for PCL tears of our study compared with other studies

Name of study	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Our Study	**100**	**97.7**	**88.9**	**100**	**100**
Ishani Patel et al. [69]	90.1	100	100	80	93.3
Rajan and Mohamed [79]	100	100	100	100	100
Bidur Gyawali et al.[94]	100	100	100	100	100
Sanjay N et al. [97]	100	97.4	-	-	97.7

A study conducted by **Ishani et al** [69] showed sensitivity of 91.67%, specificity of 55.56%, and accuracy of 70% of MRI for medial meniscus, and sensitivity of 62.5%, specificity of 72.73%, and accuracy of 70% of MRI for lateral meniscus. Another study by **Sahni et al**. [71] shows accuracy of 86% and 92% of MRI for detecting MM and LM injures. Study by **Sasnur et al.** [72] found for medial meniscus 58% accuracy, 66% sensitivity, 48% specificity and for lateral meniscus 55% accuracy, 58% sensitivity, 50% specificity. Values mentioned above are in concordance to our study where MM had 66.7% sensitivity, 90.3% specificity and accuracy of 83%. LM shows sensitivity 69.2%, specificity 89.7 % and accuracy of 86.3%. Hence we can conclude that as compared to ACL and PCL, meniscus have moderately decreased accuracy, sensitivity and specificity and among meniscus LM have better accuracy then MM, however this can be due to increased incidence of MM cases as compared to LM.

Table No.20 Results between MRI and arthroscopy findings for MM tears of our Study compared with others studies

Name of study	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Our Study	**66.7**	**90.3**	**82.4**	**82.4**	**83**
Nikolaou et al.[98]	83.3	69.0	83.3	69.1	81
Rajan and Mohamed [79]	68.42	86.66	76.47	81.20	80
Bidur Gyawali et al.[94]	95.4	90.0	87.5	96.4	92

Table No.21 Results between MRI and arthroscopy findings for LM tears of our Study compared with others studies

Name of study	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Our Study	**69.2**	**89.7**	**69.2**	**89.7**	**86.3**
Ishani Patel et al. [69]	75	77.27	54.55	89.47	76.67
Rajan and Mohamed [79]	69.23	94.10	81.81	88.88	88
Bidur Gyawali et al.[94]	77.7	88.3	58.3	95	86

In the present study, collateral ligaments have the least incidence of injury and among collateral ligament, medial collateral ligament (MCL) injury i.e.15 cases (28.8%) are more common than lateral collateral ligament (LCL) which accounts for 6 cases (11.5%). Most of the injury encountered are minor sprain and partial tear for both MCL & LCL. Complete tear was found in 3 cases of MCL tear and 1 case of LCL. MCL & LCL both had high FP. In our study MCL had 66.7% sensitivity, 82.5% specificity and accuracy of 80.4 %. LCL had 60.0% sensitivity, 93.5% specificity and accuracy of 92.2 %. The increased accuracy of LCL is probably due to less number of cases. PPV and NPV follow similar trends, with higher values for ACL and PCL, and moderate values for meniscus and cruciate ligaments, indicating varying predictive reliability. Study conducted by **Derby et al.** [99] investigated the value of MRI in detecting the posterior lateral corner and medial corner injuries for patients with knee dislocations, MCL (89% accuracy, 97% specificity) and LCL had (76% accuracy, 100% sensitivity, 67% specificity). PPV and NPV follow similar trends, with higher values for ACL and PCL, and moderate values for meniscus and cruciate ligaments, indicating varying predictive reliability.

CONCLUSION

CONCLUSION

Magnetic resonance imaging is an excellent, non-invasive, radiation free imaging modality with multilane capabilities and excellent soft tissue delineation for the assessment of knee injury and provide the most detailed evaluation in cases of various soft tissue injuries.

Cruciate ligament and meniscal injuries occur frequently in patients with posttraumatic internal derangement of knee. ACL and MM are more commonly torn when compared to PCL and LM. While ACL and medial collateral ligament tears show predilection toward MM tear, lateral collateral ligament tear showed a strong relationship with LM tear.

MRI have high accuracy in diagnosing joint effusion, articular fractures and bony contusions where specific pattern can guide us to narrow our diagnosis.

MRI was highly sensitive and accurate at the identification of both ACL and PCL tears as there was close agreement with arthroscopic diagnosis. However, the diagnostic agreement for the menisci and cruciate ligaments was moderate.

The present study shows that MRI is reliable and accurate in diagnosing cruciate ligament and high grade meniscal inquires as compared to low grade meniscus injuries and collateral ligament sprains/ partial injury.

SUMMARY

SUMMARY

The need to correctly evaluate knee injuries is crucial for proper management, outcome and to prevent chronic debility to patient. Magnetic resonance imaging (MRI) is a great help in diagnosing knee injuries. Most studies comparing MRI and arthroscopy have shown good diagnostic ability in identifying injuries of cruciate ligaments and menisci.

It is slightly difficult to assess the structures involved in multi ligamentous knee injury during clinical examination and hence, MRI is the reliable method for diagnosing these conditions.

This study was a hospital based prospective study. Total patients included in study are 52 who meet the inclusion and exclusion criteria. Out of 52 patients injuries on the right side were more frequent, accounting for 60.8%, while left side injuries represent 41.2%. Among 52 participants, 32.69% were females and 37.30% were males, showing male predominance.

Road traffic accidents (RTA) and twisting injuries are the most common mode of injury accounted in this study, each accounting for 27%.Anterior cruciate ligament (ACL) tears identified by MRI being the most common at 78.4%, in which nearly half of the ACL injuries are partial tears. Posterior cruciate ligament (PCL) injuries are seen in 17.6% cases, among which 55.5% where partial tear. Medial meniscus (MM) in seen in 33.3 % cases in which grade II injuries are most common, accounting 41.2 % of all MM injures. Lateral meniscus (LM) tears are seen in 25.5% in which again grade II injury are most common, accounting 46.2% followed by grade I constituting 30.8%.

Medial collateral ligament (MCL) injuries occurred in 29.4% of cases, while lateral collateral ligament (LCL) injuries were less common constituting 11.8%. In both MCL & LCL minor sprain (grade-I) are most common, accounting for 46.7% and 50 % respectively. Joint effusions were observed in 80.4% of cases.

Bone contusions (BC) were noted in 46.1% and Fractures were present in 13.4 % of cases. Total number of cases to have joint effusion on MRI were 41 (78 %) out of which 36 (69 %) cases had joint effusion on arthroscopy. False positive cases being 5 (9.6 %), predicting that joint effusion was over diagnosed on MRI. Similarly, total number of cases diagnosed with articular fracture on MRI were 7 (13 %), cases diagnosed on arthroscopy were 9 (17 %). False negative cases being 2 (3.8 %), predicting that articular surface was under diagnosed on MRI. Taking arthroscopy as gold standard accuracy of MRI for diagnosing Joint effusion was calculated to be (90.3 %), while the accuracy of MRI for diagnosing articular fractures was calculated to be (96.1 %).

Out of 52 cases, bony contusions were seen in 46.1 % of cases. Among 24 cases with bony contusions 79.1 % cases were associated with PCL & ACL injury and shows showed some common bony patterns, in which lateral femoral condyle and posterolateral tibial plateau *(pivot-shift)* contusion are the most common on followed by anterior tibial plateau and anterior femoral condyle *(Kissing)* contusion. Joint effusion and articular fractures shows diagnostic accuracy of 90.3% and 96.1% respectively.

The PCL has maximum specificity (100%) and specificity (97.7%), followed by ACL which had 97.5% sensitivity and 91.7% specificity. Medial meniscus and lateral meniscus injuries have moderate sensitivity (66.7% and 69.2%, respectively) but high specificity (90.3% and 89.7%, respectively). Medial collateral ligament & lateral collateral ligament show lower sensitivity (66.7% and 60%, respectively) and variable specificity (82.5% and 93.6%, respectively). Reduced sensitivity and specificity for meniscus and collateral ligament injures is likely due to multi ligamentous injuries in which collateral ligament sprain and low grade meniscus injures can be over diagnosed on MRI.

The accuracy of MRI in diagnosing ligament and meniscus injures came out to be 100% for PCL injures, followed by 98.05 for ACL injures. Among meniscus, lateral meniscus have slightly higher accuracy (86.3%) as compared to medial meniscus (82.4%). Lateral collateral ligament and medial collateral ligament had accuracy of 92.2% and 80.4% respectively. The increased accuracy of LCL is probably is due to less number of cases.

The present study supports both MRI & arthroscopy in diagnosing internal derangement of knee injuries and both MRI and arthroscopy can be used as complementary to each other, based on the clinical condition and severity of knee injury.

LIMITATIONS AND RECOMMENDATIONS

- The ACL and meniscal tears were more frequent, while PCL and collateral ligaments were less frequently involved. Collateral ligament had less cases that too most of them were found with other injuries.
- The over diagnosis of low grade meniscus and collateral injuries in multi-ligament injuries is likely caused by fluid surrounding the ligament, which can be mistaken for low grade sprains or injuries. The specific grade of ligament & menisci were not correlated with arthroscopy.
- There is a somewhat small sample size in this prospective non-randomized trial; a bigger sample size would have shown better results, especially with collateral ligament injuries.
- Inter-observer variation in terms of reporting of the MRIs performed has not been taken into consideration as it’s observed by single radiologist.

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ANNEXURE

PROFORMA

"ROLE OF MAGNETIC RESONANCE IMAGING IN EVALUATING TRAUMATIC KNEE INJURY AND ASSESSING ITS VARIOUS PATTERNS WITH ARTHROSCOPIC CORRELATION"

Consent taken : Yes / No

SUBJECT EVALUATION

Name*(Mr/Mrs)*:

Date: Time:

Hospital number:

- **Demographic Variables**

Age/ Sex:

Sex:

Occupation :

Address :

Ph. No :

Date of admission :

- **PAST HISTORY:**

  Any previous RTA/ Reconstruction history:

- **GENERAL EXAMINATION:**

- **LOCAL EXAMINATION:**

Inspection

Palpation

❖ MRI findings:

Internal derangement in patients following knee injury:

	ACL	PCL	MCL	LCL	MM	LM
Partial						
Complete						
Normal						

Bone edema/ Contusion and association with ACL/ PCL/ MM/ LM:

Bone edema/ Contusion	ACL Injury	PCL Injury	MM Injury	LM Injury
Lateral femoral condyle				
Medial femoral condyle				
Lateral tibial condyle				
Medial tibial condyle				
Patella				

Fractures:

Joint effusion:

❖ FINAL FINDINGS :

❖ ARTHROSCOPIC FINDINGS:

Correlation of MRI findings with arthroscopy	**YES**	**NO**

Remarks:

INFORMED CONSENT FORM

I Mr./Mrs. ___________ have been explained in my own understandable language, that I will be included in a study which is "**ROLE OF MAGNETIC RESONANCE IMAGING IN EVALUATING TRAUMATIC KNEE INJURY AND ASSESSING ITS VARIOUS PATTERNS WITH ARTHROSCOPIC CORRELATION**"

I have been explained that my clinical findings, MRI findings and arthroscopic findings will be assessed and documented for study purpose.

I have been explained my participation in this study is entirely voluntary, and I can withdraw from the study any time and this will not affect my relation with my doctor or the treatment for my ailment.

I have been explained about the interventions needed possible benefits and adversities due to interventions, in my own understandable language.

I have understood that all my details found during the study are kept confidential and while publishing or sharing of the findings, my details will be masked.

I have principal investigator mobile number for enquiries.

I in my sound mind give full consent to be added in the part of this study.

Signature of the patient:

Name:

Signature of the witness:

Name:

Relation to patient:

Date:

Place:

PATIENT INFORMATION SHEET

STUDY TITLE: " ROLE OF MAGNETIC RESONANCE IMAGING IN EVALUATING TRAUMATIC KNEE INJURY AND ASSESSING ITS VARIOUS PATTERNS WITH ARTHROSCOPIC CORRELATION"

STUDY SITE: R.L Jalappa Hospital and Research Centre, Tamaka, Kolar.

This is to inform you that, you require MRI knee for making diagnosis and further treatment plan for your condition that is knee injury. The MRI knee is required for making the diagnosis of the disease extent and for planning of the treatment. The patient with history of knee trauma referred to department of Radiology at R.L Jalappa hospital and research Centre, Tamaka, Kolar to undergo MRI knee as a part of protocol and of those patients who meet the inclusion criteria will be taken for the study.

We are conducting this study to predict the characterization and evaluating the patterns of knee injury.

If you are willing you will be enrolled in this study and we will do MRI knee and correlate the findings with the arthroscopy.

You will receive the standard care during the process.

This will facilitate identifying type of knee injury (if any) in an early stage and treating it. It will also benefit other patients with knee trauma management in future. You are free to opt-out of the study at any time if you are not satisfied or apprehensive to be a part of the study. Your treatment and care will not be compromised if you refuse to be a part of the study. The study will not add any risk or financial burden to you if you are part of the study.

Your identity and clinical details will be confidential. You will not receive any financial benefit for being part of the study. You are free to contact Dr. Gaurav Kumar or any other member of the above research team for any doubt or clarification you have.

Dr. GAURAV KUMAR

Mobile no: 7017513518

E-mail id: drgauravk.rajput@gmail.com

MASTER CHART

KEY TO MASTER CHART

UHID	Unique Health Identification Number
MRI	Magnetic resonance imaging
M	Male
F	Female
N	Normal
A	Absent
RTA	Road traffic accident
ACL	Anterior cruciate ligament
PCL	Posterior cruciate ligament
MM	Medial meniscus
LM	Lateral meniscus
MCL	Medial collateral ligament
LCL	Lateral collateral ligament
BC	Bony contusions
AF	Articular fractures
JE	Joint Effusion
G	Grade
AR	Arthroscopy

MRI																		ARTHROSCOPY							
s. No	UHID	AGE	SEX	AGE	SIDE	M. OF INJURY	ACL (MRI)	PCL (MRI)	MM (MRI)	LM (MRI)	MCL (MRI)	LCL(MRI)	BC (MRI)	AF.(MRI)	JE.(MRI)		ACL (AR)	PCL (AR)	MM (AR)	LM (AR)	MCL(AR)	LCL(AR)	AF (AR)	Joint E.(AR)
1	175710	49	F	26	Right	Twisting injury	complete tear	N	N	N	Partial Tear		Present	Present	Present		Tear	N	N	N	Tear	N	Present	Present
2	208043	51	F	48	Right	RTA	Partial tear	N	G-III	N	N	N	A	A	Present		Tear	N	Tear	N	N	N	A	Present
3	127520	39	F	19	Left	Twisting injury	complete tear	N	G-II b	N	Sprain	N	Present	A	Present		Tear	N	Tear	Tear	N	Tear	A	Present
4	144827	16	M	37	Left	Fall	Sprain & edema	N	N	N	N	N	A	A	Present		Tear	N	N	N	N	N	A	A
5	154958	56	F	41	Right	Direct trauma	Partial tear	Sprain & edema	N	G-III	N	N	Present	A	Present		Tear	Tear	Tear	Tear	N	N	A	Present
6	168180	46	M	22	Right	Twisting injury	Partial tear	N	N	N	N	N	A	A	A		Tear	N	N	N	N	N	A	A
7	176574	45	M	27	Right	Sports injury	N	Partial tear	N	G-I	N	sprain	A	A	Present		N	Tear	N	N	N	N	A	Present
8	173273	59	F	49	Right	Twisting injury	complete tear	N	G-lla	G-IIa	Complete	N	Present	A	Present		Tear	N	Tear	Tear	Tear	N	Present	Present
9	176574	38	M	24	Left	RTA	Partial tear	N	N	N	N	N	A	A	A		Tear	N	N	N	N	N	A	A
10	237167	38	M	39	Right	Fall	N	Buckling	N	N	Sprain	N	A	A	Present		N	N	N	N	Tear	N	A	A
11	228267	42	M	31	right	RTA	Sprain & edema	N	N	N	N	N	Present	A	A		Tear	N	N	N	N	N	A	A
12	249079	37	F	57	Left	Slip & fall	Partial tear	N	N	N	N	N	Present	A	Present		Tear	N	N	N	N	N	A	Present
13	242601	31	F	20	Left	Twisting injury	N	N	N	N	Sprain	N	A	A	Present		N	N	N	N	N	N	A	Present
14	199622	54	F	51	Right	Twisting injury	Partial tear	N	G-lla	N	N	N	A	A	Present		Tear	N	Tear	Tear	N	N	A	Present
15	264832	23	M	30	Right	RTA	N	Partial tear	N	N	N	Sprain	Present	Present	Present		Tear	Tear	Tear	N	N	Tear	Present	Present
16	286186	36	M	38	Left	H/o fall	complete tear	N	N	N	Partial Tear	N	Present	A	Present		Tear	N	N	N	Tear	N	A	Present
17	280728	23	M	19	Right	sports injury	complete tear	N	G-II b	G-II b	Sprain	N	Present	A	Present		Tear	N	Tear	Tear	N	N	A	Present
18	251041	23	F	42	Right	Twisting injury	Partial tear	N	N	N	N	N	A	A	A		Tear	N	Tear	N	N	N	A	A
19	294912	43	M	36	right	Twisting injury	Sprain & edema	N	G-I	N	N	N	A	A	Present		Tear	N	N	N	N	N	A	Present
20	285106	24	F	33	Right	H/o fall	N	N	N	N	Sprain	N	A	A	Present		N	N	N	N	N	N	A	Present
21	292699	18	M	44	Left	Sports injury	Partial tear	N	N	N	N	N	A	A	A		Tear	N	N	N	N	N	A	A
22	291541	28	M	52	left	RTA	Complete tear	Mild Buckling	G-lla	G-IIa	N	N	Present	Present	Present		Tear	N	Tear	Tear	N	N	Present	Present
23	312341	35	M	34	Right	RTA	Sprain & edema	Mild Buckling	N	N	N	N	Present	A	Present		Tear	N	N	N	N	N	A	A
24	300306	22	M	49	Left	Direct trauma	complete tear	N	N	N	N	N	A	A	Present		Tear	N	Tear	N	N	N	A	Present
25	324398	50	M	21	right	Twisting injury	complete tear	N	Buckle handle	N	N	N	A	A	Present		Tear	N	Tear	N	Tear	N	A	Present
26	327575	25	M	49	left	fall	complete tear	Mild Buckling	N	N	N	N	Present	A	Present		Tear	N	N	N	Tear	N	A	Present
27	315611	28	M	28	Right	Direct trauma	Sprain & edema	N	N	N	N	N	A	A	A		N	N	N	N	N	N	A	A
28	330372	23	F	51	Left	Slip & fall	Near complete tear	Partial tear	N	G-I	Complete	N	Present	Present	Present		Tear	N	Tear	N	Tear	N	Present	Present
29	314694	29	M	23	Left	Sports injury	Partial tear	N	G-I	G-IIa	N	N	Present	A	Present		Tear	N	Tear	Tear	N	N	A	Present
30	273765	24	M	55	Left	fall from height	Partial tear	N	N	N	N	N	A	A	A		Tear	N	N	N	N	N	A	A
31	342235	27	F	20	Left	sports injury	N	Partial tear	N	N	Partial Tear	N	Present	A	Present		N	Tear	N	N	Tear	N	A	Present
32	341972	24	M	56	Right	RTA	Partial tear	N	N	N	N	N	A	A	A		Tear	N	Tear	N	N	N	A	A
33	337799	43	M	48	Right	Twisting injury	complete tear	Mild Buckling	N	N	N	N	A	A	Present		Tear	N	N	N	N	N	A	Present
34	339721	31	M	29	Left	RTA	Sprain & edema	N	G-III	N	N	N	Present	A	Present		Tear	N	Tear	Tear	N	N	A	Present
35	334901	46	M	24	Right	RTA	Partial tear	N	G-I	N	N	N	A	Present	Present		Tear	N	N	N	N	N	Present	A
36	365497	37	M	46	right	Direct trauma	N	Complete tear	N	Complex T.	Partial tear	Complete	Present	A	Present		N	Tear	Tear	Tear	N	Tear	A	Present
37	359696	34	M	47	Left	Twisitng injury	Partial tear	Sprain & edema	G-llc	G-IIa	N	Partial	Present	Present	Present		Tear	Tear	Tear	Tear	Tear	Tear	Present	Present
38	356290	36	M	22	Right	H/o RTA	Partial tear	N	N	N	Sprain	N	A	A	Present		Tear	N	N	N	Tear	N	A	Present
39	352591	30	M	49	Right	? Twisting	Partial tear	N	N	N	N	N	A	A	A		Tear	N	N	N	N	N	A	A
40	350222	36	M	54	Right	Sports injury	N	N	N	N	N	sprain	A	A	Present		N	N	N	N	N	N	A	Present
41	374778	45	M	23	right	Twisting injury	Sprain & edema	N	Complex	G-I	N	N	Present	A	Present		Tear	N	Tear	N	N	N	A	Present
42	374245	25	F	58	Right	RTA	Partial tear	Buckling	N	N	N	N	A	A	Present		Tear	N	N	N	N	N	A	Present
43	373879	44	F	53	Right	RTA	Sprain & edema	N	N	N	N	N	A	A	A		Tear	N	N	N	N	N	A	A
44	345782	19	M	21	Left	Sports injury	N	Partial tear	G-I	N	sprain	N	Present	A	Present		N	Tear	Tear	N	N	N	A	Present
45	217023	38	M	50	left	Direct trauma	Partial tear	N	N	N	N	N	A	A	Present		Tear	N	N	N	N	N	A	Present
46	406879	41	F	33	Right	Twisting injury	Near complete tear	Buckling	G-III	G-II c	N	N	Present	A	Present		Tear	N	Tear	Tear	Tear	N	Present	Present
47	406775	33	F	24	Left	Slip & fall	Partial tear	N	N	N	N	N	A	A	A		Tear	N	N	N	N	N	A	A
48	336121	25	M	51	Left	Twisting injury	N	Complete tear	N	G-III	Partial Tear	N	Present	A	Present		N	Tear	N	Tear	N	Tear	A	Present
49	394877	19	M	23	Right	sports injury	N	N	G-I	N	N	N	Present	A	Present		N	N	N	Tear	N	N	A	Present
50	307003	41	M	53	right	Slip & fall	Sprain & edema	N	N	N	N	N	A	A	Present		Tear	N	N	N	N	N	A	A
51	378284	61	M	21	left	Direct trauma	N	Buckling	N	N	N	Partial	A	A	Present		N	N	N	N	N	N	A	Present
52	389912	48	F	34	Right	RTA	Partial tear	N	G-llc	G-I	Complete	N	Present	Present	Present		Tear	N	Tear	N	Tear	N	Present	Present