MRI EVALUATION OF TRAUMATIC KNEE JOINT

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ABSTRACT

BACKGROUND
MRI is a non-invasive technique for assessing internal ligaments and menisci of knee. MRI provides excellent soft tissue contrast and is an accurate technique for examination of the soft tissue and osseous structures of a knee.

MATERIALS AND METHODS
40 patients who underwent MRI for traumatic knee injury between the period June 2016 and June 2017 were included in this prospective study. All the patients gave a history of knee joint pain following trauma. A GE 1.5 TESLA MRI Scanner was used.

RESULTS
Most common finding was ACL tear followed by medial meniscal tear. Grade 3 tear was the most common grade of meniscal tear.

CONCLUSION
MR imaging of the knee is considered efficacious especially in the setting of indeterminate clinical findings and can stratify patients, thereby increasing the diagnostic confidence of the clinicians leading to appropriate surgical planning and management. MRI is a superior imaging modality to evaluate the internal structure as well as the surface of the meniscus. MRI is an excellent non-invasive modality for imaging the internal derangement of knee.

KEYWORDS
Magnetic Resonance Imaging, Anterior Cruciate Ligament.

HOW TO CITE THIS ARTICLE: Eowin FJ, Thangadurai B. MRI evaluation of traumatic knee joint. J. Evolution Med. Dent. Sci. 2017;6(86):5960-5963, DOI: 10.14260/jemds/2017/1297

BACKGROUND

Arthroscopy is usually considered as a gold standard for the evaluation of knee injury. However, the accuracy of arthroscopy varies from 69% to 98%.[1] Intrasubstance tears cannot be evaluated in arthroscopy. MRI provides excellent soft tissue contrast and is capable of evaluating the soft tissue and bony structures in multiple imaging planes which provide significant advantages over other imaging techniques. Improved diagnostic accuracy has been clearly demonstrated and MRI is shown to result in changes in patient management in 41% of patients.[2] In this article, we were going to discuss about MRI findings of 40 patients who were diagnosed with traumatic knee injuries.

Aim of the Study

Aim of the study is to evaluate the usefulness of MRI in assessing the ligament and meniscal tear and also to assess the commonest structure to get involved in traumatic knee.

MATERIALS AND METHODS

This is a descriptive study of 40 patients who underwent MRI for internal derangement of knee. The study period was June 2016 to June 2017. All the patients gave history of knee joint pain following trauma and clinically suspected to have meniscal and ligament tears. Patients were evaluated using a GE 1.5 Tesla MRI scanner. The inclusion criteria were history of traumatic injury with knee joint pain.

The exclusion criteria were arthritis, infections and previous surgery to knee. The knee joint was examined in sagittal, coronal and axial planes with T1, T2 and PD sequences. The sagittal plane is primarily used to evaluate the cruciate ligaments, menisci and synovial anatomy as the coronal plane optimally evaluates the collateral ligament and body of menisci. Patient is placed in supine position with the knee externally rotated 15˚ - 20˚ and flexed 5˚ - 10˚. This position increases and facilitates the evaluation of ACL and patellofemoral compartment.

RESULTS

Majority of the patients had anterior cruciate ligament tear and medial meniscal tear as evident from Table 1**.** Lateral meniscal injuries were not so common than the medial meniscal tears. 16 cases of ACL injuries coexisted with medial meniscus injuries (40%). There was an increased frequency of occurrence of MCL injury in patients with coexisting ACL injuries.

MRI	No. of cases	Percentage %
ACL tear	24	60
PCL tear	4	10
MM tear	20	50
LM tear	14	35

Table 1

'Financial or Other Competing Interest': None.
Submission 27-07-2017, Peer Review 01-10-2017,
Acceptance 19-10-2017, Published 26-10-2017.
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DOI: 10.14260/jemds/2017/1297

DISCUSSION

The major advantage of MRI is its non-invasive and non-ionising nature. Although arthroscopy is considered the gold standard, improved diagnostic accuracy with MRI has been clearly demonstrated.[3]

Another study by Vincent et al reported that MRI reduces the need for arthroscopy in 42 patients. Majority of the patients in our study were male (111) and their common cause of injury was contact sports followed by road traffic accidents.

Another conclusion drawn from the study was the superior sensitivity of MRI in the detection of multiple meniscal tears.[4]

The anterior cruciate ligament (ACL) is the most commonly injured of the major knee ligaments affecting both athletes and non-athletes. Patients with ACL injury have variable knee instability particularly difficulty in pivoting and ambulating on uneven surfaces thereby limiting ordinary daily activities. The torn ACL undergoes limited healing. Long-term morbidity is common with sequelae including injury to the articular cartilage, secondary meniscal tears, and osteoarthritis.

The Primary Features of Complete Acute Tears are-

- Disruption of substance of ACL with increased signal intensity.
- Abnormal ligament course (Abnormal Blumensaat angle)/wavy appearance.
- Complete absence of the ligament with effusion and high signal intensity in the mid-joint space.

Acute incomplete tears of ACL are seen as increased signal intensity (T2WI) with thickening and normal course.

The Blumensaat line courses parallel to the roof of the intercondylar notch (The posterior surface of the femur). The Blumensaat angle is formed by the Blumensaat line and a line along the margin (Including the distal portion) of the ACL. A negative (normal) Blumensaat angle occurs when the apex of the angle is directed superiorly, and a positive (Abnormal) Blumensaat angle occurs when the apex of the angle is directly inferior.

Secondary Signs of ACL Tear

- Pivot-shift bone bruises and fractures - tibial/femoral side. Lateral compartment osseous contusions or osteochondral fracture (posterolateral tibial plateau is most specific).
- Deep lateral femoral-notch sign - exaggerated (>1.5 mm-deep) condylopatellar notch of the lateral femoral condyle.
- Posteromedial tibial plateau contusion or fracture.
- Anterior tibial subluxation – measured in sagittal images at the level of mid-lateral femoral condyle. Subluxation of more than 5 mm (grade 2) resulted in a sensitivity of 86% and specificity of 99% for ACL tears.
- Buckling of PCL - "question mark" configuration. A PCL angle of <105° was 72%-74% sensitive and up to 86% specific for ACL tears. The normal PCL angle is 113°-114°.
- Fracture of the tibial spine.
- Uncovered posterior horn lateral meniscus sign - Posterior displacement of the lateral meniscus with relation to the tibia on sagittal images is also a sign of tibial shift. A vertical line constructed through the posterior cortical margin of the tibia should not intersect the lateral meniscus. Studies have demonstrated a sensitivity of 56% and specificity of 97% using this technique.
- Segond fracture - an elliptical, vertical, 3 x 10 mm bone fragment paralleling the lateral tibial cortex about 4 mm distal to the plateau. It has been attributed to traction avulsion of slips of the iliotibial band and lateral collateral ligament complex and has a 75-100% association with ACL tear.
- Associated injuries to menisci, MCL & PCL, joint effusion.

PCL injuries constitute 3-20% of knee injuries. The rate may be higher because acute tears often go undiagnosed. More than one half of PCL injuries occur through traffic and industrial accidents; less than one half occur through sports-related injuries.

MR findings in PCL injuries retrospectively reviewed by Sonin et al showed that complete tears occur in 38% of cases; partial tears in approximately 55%; and avulsion tears in 7%.

MRI Findings

Signs of Complete tears of PCL include-

- Failure to identify the PCL.
- Focal discrete disruption of all visible fibres.
- Inability to define ligamentous fibres with amorphous areas of high signal intensity on T1- and T2WI Posterior sag sign – posterior subluxation of tibia relative to femur.

Partial tear or intrasubstance injury refers to PCLs that do not meet these criteria but have some intact and some discontinuous fibres or contain abnormal signal intensity within their substance respectively. They may contain a ring of haemorrhage and oedema around the margins of the PCL with preservation of most of its internal architecture (halo sign), which is dark on T1WI and bright on T2WI.

The approximate site of a complete or partial tear can be subjectively categorised as proximal, midsubstance, or distal based on the location of areas of abnormal signal intensity on sagittal MR images in the proximal, distal or middle third of the ligament respectively. In over 90% of patients with PCL tears, the PCL measured more than 7 mm in anteroposterior diameter on sagittal T2-weighted images. Avulsion fractures are common at the tibial insertion site of PCL and often bone marrow oedema exists at the fracture site.

According to Mink et al, combined injuries to the PCL and other structures of the knee are much more common (97%) than isolated PCL injuries (3%). The ACL is injured most commonly (65%), followed by the MCL (50%), the medial meniscus (30%), the posterior capsule, and fibular collateral ligament.

Grade III or complete PCL tears must be distinguished from combined injuries because the prognoses are different. Isolated PCL injuries are treated conservatively and have an excellent prognosis. Combined injuries involving the PCL have a more guarded prognosis. They are treated with surgical repair or reconstruction within 3 weeks of injury. Surgical results are better than results seen with conservative management; however, it is difficult to distinguish clinically between the two injuries.

The meniscus can be divided into three zones moving from periphery to the centre; the peripheral third is the only vascularised zone. Because of vascularisation, tears may heal spontaneously, especially in young patients, and suturing of meniscal tears in this vascularised zone is an option instead of partial resection. The meniscus can also be divided into three zones going from anterior to posterior: anterior horn, body (pars intermedia) and posterior horn. Both divisions, going from the periphery to the centre and going from anterior to posterior, are used to localise meniscal abnormalities. The most common site for meniscal tear is the posterior horn of the medial meniscus.

Meniscal Tears are depicted on MR images as areas of linear abnormally increased signal intensity within the meniscus, which extend to and communicate with an articular surface.

Grading of Meniscal Tears-

Grade 1 - Meniscal lesion is globular and does not communicate with the articular surface.

Grade 2 - Meniscal lesion is linear in nature and remains within the substance of the meniscus not communicating with the articular surface.

Grade 3- Increased signal intensity within the meniscus that extends to the articular surface.

Grade 1 & 2 meniscal lesions represent mucinous or myxoid degeneration of menisci and generally they are not operated. It is due to structural weakening within collagen fibres and grade 3 tears may develop in continuity or adjacent to these lesions.

Grade 3 Meniscal Tears-

They can be classified as following.

Based on Circumferential or Surface Anatomy-

- Longitudinal – vertical/horizontal.
- Flap tear - vertical/horizontal.
- Radial tear – vertical.

Based on MRI sagittal sections-

- Horizontal.
- Vertical.

Longitudinal tears correspond to the longitudinal axis of the meniscus in the axial plane extending circumferentially along the anteroposterior extent of the meniscus parallel to the meniscal margin in the long axis. They are commonly vertical and rarely horizontal. Vertical longitudinal tears are most likely to occur in younger patients in an acute traumatic setting. They are usually found in the peripheral aspect of the meniscus communicating to one or both (superior & inferior) articular surfaces.

Bucket handle tear is a full thickness vertical-longitudinal tear with the inner fragment displaced towards intercondylar fossa. It is called because the separated inner fragment resembles the handle of a bucket and remaining larger peripheral section of the meniscus is the bucket. Medial meniscus bucket-handle tears are three times more frequent than bucket-handle tears involving the lateral meniscus.

Signs in Bucket Handle Tears

- Absent bowtie sign- bucket-handle tear effectively reduces the width of the meniscus, and peripheral sagittal images fail to demonstrate the normal bowtie configuration of the body of the meniscus that is seen in at least 2 sections of slice thickness 4-5 mm.
- Double PCL sign is seen in coronal and sagittal images when the displaced fragment lies below the PCL, giving the appearance of two ligaments.
- Double delta sign- visualisation of flipped inner meniscal fragments adjacent (posterior) to the anterior horn of the donor site.
- Flipped fragment sign occurs when the fragment is flipped anteriorly so the anterior horn of the meniscus appears enlarged.
- Fragment in notch appears as a band like area of low signal intensity within the notch but not appearing on the same slice as PCL.
- Foreshortening of the posterior horn- normal medial meniscus without tear, the posterior horn is wider and thus has greater height than the anterior horn. Foreshortening of the posterior horn of the medial meniscus without history of previous partial meniscectomy is associated with bucket-handle morphology.

Flap tears usually result from extensions of radial or horizontal cleavage tears and represent the most common clinical tear type. A flap tear starts on the free edge of the meniscus and curves obliquely into the meniscal fibrocartilage. These tears may also be referred to as oblique tears. Flap tears may display either a primary vertical or horizontal tear pattern. On sagittal images, flap tear is usually seen as obliquely oriented grade 3 meniscal signal, but it does not necessarily indicate its presence since longitudinal tears may also appear as an oblique course. Flap tears involve the inner one third to one half of the meniscus, with superior or inferior leaf extension creating the mobile limb or flap of fibrocartilage. In contrast, longitudinal tears are more likely to involve the peripheral third of the meniscus, where there is a greater concentration of circumferential fibres. Flap tears most commonly involve the posterior horn of the medial meniscus than lateral meniscus. Complex flap displacement and rotation of the posterior horn of the lateral meniscus may be mistaken for ACL (double ACL sign).

Radial tears are defined as vertical tears perpendicular to the free edge of the meniscus of varying length. They are subdivided into classic radial tears and root tears. Classic radial tears are common in the lateral meniscus. Based on location tear can be in the body or at junction of anterior horn–body or posterior horn–body. The most common classic radial tear involves the anterior horn-body junction of the free edge of the lateral meniscus with MR sagittal images show blunting of both the anterior horn-body junction and blunting and elongation of the posterior horn-body. Radial tears may extend to form flap tears.

In our study, we studied 40 patients. Sixty percentage of our cases showed ACL tears (Table 1).

This was the most common ligament injury in our study. Shetty et al reported 37% of knee injuries to the ACL.[5] Hyperintensity of the ligament was the most common sign (50%). 30% showed discontinuity and 15% of the ligaments

were not visualised which corresponded with Gentili et al study.[6] This was also comparable to study by Shetty et al who reported hyperintensity as the most common sign observed followed by discontinuity and lastly non-visualisation.

We had ten percentage of cases having posterior cruciate ligament tear. Berquist reported between 2% - 23% of tears to be PCL tears.[3]

The main findings in collateral ligament injuries were adjacent fascial oedema and increased signal intensity. The incidence of medial meniscus tear is more common than lateral meniscus tears (Table 1) which correlated with the study by Berg et al.[7] Grade 3 lesions were the most common (40%) subset of meniscal tears.

Bone contusions showed a high association with ACL tears (50%), and PCL tears (40%). This corresponds to the study by Remer et al who found up to 68% bone injury associated with ACL injury.[8] McCauley et al also reported a high incidence of bone bruise with ACL tears.[9] We found 16 cases of ACL injuries to coexist with medial meniscus injuries. Other associated injuries were seen in medial collateral ligament (22%) and lateral meniscus (16%). This corresponds to the report by Remer et al who observed 68% of meniscal tears to be associated with ACL injuries. He also reported an increased frequency of occurrence of MCL injury in patients with coexisting ACL injuries (18%).

CONCLUSION

Commonest lesion identified in our study was ACL tear followed by meniscal tear. There was an increased incidence of medial meniscal and collateral ligament tears associated with ACL tears. The most common sign of cruciate ligament injury was hyperintensity in the ligament. Grade 3 was the most common grade of meniscal tear. Bone contusion showed a higher frequency with ACL injury. MRI is unique in its ability to evaluate the internal structure as well as the surface of the meniscus. MRI is an excellent non-invasive modality for imaging the knee.

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