ORIGINAL ARTICLE

MRI FINDINGS OF INTERNAL DERANGEMENT OF KNEE IN TRAUMA

Ravi Ningappa[1], Jayasudha[2]

HOW TO CITE THIS ARTICLE:
Ravi Ningappa, Jayasudha. "MRI Findings of Internal Derangement of Knee in Trauma". Journal of Evidence based Medicine and Healthcare; Volume 2, Issue 09, March 02, 2015; Page: 1188-1197.

ABSTRACT: AIMS AND OBJECTIVES: 1. To evaluate ligament and meniscal injuries and secondary signs, using MRI. 2. To analyse the types and grades of the tears. **MATERIALS AND METHODS**: MR imaging studies of knee was performed in 200 patients, presenting to the department of radiodiagnosis, BMCRI from September-2013 to September -2014 with history of trauma and clinical suspicion of internal derangement of knee. Various sequences in coronal, sagittal and axial planes were obtained. **RESULTS:** Out of 200 patients evaluated, medial meniscus tear was the most common internal derangement. 94 patients showed medial meniscus tear and associated anterior cruciate ligament tear was found in 76 patients. Medial collateral ligament sprain was seen in 18 patients, lateral meniscus injury was seen in 26 patients, lateral collateral ligament injury was seen in 8 patients, posterior cruciate ligament injury was seen in 16 patients, 20 patients showed cartilage defect and 18 percent showed no internal derangement. Associated secondary signs such as bone contusions were seen in 60 individuals and minimal to moderate joint effusion was seen in 74 individuals. **CONCLUSION:** MRI is an accurate, non-invasive modality in detecting ligament and meniscal injury of knee. It shows great capability in classifying them into types and grades. Special sequences are useful and should be included in the protocol.

KEYWORDS: MRI, Knee, Trauma.

INTRODUCTION: Internal derangement of knee is a term used to collectively indicate a group of disorders involving disruption of the normal functioning of the ligaments or cartilages of the knee joint.

In the setting of acute injury to the knee, it is not always feasible to diagnose these injuries in terms of history, clinical examination and tests alone. Though arthroscopy is considered the gold standard, it is an invasive and an expensive procedure. It is rather considered a therapeutic procedure, than a diagnostic tool in this era.

MRI is currently considered the gold standard in evaluating ligament and meniscal injuries as it provides a detailed visualization of the internal structures of the knee joint.

MATERIALS AND METHODS: This is a prospective hospital based study conducted in the department of Radio-Diagnosis, BMCRI.

200 patients presenting to the department of Radio-Diagnosis with a history of specific type of trauma and clinical suspicion of internal derangement of knee were subjected to MRI after taking informed consent.

PROTOCOL[3]: A dedicated surface coil is used with a small field of view (14-16cm). A slice thickness of 4mm is used with an interslice gap of 0.4mm. The matrix size used is 256x192/

256x256. Supine position with knee in 5degree external rotation and 15-30 degree flexion is used.

- Sagittal conventional spin echo PD with fat suppression for menisci.
- Sagittal FSE-T2W with fat suppression for cruciate ligaments, cartilage and bones. Gradient echo sagittal image for cruciate ligaments and cartilage.
- Bone marrow sensitive sequence in coronal/axial plane for bone marrow.
- Coronal T2 weighted with fat suppression for collateral ligaments, cruciate ligaments(Additional sequence), menisco-capsular separation(fat-suppression is a must)
- Axial T2 weighted image- patellar cartilage, trochlear cartilage, medial patellar plicae, collateral and cruciate ligaments(Additional look)

INCLUSION AND EXCLUSION CRITERIA:

INCLUSION	EXCLUSION
AGE 21-40 YEARS	OPEN, COMMINUTED FRACTURES OF FEMUR, TIBIA/ FIBULA
HISTORY OF ACUTE PAIN, SWELLING AND LIMITATION OF MOVEMENTS IN THE KNEE FOLLOWING TRAUMA	NEOPLASMS, INFLAMMATORY CONDITIONS INVOLVING THE BONES AROUND THE KNEE JOINT.
	GENERALISED CONTRAINDICATIONS TO MRI

Table 1

OBSERVATIONS AND RESULTS: Our study was a hospital based prospective study of 200 patients with clinical suspicion of internal derangement of knee. Patients were of the age group between 21-40 years. Males formed the majority. Common complaints were pain (65%), swelling (30%) and limitation of motion in the form of locking of the knee during motion(25%), the most common being pain. Overlapping complaints were seen in 40% of the individuals.

Most common clinical findings were positive MC MURRAY'S AND LACHMANN TEST. Our study revealed that the medial meniscus was the most common internal derangement followed by and most commonly associated with anterior cruciate ligament injury.

Sl. NO	STRUCTURE INVOLVED IN TEAR	NO OF CASES	% OF CASES
1	MEDIAL MENISCUS	94	47%
2	LATERAL MENISCUS	26	13%
3	ANTERIOR CRUCIATE LIGAMENT	76	38%
4	POSTERIOR CRUCIATE LIGAMENT	16	8%
5	MEDIAL COLLATERAL LIGAMENT	18	9%
6	LATERAL COLLATERAL LIGAMENT	8	4%
7	CARTILAGE DEFECT	20	10%
8	NO INJURIES	18	9%

Table 2

MENISCAL INJURIES: In our study medial meniscus injury was the most common internal derangement. Laxman Prasad et al[4] also had the same findings. Crues et al[8] in their study also found meniscal tears involving the posterior horns which accounts for 57% compared to the 16% involving the anterior horn. Weiss et al[9] also reported meniscal tears involving the posterior horn accounting for 50%-60% and tears involving the anterior horn accounting for 5%- 20%. D Smet et al [10]also found same result in their study. Most common morphological meniscal tear was complex type followed by horizontal. This is similar to the study by De Smet et al, in their study of MM tears in 343 patients found complex type of medial meniscus tear as a most common 116 patients.

Out of a 200 patients, 120(60%) had meniscal injuries. Out of 120, 94(78.33%) had medial meniscus injuries and 26(21.66%) had lateral meniscus injuries.

MEDIAL MENISCUS TEARS: Out of these medial meniscus tears, 58(61.8%) had a torn posterior horn, 6(6.4%) had a tear involving the anterior horn, 14(14.8%) had tears in the body and 16(17%) had tears involving the entire meniscus. Out of 94, 14(14.8%) were grade I, 20(21.2%) were grade II and 60(63.8%) were grade III. Out of the 60 grade III tears, there were 22(36%) complex tears, 14(23%) horizontal tears, 8(13%) vertical tears, 8 (13%)bucket handle tears, 4(6%) radial tears and 4(6%) flap tears.

Sl. NO	SUBTYPE OF GRADE III TEAR	NO OF CASES	% OF CASES
1	COMPLEX	22	36%
2	HORIZONTAL	14	23%
3	VERTICAL	8	13%
4	BUCKET HANDLE	8	13%
5	RADIAL TEAR	4	6%
6	FLAP TEAR	4	6%

Table 3

LATERAL MENISCUS TEARS: Out of these lateral meniscus tears, 14(53%) had a torn posterior horn, 2(7%) had a tear involving the anterior horn, 6(23%) had tears in the body and 4(15.3%) had tears involving the entire meniscus. Out of 26, 2(7.6%) was grade I, 2(7.6%) were grade II and 22(84%) were grade III. Out of the 22 grade III tears, there were 4(18%) complex tears, 10(45%) horizontal tears, 4(18%) vertical tears, 2 (9.5%)bucket handle tears,2(9.5%) radial and flap tear.

Sl. NO	SUBTYPE OF GRADE III TEAR	NO OF CASES	% OF CASES
1	COMPLEX	4	45%
2	HORIZONTAL	10	18%
3	VERTICAL	4	18%
4	BUCKET HANDLE	2	9%
5	RADIAL	2	9%
6	FLAP	2	9%

Table 4

CRUCIATE LIGAMENT TEARS: Out of 200 patients, 92(46%) had cruciate ligament injuries. Out of the 92, 76(82.6%) had anterior cruciate ligament injuries. Out of the 76, 60(78.9%) tears were complete and 16(21%) were partial. Out of the 76, 26(34%) involved the proximal segment, 40(53.2%) involved the mid substance and 10(12.5%) involved the distal segment. Posterior cruciate ligament injuries were seen in 16(17.3%) patients. Out of which complete tears were seen in 14(87.5%) and partial tears were seen in 2(12.5%).

COLLATERAL LIGAMENT INJURIES: Out of the 200 patients, 26(13%) had collateral ligament injuries. Medial collateral ligament tears were seen in 18(69.2%) and lateral collateral ligament tears were seen in 8. Out of the 9 medial collateral ligament tears, 6 (36%) were grade I, 8(45%) were grade II and 4(18%) were grade III. Out of the 8 lateral collateral ligament injuries, 2(25%) were grade I. 2(25%) were grade II and 4(50%) were grade III.

CHONDRAL INJURIES: were seen in 20(10%) patients.

DISCUSSION:

LIGAMENT TEARS IN MRI:

PRIMARY SIGNS:

1. Discontinuity (T2).
2. Abnormal orientation.
3. Non-visualisation.
4. Bone bruises (fat-suppressed images).

Same criteria are applied in MRI for all ligament injuries.

ANTERIOR CRUCIATE LIGAMENT INJURIES:

CRITERIA: for normal ACL[1]

1. Fiber orientation as steep or steeper than the intercondylar roof.
2. Fibers all the way from tibia to the femur.

SIGNS of ACL TEAR:

PRIMARY SIGNS[1]: ACL tears typically occur in the mid substance of the ligament as was seen in our study and appear as discontinuity of the ligament, non-visualization or abnormal contour or signal. [Brandser EA et al.]

SECONDARY SIGNS[1,2]:

- Bone contusion in lateral femoral condyle and posterior tibial plateau(Kissing contusions).
- >7mm of anterior tibial translation (Anterior drawer sign)[Reference chiu SS et al].
- Uncovered posterior horn of lateral meniscus.
- SEGOND fracture.
- ARCUATE sign.
- ACL angle that is less steep than the BLUMENSAAT'S LINE.
- Reduced PCL angle due to buckling of PCL.

- Empty notch sign.
- Positive PCL line.

POSTERIOR CRUCIATE LIGAMENT:
COMPLETE TEAR: Discontinuation or loss of the ligament fibres.

PARTIAL TEAR:
- Swollen ligament
- Intra substance hyperintensity.
- Avulsion fracture of the tibial PCL attachment site.

COLLATERAL LIGAMENT INJURIES:
MEDIAL COLLATERAL LIGAMENT:
Grading of SPRAIN:

GRADE I: (Minor sprain)high signal is seen medial (Superficial) to the ligament, which looks normal.

GRADE II: (Severe sprain or partial tear)high signal is seen medial to the ligament, with high signal in or partial disruption of the ligament.

GRADE III: Complete disruption of the ligament.

PELLEGRINI STIEDA SYNDROME: Post traumatic/ post avulsion calcification of the proximal medial collateral ligament.
(Reference Kaplan P. Musculoskeletal MRI. W B Saunders Co. (2001) ISBN:0721690270.)

LATERAL COLLATERAL LIGAMENT:
POSTEROLATERAL CORNER STRUCTURES:
The three structures visible on MRI are:
1. Fibular collateral ligament
2. Biceps femoris muscle and tendon
3. Popliteal tendon

MECHANISM OF INJURY:
1. Direct blow to the medial knee leads to isolated LCL tears.
2. POSTEROLATERAL CORNER INJURIES comes from medial blow to the knee with the knee in flexion and from rotational forces placed on the knee at the same time.

The finding of gap between biceps femoris tendon and collateral ligament on one side and fibular head on the other side on PD-FAT-SAT sagittal images indicates conjoint tendon rupture.

MENISCAL INJURIES: MEDIAL MENISCUS TEAR is the most common internal derangement of knee.

CRITERIA for diagnosing meniscal tears[1,2]:

1. **SIGNAL UNEQUIVOCALLY CONTACTING SURFACE ON SHORT TE IMAGE.**
2. **ABNORMAL MORPHOLOGY WITHOUT PRIOR SURGERY.**

If high signal clearly disrupts an articular surface of the meniscus, it is an easy call: it is a torn meniscus. If high signal comes close to the articular surface, but does not quite reach the articular surface, it is an easy call: it is not a tear, it is intrasubstance degeneration.[3]

Tears are mainly classified on the basis of SHAPES[1,2]

1. Longitudinal/ vertical.
2. Horizontal.
3. Radial.

Complex tears are a combination of these tears.

DISPLACED TEARS[1]:

1. Bucket-handle tear: Displaced longitudinal tear.
2. Flap tear: Displaced horizontal tear.
3. Parrot-beak: Displaced radial tear.

Longitudinal tears parallel the long axis of the meniscus dividing the meniscus into an inner and an outer part. Vertical longitudinal tears make up the common bucket-handle tear that occurs in about 10% of meniscal tears. When the inner edge of the meniscus displaces, a bucket-handle tear is easily diagnosed by noting only one instead of the normal two body segments present on the outermost sagittal images through the meniscus. This is called the absent bow tie sign because the body segments normally have a bow tie appearance on the sagittal images[3]

SIGNS IN BUCKET HANDLE TEARS:

1. Absent bow tie sign(as has been described above)
2. Double-PCL sign
3. Anterior flipped meniscus sign.

DOUBLE PCL SIGN[1,2]: The double PCL sign is a low signal intensity band that is parallel and anteroinferior to the posterior cruciate ligament on sagittal MR images. A displaced meniscal fragment should always be found, most often in the intercondylar notch. A careful search for a fragment should be made when only one body segment is seen on the sagittal images. The displaced meniscal fragment can lie in front of the posterior cruciate ligament (PCL), which is called a double PCL sign.[3]

ANTERIOR FLIPPED MENISCUS SIGN: A flipped meniscus is a special form of the bucket – handle tear. It occurs when the when the ruptured fragment of the posterior horn is flipped anteriorly so the anterior horn of the meniscus appears to be enlarged.[1,2]

RADIAL TEARS: The absent bow tie sign also is positive in free edge tears (also called radial tears or parrot beak tears). Free edge tears are common and are an unusual source of symptoms, unless they are large. The absent bow tie sign is useful in recognizing these tears. They are easily differentiated from bucket-handle tears because the second body segment, or bow tie, has only a small gap, rather than the large gap seen in bucket-handle tears, and no displaced fragment is present.

There are three basic recognized types;

1. GHOST.
2. CLEFT.
3. TRUNCATED TRIANGLE.

GHOST MENISCUS/ EMPTY MENISCUS: A ghost meniscus is seen when a radial tear has completely traversed the meniscus. The MRI slice is parallel to the tear, and partial volume averaging of the adjacent meniscal tissue creates an intermediate or gray signal.

A CLEFT is the most reliable sign for a radial tear and is seen when the MRI slice is perpendicular to the tear. When the MRI slice is parallel to the same tear with a cleft, it results in a TRUNCATED TRIANGLE. A radial tear usually, but not always, will have two of the signs, depending on the orientation of the tear to the imaging plane.[3]

PARROT BEAK TEAR IS A DISPLACED RADIAL TEAR[1,2]:

HORIZONTAL TEAR: Horizontal tears divide the meniscus into a top and a bottom part. If they go all the way from the apex to the outer margin of the meniscus they may result in the formation of a meniscal cyst.

3 CRITERIA FOR THE DIAGNOSIS OF A MENISCAL CYST[1,2]

1. Horizontal tear
2. Fluid accumulation bright on T2
3. Flat lining against the outside margin of the meniscus.

Joint effusion was associated with most of the positive cases. Bone marrow edema was the most common associated osseous injury.[4] Pattern of bony injury was associated with specific type of injury in many patients. 14 patients with injury of the posterolateral tibial plateau and 8 patients with lateral femoral condyle found to be associated with ACL tear. This is similar to the observation seen by Robertson et al in their study of multiple signs of anterior cruciate ligament on MR imaging in 103 patients found that posterolateral tibia bruise associated with ACL tear had 53% sensitivity, 97% specificity and 79% accuracy. The presence of lateral femoral bruise with ACL tear had a sensitivity of 47%, specificity of 97% and an accuracy of 76%[4].

CONCLUSION: Hereby, we conclude that magnetic resonance imaging is an accurate, non-invasive modality in the setting of trauma to detect the internal derangements of the knee. It shows great capability in classifying the tears into types and grades. Special sequences are used for detection of specific tears and should be included in the protocol.

REFERENCES:

1. Rubin DA: magnetic resonance imaging of chondral and osteochondral injuries. Top magn reson imaging 1998; 9: 348-359.
2. Rubin DA, kettering JM, Towers JD, Britton CA: MR imaging of knees having isolated and combined ligament injuries.
3. Musculoskeletal system—Magnetic resonance imaging. I. Helms, Clyde A.
4. Laxman Prasad Ahirwar, Chandraprakash Ahirwar. "Can MRI replace diagnostic arthroscopy in evaluation of internal derangement of knee joint – a prospective study". Journal of Evolution of Medical and Dental Sciences 2013; Vol2, Issue 40, October 07; Page: 7621-7631.
5. Escobedo EM, Hunter JC, Zinkbrody GC, et al: Usefulness of turbo spin-echo MR imaging in the evaluation of meniscal tears—comparison with a conventional spin-echo sequence. AJR Am J Roentgenol 1996; 167: 1223-1227.
6. Rubin D, Kneeland J, Listerud J, et al: MR diagnosis of meniscal tears of the knee: value of fast spin-echo vs conventional spin-echo pulse sequences. AJR Am J Roentgenol 1994; 162: 1131-1136.
7. Vassilios S Nikolaou, corresponding author1 Efstathios Chronopoulos, 2 Christianna Savvidou, 2 Spyros Plessas, 2 Peter Giannoudis, 1 Nicolas Efstathopoulos, 2 and Georgios Papachristou, MRI efficacy in diagnosing internal lesions of the knee: a retrospective analysis. Journal of Trauma Management & Outcomes 2008 June 2. doi: 10.1186/1752-2897-2-4.
8. Crues J V, Stoller DW, Martin C, Kaplan L and Mink JH. Meniscal tears: pathologic correlation with MR imaging Radiology 1987; 163: 731-735.
9. Weiss CB, Lundberg M, Hamberg P. Non operative treatment of meniscal tears. J Bone Joint Surg Am 1989; 71A: 811-822.
10. D Smet, David H Nathan, Ben K Graf, Benjamin A. Haaland and Jason P. Fine. Clinical and MRI Findings Associated with False-Positive Knee MR Diagnoses of Medial Meniscal Tears. AJR: July 2008; 191: 93–99.

Fig. 1: Bucket handle tear of medial meniscus

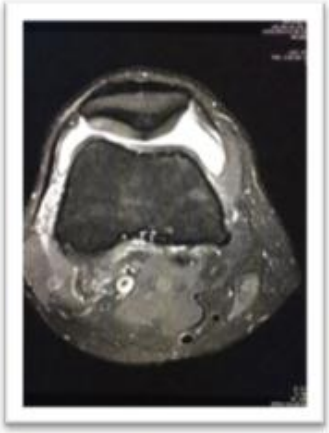

Fig. 2: Joint effusion

Fig. 3: PCL Tear

Fig. 4: Partial ACL TEAR

Fig. 5: MCL Sprain

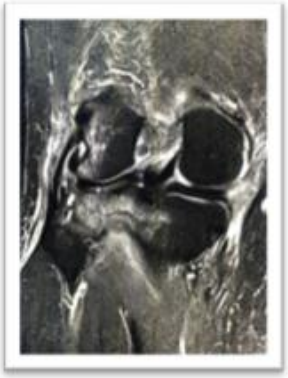

Fig. 6: LCL SPRAIN

Fig. 7: Horizontal tear of MM

Fig. 8: Complex tear

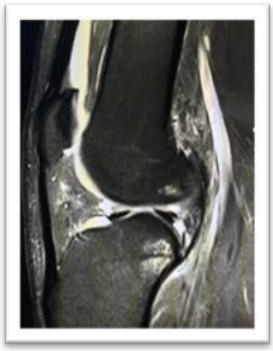

Fig. 9: Lateral meniscus tear

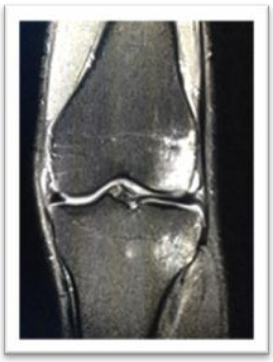

Fig. 10: Bone contusion

AUTHORS:

1. Ravi Ningappa
2. Jayasudha

PARTICULARS OF CONTRIBUTORS:

1. Associate Professor, Department of Radio-diagnosis, Victoria Hospital Bangalore Medical College & Research Institute.
2. Resident, Department of Radio-diagnosis, Victoria Hospital Bangalore Medical College & Research Institute.

NAME ADDRESS EMAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Jayasudha,
Ganesh Krupa, # 449, 7th A Cross,
5th Main, Jagadish Nagar,
Bangalore-75.
E-mail: jayasudha.sambedu@gmail.com

Date of Submission: 13/01/2015.
Date of Peer Review: 14/01/2015.
Date of Acceptance: 28/01/2015.
Date of Publishing: 24/02/2015.