

“A COMPARATIVE STUDY OF THE DIAGNOSTIC ACCURACY OF 1.5 TESLA MRI WITH ARTHROSCOPY IN THE EVALUATION OF LIGAMENTOUS INJURIES OF THE KNEE”

Dr. Disha Shah¹ (Post Graduate Resident-3rd year), Dr. Amlendu Nagar² (Professor), Dr. Sheetal Singh³ (Professor & Hod), Dr. Sonal Banzal⁴ (Post Graduate Resident-3rd year)

^{1,2,3,4} Department of Radiodiagnosis-Index Medical College, Hospital & Research Centre- Malwanchal University-Indore-(M.P)

Corresponding and 1st Author - Dr. Disha Shah (Post Graduate Resident-3rd year)

ABSTRACT

Background: Ligamentous injuries to the ligaments and menisci of the knee can lead to significant morbidity and may precipitate osteoarthritis. Arthroscopic diagnosis though invasive is considered as the gold standard. Various imaging modalities like CT scan and MRI have also been used in the diagnosis of these injuries and the quest for the best technique goes on.

Aim: The aim of this study is to assess the diagnostic accuracy of 1.5 T MRI in cases of ligamentous injuries of the knee joint and compare its efficacy with arthroscopy.

Materials & Methods: This is a comparative observational study which included 50 patients who were clinically suspected to be having ligamentous injuries of the knee. MRI was done for all these patients and all of them later underwent arthroscopy in the Department of Orthopaedics-IMCHRC. Statistical analysis was done to derive the sensitivity, specificity, positive predictive value (PPV) and the negative predictive value (NPV) and for this the findings at arthroscopy were taken to be the true diagnosis.

Results: The patients were commonly in the age group of 21-30 years and males with RTA being the commonest mode of injury and duration of injury commonly between 6weeks to 6 months. ACL tear was the commonest injury found in 76% followed by PCL tear in 38% , MM tear in 36%, LM tear in 32%. Regarding the efficacy of 1.5T MRI for ACL tears the sensitivity was 94.6%, specificity 76.9%, PPV 92.1%, NPV 83.3% and accuracy 90%. For PCL it was 94.4%, 93.8%, 89.5%,96.8%,94% respectively. For MM it was 94.7%,100%,100%,96.9%,98% respectively and for LM 83.3%,96.9%.93.9%,91.2%,92% respectively.

Conclusion: MRI is of proven diagnostic value in the evaluation of internal ligamentous injuries of the knee joint. It has a fairly good PPV and its routine use in all clinically suspicious ligamentous injuries of the knee may be recommended. Further since MRI has a high NPV, a normal MRI scan may be used to exclude any pathology and thus avoid an expensive and invasive procedure like arthroscopy.

Keywords: MRI, Arthroscopy, Anterior Cruciate Ligament, Posterior Cruciate Ligament, Medial & Lateral Meniscus

INTRODUCTION

The knee joint is the largest joint in the human body and has a number of structures responsible to maintain stability and aid in mobility like the ligaments and menisci. Injuries to the ligaments and menisci is common in the young and sportsmen. Any injury to these elements can lead to significant morbidity and may need surgical management. In the long run this may lead to osteoarthritis¹ Clinical examination has its own limitations in the

diagnosis of such injuries of ligaments and menisci especially in the acute phase of the injury. Therefore surgical method of diagnosis with arthroscopy though invasive is considered as the gold standard². MRI as an imaging modality has many advantages due to its excellent soft tissue contrast resolution and multi-planar imaging capabilities². Further it is non-invasive and radiation-free which gives it added advantage. It is also a cost effective technique and also reduces unwarranted surgical interventions³

AIMS AND OBJECTIVES

AIM: To assess the diagnostic accuracy of 1.5 T MRI in cases of ligamentous injuries of the knee joint.

OBJECTIVES:

1. To evaluate the diagnostic role of different MRI sequences in ligamentous injuries of the knee.
2. To compare the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 1.5T MRI as compared to arthroscopy in ligamentous injuries of knee.
3. To study the spectrum of MRI findings in all the cases of suspected ligamentous injuries of the knee referred from orthopaedic OPD.

MATERIALS AND METHODS

This is a comparative observational study which included 50 patients who were clinically suspected to be having ligamentous injuries of the knee, referred to the Department of Radio diagnosis, Index Medical College and Research Centre , Indore for imaging during the period from September 2020 to October 2021. MRI was done for all these patients. All of them later underwent diagnostic and therapeutic arthroscopy in the Department of Orthopaedics, IMCRC.

Inclusion Criteria:

1. Patients clinically suspected to have ligamentous injury
2. Patients who have undergone MRI
3. Patients who have subsequently undergone arthroscopy

Exclusion Criteria:

1. Patient with implanted electric/electronic devices
2. Patients with prior significant knee pathology/knee surgery or degenerative changes or evidence of loose bodies on plain radiographs
3. Claustrophobic patients,
4. Patients not willing to participate in the study

Informed consent was taken from those who fulfilled the above criteria after explaining the procedure in detail. All the MRI scans of the knee in this study were performed on a GE SIGNA EXPLORER MR machine with 1.5 Tesla field strength magnet.

During the procedure the patient was kept in a supine position, with the knee externally rotated at 15-20°, to improve the assessment of patella-femoral compartment, as excessive flexion or extension may hinder evaluation of patellar alignment. The MRI protocol consisted of following sequences (Table1)

TABLE-1: SEQUENCE FOR VARIOUS STRUCTURES

STRUCTURES TO BE EVALUATED	SEQUENCE
Cruciate ligaments(ACL & PCL)	Sagittal PD
Collateral ligaments	Coronal PD
Retinacular ligaments	Axial PD
Menisci (medial& lateral)	Sagittal PD
Tendons (Quadriceps & Patellar)	Sagittal PD
Bones	Sagittal T1 T2



Figure – 1 :Coronal & Sagittal FS PD image showing ACL tear with bony contusion in the tibial plateau

The MRI findings are recorded on pre-structured proforma for the study. Arthroscopies were performed under Spinal or general anaesthesia. Operative findings were documented in the operation theatre by operating orthopedic surgeon.

STATISTICAL ANALYSIS

Statistical analysis was done to derive the sensitivity, specificity, positive predictive value (PPV) and the negative predictive value (NPV) and for this the findings at arthroscopy were taken to be the true diagnosis.

The data analysis was done using IBM SPSS version 20 software. Microsoft office 2010 was used to prepare graph for the tables. Quantitative data was expressed as mean ± SD whereas categorical data is expressed as percentage. Independent sample t test, one way ANOVA was used or qualitative data whereas Chi square was used for categorical data. Level of significance was assessed at 5% level. P value of < 0.05 was taken as significant, and P value of < 0.01 as Highly significant, P > 0.05 - Not significant

OBSERVATION & RESULTS

AGE DISTRIBUTION (Table 2)

In present study, most common age group was 21-30 years with 22(44%) patients followed by 31-40 years with 15(30%) patients.

TABLE - 2 – AGE DISTRIBUTION

Age group in years	No. of Patients	Percentage
<20	2	12
21-30	22	44
31-40	15	30
41-50	5	10
>50	2	04
Total	50	100

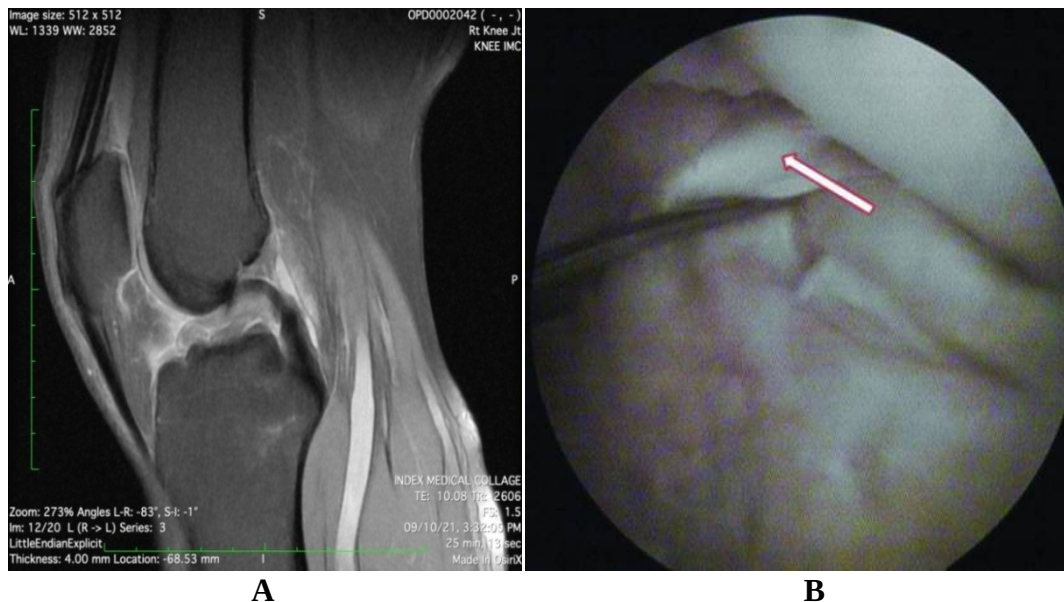


Figure 2: A) Sagittal FS PD image showing ACL tear with wavy appearance and horizontally oriented torn ACL fibres; B) Arthroscopic picture showing ACL tear

SEX DISTRIBUTION (Table-3)

Maximum patients were male {38 (76%)} followed by female{12 (24%)}

TABLE – 3 – SEX DISTRIBUTION

Sex	No. of Patients	Percentage
Male	38	76
Female	12	24
Total	50	100



Figure 3: Sagittal FS PD images showing partial tear of ACL involving more than 50% of its fibres thickness

MODE OF INJURY DISTRIBUTION (Table 4)

The most common mode of injury was RTA {25 (50%)} followed by self fall {13 (26%)} and sports {12 (24%)}

TABLE –4 – MODE OF INJURY DISTRIBUTION

Mode of Injury	No. of Patients	Percentage
Road Traffic Injury	25	50
Self Fall	13	26
Sports Injury	12	24
Total	50	100



Figure 4: Coronal and Sagittal FS PD images showing PCL tear with bony contusion in the tibial plateau.

DURATION OF INJURY DISTRIBUTION (Table 5)

Most of the patients had duration of injury between 6 weeks-6 months {23 (46%)} followed by duration less than 6 weeks {18 (36%)} and >6 months [9 (18%)].

TABLE – 5 – DURATION OF INJURY DISTRIBUTION

Duration of Injury	No. of Patients	Percentage
< 6 weeks	18	36
6weeks-6 months	23	46
>6 months	9	18
Total	50	100



Figure 5: Sagittal FS PD images showing partial tear of PCL with buckling of its fibres

PRESENTING COMPLAINT DISTRIBUTION (Table 6)

Most of the patients presented with knee pain and instability {23(46%)} followed by those presenting with knee pain & locking {10(20%)} and those with only instability {8(16%)}. Few also presented with only knee pain {7(14%)} and only locking {2(4%)}

TABLE – 6 – PRESENTING COMPLAINT DISTRIBUTION

Presenting complaint	No.of Patients	Percentage
Instability	8	16
Knee pain	7	14
Knee pain & instability	23	46
Knee pain & Locking	10	20
Locking	2	4
Total	50	100



Figure 6 :Sagittal FS PD images showing complete PCL tear seen as hyper intense signal in the midsubstance of PCL

SPECTRUM OF MRI FINDINGS (Table 7)

ACL tear was the commonest injury found in 76% followed by PCL tear in 38% , MM tear in 36%, LM tear in 32%. The least were the MCL and LCL tears at 22% and 12% respectively.

TABLE – 7 – SPECTRUM OF MRI FINDINGS

MRI Findings	Positive Findings(n=50)	Percentage
Joint effusion	42	84
ACL Tear	38	76
PCL Tear	19	38
MCL Tear	11	22
LCL Tear	06	12
MM Tear	18	36
LM Tear	16	32
Associated bony injuries	12	24



Figure 7: Sagittal FS PD images showing high grade partial tear of ACL and PCL with hyperintense signal seen in the substance of their fibres

CORRELATION OF MRI ACL FINDINGS WITH ARTHROSCOPIC ACL FINDINGS (Table 8)

Out of 38 patients who were diagnosed to have ACL tear in MRI, 3 were found to be normal in arthroscopy ($p < 0.001$). Similarly out of 12 initially reported normal ACL on MRI, 2 patients were found to have ACL tear in arthroscopy. Sensitivity and Specificity for of MRI in predicting tear is 94.6% and 76.9% and positive predicting value and negative predictive value was 92.1% and 83.3% respectively and accuracy is 90%

TABLE – 8 – CORRELATION OF MRI ACL FINDINGS WITH ARTHROSCOPIC ACL FINDINGS

MRI ACL	ARTHROSCOPY ACL		Total	P- value
	Normal	Tear		
Normal	10	2	12	0.00000263 (< 0.001)
Tear	3	35	38	
Total	13	37	50	



Figure 8: Sagittal FS PD images showing complex tear in posterior horn of Medial Meniscus with vertical and horizontal components extending upto the articular surface

CORRELATION OF MRI PCL FINDINGS WITH ARTHROSCOPIC PCL FINDINGS (Table 9)

Out of 19 patients who were diagnosed to have PCL tear in MRI, 2 were normal in arthroscopy ($p < 0.001$). Similarly out of 31 initially reported normal PCL on MRI, 1 patient was found to have PCL tear in arthroscopy. Sensitivity and Specificity for of MRI in predicting tear is 94.4% and 93.8% and positive predicting value and negative predictive value was 89.5% and 96.8% respectively. Accuracy is 94%.

TABLE – 9 – CORRELATION OF MRI PCL FINDINGS WITH ARTHROSCOPIC PCL FINDINGS

MRI PCL	ARTHROSCOPY PCL		Total	P- value
	Normal	Tear		
Normal	30	1	31	(< 0.001)
Tear	2	17	19	
Total	32	18	50	



Figure 9: Sagittal FS PD images showing vertical tear in posterior horn of Medial Meniscus extending upto the articular surface

CORRELATION OF MRI MCL FINDINGS WITH ARTHROSCOPIC MCL FINDINGS (Table 10)

Out of 11 patients who were diagnosed to have MCL tear in MRI, 10 (90.9%) were found to have tear in arthroscopy. Similarly out of 39 initially reported normal MCL on MRI, 2 (5.1%) patients was found to have MCL tear in arthroscopy ($p < 0.001$). Sensitivity and specificity for of MRI in predicting tear is 83.3% and 97.4% and positive predicting value and negative predictive value was 90.9% and 94.9% respectively. Accuracy is 94%.

TABLE – 10 – CORRELATION OF MRI MCL FINDINGS WITH ARTHROSCOPIC MCL FINDINGS

MRI MCL	ARTHROSCOPY MCL		Total	P- value
	Normal	Tear		
Normal	37	2	39	0.00000007 (< 0.001)
Tear	1	10	11	
Total	38	12	50	



Figure 10: A) MRI sagittal view of Medial meniscus bucket – handle tear showing Double PCL sign

CORRELATION OF MRI LCL FINDINGS WITH ARTHROSCOPIC LCL FINDINGS (Table 11)

Out of 6 patients who were diagnosed to have LCL tear in MRI, 6 (100%) were found to have tear in arthroscopy. Similarly out of 44 initially reported normal LCL on MRI, 4 (9.1%) patients were found to have LCL tear in arthroscopy ($p < 0.001$). Sensitivity and specificity for of MRI in predicting LCL tear is 60% and 100% and positive predicting value and negative predictive value was 100% and 90.9% respectively. Accuracy is 92%

TABLE – 11 – CORRELATION OF MRI LCL FINDINGS WITH ARTHROSCOPIC LCL FINDINGS

MRI LCL	ARTHROSCOPY LCL		Total	P- value
	Normal	Tear		
Normal	40	4	44	0.00000406 (< 0.001)
Tear	0	6	2	
Total	40	10	50	



Figure 11: Sagittal FS PD images showing complex tear in posterior horn and horizontal tear in the anterior horn of Lateral Meniscus extending upto the articular surface

CORRELATION OF MRI MEDIAL MENISCUS WITH ARTHROSCOPIC MEDIAL MENISCUS FINDINGS (Table 12)

Out of 18 patients who were diagnosed to have MM tear in MRI, all 18 (100%) were found to have tear in arthroscopy. Similarly out of 32 initially reported normal MM on MRI, 1 (3.1%) patients were found to have MM tear in arthroscopy ($p < 0.001$). Sensitivity and specificity for of MRI in predicting MM tear is 94.7% and 100% and positive predicting value and negative predictive value was 100% and 96.9% respectively. Accuracy is 98%.

TABLE – 12 – CORRELATION OF MRI MEDIAL MENISCUS WITH ARTHROSCOPIC MEDIAL MENISCUS FINDINGS

MRI MM	ARTHROSCOPY MM		Total	P- value
	Normal	Tear		
Normal	31	01	32	0 (<0.001)
Tear	00	18	18	
Total	31	19	50	



A

B

Figure 12 : A) Coronal FS PD images showing MCL sprain seen as high signal intensity in the MCL with bony contusions in the articular surfaces of lateral condyles of femur and tibia

B) Coronal FS PD images showing tear of LCL seen as laxity and hyperintensity near the fibular attachment of LCL with bony contusion at the articular surface of tibia

CORRELATION OF MRI LATERAL MENISCUS WITH ARTHROSCOPIC LATERAL MENISCUS FINDINGS (Table 13)

Out of 16 patients who were diagnosed to have LM tear in MRI, 15 (93.8%) were found to have tear in arthroscopy. Similarly out of 34 initially reported normal LM on MRI, 3 (8.8%) patients were found to have LM tear in arthroscopy (p<0.001). Sensitivity and specificity for of MRI in predicting LM tear is 83.3% and 96.9% and positive predicting value and negative predictive value was 93.8% and 91.2% respectively. Accuracy is 92%

TABLE – 13 – CORRELATION OF MRI LATERAL MENISCUS WITH ARTHROSCOPIC LATERAL MENISCUS FINDINGS

MRI LM	ARTHROSCOPY LM		Total	P- value
	Normal	Tear		
Normal	31	03	34	0.00000001 (0.001)
Tear	01	15	16	
Total	32	18	50	

TABLE – 14 – CORRELATION OF MRI WITH ARTHROSCOPY FOR VARIOUS INTERNAL STRUCTURES OF THE KNEE

Structure of knee joint	Sensitivity	Specificity	PPV	NPV	Accuracy
ACL	94.6%	76.9%	92.1%	83.3%	90%
PCL	94.4%	93.8%	89.5%	96.8%	94%
MCL	83.3%	97.4%	90.9%	94.9%	94%
LCL	60%	100%	100%	90.9%	92%
MM	94.7%	100%	100%	96.9%	98%
LM	83.3%	96.9%	93.9%	91.2%	92%

DISCUSSION

This study is a comparative, observational study which was carried out with the purpose of comparing the diagnostic accuracy of MRI with arthroscopy in the diagnosis of ligamentous and meniscal injuries of the knee joint.

The most common mode of injury was RTA corresponding to 50% followed by self fall 26% and sports 24% which is similar to the study done by Vijay Chandru et al⁴ where fall from a motor vehicle is the common mode of injury.

ACL was the most commonly injured ligament among all the ligaments of the knee joint. In our study sensitivity and specificity for of MRI in predicting tear is 94.6% and 76.9% and positive predicting value and negative predictive value was 92.1% and 83.3% respectively. However in a study by Krishna et al²², the sensitivity was found to be 100% and specificity 94.1%. In another study by Ganesan et al⁵ the sensitivity was 91%, specificity 89%, PPV 93%, NPV 84% and accuracy 90%. These studies are in agreement with the present study. In yet another study by Gupta K⁶ the sensitivity was 100%, specificity 57%, PPV 60%, NPV 100% and accuracy 65%. Singh et al⁷ reported a comparison of MRI with arthroscopy in 173 patients and showed that among the patients with the Anterior cruciate ligament tears, arthroscopically was able to detect 78 tears whereas MRI findings showed 77 true positive cases, 94 true negative cases, false positive-1 and false negative-1 which is in agreement to present study findings. Overall sensitivity (94.6%) was found to be higher than specificity (76.9%) and positive predictive value(92.1%) was higher than negative predictive value(83.3%) in cases of ACL complete tears. Regarding partial ACL tears the results of two large studies by Yao L, Gentili A et al⁸ and Umans H et al⁹ showed that MR imaging has relatively low sensitivity (40%-75%) but moderate to high specificity (62%-94%) in diagnosis of partial tears

PCL was the next common ligament to be injured in the knee joint. Sensitivity and specificity for of MRI in predicting tear is 94.4% and 93.8% and positive predicting value and negative predictive value was 89.5% and 96.8% respectively in our study. In the study by Krishna et al¹⁰, the sensitivity was found to be 100% and specificity 98.1%. In another study by Ganesan et al⁵ the sensitivity was 75%, specificity 98%, PPV 75%, NPV 98% and accuracy 96%. In

yet another study by Gupta K⁶ the sensitivity was 57%, specificity 60%, PPV 30%, NPV 82% and accuracy 60%.

Medial meniscus was the next common structure to be injured after ACL and PCL in the knee joint. Sensitivity and specificity for of MRI in predicting MM tear is 94.7% and 100% and positive predicting value and negative predictive value was 100% and 96.9% respectively. Accuracy is 98%. These findings are in agreement with those with most other studies. A study done by Krishna et al¹⁰ shows a sensitivity and specificity of 100%. Likewise the study by Ganesan P.⁵ shows a sensitivity of 86% and a specificity of 82% and PPV of 86% and NPV of 82% with an accuracy of 84%. Sharma et al¹¹ showed a sensitivity of 92.3, a specificity of 100%. However the study by Gupta K.⁶ shows a sensitivity of 100% but a specificity of only 20% and PPV of just 38% and an accuracy of just 46%. Sensitivity and specificity for of MRI in predicting LM tear is 83.3% and 96.9% and positive predicting value and negative predictive value was 93.8% and 91.2% respectively. Accuracy is 92%. Various other studies showed similar results but the PPV was considerably low as compared to the present study in a study by Gupta K.et al⁶ suggesting that MRI could not be used routinely to confirm the diagnosis. Krishna et al¹⁰ in their study showed a sensitivity of 100% and specificity of 97.6%. Ganesan et al⁵ in their study show a sensitivity, specificity, PPV, NPV & accuracy of 82%,79%,67%,90% & 80% respectively and Gupta K. et al⁶ 75%, 31%,28%, 77%, 55% respectively.

Mackenzie R et al¹² described the overall sensitivity of MRI for picking up menisci and cruciate ligament injuries to be 88% with overall specificity 94% when correlated with arthroscopic evaluation. Excellent correlation was found between MRI and arthroscopy in our study as results were comparable to previous studies in literature.

CONCLUSION

MRI is of proven diagnostic value in the evaluation of internal ligamentous injuries of the knee joint. Many studies which have been done to establish this, have shown MRI as an effective, reliable, non-invasive and cost-effective diagnostic tool in this regard. However arthroscopy has always been considered as the gold-standard for the diagnosis of ligamentous injuries of the knee joint.

Clinical examination may be inadequate to detect multi ligamentous injuries and in acute painful conditions, where MRI remains the only available non-invasive diagnostic tool. As it has been found in our study as also in other studies, that MRI has a fairly good PPV, its routine use in all clinically suspicious ligamentous injuries of the knee may be recommended. Further since MRI has a high NPV, a normal MRI scan may be used to exclude any lesion or pathology and thus avoid an expensive and invasive procedure like arthroscopy.

REFERENCES

1. Vincken PW, terBraak BP, van Erkel AR et al. Effectiveness of MR imaging in selection of patients for arthroscopy of the knee. *Radiology* 2002; 223: 739-746.
2. Glazebrook KN, Brewerton LJ, Leng S, et al. Case-control study to estimate the performance of dual-energy computed tomography for anterior cruciate ligament tears in patients with history of knee trauma. *Skeletal Radiol* 2014;43(3):297–305.
3. Del Grande F, Santini F, Herzka DA, et al. Fat-suppression techniques for 3-T MR imaging of the musculoskeletal system. *Radio Graphics* 2014;34(1):217–233.
4. Vijay Chandru, Ravikiran HG, AnupamaChandrappa and Ishani Patel." Clinical, MRI findings and arthroscopic correlation of the posterior horn meniscal injuries of theknee joint" *IJOS* 2018; 4(4): 724-727.

5. Ganesan P, Durai I, Selvaganapathy A, Moorthy D, Premkumar G. A Prospective Study on the Role of Magnetic Resonance Imaging in Evaluation of Internal Derangement of Knee with Arthroscopic Correlation. *Int J Adv Health Sci* 2016;3(1):1-5.
6. Gupta K, Kulkarni PN, Patil N. Comparison of MRI Findings with Arthroscopy Findings in Internal Derangement of Knee. *International Journal of Recent Trends in Science And Technology*. 2013;9(2): 159-163.
7. Singh J P, Garg L, Shrimali R, Setia V, Gupta V. MR Imaging of knee with arthroscopic correlation in twisting injuries. *Indian J Radiol Imaging* 2004;14:33-40.
8. Yao L, Gentili A, Lee K. Partial ACL rupture: an MR diagnosis? *Skeletal Radiology* 1995; 24: 247-251. Back to cited text no. 13.
9. Umans H, Wimphfeimer O, Haramati N, et al . Diagnosis of partial tear of the anterior cruciate ligament of the knee: Value of MR imaging. *AJR* 1995; 165: 893-897.
10. Krishna G, Sandeep MMR, Prakash A, Jose A. Correlation between magnetic resonance imaging and arthroscopy in internal derangement of knee. 2017 May;3(3):476-481.
11. Sharma UK, Shrestha BK, Rijal S, Bijukachhe B, Barakoti R, Banskota B et al. Clinical, MRI and arthroscopic correlation in internal derangement of knee. *Kathmandu Univ Med J (KUMJ)*. 2011 Jul-Sep;9(35):174-8.
12. Mackenzie R, Dixon AK, Keene GS, Hollingworth W, Lomas DJ, Villar RN. Magnetic imaging of the knee: assessment of effectiveness. *ClinRadiol*. 1996;51:245-250.