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Radiology Section

Intra-articular Traumatic Knee Joint Evaluation using 3T MRI: A Prospective Study

VINEELA REKHA VIDAVALURU[1], SWARNALATHA SEELAM[2], PRAVEENA GOURA[3], VINAY KUMAR RAVILALA[4]

ABSTRACT

Introduction: Numerous studies have been performed in the past for assessing diagnostic efficacy of Magnetic Resonance Imaging (MRI) against arthroscopy in evaluating meniscal and cruciate ligament injuries of knee joint and adequate correlation was observed. However, many of these studies have been performed on scanners of 1.5 T (Tesla) or lower field strengths.

Aim: To assess the incidence and characterise the primary and secondary signs of intra-articular traumatic knee injuries and to assess the accuracy of 3T MRI by comparing the imaging findings with arthroscopy.

Materials and Methods: A cross-sectional prospective study was conducted between November 2017 to March 2020. During this period, a total of 287 patients with clinical suspicion of traumatic cruciate ligament/meniscal injuries who were referred for MRI at ESIC Super Speciality Hospital, Sanath Nagar, Hyderabad, Telangana, India, were included in the study. Among those who underwent the procedure, operative findings of 60 patients who revisited the hospital were obtained and compared to preoperative 3T MRI findings. Correlation between 3T MRI and arthroscopy findings was obtained by calculating sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), accuracy, positive and negative likelihood ratios for Anterior Cruciate Ligament (ACL), Posterior Cruciate Ligament (PCL), Medial Meniscus (MM) and Lateral Meniscus (LM) tears individually.

Results: Sensitivity, Specificity, PPV, NPV and Accuracy were calculated for respective categories. For ACL tears it was 95.45%, 81.25%, 93.3%, 86.6%, 91.6%; For PCL tears it was 100%, 96.3%, 97%, 100%, 98.33%; For MM tears it was 97.1%, 88%, 91.8%, 95.6%, 93.3%; and for LM tears it was 95.65 %, 94.59%, 91.6%, 97.22%, 95%.

Conclusion: A 3T MRI improves the diagnostic accuracy of cruciate and meniscal injuries due to improved Signal-to-Noise Ratio (SNR), spatial resolution, better anatomical depiction of structures that are usually blind spots on arthroscopy (inferior surface and intrasubstance tears, posterolateral corner injuries, displaced small fragments into the recesses etc.).

Keywords: Cruciate ligament tears, Diagnostic efficacy, Indirect signs, Meniscal tears

INTRODUCTION

Intra-articular trauma results in damage to articular cartilage due to abnormal axial loading from weight bearing as the cushioning by menisci and cruciate ligaments is lost. Early detection of intra-articular pathology can prevent premature onset of degenerative osteoarthritis [1]. Accurate characterisation of the meniscal and cruciate ligament injuries aids in deciding an effective treatment protocol. Trial of conservative management can be given for partial tears of ACL. Surgical roadmap for meniscal tears can be planned i.e., repair can be done for longitudinal tears, but partial meniscectomy is necessary for radial and horizontal tears [2].

MRI has become a non-invasive investigation of choice for evaluation of knee as it is non-ionising, has multiplanar imaging capabilities and excellent soft tissue resolution [3]. Arthroscopy is a gold standard technique as it can be diagnostic and therapeutic at the same time, but it is much operator dependent, invasive, expensive and can lead to postoperative morbidity due to pain and infection [4]. The accuracy of clinical examination, MRI and arthroscopy has been debated time and again [5]. Although the accuracy with arthroscopy is nearly 90% [6], an invasive procedure such as this can be avoided in patients who can benefit from conservative management alone.

Studies done by Ruwe PA et al., Rangger C et al., etc. have concluded that unnecessary arthroscopy can be avoided if MRI is performed prior to surgery [7,8]. Better patient compliance is noted with MRI than arthroscopy according to Reicher MA et al., as it is non-invasive [9]. MRI has a higher accuracy when compared to arthroscopy in detecting intrasubstance and inferior surface meniscal tears, multiple meniscal and peripheral meniscal tears, and extra-articular pathologies [10]. Studies done by Behairy NH et al., Bhavani Prasad T et al., Khanda GE et al., have revealed adequate correlation between MRI and arthroscopy in detection of meniscal and cruciate ligament injuries [11-13]. However, many of them were performed on a 1.5T or lower field strength MR scanners. Since the advent of 3T MRI, there has been a revolution in the imaging as a higher field strength magnet produces greater SNR from the tissues thus enhancing the resolution of images with significantly shorter acquisition times and reduced artifacts [14]. Improved resolution provides greater anatomical details of the knee, aiding in accurate diagnosis [15].

The purpose of this study was to determine the incidence of primary and ancillary findings of traumatic intra-articular injuries, to characterise them according to the laid down criteria and to assess the accuracy of 3T MRI by comparing the imaging findings with arthroscopy. The literature available on meta-analysis on diagnostic accuracy of MRI on 1.5T and 3T scanners was reviewed and the results of present study were compared with them.

MATERIALS AND METHODS

This prospective study was time bound and was conducted between November 2017 to March 2020 and hence 287 patients with history of knee trauma and clinical suspicion of ligamentous and meniscal injuries of the knee, referred for an MRI scan in the Department of Radiodiagnosis in ESIC Superspeciality Hospital, Sanathnagar, Hyderabad, Telangana, India, were included. Institutional Ethical Committee clearance was obtained (Ref No. 799/UIIEC/ESICMC/F0049/06-2017).

Patients with previous knee surgeries, evident degenerative, infective or neoplastic changes on plain radiography and those with contraindications for MRI (cardiac pacemaker, metallic implants, claustrophobia) were excluded.

Study Protocol

All the patients who consented for the study, after thorough screening, were positioned in supine position with the knee externally rotated by 15-20° and flexed by 5-10° (for adequate visualisation of the ACL and patello-femoral compartment, respectively) in a dedicated knee joint coil in SEIMENS MAGNET VARIO 3T MR machine.

Pulse Sequences and Imaging Planes

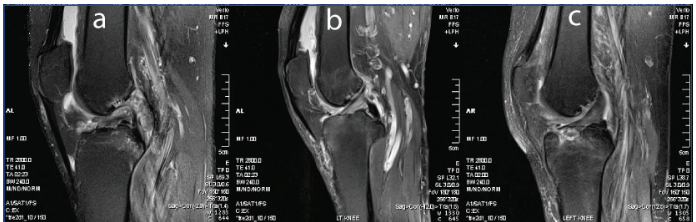
Image acquisition parameters standard for our institution have been summarised in [Table/Fig-1].

Sequences	TE (ms)	TR (ms)	Slice thickness (mm)	FoV (mm)	Matrix	Scan time (min)
T1 Sagittal	16	546	3.0	180	320x80	01:18
T2 Sagittal	72	4000	3.0	180	320x80	02:22
PD Fat Sat Sagittal	41	2800	3.0	160	320x70	02:33
PD Fat Sat Coronal	41	2800	3.0	160	320x75	02:58
PD Fat Sat Axial	41	2800	3.0	130	320x70	02:29
T2 TSE Oblique_ACL	71	2700	2.0	140	384x60	02:19

[Table/Fig-1]: Imaging protocol and parameters.
PD Fat Sat: Proton density fat saturation; TE: Echo time; TR: Repetition time; FOV: Field of view

MR Image Interpretation

ACL tears were considered in presence of: i) Discontinuity in the ligament, either at midsubstance / femoral / tibial attachments; ii) Hyperintensity within the intercondylar fossa along the course of ACL with effusion; iii) Abnormal course of the ligament mal-aligned to blumensaat's line and increased blumensaat's angle [16]; iv) Non-visualisation of the ligament. Indirect signs [16] of ACL tear like empty notch sign, Angulated PCL (angle <113°) with question mark configuration, positive PCL line sign [17], anterior tibial translation (>7 mm) [18], uncovered lateral meniscus, deep lateral femoral notch (>2.5 mm), femorotibial fractures, segond fractures, and associated meniscal and collateral ligament injuries, Hoffas fat pad sprain or fracture were assessed. Disruption of both the bundles was considered as a complete tear [Table/Fig-2a], whereas continuity of at least few fibres of one bundle was considered as a partial tear [Table/Fig-2b]. Fractured and avulsed tibial intercondylar eminence with intact tibial attachment of ACL was considered as ACL avulsion fracture [Table/Fig-2c].



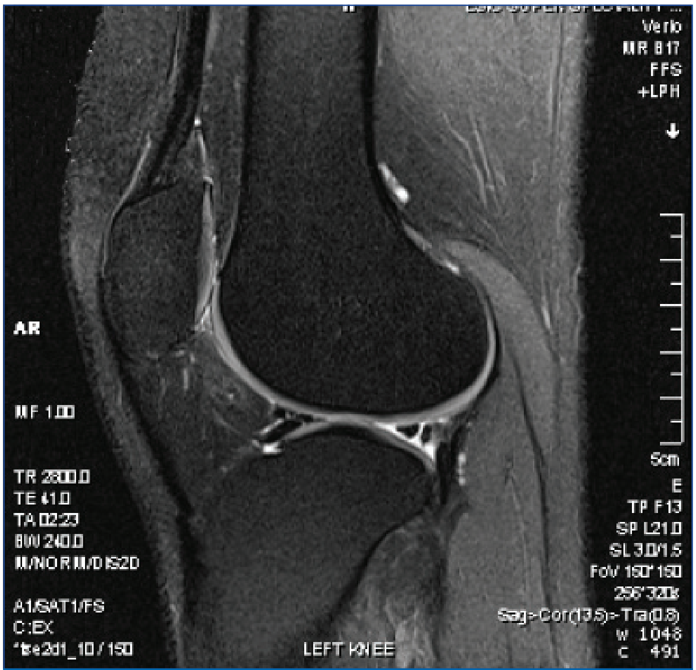
[Table/Fig-2]: a) ACL total tear; b) ACL partial tear; c) ACL avulsion fracture.

Non-visualisation of PCL with high signal in the notch in all sequences, or focal discrete disruption of all visible fibres was considered as a total tear [Table/Fig-3a]. Partial tears of PCLs were considered in the presence of abnormal high intrasubstance signal with discontinuity in few fibres [Table/Fig-3b]. Fractured and avulsed posterior tibial plateau with intact tibial attachment of PCL was considered as PCL avulsion fracture [Table/Fig-3c].

Meniscal tears were diagnosed in the presence of: a) An abnormal intrameniscal signal with '2 slice touch rule' (signal reaching the articular surface in the same area at least on 2 consecutive images in the same plane or different planes) [2]; or b) Abnormal meniscal morphology (Blunted tip, displaced portion of the meniscus

[Table/Fig-3]: a) PCL total tear; b) PCL partial tear; c) PCL avulsion fracture.

with disproportionate size of the residual meniscus or menisco-capsular separation). Tears were also classified according to the location (anterior/posterior horns/body/complex) and graded into 3 categories: Grade 1 (globular intrameniscal signal perse); Grade 2 (linear meniscal signal not reaching the articular surface); and Grade 3 (abnormal signal unequivocally extending to one or more articular surfaces) [19]. Only Grade 3 signals and fragmented meniscal horns were considered as tears [Table/Fig-4].



[Table/Fig-4]: Complex tear in anterior horn and vertical tear in posterior horn in LM.

Based on the orientation, meniscal tears were classified as: Vertical tears, Horizontal tears, Radial tears, Root tears [20] and complex tears. Displaced tears were classified as Bucket handle tears, flap tears and parrot beak tears. Bucket handle tears were diagnosed when a large portion of the meniscus was not visualised on the serial imaging sections along with one or more of the following common signs: Absent bow-tie, Double posterior cruciate ligament sign [Table/Fig-5a]; Flipped meniscus sign [Table/Fig-5b]; Fragment in notch [Table/Fig-5c], ghost sign and truncated triangle sign. Uncommon signs included were double ACL sign (bucket handle tear of LM aligning along ACL giving a pseudo ACL tear appearance), Boomerang sign (displaced fragment of a flap tear into menisco-tibial recess) [2,21], Marching cleft sign (cleft of hyperintensity moving away from free edge of meniscus on consecutive images). Cleft sign was non-specific for a particular tear and the orientation was confirmed on other orthogonal planes.

[Table/Fig-5]: a) Bucket handle tear -Double PCL sign, b) Flipped fragment; c) Fragment in notch sign.

Secondary signs specific to meniscal tears such as parameniscal cysts, meniscal extrusion 3 mm beyond lateral tibial margin [22], linear subchondral shallow (<5 mm in depth) marrow oedema paralleling the articular surface [23] were also evaluated.

Bone marrow oedema and joint effusion were common to both meniscal and cruciate ligament injuries [24]. T2 and Proton Density Fat Saturation (PDFS) hyperintensities in marrow suggestive of oedema was classified into 5 types-pivot shift pattern (posterolateral tibial plateau and mid femoral condyle), hyperextension pattern (kissing contusions in anterior aspect of juxta-articular femur and tibia), clip injury (larger contusion in lateral femoral condyle and smaller area in medial femoral condyle), dashboard injury (anterior aspect of proximal tibia) and nonspecific type. Joint effusion was evaluated my measuring the anteroposterior thickness in the lateral gutter of suprapatellar pouch in sagittal plane [25].

Arthroscopy

Patients who needed diagnostic arthroscopy were sent to referral hospitals as the procedure was unavailable in our centre, thus making their follow-up difficult. Among those who underwent the procedure, operative findings of 60 patients who revisited our hospital were obtained and compared to pre-operative 3T MRI findings. Representative arthroscopic images are shown in [Table/Fig-6].

[Table/Fig-6]: Arthroscopic images: a) ACL total tear with empty notch sign; b) Medial meniscus radial tear; c) PCL total tear.

STATISTICAL ANALYSIS

Frequency and central tendency measures of descriptive statistics were utilised. Two by two contingency tables were plotted to assess the correlation between 3T MRI and arthroscopy findings by calculating sensitivity, specificity, PPV, NPV, accuracy, positive and negative likelihood ratios for ACL, PCL, MM and LM tears individually. Microsoft EXCEL 365 version 2020 was used for the statistical analysis.

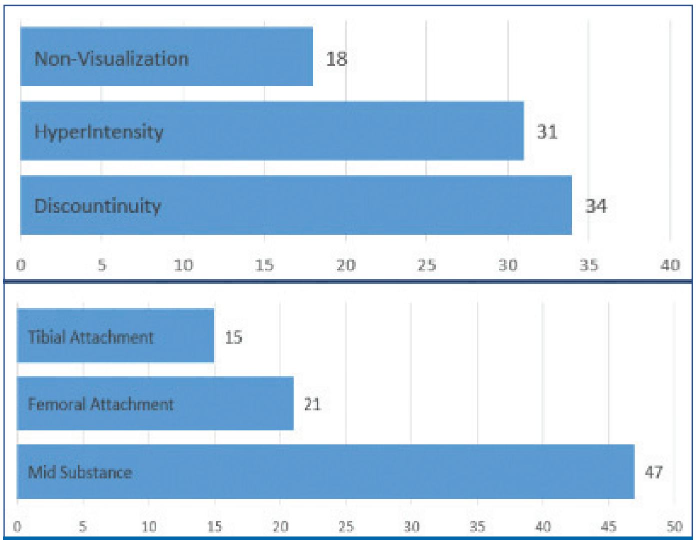
RESULTS

Out of 287 patients, intra-articular knee trauma was noted more commonly in males (81.53%). Right knee joint involvement was slightly more (57.14%) than left knee involvement. Majority of the patients were within the 31-40 years age group. Mean age was 34.8 years [Table/Fig-7].

Age group (years)	Male		Female	
	Right knee	Left knee	Right knee	Left knee
1-10	2	0	0	0
11-20	5	2	4	3
21-30	40	35	5	12
31-40	54	37	7	3
41-50	26	11	10	7
51-60	8	9	1	0
61-70	2	3	0	1

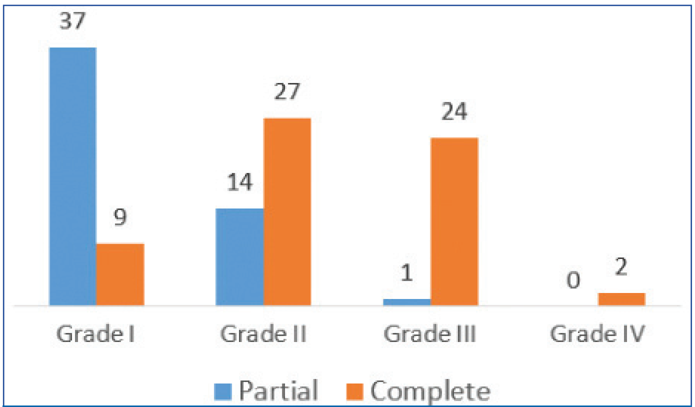
[Table/Fig-7]: Demographic distribution of tears.

Multiple intra-articular knee injuries (62.2%) were common than isolated ligament injuries (37.7%). ACL tears were the most common and were seen in 221 (77%) patients, followed by MM tears in 98 (34%) patients, LM tears in 57 (19.86%) patients and PCL tears in 35 (12.19%) patients. About 14 patients had combined injuries of ACL, MM and Medial Collateral Ligament (MCL)- O'Donoghue's Medial unhappy triad. However, 16 patients had involvement of LM instead of MM, in combination with ACL and MCL. Among the 221 ACL tears, partial tears were the commonest and seen in 133 (60.18%) patients. Complete tears were seen in 83 (37.55%) patients, 5 (2.26%) patients had avulsion fractures of the tibial intercondylar tubercle. Among 83 complete ACL tears, discontinuity of both the bundles was the most common presentation in present study (40.9%) followed by hyperintensity throughout the tear with ill-defined fibres (37.3%) and non-visualisation of the ligament (21.6%). Mid substance tears were the most common (56.6%), followed by total disruption at femoral attachment (25.3%) and then disruption at the tibial attachment (18%) [Table/Fig-8].



[Table/Fig-8]: Presentation of ACL tears and site of total ACL tears.

Anterior tibial translation was noted in 62 cases with total tear and 52 patients with partial tears of ACL. Grade wise distribution of anterior tibial subluxation is shown in [Table/Fig-9]. Incidence of other indirect signs is summarised in [Table/Fig-10]. Segond's fracture was seen in nine patients with ACL total tear.



[Table/Fig-9]: Distribution of anterior tibial subluxation.

Parameter	Partial	Complete
PCL buckling	48.8% (65 of 133)	73.4% (61 of 83)
Mean PCL angle	119°	106°
Hoffa's fat pad abnormalities	53.3% (71 of 133)	67.4% (56 of 83)
Uncovered LM PH sign	-	37.3% (31 of 83)
Empty notch sign	-	25.3% (21 of 83)
Mean blumensaat's angle	4°	21°

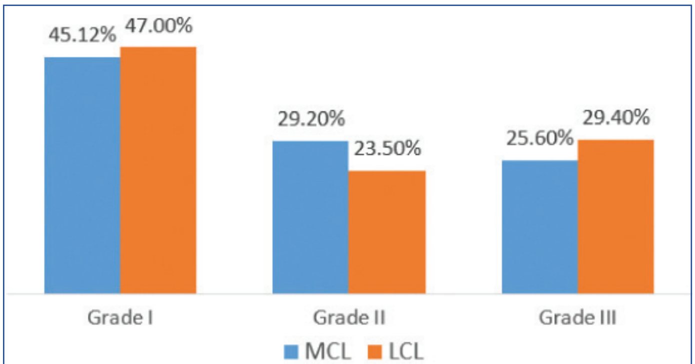
[Table/Fig-10]: Indirect signs of ACL tear.
PCL: Posterior cruciate ligament; LM PH: Lateral Meniscus Posterior Horn

Out of 287 cases, 35 had PCL tears, of which 21 (60%) were partial, 7 (20%) were total tears and 7 (20%) were PCL Avulsion fractures. Out of the 243 menisci involved, 151 (62.13%) were MM and 92 (37.8%) were LM. Posterior Horn (PH) involvement was seen in 143 (58.8%) menisci, Anterior Horn (AH) in 69 (28.3%) menisci and body in 31 (12.7%) menisci. In this study, grade III signals were (155 menisci-63.7%) compared to grade I (41 menisci-16.8%) and grade II signals (47 menisci-19.3%). Vertical tears were commonly seen followed by the horizontal tears and bucket handle tears. Root tears were the least common [Table/Fig-11]. Bucket handle tears were the commonest pattern of displaced meniscal tears. No flap and parrot beak tears were noted in this study. Bucket handle tears were commonly seen with MM (62%) than with the LM (37.9%). Fragment in notch sign was the commonest appearance of the Bucket handle tears (62%-11 in MM and 7 in LM), followed by Double PCL sign (31%-5 in MM and 4 in LM) and the flipped meniscus/double delta sign was the least common (6.8% -2 in MM and 0 in LM).

Types of tears	MM	LM	Total
Vertical tears	36	16	52
Horizontal tears	29	20	49
Radial tears	8	6	14
Root tears	3	2	5
Complex tears	4	2	6
Bucket handle tears	18	11	29

[Table/Fig-11]: Classification of grade III meniscal tears.

Two Discoid menisci were noted in this study, one in LM with grade III vertical tear, and one in the MM with grade III horizontal tear. Thirteen patients with horizontal tears revealed associated parameniscal cysts, nine adjacent to the LM and four adjacent to the MM. Bone marrow contusion was seen in 136 patients. Pivot shift type of marrow contusions were seen in 54 (39.70%) patients with underlying ACL tears. Dashboard type oedema was seen in 26 (19.11%) patients with PCL tears, Hyperextension type was seen in 31 (22.79%) patients who had combined injuries. Clip injury pattern was noted in 14 (10.29%) patients with medial unhappy triad involvement and Non-specific contusion pattern was seen in 11 (8.08%) patients who had high grade combined injuries. Joint effusion was present in 255 (88.8%) patients in this study and absent in 32 (11.2%) patients. Out of them cruciate ligament or meniscal injuries were present in 225 (78.40%) patients and absent in 30 (10.45%) patients. The mean diameter of effusion in the patients with no associated ligamentous or meniscal pathology was 11.2 mm, whereas in those with the injuries was 18.2 mm. MCL injuries were seen in 82 patients with cruciate and/or meniscal injuries, whereas Lateral Collateral Ligament (LCL) was involved in 51 patients. Grade 1 signal was the common presentation with both MCL and LCL [Table/Fig-12].



[Table/Fig-12]: MCL and LCL injuries.

Sixty patients who underwent MRI in our institution and arthroscopy in referral centres could be followed up for obtaining correlation between the two modalities. True and false positives, true and false negatives were calculated for each ligament independently [Table/Fig-13]. The sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios and accuracy are shown in [Table/Fig-14].

DISCUSSION

Improved spatial resolution in a 3T MRI facilitates better

Test description	True +ve	True -ve	False +ve	False -ve
ACL MRI findings	42	13	3	2
PCL MRI findings	33	26	1	0
MM MRI findings	34	22	3	1
LM MRI findings	22	35	2	1

[Table/Fig-13]: True positive, True negative, False positive, False negative values of 3T MRI vs. arthroscopy.

Component test	ACL	PCL	MM	LM
Sensitivity	95.45%	100.00%	97.14%	95.65%
Specificity	81.25%	96.30%	88.00%	94.59%
Positive predictive value	93.33%	97.06%	91.89%	91.67%
Negative predictive value	86.67%	100.00%	95.65%	97.22%
Accuracy	91.67%	98.33%	93.33%	95.00%
Positive likelihood ratio	5.091	27.000	8.095	17.696
Negative likelihood ratio	0.056	-	0.032	0.046

[Table/Fig-14]: Statistical parameters for diagnostic efficacy of 3T MRI.

characterisation of tears. Anatomic structures that mimic a tear are anterior intermeniscal ligament (mimics AH tear), oblique intermeniscal ligament (resembles a bucket handle tear), meniscofemoral ligaments and popliteomeniscal fascicles (mimic PH of LM tears). Discoid meniscus, Meniscal ossicle and Meniscal flounce are the anatomic variants that can mimic a tear. High NPV of MRI can reduce unnecessary arthroscopy and its iatrogenic complications [26]. Although sagittal T2 and PD FAT SAT sequences are of significance for diagnosis of ACL tears [27], partial tears may be missed on standard imaging planes due to the obliquity of ACL. Distinguishing partial (involving one bundle) versus complete tears (involving both the bundles) of ACL is necessary as treatment can either be conservative management or an isolated single bundle graft augmentation rather than a full ACL graft reconstruction [28]. A study by Kamal HA et al., showed an increase in the sensitivity for ACL tears as from 74% to 95 % and the accuracy from 76% to 95%, with specificity remaining unaltered among the same study population by using oblique axial imaging [29]. In a study performed by Kwon JW et al., [30], addition of this ACL specific sequence improved the specificity and accuracy of ACL tears while the sensitivity remained the same.

Indirect signs of cruciate and meniscal injuries need to be sought for as they improve the diagnostic accuracy and reporting confidence in the presence of evident ligament injuries, and provide clues to underlying injuries in equivocal cases where the ligaments are not evident on imaging [16]. Three false positive ACL tears were found in present study. These were interstitial tears with intact superficial fibres and thus were undetected on arthroscopy. Two patients had false negative results on MRI. One of them had imaging appearance of myxoid degeneration and the other of a partial volume artifact. There was one false positive PCL case in present study, which retrospectively was found to be enlarged ligament of Humphry mimicking a partial tear. Three MM were falsely reported as torn in present study. One was a small PH tear and the other was an inferior surface tear, thus were not easily visible on arthroscopy. The reason for the 3rd FP tear was unclear and could be due to spontaneous healing. Reason behind the single false negative MM tear was unknown, probably due to the occurrence of a secondary tear in the time period between MRI and arthroscopy. Two false positive LM cases were found in present study. In one patient, AH tear on MRI was actually an anatomical variant with meniscal insertion of few fibres of ACL. In the second patient, PH tear that was reported on MRI, was attachment of Menisco-Femoral Ligament (MFL). The reason for the FN tear could not be detected. The pattern of traumatic bone marrow contusions indicates the biomechanics of injury and thus provides a clue to the underlying inconspicuous cruciate and or meniscal injuries if any [24].

ACL is an intra-articular but extra synovial ligament and is commonly associated with effusion when injured. According to Kolman BH et al., the cut-off value to differentiate physiologic from pathologic amount of fluid in the lateral gutter of suprapatellar pouch in sagittal plane was 10 mm [25]. In the present study, nearly 89% of the patients had joint effusion. In the patients who had associated cruciate and or meniscal injuries, the effusion was moderate to severe. In those patients without an associated intra-articular ligamentous injury, there was a mild effusion, similar to the study done by Bari AA et al., [31].

The studies done by Magee T and Williams D and Ramnath RR et al., revealed the superior diagnostic efficacy of 3T scanners over 1.5T scanners [32,33]. However, these results were limited as the 3T MRI results were correlated with the results of meta-analysis of studies done on a 1.5T scanner. On the contrary, Van dyck P et al., Grossman JW et al., and Krampla W et al., have concluded that diagnostic accuracy of a 3T scanner is not much superior to a 1.5T scanner [34-36]. Van dyck P et al., provided arthroscopic correlation of the results from two cohorts undergoing MRI knee on a 1.5T and a 3T machine separately [34]. In the study done by Grossman JW et al., the same set of 100 patients underwent sequential MRI knee on a 1.5T and 3T scanner and eventually arthroscopy [35]. Smith C et al., compared a meta-analysis of MRI knee studies using 3T MRI with a meta-analysis of studies done in the past with a 1.5T scanner and concluded that there was no significant variation in the diagnostic efficacy of both the scanners [37]. They observed a drop in the specificity in detection of lateral meniscus injuries with a 3T scanner on comparison with a 1.5T scanner.

When compared to the meta-analysis of studies done on 1.5T scanners [Table/Fig-15] [37-39], there was observed a marginal rise in the sensitivity and specificity of MM tears on 3T MRI. There was an increase in the sensitivity of ACL tears but a significant drop in the specificity, which could be due to the presence of a higher number of interstitial partial tears in present study, which went undetected on arthroscopy.

Meta-analysis		Crawford R et al., [38] 1.5T	Oei EH et al., [39] 1.5T	Smith C et al., [37] 3T	Present study 3T
Medial meniscus	Sensitivity	0.91	0.933	0.94	0.971
	Specificity	0.81	0.884	0.79	0.88
Lateral meniscus	Sensitivity	0.76	0.793	0.81	0.956
	Specificity	0.93	0.957	0.87	0.945
ACL	Sensitivity	0.87	0.944	0.92	0.954
	Specificity	0.95	0.943	0.99	0.812

[Table/Fig-15]: Comparative analysis of diagnostic efficacy of 1.5T and 3T MRI meta-analysis [37-39].

However, the sensitivity and specificity of LM tear detection on 3T MRI was higher compared to 1.5 T scanners, contradicting the results of the meta-analysis by Smith C et al., [37]. The reason for this improved specificity in present study could be due to the better anatomic delineation of the lateral meniscus, especially the posterolateral corner, thus avoiding the overdiagnosis of pitfalls like popliteus tendon pseudo tear as grade III injuries of the LM.

Limitation(s)

Small sample size for correlation with arthroscopy (21%) is one of the limitations of present study, which hindered the extrapolation of the results of present study to the general population.

CONCLUSION(S)

High field strength MRI scanners improve the diagnostic accuracy in evaluation of knee trauma due to high SNR and better spatial resolution. A 3T MRI provides better characterisation of tears and avoids misinterpretation of anatomical pitfalls and variants. Reduced image acquisition time compared to 1.5T scanners also improves patient compliance. Missed and displaced meniscal fragments, inferior surface tears, extra-articular ancillary features can be detected prior to arthroscopy, and these findings can guide the orthopaedician to provide an effective treatment.

REFERENCES

[1] Englund M, Guermazi A, Lohmander SL. The role of the meniscus in knee osteoarthritis: A cause or consequence? Radiol Clin North Am. 2009;47(4):703-12.
[2] Nguyen JC, De Smet AA, Graf BK, Rosas HG. MR imaging-based diagnosis and classification of meniscal tears. Radiographics. 2014;34(4):981-99.
[3] Edwin HG Oei, Abida Z Ginai, MG Myriam Hunink. MRI for traumatic knee injury: A review. Semin Ultrasound CT MRI. 2007;28:141-57.
[4] Vaz CES, Camargo OP de, Santana PJ de, Valezi AC. Accuracy of magnetic resonance in identifying traumatic intraarticular knee lesions. Clinics. 2005;60(6):445-50.
[5] Mohan BR, Gosal HS. Reliability of clinical diagnosis in meniscal tears. Int Orthop. 2007;31(01):57-60
[6] Bredella MA, Tirman PF, Peterfy CG, Zarlingo M, Feller JF, Bost FW, et al. Accuracy of T2-weighted fast spin-echo MR imaging with fat saturation in detecting cartilage defects in the knee: Comparison with arthroscopy in 130 patients. AJR Am J Roentgenol. 1999;172(4):1073-80.
[7] Ruwe PA, Wright J, Randall RL. Can MR imaging effectively replace diagnostic arthroscopy? Radiology. 1992;183:335-39.
[8] Rangger C, Klestil T, Kathrein A, Inderster A, Hamid L. Influence of magnetic resonance imaging on indications for arthroscopy of the knee. Clin Orthop Relat Res. 1996;(330):133-42.
[9] Reicher MA, Bassett LW, Gold RH. High-resolution magnetic resonance of the knee joint: Pathological correlation. AJR. 1985;145:903-09.
[10] Arumugam, V, Ganesan G, Natarajan, P. MRI evaluation of acute internal derangement of knee. Open Journal of Radiology. 2015;5:66-71.
[11] Behairy NH, Dorgham MA, Khaled SA. Accuracy of routine magnetic resonance imaging in meniscal and ligamentous injuries of the knee: Comparison with arthroscopy. International Orthopaedics. 2009;33(4):961-67.
[12] Bhavani Prasad T, Sasibhushan Reddy B, Saraf S, Dinesh, Teja R, Reddy R. Correlation of MRI Vs arthroscopic correlation of internal derangement of knee. Journal of Evidence Based Medicine and Health Care. 2014;1(13):1649-55.
[13] Khanda GE, Akhtar W, Ahshan H, Ahmad N. Assessment of menisci and ligamentous injuries of the knee on magnetic resonance imaging: correlation with arthroscopy. J Pak Med Assoc. 2008;58(10):537-40.
[14] de Zwart JA, Ledden PJ, van Gelderen P, Bodurka J, Chu R, Duyn JH. Signal-to-noise ratio and parallel imaging performance of a 16-channel receive-only brain coil array at 3.0 Tesla. Magn Reson Med. 2004;51:22-26.
[15] Schoth F, Kraemer N, Niendorf T, Hohl C, Gunther RW Krombach GA. Comparison of image quality in magnetic resonance imaging of the knee at 1.5 and 3.0 Tesla using 32-channel receiver coils. Eur Radiol. 2008;18(10):2258-64.
[16] McCauley TR, Moses M, Kier R, Lynch JK, Barton JW, Jokl P. MR diagnosis of tears of anterior cruciate ligament of the knee: Importance of ancillary findings. AJR Am J Roentgenol. 1994;162:115-19.
[17] Schweitzer ME, Cerville V, KursunogluBrahne S, Resnick D. The PCL line: An indirect sign of ACL injury. Radiology. 1999;213:705-08.
[18] Chan WP, Peterfy C, Fritz RC, Genant HK. MR diagnosis of complete tears of anterior cruciate ligament of the knee: Importance of anterior subluxation of tibia. AJR. 1994;162:355-60.
[19] Greis PE, Bardana DD, Holmstrom MC, Burks RT. Meniscal injury: I. Basic science and evaluation. J Am Acad Orthop Surg. 2002;10(3):168-76.
[20] Koenig JH, Ranawat AS, Umans HR, Difelice GS. Meniscal root tears: Diagnosis and treatment. Arthroscopy. 2009;25(9):1025-32.
[21] Saad SS, Gorbachova T, Saing M. Meniscal tears: Scanned, scoped, and sculpted. Radiographics. 2015;35(4):1138-39. doi:10.1148/rg.2015140173
[22] Costa CR, Morrison WB, Carrino JA. Medial meniscus extrusion on knee MRI: is extent associated with severity of degeneration or type of tear? AJR Am J Roentgenol. 2004;183(1):17-23.
[23] Bergin D, Hochberg H, Zoga AC, Qazi N, Parker L, Morrison WB. Indirect soft-tissue and osseous signs on knee MRI of surgically proven meniscal tears. AJR Am J Roentgenol. 2008;191(1):86-92.
[24] Sanders TG, Medynski MA, Feller JF, Lawhorn KW. Bone contusion patterns of the knee at MR imaging: footprint of the mechanism of injury. Radiographics: A Review Publication of the Radiological Society of North America, Inc. 2000;20 Spec No:S135-51. DOI: 10.1148/radiographics.20.suppl_1.g00oc19s135.
[25] Kolman BH, Daffner RH, Sciulli RL, Soehnlen MW. Correlation of joint fluid and internal derangement on knee MRI. Skeletal Radiol. 2004;33:91-95.
[26] Khan HA, Ahad H, Sharma P, Bajaj P, Hassan N, Kamal Y, et al. Correlation between magnetic resonance imaging and arthroscopic findings in the knee joint. Trauma Monthly. 2015;20(1):e18635.
[27] Ha Taryn P, King CP, Beaulieu CF, Bergman G, Ch'en IY, Eller DJ, et al. Anterior cruciate ligament injury: Fast spin echo MR Imaging with arthroscopic correlation. AM J Roentgenol. 1998;170:1215-19.
[28] Siebold R, Fu FH. Assessment and augmentation of symptomatic anteromedial or posterolateral bundle tears of the anterior cruciate ligament. Arthroscopy. 2008;24:1289-98.
[29] Kamal HA, Nagui A, Nevien EL. The role of oblique axial MR imaging in the diagnosis of ACL bundle lesions. The Egyptian Journal of Radiology and Nuclear Medicine. 2015;73:10. 1016/j.ejrnm.2015.05.007.
[30] Kwon JW, Yoon YC, Kim YN, Ahn JH, Choe BK. Which oblique plane is

more helpful in diagnosing an anterior cruciate ligament tear? Clin Radiol. 2009;64:291.
[31] Bari AA, Kashikar SV, Lakhkar BN, Ahsan MS. Evaluation of MRI versus arthroscopy in anterior cruciate ligament and meniscal injuries. J Clin Diagn Res 2014;8:RC14-18.
[32] Magee T, Williams D. 3.0-T MRI of meniscal tears. AJR American Journal of Roentgenology. 2006;187(2):371-75.
[33] Ramnath RR, Magee T, Wasudev N, Murrah R. Accuracy of 3T MRI using fast spin-echo technique to detect meniscal tears of the knee. American Journal of Roentology. 2006;187(1):221-25.
[34] Van Dyck P, Vanhoenacker FM, Lambrecht V, Wouters K, Gielen JL, Dossche L, et al. Prospective comparison of 1.5 and 3.0-T MRI for evaluating the knee menisci and ACL. J Bone Joint Surg Am. 2013;95(10):916-24.
[35] Grossman JW, De Smet AA, Shinki K. Comparison of the accuracy rates of 3T and 1.5T MRI of the knee in the diagnosis of meniscal tear. AJR American Journal of Roentgenology. 2009;193(2):509-14.
[36] Krampla W, Roesel M, Svoboda K, Nachbagauer A, Gschwantler M, Hruby W. MRI of the knee: How do field strength and radiologist's experience influence diagnosisaccuracy and interobserver correlation in assessing chondral and meniscal lesions and the integrity of the anterior cruciate ligament? Eur Radiol. 2009;19(6):1519-28.
[37] Smith C, McGarvey C, Harb Z, Back D, Houghton R, Davies A, et al. Diagnostic efficacy of 3-T MRI for knee injuries using arthroscopy as a reference standard: A meta-analysis. AJR Am J Roentgenol. 2016;207(2):369-77.
[38] Crawford R, Walley G, Bridgman S, Maffulli N. Magnetic resonance imaging versus arthroscopy in the diagnosis of knee pathology, concentrating on meniscal lesions and ACL tears: A systematic review. Br Med Bull. 2007;84:5-23.
[39] Oei EH, Nikken JJ, Verstijnen ACM, Ginai AZ, Myriam Hunink MG. MR imaging of the menisci and cruciate ligaments: A systematic review. Radiology. 2003;226:837-48.

PARTICULARS OF CONTRIBUTORS:
1. Senior Resident, Department of Radiology, ESIC Super Specialty Hospital, Hyderabad, Telangana, India.
2. Assistant Professor, Department of Radiology, ESIC Super Specialty Hospital, Hyderabad, Telangana, India.
3. Senior Resident, Department of Radiology, ESIC Super Specialty Hospital, Hyderabad, Telangana, India.
4. Senior Specialist, Department of Radiology, ESIC Super Specialty Hospital, Hyderabad, Telangana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Swarnalatha Seelam,
Assistant Professor, Department of Radiology, ESIC Medical College, Sanathnagar, Hyderabad-500038, Telangana, India.
E-mail: swarnal.seelam@esic.nic.in

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