

Efficacy of Routine Magnetic Resonance Imaging (MRI) in Evaluation of Knee Joint Pathologies

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Abstract

Background: Imaging modalities like ultrasonography (USG), magnetic resonance imaging (MRI) and magnetic resonance arthrography (MRAr) provide different form of information about the joint space and tendons related to the knee joint. Knee is the most frequently examined joint by MRI / MRAr as it is relatively non-invasive and highly accurate in assessing joint structures, saving majority of patients from non-therapeutic arthroscopy procedures. The main objective of this study is to understand the comparative role of routine MRI and MRAr in our hospital settings. **Subjects and Methods:** Twenty-five patients included in the study underwent both MRI and MRAr on the same day. Results were interpreted by radiologists and data was tabulated with the final diagnosis established on MRAr. **Results:** Efficacy of MRI was inferior in evaluation of Anterior Cruciate ligament, meniscal and capsular tears. In patients, where MRI was normal, MR Arthrography revealed significant findings. **Conclusion:** Routine MRI misses significant outcome information when compared to MRAr in evaluation of knee joint. Hence, MR Arthrography should be done for optimal evaluation of knee joints in all patients especially those with clinicoradiological discordance.

Keywords: Efficacy, Magnetic Resonance Imaging, Knee Joint

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Received: 29 January 2020

Revised: 27 February 2020

Accepted: 08 March 2020

Published: 30 May 2020

Introduction

Imaging modalities like ultrasonography (USG), magnetic resonance imaging (MRI) and magnetic resonance arthrography (MRAr) provide information about the joint space and tendons around the joint which is useful to the clinician.^[1]

MRI was introduced in 1980's and has since then gained popularity as a relatively accurate and safe tool for diagnosing musculoskeletal disorders.^[2] Knee is the most frequently examined joint by MRI and MRAr as they are not only accurate and relatively non-invasive method for its evaluation but also saves the patient from non-therapeutic arthroscopy procedures.^[3] Multiple studies have already quoted the superior performance of MRAr over conventional MRI in joint pathologies especially on 1.5T; however the disadvantage being that it is a relatively invasive procedure.^[4] Even though MRAr is an invasive procedure it is relatively less cumbersome when compared to conventional contrast-arthrography and it also enables the evaluation of extra-articular anatomy helping in a satisfactory preoperative analysis of the joint space increasing the confidence of both the radiologist

and treating orthopedician. It also helps in reducing non-therapeutic arthroscopic procedures.^[5] MRAr is minimally invasive when compared to arthroscopy and provides nearly the same detection accuracy as arthroscopy.^[6]

Aim & Objectives

Aim: Efficacy of routine magnetic resonance imaging (MRI) in evaluation of knee joint pathologies

Objectives:

- To evaluate the role of MRI in assessment of knee joint abnormalities related to cruciate ligaments, capsule and menisci
- To evaluate the role of MRAr in assessment of knee joint abnormalities related to cruciate ligaments, capsule and menisci
- Efficacy of routine MRI in evaluating various knee joint abnormalities related to cruciate ligaments, capsule and menisci

- Assessing pathologies where MRAr provides information critical to management.

Subjects and Methods

- A study was conducted on 25 knee joints in 25 patients above the age of 21 years with clinical indication of MRI knee.
- An informed consent was obtained from the patients before the procedure about the procedure-related risks.
- After a thorough inspection with a metal detector, surgical history and history of allergy to Iohexol or Gadolinium, all patients underwent MRI followed by MRAr. Contrast-solution used for MRAr contained 4ml of 2% lidocaine, 0.1ml Gadolinium, 5ml Iohexol and 6 ml of normal saline.
- The patients were examined using 1.5T (Siemens Magnetom Avanto system). Images were acquired in a sequence for knee (Meniscal, ligamentous and Capsular tears) analysis.
- The findings of conventional MRI and MRAr were recorded in a double-blinded manner.
- The findings of MRI were compared with MRAr as a gold standard.

Knee Joint Protocol

Sequence	FOV-(Read) (Phase)	Image Matrix(mm)
3D T2 weighted	230 100	230 * 256
3D T1 weighted	230 100	205 * 256
3D T2 STIR	230 100	182 * 256
3D T2 GRE	230 100	265 * 320
3D T1 GRE	230 100	265 * 320
3D T1 GRE (MRAr)	230 100	265 * 320

After acquisition of images, they were interpreted and the findings were recorded on a predefined proforma. The data was analyzed statistically by “Cohen’s Non-Parametric Kappa test” and a p value was obtained for the same. In addition the sensitivity, specificity, positive & negative predictive values (PPV & NPV) and accuracy were also calculated.

Results

[Table 1] shows mean and standard deviation of age in years among patients with knee joint pathologies.

[Table 2] shows degree of agreement of MRI with MRAr in diagnosing various knee joints pathologies in 25 patients included in our study.

Table 1: Mean age of patients

Variable	Mean \pm SD
Age in Years	33.0 \pm 7.91

The data presented in [Table 2] was assessed by “Cohen’s Non-Parametric Kappa test”. The “degree of agreement judged using criteria proposed by Landis and Koch the agreement excellent (co-efficient $K=0.81-1$), good (co-efficient $K=0.61-0.80$), moderate (co-efficient $K=0.21-0.60$), poor (co-efficient $K=0-0.2$) and very poor (co-efficient $K<0$)”.

[Table 3] shows the sensitivity, specificity, positive & negative predictive values and accuracy of MRI for various findings using MRAr as Gold-standard.

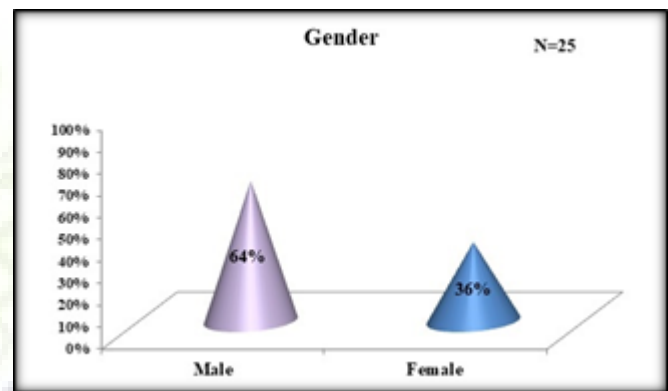


Figure 1: Conical graph showing distribution of patients according to sex

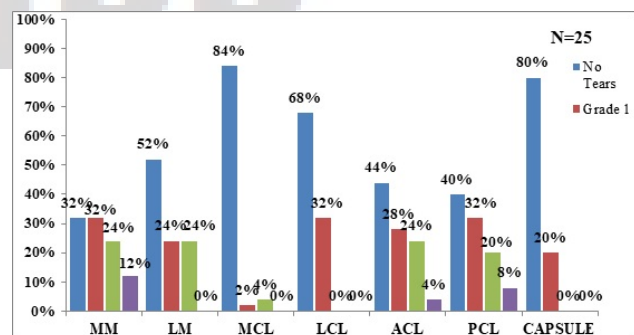


Figure 2: Bar graph showing distribution of patients with Grades of different findings on Plain MRI.

Discussion

The total sample size was 25 and the majority of the sample was above the age of 30 years (52%), and the knee joint

Table 2: Statistical Correlation of Plain MRI with MRI Arthrography

		f	%	K	p
Medial	True Positive Result (Sensitivity)	17	73.9	0.31	0.03*
	False Positive Result	0	0		
	False Negative Result	6	26.1		
	True Negative Result (Specificity)	2	100		
	Reliability	-	31%		
Lateral	True Positive Result (Sensitivity)	12	60.0	0.37	0.01*
	False Positive Result	0	0		
	False Negative Result	8	40		
	True Negative Result (Specificity)	5	100		
	Reliability	-	37%		
Medial	True Positive Result (Sensitivity)	3	42.9	0.42	0.02*
	False Positive Result	1	5.6		
	False Negative Result	4	57.1		
	True Negative Result (Specificity)	17	94.4		
	Reliability	-	42%		
Lateral	True Positive Result (Sensitivity)	8	80.0	0.82	0.01*
	False Positive Result	0	0		
	False Negative Result	2	20.0		
	True Negative Result (Specificity)	15	100		
	Reliability	-	82		
Anterior	True Positive Result (Sensitivity)	13	65.0	0.42	0.001*
	False Positive Result	0	0		
	False Negative Result	7	35.0		
	True Negative Result (Specificity)	5	100		
	Reliability	-	42%		
Posterior	True Positive Result (Sensitivity)	15	75	0.54	0.002*
	False Positive Result	0	0		
	False Negative Result	5	25		
	True Negative Result (Specificity)	5	100		
	Reliability		54%		
Capsule	True Positive Result (Sensitivity)	5	41.7	0.42	0.009*
	False Positive Result	0	0		
	False Negative Result	7	58.3		
	True Negative Result (Specificity)	13	100		
	Reliability	-	42%		

p< 0.05*-level of significance.

pathologies were more commonly found in male patients constituting nearly two-third (64%) of sample size. This was found to be in concordance to previously conducted multiple studies by Magee T et al (2009), Magee T et al (2004), L. Mathieu et al (2008), Douglas W. Brown et al (1978) which also showed internal derangements of the knee joints majorly

within young patient population of which the majority were found to be below the age of 30 years, most of them being male.

23 patients had medial meniscus tears, 20 had lateral meniscus tears, 7 had medial collateral ligament tears, 10 had lateral

Table 3: Statistical Parameters of Plain MRI versus MR Arthrography

Knee joint pathologies	Sensitivity (%)	Specificity (%)	Positive Predictive value (%)	Negative predictive value (%)	Accuracy (%)
Medial Meniscus	73.9	100	100	25	76
Lateral Meniscus	60	100	100	38.5	68.0
Medial Collateral Ligament	42.9	94.9	75	81	80
Lateral Collateral Ligament	80	100	100	88.2	92
Anterior Cruciate Ligament	65	100	100	41.1	72
Posterior Cruciate Ligament	75	100	100	50	80
Capsule	41.7	100	100	65	72

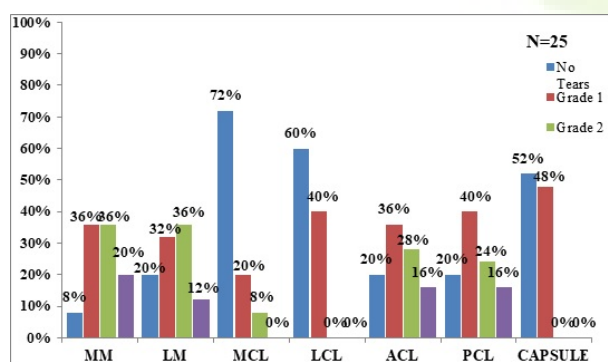


Figure 3: Bar graph showing distribution of patients with Grades of different findings on MR Arthrography.

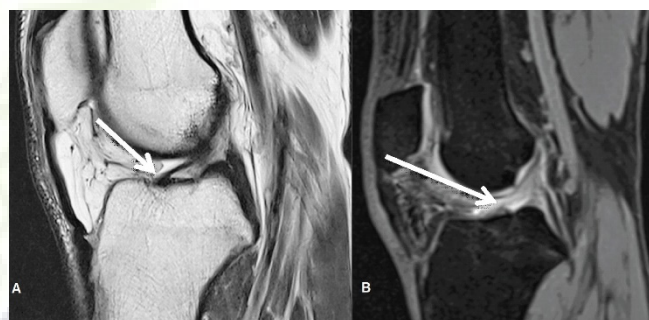


Figure 5: a) Short Arrow - T2W Sagittal image of left knee joint depicting a thinned out Anterior Cruciate ligament, b) Long Arrow - T1W post contrast sagittal image of the same patient showing hyperintensity within the distal segment of the ACL consistent with grade II degeneration .

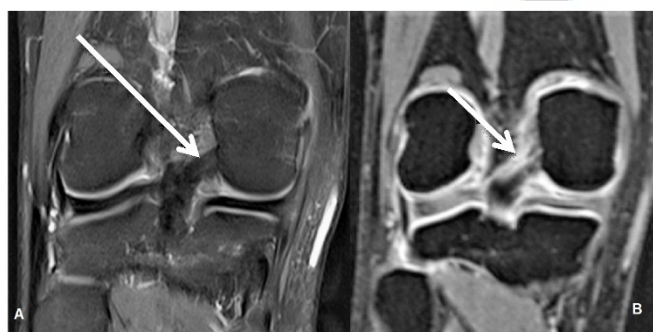


Figure 4: a) Long Arrow – T2GRE Coronal image of right Knee joint depicting a normal PCL bundle, b) Short Arrow - T1W Postcontrast Coronal image of the same patient showing Contrast within PCL substance with tear of PCL bundle fibers.

collateral ligament tears, 20 had anterior cruciate ligament tears, 18 had posterior cruciate ligament tears & 12 capsular tears on MRAr. MRAr showed additional findings that were missed on plain MRI viz. 6 MM tears (24%), 8 LM tears (32%), 4 MCL tears (16%), 2 LCL (8%) tears, 10 ACL (40%) tears, 5 PCL tears (20%) & 7 capsular tears (28%).

Routine MRI showed moderate reliability to MRAr on application of Cohen's Kappa test with excellent reliability only seen in the case of LCL K value 0.82 which was statistically significant ($P < 0.01$).

Sensitivity and Specificity for various knee joint pathologies on routine MRI are as following: MM 70% sensitive & 100% specific, LM 60% sensitive & 100% specific, MCL 43% & 95% specific, LCL 80% sensitive & 100% specific, ACL 65% sensitive & 100% specific, PCL 75% sensitive & 100%

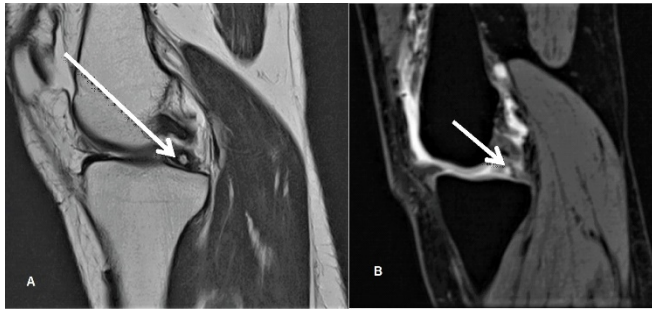


Figure 6: a) Long Arrow - T2W Sagittal image of right knee joint showing intrasubstance hyperintensity within the posterior horn of medial meniscus. (GRADE I degeneration), b) Short Arrow - T1W Post contrast sagittal image showing intrasubstance extension of contrast solution into the posterior horn of the medial meniscus.

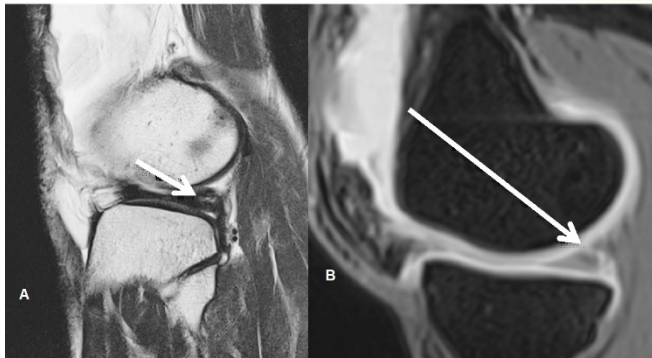


Figure 7: a) Short Arrow -T2W sagittal image of left knee joint showing horizontal grade I tear of posterior horn of lateral meniscus. b) Long Arrow -T1W post contrast sagittal image depicting contrast material within the substance of tear of posterior horn of medial meniscus

specific, Capsule 42% sensitive & 100% specific.

Diagnostic accuracy of routine MRI compared to MRAr is: MM 76%, LM 96% compared to 68% on MR, MCL 88% compared to 80% on MR, LCL had similar accuracy 92% on both, ACL 96% compared to 72% on MR, PCL 88% compared to 80%, Capsule 92% compared to 72% on MR.

From this study we can conclude routine MRI is inferior to MRAr in meniscal and capsular tears. Also, false positive results are seen with routine MRI especially when there is scarring of meniscus. Previous studies have shown better performance of Arthrography in operated meniscal tears if the meniscal tear repair is more than 25% of meniscal substance with 89% reliability over 63% of MR.^[7] However,

postoperative work-up was not included in our study.

Nikolaou V et al stated that MR had sensitivity & specificity for Medial meniscus of 83 & 69%, Lateral Meniscus 62% & 88%, ACL it was 83 & 89%, PCL 100 & 98%, LCL was 77 & 62%.^[8] Chondral defects showed even lower values of sensitivity and specificity on MR 42% sensitivity 73% specificity & 60% diagnostic accuracy. Our study showed almost 100% specificity for the evaluated tears, sensitivity values were MM 70%, LM 60%, LCL 80%, ACL 65% & PCL 75%. On comparison, our study reveals that routine MR has poor correlation with MRAr.

Mathieu L et al stated that routine MRI had more false-positive as compared to Arthrography.^[4] Arthrography had a superior agreement with arthroscopy ($k=0.84$), as compared to MR ($k=0.69$). MRAr also showed a higher sensitivity for meniscal lesions reaching 100%, compared to 92.3% of routine MRI. The MRAr data also agreed more with arthroscopic data (10/13 patients) as compared to routine MRI (6/13 patients). Even in the case of chondral lesions, routine MRI is inferior in sensitivity, specificity, NPV, PPV and accuracy relative to arthrography with reliability of 95% compared to 92% of routine MRI. Our study showed almost 100% specificity for the evaluated tears, sensitivity values were 70% for MM, 60% for LM, 80% for MCL, 65% for ACL & 75% for PCL with moderate correlation of MRI with MRAr ($k=0.65$) with excellent correlation ($k=0.82$) only in the case of Lateral collateral ligament, which is similar to the study by Mathieu L et al.

Crawford R et al found that MRAr is a highly precise tool in establishing ACL and Meniscal tears, it was found to be most sensitive for screening purposes and can be preferred over diagnostic-arthroscopy in majority of the patient groups as it is quicker, minimally-invasive and has significantly lesser complications.^[9] Sensitivity & Specificity were found to be MM 91% sensitive & 81% specific; LM 76% sensitive & 93% specific; ACL 86% sensitive & 95%. There is variable diagnostic confidence of ACL, medial & lateral meniscus however diagnostic specific and accuracy of approximately 85% for all of them. Our study showed almost 100% specificity for the evaluated tears, sensitivity values were MM 70%, LM 60%, LCL 80%, ACL 65% & PCL 75% with a diagnostic accuracy of routine MRI as MM 76%, LM 68%, MCL 80%, LCL 92%, ACL 72% and PCL 80%.

Conclusion

- Accuracy & Sensitivity of routine MRI is inferior to MRAr in cases of anterior cruciate ligament & meniscal tears with partial-thickness tears being commoner.
- Meniscal pathologies were most common among knee joint pathologies followed by anterior cruciate ligament tears which had higher detection rate on MRAr.

- Routine MRI is inferior to MRAr in detection of knee joint capsular tears due to joint distension & visualisation of extracapsular contrast extravasation.
- Routine MRI was equivalent to MRAr where significant joint effusion was present.
- Routine MRI over-graded the meniscal tears as Grade III.

Summary

Since the results of MR Arthrography are superior to routine MRI in evaluation of knee joint pathologies, hence MR Arthrography should be preferred in patients with higher clinical suspicion of knee joint pathology or when there is clinico-radiological discordance related to routine MRI. Also, MR Arthrography should be preferred whenever invasive Arthroscopy or knee joint surgery is contemplated.

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How to cite this article: Khan AA, Rastogi R, Pratap V, Pathak S, Pant A, Gupta Y, Mittal V, Goel S. Efficacy of Routine Magnetic Resonance Imaging (MRI) in Evaluation of Knee Joint Pathologies. *Asian J. Med. Radiol. Res*. 2020;8(1):48-53.

DOI: dx.doi.org/10.47009/ajmrr.2020.8.1.10

Source of Support: Nil, **Conflict of Interest:** None declared.