The Egyptian Journal of Hospital Medicine (October 2017) Vol. 69 (7), Page 2897-2905

Role of Magnetic Resonance Imaging in Evaluation of Anterior Cruciate Ligament Injuries

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ABSTRACT

Background: Magnetic resonance imaging (MRI) is used more commonly in evaluation of knee trauma compared to other modalities. It is an excellent diagnostic tool that may help clinicians in the evaluation of injuries to menisci and ligaments, osseous structures, articular surfaces, and tendon, it plays an important role in clinical decision-making.

Aim of the Work: The aim of the study was to determine the role of magnetic resonance imaging (MRI) in the assessment of injuries related to anterior cruciate ligament compared to arthroscopy.

Patients and Methods: This study included (20) ACL injury patients referred to the Radiology Department from the Orthopedics outpatient clinic department, Al-Demerdash Hospital, Faculty of Medicine, Ain Shams University from December of 2016 to August of 2017. **Results:** eighteen (90%) male and 2 (10%) female patients were enrolled in this study. We found that sensitivity, specificity, PPV, NPV and accuracy were (90%, 70%, 71.4% 100%, 80 %) respectively in partial ACL injury. And the sensitivity, specificity, PPV, NPV and accuracy in complete ACL injury were (78.4%, 100%, 100%, 71.4%, 82 %) respectively. And the sensitivity, specificity, NPV, PPV and accuracy of medial meniscal tear were 99.8 %, 91.7%, 92.3%, 100%, 94% respectively and the sensitivity, specificity, NPV, PPV of lateral meniscal tear were 95.4%, 97.3%, 99%,100%, 98% respectively**. Conclusion:** MRI is now commonly used before diagnostic arthroscopy in most settings as an effective screening tool with most patients because it is faster, non-invasive and does not involve morbidity associated with arthroscopy. MRI findings before arthroscopy help in the management of meniscal and ligament injuries, ultimately improving patient outcome.

Keywords: magnetic resonance image, anterior cruciate ligamgent injuries, arthroscopy.

INTRODUCTION

The knee is a major weight bearing joint that provides mobility and stability during physical activity as well as balance while standing. Traumatic knee injuries are frequently encountered both in general practice and in the hospital setting. These injuries are often caused by sports activities and may lead to severe pain and disability [(1)]. The anterior cruciate ligament (ACL) is a dense fibrous band composed of collagen fibrils. It is approximately 3.5-3.8 cm long and 1 cm in transverse diameter. the ligament originates from the posteromedial aspect of the lateral femoral condyle in the intercondylar notch. It courses through the notch in an anterior, inferior, and medial direction [(2)]. Magnetic resonance imaging (MRI) is used more commonly in the assessment of knee trauma comparing to other modalities as it is an excellent diagnostic tool that may help clinicians in the evaluation of injuries to menisci and ligaments, osseous structures, articular surfaces, and tendon. Moreover, it plays an important role in clinical decision-making [(3)].

Arthroscopy considered the gold standard for diagnosis of Anterior Cruciate Ligament and Meniscal injuries yet, MRI considered an alternative to diagnostic arthroscopy as many articles detected high sensitivity and specificity of MRI in assessment of knee joint injuries [(4)].

AIM OF THE STUDY

The aim of the study was to determine the role of magnetic resonance imaging (MRI) in the assessment of injuries related to anterior cruciate ligament compared to arthroscopy.

PATIENTS AND METHODS

This study Included (20) patients referred to the Radiology Department from the Orthopedics outpatient clinic department, Al-Demerdash Hospital, Faculty of Medicine, Ain Shams University from December of 2016 to August of 2017. The patients presented with suspected ACL injury. All patients were submitted to history taking and clinical provisional diagnosis and each patient exposed to MRI examination followed by arthroscopy.

Inclusion criteria

Inclusion criteria are suspicious injury of ACL (tear) and meniscal injuries.

Received: 3 /09/2017
Accepted:12 /09/2017
DOI: 10.12816/0042584

Exclusion criteria

1. Contraindications to magnetic resonance imaging, e.g. claustrophobia, cardiac prosthesis, and metallic plates.
2. Patients with previous history of knee operations.

MR imaging was performed on a 1.5-T MR imaging unit (Achieva, Philips medical system). All patients were imaged in the supine position using phased-array knee coil at radiology department.

Protocol of MR imaging

Preliminary scout localizers in sagittal, coronal and axial sections were done. The axial view serves as a localizer for achieving the coronal and sagittal oblique sections. The coronal sections are graphically arranged on an axial image from the patella to the posterior surfaces of the femoral condyles. The planes are oriented parallel to the anterior/posterior surfaces of the femoral condyles. The sagittal sections are graphically prescribed from the lateral to the medial collateral ligament and aligned parallel with the anterior cruciate ligament. The coverage included all the anterior, posterior, medial, and lateral supporting structures of the knee. Superiorly, the distal aspects of the quadriceps tendon also included. The distal insertions of the patellar tendon must be included inferiorly. The standard knee protocols (sagittal dual DRTSE, sagittal PD SPIR, coronal T1, coronal PD SPAIR, axial PD SPIR and axial FFE) were performed in all cases.

MRI Analysis

The ability to delineate the anteromedial and posterolateral bundles of the ACL near the tibial insertion, the mid-portion, and near the femoral origin was assessed. Musculoskeletal radiologists who were unaware of arthroscopic findings, reviewed all knee MR examinations and ACL status by consensus. Firstly, the standard imaging planes of the knee were evaluated with each ACL bundle being classified as intact, partially torn, or completely torn.

- Intact ACL was defined by the normal appearance of both ACL bundles
- Partial ACL tear or ACL tear was defined by high signal intensity within the ACL or individual, focal swelling or thinning of the ACL or ACL and/or a wavy course of the ACL or ACL with maintained continuity.
- complete ACL tear or ACL tear was defined as a complete lack of continuity of the ACL or ACL bundle tear with or without gapping/retraction.
- Other knee structures are commonly injured with ACL especially during a complicated rotational trauma (MM, LM, MCL, LCL). In our study, we focused on medial and lateral menisci injuries (ML LM), The two most important criteria for meniscal tears are an abnormal shape of the meniscus and high signal intensity unequivocally contacting the surface on MRI images.
- MRI results were compared with those of the arthroscopic findings.

Arthroscopic analysis

All arthroscopies were performed by orthopedic surgeons, with experience in knee arthroscopy. At arthroscopy, each bundle was classified as normal, partially torn, or completely torn.

- An intact ACL was appeared as fibers which were taut and visibly intact from the tibial to the femoral attachment.
- Partial ACL tear was diagnosed when some, but not all fibers were visibly torn on direct inspection and the remaining fibers exhibited expected resistance to deformation on physical probing.

* A complete tear was diagnosed when there was no continuity of the ACL and complete lack of tautness on direct probing.

Statistical analysis

Data were analyzed using Statistical Program for Social Science (SPSS) version 20.0. Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done

- Chi-square (X^2) test of significance was used in order to compare proportions between two qualitative parameters.
- Receiver operating characteristic (ROC curve) analysis was used to find out the overall predictivity of parameter in and to find out the best cut-off value with detection of sensitivity and specificity at this cut-off value.

- Sensitivity = (true +ve)/ ((true +ve) + (false –ve)).
- Specificity = (true –ve) / ((true –ve) + (false +ve)).
- PPV = (true +ve) / ((true +ve) + (false +ve)).
- NPV = (true –ve)/ ((true –ve) + (false –ve)).

- Probability (P-value)
  - P-value <0.05 was considered significant.
  - P-value <0.001 was considered as highly significant.
  - P-value >0.05 was considered insignificant.

RESULTS

The study included twenty patients presented with suspected ACL injuries, associated with pain, limitation of movement, and swelling of the knee joint.

Regarding sex distribution, 18 patients (90%) were males, while only 2 patients (10%) were females (Table 1 and Figure 1).

Table (1): Gender distribution of the study group

Gender	No.	%
Male	18	90
Female	2	10
Total	20	100

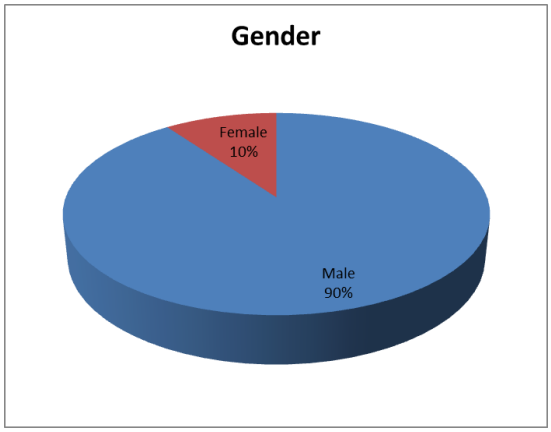

Figure (1): Pie chart gender distribution of the study group.

Regarding age distribution, the age group of patients were ranged from 20-40 years old and mean age was (31.5±4.5).

also, we found that maximum number of patients were 60% in the age group of 21-30 years and (40%) in age group 30-40 years (Table 2 and Figure 2).

Table(2): Age(years) distribution of the study group

Age (years)	No.	%
<30	12	60
>30	8	40
Total	20	100
Range Mean±SD)	20-40 (31.5±4.5)	

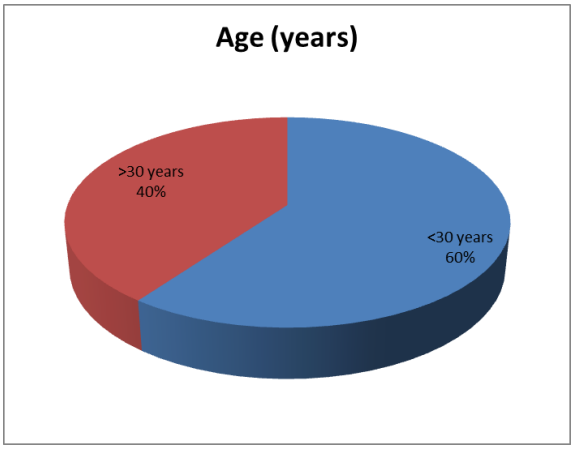

Figure (2): Pie chart age (years) distribution of the study group.

According to the type of ACL tears seen in MRI, 10 patients (50%) displayed complete tear and 10 patients (10%) revealed partial tear but regarding Arthroscopic findings of ACL tears, our study showed 14 patients (70%) with complete tear and 6 patients (30%) with partial tears (Table 3 and Figure 3).

In Correlation between MRI and arthroscopy, showed that 4 patients were diagnosed as partial tear in MRI while in arthroscopy they were diagnosed as complete ACL tear yet the difference between MRI and arthroscope was insignificant with P value of 0.481 (table3).

Table (3**):** Comparison between MRI and arthroscopy according to type of injury

Type of tear	MRI	Arthroscopy	X2	P-value
Partial ACL tear	10 (50%)	6 (30%)	3.441	0.481
Complete ACL tear	10 (50%)	14 (70%)		

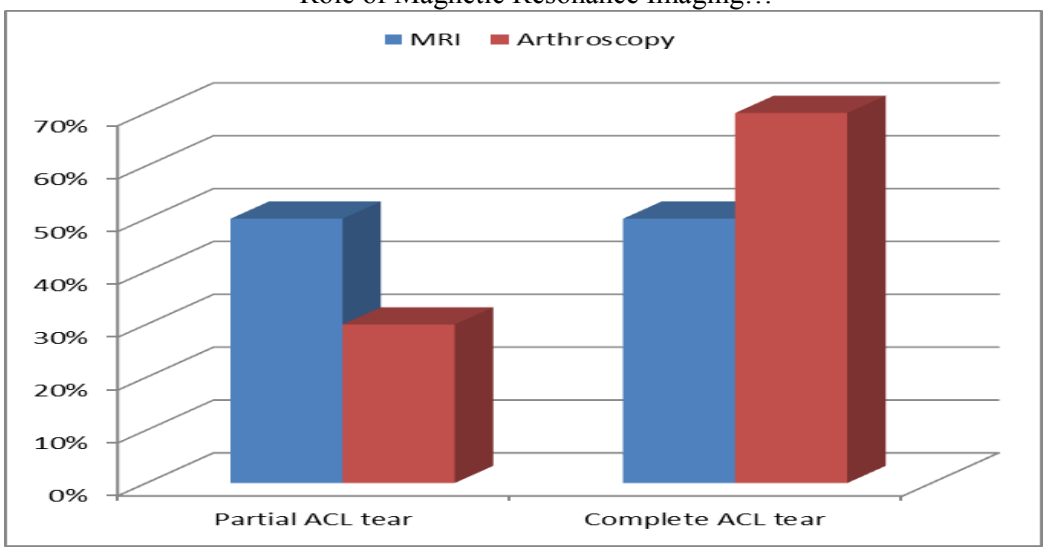

Figure (3): Bar chart shows the arthroscopic and MRI finding according to ACL tear.

We compared the finding of ACL injury in MRI with arthroscopy results regarding type of injury (partial and complete). It was found that MRI sensitivity, specificity, PPV, NPV and accuracy were (90%, 70%, 71.4% 100%, 80 %) respectively in partial ACL injury while sensitivity, specificity, PPV, NPV and accuracy in complete ACL injury were (78.4%, 100%, 100%, 71.4%, 82 %) respectively(table4).

Table (4): Sensitivity, specificity, PPV, NPV and accuracy of MRI finding in partial ACL tears in correlation with arthroscopy

Type	Sens.	Spec.	PPV	NPV	Accuracy
Partial ACL tear	(90%)	(70%)	(71.4%)	(100%)	80%
Complete ACL tear	(78.4%)	(100%)	(100%)	(71.4%)	82%

According to the associated injuries resampling the type of meniscal injuries, the incidence of medial meniscus tear (60%) was more than lateral meniscus tear (20%) (Table 5 and figure 4).

Table (5): Type of meniscal injury distribution according to MRI in correlation with arthroscopy.

Type	MRI	Arthroscopy	χ^2	p-value
Medial meniscus	12 (60%)	11 (55%)	2.691	0.547
Lateral meniscus	4 (20%)	4 (20%)	-	-

Figure (4): Bar chart shows the arthroscopic and MRI finding according to meniscal tears.

Regarding comparison between MRI and arthroscopy in cases of medial and lateral meniscal tears, we found that the sensitivity, specificity, NPV, PPV and accuracy of MRI in detection of medial meniscal tear injury were (99.8%, 91.7%, 92.3%, 100%, 94%) respectively and the sensitivity, specificity, NPV, PPV of MRI compared to arthroscopy results of lateral meniscal tear injury were (95.4 %, 97.3%, 99%,100%, 98%) respectively(Table 7).

Table (6**):** The sensitivity, specificity, NPV, PPV Accuracy of MRI in correlation with arthroscopy diagnosing medial meniscus, lateral meniscus

Type	Sens.	Spec.	PPV	NPV	Accuracy
Medial meniscus	(100%)	(91.7%)	(92.3%)	(100%)	94%
Lateral meniscus	(95.4%)	(97.3%)	(99%)	(100%)	98%

Regarding the associated injuries with ACL tear we found that 16 patients (80%) were represented with associated knee injuries (medial and lateral menisci) and 6 patients (20%) were represented with isolated ACL injury (table 7).

Table (7**):** Type of injury distribution of the study group

Type of injury	No.	%
Isolated ACL injury	4	(20%)
Combined knee injuries	16	(80%)
Total	20	(100%)

CASES

1) A 27- years -old male football player presented with pain restriction of right knee joint movement after exposure to direct traumas to his knee joint during football game.

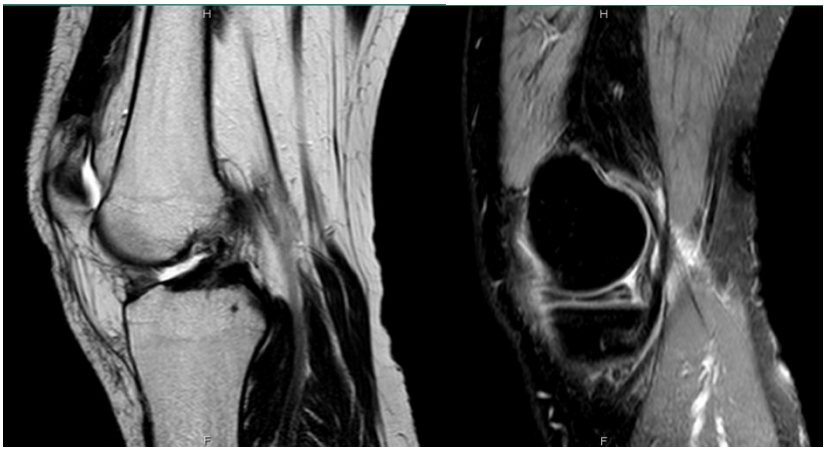

Figure 5: Sagittal T2 and PD SPIR MRI images displaying a Partial thickness tear of ACL and Tear of posterior horn of MM (PHMM) reaching the articular surface with mild joint effusion, but the arthroscopy showed us there is complete tear of ACL

2) A 20-years-old male presented with severe pain restriction of left knee joint movement after twisting during football game.

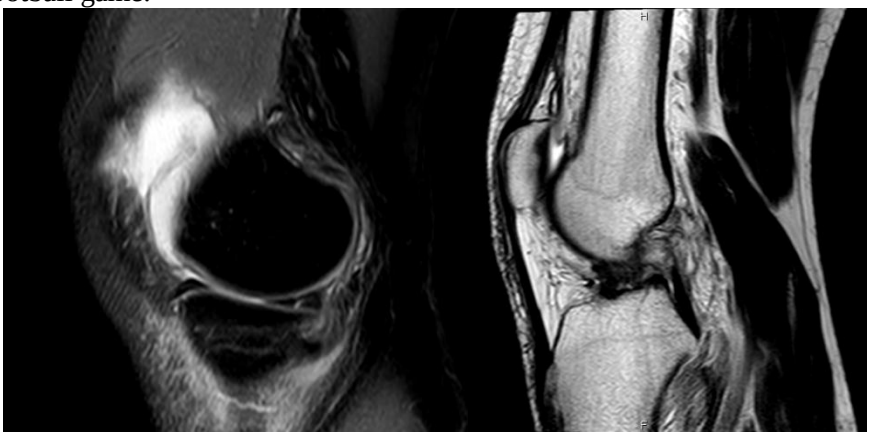

Figure 6: sagittal T2 WI and PDW SPIR display a completely torn ACL with a linear band of abnormal signal intensity is seen at the posterior horn of the medial meniscus(PHMM) reaching the superior and inferior articular surfaces representing complex tear. (arthroscopy also showed us there is complete tear of ACL and PHMM).

3) A 21-year-old male patient subjected to trauma and twisting of his right knee while playing football followed by swelling, pain and difficulties in kneeling.

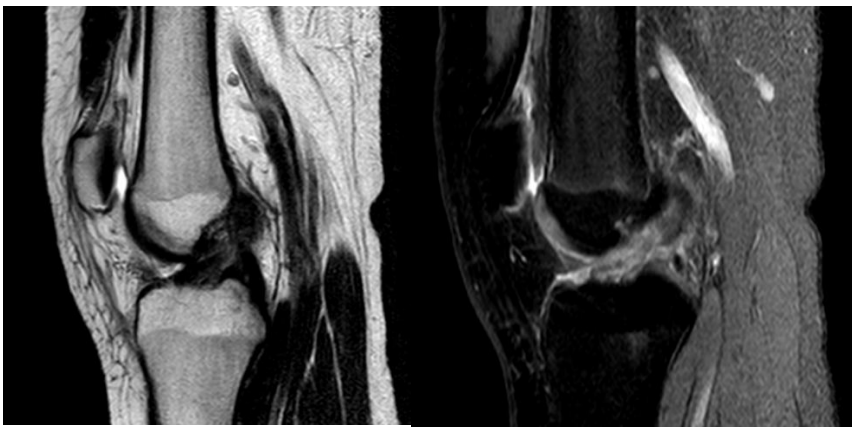

Figure 7: sagittal T2 and PDW SPAIR MRI showed The ACL is edematous, cloudy, thickened showing a high signal intensity, denoting high grade partial tear of ACL (but arthroscopy revealed complete tear).

DISCUSSION

The role of MRI has steadily increased and now it has become the investigation of choice for most of the lesions of knee. It is also being used for pre-and post-operative evaluation. It is a non-invasive technique that does not require contrast administration and is not operator dependent [5].

Arthroscopy is used to clarify doubtful cases of meniscal tears and remains the gold standard for many years in ACL tears with a diagnostic accuracy of 69 to 94% but is an invasive and risky surgical procedure for diagnosing the ACL tears, with a complication rate of 2.5%, including superficial and deep infections, peroneal and saphenous nerve injures, blood vessels injuries and pulmonary embolism. Occasionally, arthroscopy may reveal no abnormality in the ACL [5,6].

Age distribution evaluation in this research displayed a narrow range (20-40) years. The percentage of patients younger than 30 years (20-30 years) was 60% and older than 30 years was 40. Sex distribution of patients was 18 males and 2 females. This indicated that knee injuries prevail mostly in young males. Almost similar results, have shown that most patient by ***Kostov et al.*** [7]. suffered knee injuries were in the age group of 21-30 years and were mostly males Other investigators displayed similar results (8, 9, 10). ***Clayton et al.*** [8], ***Nasir*** [9] and ***Avcu et al.*** [10]

Also, other study performed by ***Avcu et al.*** [10] demonstrated that males are most likely to suffer knee injuries since they are active in sports and the right knee was more frequently injured than left. In our study, we made a differentiation between complete and partial ACL tear. Non-visualization and discontinuity of ACL fibers were considered indicator of a complete ACL tear. Thus, a complete ACL tear was seen on MRI in 10 patients (50%) and partial tear identified also in 10 patients (50%) but in arthroscopy, a complete tear was in 14 patients (70%) and partial tear was in 6 patients (30%).This means that 4 cases with complete ACL tear was diagnosed as partial tear by MRI. ***Panigrahi et al.*** [11] reported, when he studied MRI of 76 patients of ACL tear against arthroscopy, the sensitivity, specificity, PPV, NPV and accuracy were 94.7%, 78.6%, 92.3%, 84.6% and 90.4%, respectively and 4 cases with complete ACL tears were missed on MRI and detected as partial tear of ACL In our study, we have correlated the MRI finding with arthroscopy in 20 patients, we compared the finding of ACL injury in MRI with arthroscopy regarding type of injury (partial and complete), we found that sensitivity and specificity were (90%, 70%) respectively in partial ACL injury. And the sensitivity, specificity in complete ACL injury were (78.4%, 100%)respectively, which was near to the study done by ***Behairy et al.*** [12] who reported that the sensitivity of MRI was 77.8% and specificity was 100 %. ***Jah et al.*** [13] found that sensitivity and specificity of MRI were 78.3% and 95.7% respectively. and ***AbdulBari et al.*** [5] showed the sensitivity and specificity of MRI were 87.8% and 81.5%, respectively.

Vincken et al. [14] said that patients who required arthroscopic management could be properly identified by MRI examination, due to the sensitivity rate of 87% and specificity rate of 88%[61].

Oei et al. [15]reported by using firm exclusion and inclusion criteria and 30 patients were included in his study of the MRI examination in suspected ACL injury and he revealed that ACL tears collective sensitivities and specificities were 94%, 91% respectively.

This study showed that (80%) of injuries were combined injuries (associated with meniscus injuries) in MRI examination, while only (20%) were isolated. also, we noted that the incidence of medial meniscus tear (60%) was more than lateral meniscus tear (20%). ***Hetta and Niazi*** [16] reported that Only 28% of patients were represented with isolated injury and 72% of patients were represented with combined injuries and the incidence of medial meniscal tear was more than lateral meniscal tear, and this result was also near to that results revealed by ***Lim and Peh*** [17] .

In our study, regarding comparison between MRI and arthroscopy in cases of medial and lateral meniscal tears, we found that the sensitivity, specificity, NPV, PPV and accuracy of medial meniscal tear were (99.8%, 91.7%, 92.3%, 100%, 94%) respectively and the sensitivity, specificity, NPV, PPV of lateral meniscal tear were (95.4 %, 97.3%, 99%,100%, 98%) respectively. ***Yaqoob at al.*** [18] reported that the sensitivity, specificity, NPV, PPV and accuracy of medial meniscal tear were (100%, 88.4%, 90%, 100%, 94.4%) respectively and the sensitivity, specificity, NPV, PPV of lateral meniscal tear were (85.7%, 95%, 85.7%, 95%, 92. 5%) which were near to our results.

Abdul Bari et al. [5] was showed that during statistical analysis of 71 patients having arthroscopic correlation with MRI, the sensitivity and specificity of medial meniscus tear were (93.54%, 87.50%) respectively while the sensitivity and specificity were (77.77%, 81.8%) respectively**.**The radiologist's training, skill and experience were essential factors in interpretation of MRI. Also, reliable statistical data of the diagnostic role of the MRI are also linked to the independent base of reference [19]. This assumes that arthroscopy is 100% accurate in the diagnosis of all possible ACL injuries. Yet, is not constantly true. Arthroscopy is a technically demanding technique and the results are different according to surgeon's training and experience, particularly in complicated cases [20].

CONCLUSION

Our study revealed that MRI having high sensitivity, specificity and accuracy for meniscal and ligament injuries of the knee joint. Results of the present study are consistent with earlier larger studies, therefore there is substantial evidence to conclude that MRI is highly accurate in diagnosing meniscal and ACL tears. MRI is now commonly used before diagnostic arthroscopy in most settings, and is considered an effective screening tool in most patients because it is faster, non-invasive and does not involve morbidity associated with arthroscopy. MRI findings before arthroscopy help in the management of meniscal and ligament injuries, ultimately improving patient outcome.

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