International Research Journal of Medical Sciences ______________________________ ISSN 2320 –7353
Vol. **1(5),** 1-7, June **(2013)** *Int. Res. J. Medical Sci.*

The Role of Magnetic Resonance Imaging in the Knee Joint Injuries

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Available online at: www.isca.in
Received 9th January 2013, revised 4th April 2013, accepted 12th May 2013

Abstract

Many surgeons tend to believe that MRI is an accurate, non invasive diagnostic method, enough to lead to decisions for conservative treatment and save a patient from unnecessary arthroscopy. We conducted a retrospective study to investigate the accuracy of the MRI of the knee for the detection of injuries of the meniscus, cruciate ligaments and articular cartilage, in comparison with the preoperative clinical examination and intraoperative findings. during the period from September 2009 to April 2010 Fifty patients (50 knees) were examined, 39 patients males and 11 patients females their ages ranging from (19-79) years, presented with various knee joint problems, and were referred from Orthopedic and Rheumatology Departments in AL-Shaheed Gassy AL-Hariri Hospital and Nero Surgical Hospital, after physical and clinical examination were diagnosed with meniscal or cruciate injury and underwent definitive treatment. The diagnostic performance of the initial clinical examination was also calculated for the meniscal and cruciate ligament injuries. MRI is a very good imaging modality since it is non invasive, free of ionizing radiation, direct multiplanar and can identify most of the knee pathologies.

Keywords: MRI, knee joint, meniscus tears, cruciate ligament.

Introduction

ž MRI involves imaging of proton. The hydrogen nucleus, is best for MR imaging as hydrogen occurs in large abundance throughout the body and gives the most intense signal among the nuclei (from an equal number of different nuclei in the same magnetic field). A proton because of its change and spinning has a minute magnetic field and acts somewhat like a compass needle when placed in a magnetic field. When the patient is inside the tunnel of MRI system (strong external magnetic field) the longitudinal component of the magnetic moment of the proton, aligned in the external magnetic field produces an overall longitudinal magnetic field. The radio frequency (RF) pulse is applied, it is electromagnetic wave, has the same precession frequency of the proton at the section plane, so the energy is transferred to the proton, the proton spinning in phase and its energy increase, translate the longitudinal component into transverse component, which can be detected by MRI system. When (RF) pulse turned off the protons subsequently release the absorbed energy and "relax" back to the original alignment at a rate determined by T_1 (longitudinal) and T_2 (transverse) relaxation time. The T_1 and T_2 relaxation times depend in a complex way on the physical and chemical characteristics of the tissues. According to that the MR signal created mainly from proton of water and lipid molecules, while protons of protein and solid structure like bones usually do not contribute to the signal, because there is no freely mobile hydrogen protons, rendering them undetected by typical imaging system[1,2].

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Also called longitudinal or spin-lattice relaxation time, referring to the time taken for the spins to give the energy obtained from the initial RF pulse back to the surrounding lattice (environment) and return to equilibrium. T_1 relaxation time represent the time required for the longitudinal magnetization (M_z) to increment from 0 to 63% of its final maximum value. This is termed transverse or spin-spin relaxation time and is the characteristic time for loss of phase coherence among spins oriented at an angle to the static main magnetic field. This time constant arises from interaction between the spins (hence the term "spin-spin"). This can be mathematically (M_z or M_y) to decay to about 37% of its maximum value.

MRI has several advantages compared with other modalities in evaluation the internal architecture of the knee. MRI is non invasive and painless and provides excellent soft tissue contrast. The first MRI of the knee was reported in 1985, but initial results were compromised by boor SNR and resolution. The implementation of local coils for extremity imaging and higher-field-strength magnets (1.0-1.5T) helped to overcome these limitations. MRI plays a dominant role in the evaluation of knee abnormalities.

A complete examination of the knee must include evaluation of the menisci, ligaments, articular cartilage and bone marrow. A suggested approach for scanning the knee includes sagittal and coronal thin-section (3mm) T_1 and T_2 weighted images. Fast spin echo technique is usually used for T_2-weighted exams and should be implemented with fat suppression. Sagittal images with the knee externally rotated 10 to 15 degrees (or angled to achieve these results) allow optimal depiction of the anterior cruciate ligament (ACL). The knee should be imaged in the neutral position for coronal scans. All scans must be obtained using an extremity coil. Good spatial resolution requires a small (15cm) field of View (FOV), which best demonstrates the menisci and ligaments. From the T_1 –weighted scans, a second set of images is often filmed to improve visualization of the menisci, using a narrow window to give high contrast and large magnification. Some sites also acquire a Three-dimensional (3D) gradient echo scan. Articular cartilage can be highlighted using the approach. The scan also provides very thin contiguous section. If the patella femoral joint space needs to be imaged, axial scans should be acquired. Unfortunately, patient throughput must be considered, and the incorporation of all the prior pulse sequences requires excessive scan time. The 3D acquisition and axial scans should be reserved for situations in which the cartilage and patellofemoral joint, respectively, are specific clinical concern.

Methodology

Patient and Methods: A prospective study was conducted at the department of radiology in AL-Shaheed Gassy AL-Hariri Hospital and Nero Surgical Hospital (MRI unit) during the period from September 2009 to April 2010. Fifty patients (50 knees) were examined, 39 patients males and 11 patients females their ages ranging from (19-79) years, presented with various knee joint problems, and were referred from Orthopedic and Rheumatology Departments in AL-Shaheed Gassy AL-Hariri Hospital and Nero Surgical Hospital, after physical examination.

MRI examination: Instrument: The examination done using 1.5 Tesla Philips Gyro scan ACS-NT super conductive magnet with a useful aperture of 61 cm in diameter and dedicated extremity coils (surface coils) as both transmitter and receiver of radio-frequency waves was applied. The imaging system is enclosed in a radio frequency room.

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Preparation: No patient preparation or sedation was required. The clinical details of any prior imaging diagnostic result were available to the examiner undertaking the examination. The patients were questioned about history of intracranial surgical clips, cardiac pacemakers, cochlear implants and metallic objects in the body before the MR examination. The patient was examined in the tunnel of the machine in supine position. No patient was excluded due to contra indication mentioned above.

Imaging protocols: In the evaluation of internal derangement of the knee routine protocols included T_1-weighted images in the axial, sagittal and coronal planes and T_2^*-weighted two-dimensional (2D) or (3D) Fourier transform gradient echo sagittal images were used.

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T_2 fast spin-echo proton density-weighted images with fat suppression were routinely used to assess fluid and articular cartilage and identify areas of marrow hyperemia. In the coronal, sagittal and axial planes. A 14 cm field of view provided adequate imaging of the knee in all planes. Acute trauma, arthritis, infection, and neoplasia required T_2- or fast spin-echo T_2-weighted images.

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Conventional T_2-weighted images were generated in conjunction with fat suppression. Trabecular bone contusion and fractures were identified with greater sensitivity on short tau inversion recovery (STIR) or on T_2-weighted or proton density weighted fast spin echo fat suppression images. Neoplastic lesions both benign and malignant required either T_1 or T_2-weighted images or STIR images, in the axial plane to demonstrate compartment and neurovascular anatomy.

Fifty patients with various knee complaints and of various age groups were referred from Orthopedic and Rheumatology Departments for MRI examination.

From the Fifty patients 39 were males (78%), and 11 were females (22%)

Table 1 shows the distribution of patients according to the age and sex.

Table 2 shows that the most common cause of referral was clinically suspected Meniscal injuries.

Table 3 shows the distribution of abnormality at MRI in both sexes, and the most common MRI finding was Meniscal injuries (Meniscal Tears).

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Fifty knee were examined by MRI, 12 knees (24%) were normal on MRI. 38 knees (76%) showed abnormal signs on MRI.

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This abnormality was detected in 38 patients (76%), of those 38patients 29 patients (58%) were males and 9 patients (18%) were females. Other lesions are followed by less percentages as shown in table 3.

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Table 4 shows the location of meniscal tears. There were 16 meniscal tears involving the medial meniscus (32%), 11 tears (22%) involving the anterior horn and 5 tears (10%) involving the posterior horn of the medial meniscus. While there were 10 tears (38.46%) involving the lateral meniscus, 3 tears (11.53%) involving the anterior horn and 7 tears (26.92%) involving the posterior horn of the lateral meniscus, those 26 meniscal tears, 3 (10%) were of Bucket Handle tear type.

Results and Discussion

The purpose of this study was to demonstrate the diagnostic value of MRI in diagnosing the presence or absence of the most common injuries of the knee; the meniscus tears, the cruciate ligament ruptures.

There are studies that support the view that the diagnostic accuracy of the MRI could affect in a critical way the treatment pathway of knee injuries. There is no doubt that the radiologist's experience and training are very important factors in interpretation of MRI. At the same time reliable statistical data of the diagnostic value of MRI are also related with the independent base of reference. Arthroscopy is considered as "the gold standard" for diagnosis of traumatic intraarticular knee lesions[1]. However, MRI is a non invasive procedure that requires hospitalization and anaesthesia, thus presenting all the potential complications of a surgical procedure[2]. Since it's introduction in the 1980's Magnetic Resonance Imaging (MRI) has gained in popularity as a diagnostic tool of the musculoskeletal disorders[3]. Especially the knee is the most frequent examined joint with MRI. Many surgeons tend to believe that MRI is an accurate, non invasive diagnostic method of the knee injuries, enough to lead to decisions for conservative treatment and save a patient from unnecessary arthroscopy. Nevertheless, even nowadays, remains very expensive. Taking in account that health-economics play important role in patients management, many questions arise regarding when and how often one must ask for an MRI when clinical examination has already confirm the diagnosis of meniscal tear or cruciate ligament rupture[4].

Table-1
The distribution of patients according to the ages and sexes

Age group	Male		Female		Total	
	No.	%	No.	%	No.	%
1-19 years	7	14%		-	7	14%
21-39years	18	36%	7	1 4%	25	50%
41-59years	9	18%	3	6%	12	24%
61-79years	5	10%	1	2%	6	12%
Total	39	78%	11	22%	50	100%

Table-2
The Distribution of patients according to the cause of Referral

Cause of Referral (clinical diagnosis)	Male		Female		Total	
	No.	%	No.	%	No.	%
1.Meniscal Injury	21	42%	5	10%	26	52%
2.Ligamentous Injury	13	26%	3	6%	16	32%
3.Baker's cyst	2	4%	1	2%	3	6%
4.Joint Effusion	3	6%	2	4%	5	10%
Total	39	78%	11	22%	50	100%

Table-3
Distribution of abnormalities at MRI in both sexes

MRI Finding	Male	Female	Total
Meniscal injuries (tears)	17	9	26
Joint effusion	7	3	10
Anterior cruciate ligament injuries	11	5	16
Intramedullary bone fracture	5	3	8
Medial collateral ligament injuries	6	3	9
Baker's cyst	17	9	26
Discoid meniscal	3	-	3
Lateral collateral ligament injuries	2	1	3
Posterior cruciate ligament injuries	-	-	-
normal	8	4	4

Table-4
Location of meniscal tears

Meniscal tears26 (100)							
Medial meniscus tears				Lateral meniscus tears			
16		61.53%		10		38.46%	
Anterior Horn of Med. Meniscus		Posterior Horn of Med. Meniscus		Anterior Horn of lat. Meniscus		Posterior Horn of lat. Meniscus	
11	42.30%	5	19.23%	3	11.53%	7	26.92%

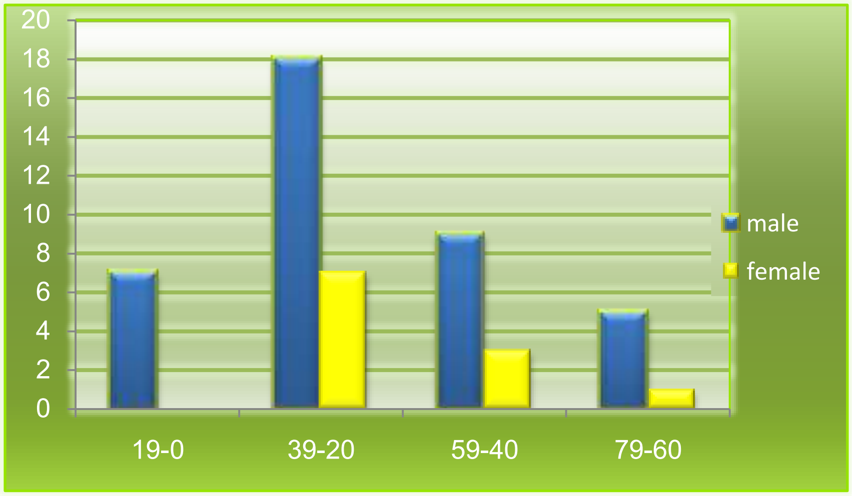
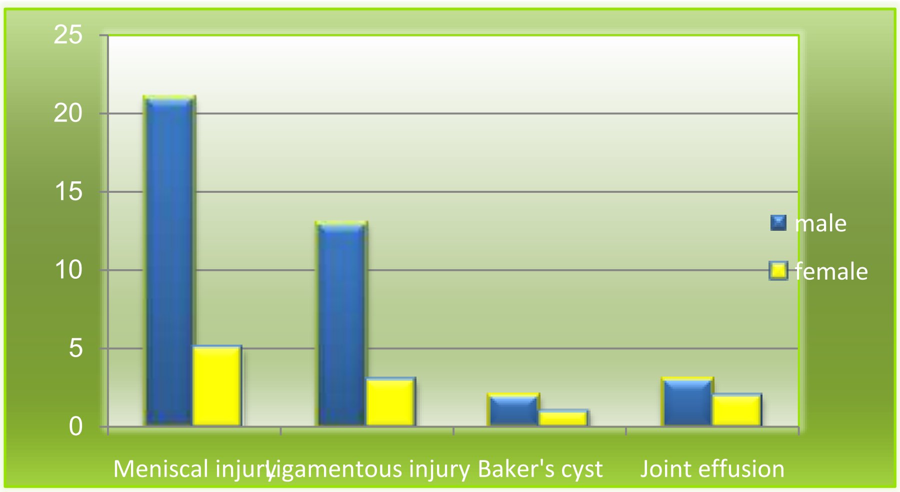


Figure-1
Distribution of patients according to the ages and sexes



ž **Figure-2**
Distribution of patients according to referral

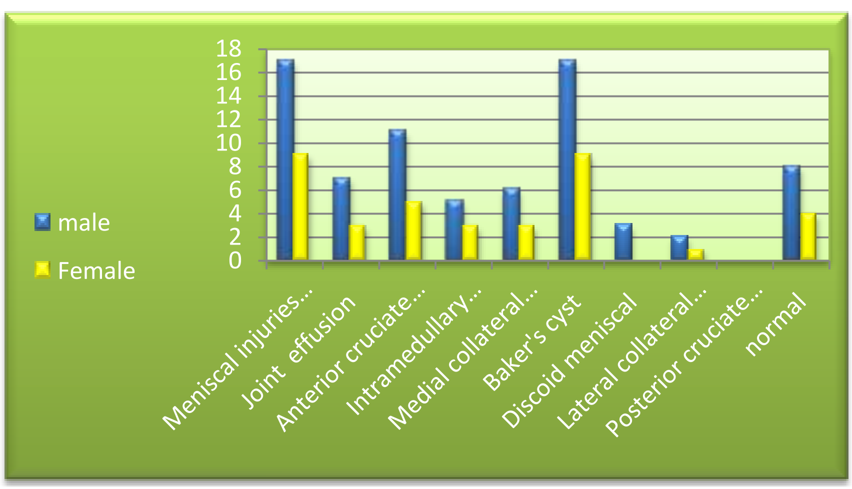
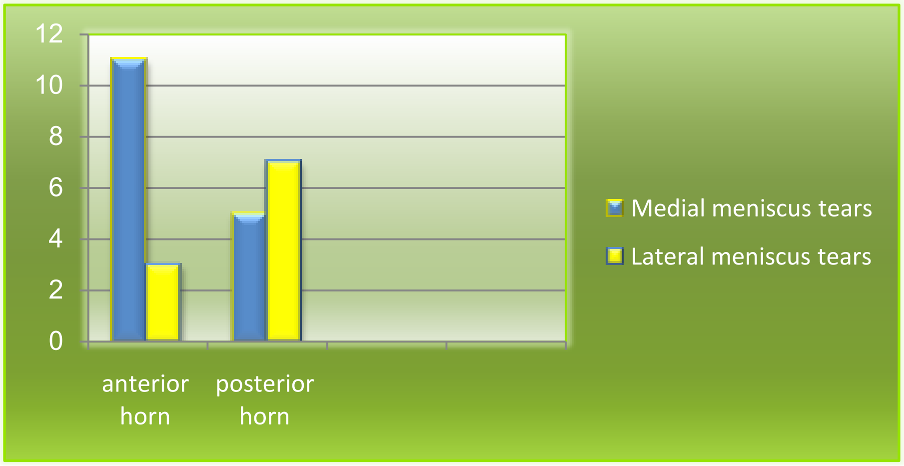


Figure-3
Distribution of abnormalities at MRI in both sexes



ž **Figure-4**
ž **Location of meniscal tears**

Patients that in plain X-rays had fractures, loose bodies or signs of severe osteoarthritis were excluded from the study. Additionally, patients that after the MRI examination have had new injury to the same knee, before the arthroscopy or delayed to undergo arthroscopy for more than 3 months, were also excluded[5,6].

In this study MRI examination was performed on (50) patients with various complaints. Regarding the most common age group affected was the age group of (21-39) (table 1) and this is explained by the fact of this age group being the most active group. From (50) patients examined in this study, 38 patients (76%) showed abnormal signs on MRI. In this study 26 patients (52%) showed meniscal tears (injuries). Of those 26 patients, 17 (34%) were males and 9 (18%) were females. This finding was in greement with results obtained by Uppal et al[7] who reported meniscal tears at incidence of (45%) and mentioned that MRI of the knee has been shown to be accurate in the assessment of menisci in addition to ligamentous and articular cartilages[8-12].

The meniscal injuries appeared on MRI as an increased signal intensity in all pulse sequences applied (T_1-weighted, T_2-weighted, T_2^*-weighted, T_2-weighted fast spin-echo, proton density and fat suppression techniques) and this also In agreement with Stoller et al[13], Kaplan et al[14], Cheung et al[15].

There are studies that support the view that the diagnostic accuracy of the MRI could affect in a critical way the treatment pathway of knee injuries[16].

Table (4) shows the location of the meniscal tears. There were 16 meniscal tears (61.53%) involving the medial meniscus and 10 tears (38.46%) were involving the lateral meniscus.

In this study no injury related to the posterior cruciate ligament was detected, this is in agreement with MRI findings of Schweitzer et al[17].

This finding is in agreement with results obtained by Cheung et al[15] who reported medial meniscal tear incidence of 65% and lateral meniscal tear incidence of 35%. Regarding the 16 medial meniscal tears, 11 tears (42.30%) were involving the anterior horn, and 5 tears (19.23%) were involving the posterior horn of the medial meniscus, while there were 3 tears (11.53%) involving the anterior horn of the lateral meniscus and 7 tears (26.92%) were involving the posterior horn of the lateral meniscus. Of these 26 meniscal tears, there were 3 tears (7.89%) of Bucket Handle type i.e. displaced longitudinal tears of the meniscus.

Regarding ligamentous injuries, there were 16 patients (32%) that showed anterior cruciate ligamentous injuries on MRI, 11 were male (22%) and the other 5 were females (15%).

Those injuries appeared as an increased signal intensity on T_2-weighted and T_2^*-weighted images in the acute tears or strains because of fluid or edema others appeared as discontinuity of the low signal intensity with or without loss of normal tout parallel margin, especially in the complete tears. This is in agreement with MRI findings in anterior cruciate ligamentous injuries of Uppal et al[7] and those reported ACL injuries in incidence of 27% and 22% respectively.

In these study 16 patients (32%) showed medial collateral ligamentous injuries, 13 of them (26%) were males and 3 (6%) were females.

Those injuries demonstrated increased signal intensity on T_2-weighted images because of edema and hemorrhage and others demonstrated displacement or complete loss of continuity of ligamentous fibers, depending on the severity of the injury.

This was agreement with findings of Uppal[7] who reported MCL injuries, in incidence of (7%). Three patients (6%) showed lateral collateral ligamentous injuries, two of them were a male and one was females.

LCL injuries showed similar appearance to MCL injuries i.e. increased signal intensity with displacement or loss of continuity of the ligamentous fibers[16,18].

This was in agreement with findings of Maurer et al[19] and Uppal et al[7] and those reported LCL injuries in incidence of 1%.

Robertson etal[20] reported that the diagnosis accuracy of MRI in assessment of ligamentous and cartilaginous injuries in the knee has been well documented and provides a legitimate standard on which to base any statistical observation[8,9,21].

In this study, 8 patients (10%) showed intramedullary trabecular bone fracture (bone contusion, bone bruises), 5 of them were males (10%) and 3 were females (6%).

This result was in agreement with findings of Maurer et al[17] and Uppal et al[7] and those reported bone contusions and bruises in incidences of 19% and 15% respectively.

Those bone bruises demonstrated increased signal intensity on STIR T_2-weighted (including T_2-weighted fast spin-echo) or T_2^*-weighted images in the acute fracture because of fluid or hemorrhage.

Joint effusion was detected in 10 patients (20%),(7) knee were related to male patients (14%) and other 3 knees were related to female patients (6%) joint effusion demonstrated low signal intensity on T_1 weighted images and bright signal intensity on corresponding T_2-weighted images.

Most of the patients were not studied in the acute period after trauma; the lower results of the joint effusion in this study compared with other literatures may be related to the temporal delay[8,9,22].

In this study 5 patient (12%) showed Baker's cyst (poplital cyst), 2 were male patients (4%) and the other 4 were female patients (8%).

These cysts demonstrated low signal intensity on T_1-weighted images and uniformly increased signal intensity on T_2-weighted images.

Some of these cysts showed septa which divided the cyst into compartments. In comparison with other studies[7], poplital cysts were detected in high incidence (23%), this difference from the incidence of the poplital cyst in this study, is due to the difference in the cause of referral of the patients to MRI studies.

It is true that our results have yield worst diagnostic value of MRI in comparison with the results of larger multicenter studies[21].

Conclusion

In conclusion, the present study supports that MRI is very helpful in diagnosing meniscal and cruciate ligament injuries. In any case, what one must always have in mind is that diagnosis alone is not the end point of the treatment and does not solve the problem. It is the beginning of new thoughts and actions one must follow to achieve accurate prognosis and correct treatment. In order to plan and apply the correct treatment pathways, the most important is not statistics or cost effectiveness data. Clinical experience and adequacy of the surgeon always have the greatest value, when it comes to the assurance of the patient optimal treatment. MRI is a safe, non invasive imaging modality. MRI of the knee has been shown to be accurate in the assessment of menisci, ligaments and articular cartilage, i.e. excellent modality for assessment of soft tissue and knee joint derangements. MRI can accurately diagnose the ligament injuries of knee joint,which is an ideal technique in the diagnosis of ligament injuries of knee joint, and should be used as a routine examining method. So MRI affect the diagnosis and management of the knee injuries by decreasing the number of arthroscopic procedures, improving clinician diagnostic certainty, and assisting in management decision.MRI of the knee provides the potential for the rapid, definitive diagnosis with a non invasive examination.

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