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Radiology

Comparative Study of the Sensitivity of 3.0T and 1.5T MRI Imaging in Diagnosis of Knee Injuries in Taif Hospitals

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Abstract **Original Research Article**

Background: Imaging of knee joint to detect joint disorder using magnetic resonance imaging (MRI) is an efficient tool and safest one. ***Purpose:*** The current research was conducted to compare between two MRI machines with different magnetic field strength for detection knee lesion.100 images was done at King Fiasal hospital at Taif city KSA from mid-February till mid-March 2019, special data collection sheet was designed to record patient gender and ages as well as protocol for each knee examination. ***Results:*** From the 100 images there were 15 images that diagnosed as normal cartilage and lesion detected, more frequent women patient was detected compared to male patients (60% and 40% respectively. The most common age of patients was 51-60 years, 3.0 Tesla (T) MRI machine was more sensitive in detection of knee cartilage lesion than 1.5T. 3T give better signal to noise ratio and better resolution with large matrix size. ***Conclusion and recommendations;*** MRI at 3.0 T improved visualization of anatomical structures and improved diagnostic confidence compared to 1.5 T. More study are required to detect specificity and accuracy as well as phantoms based study, to establish local protocol for imaging knee that compatible with our local society

Keywords: MRI, Knee lesion, sensitivity, Gender.

INTRODUCTION

Magnetic resonance imaging MRI plays an important role in the diagnosis of knee injuries, diseases and in imaging acute and chronic bone joint disorder changes [1]. In the joint and knee ligaments, MRI in general offers an accurate means of identifying acute bone changes, soft tissue pathology specifically [2]. Recent advances in 3T MRI systems offer significant advantages for musculoskeletal imaging [3-5]. The better signal-to-noise ratio can be utilized in imaging ligaments and cartilages as well as meniscal structures of the knee [6-8]. Some previous studies of the knee [9-11] indicate the 3T images have excellent sensitivity and specificity for detecting meniscal tears and anterior cruciate ligament ACL ruptures compared to arthroscopy and other imaging modalities and account for non-ionizing radiation applied here for MRI compared to computed tomography and x-ray imaging.

Injury and degeneration of the articular cartilage of the knee is common and may be the sole structural deformity in a painful knee [5]. With the availability of newer treatment options, there is a pressing need for reliable diagnosis of cartilage pathology in order to plan treatment [1, 2]. MRI is the optimal non-invasive method for assessment of articular cartilage [3-9]. The standard magnet strength for clinical cartilage imaging is currently 1.5 T [7]. However, the fundamental trade-off between image resolution and signal-to-noise ratio still limits our ability to image cartilage in vivo at high resolution and in an efficient manner [7].

Common chondral lesions in the knee are: Chondromalacia / Degenerative Chondrosis (Cartilage tears away unevenly, with shallow walls), Osteochondritis Dissecans / Osteochondral Fracture (Cartilage breaks away with a piece of the bone), Chondral Flap (Cartilage separates from the bone and moves like a door with a hinge at one end) and Chondral Fracture (Cartilage separates from the bone and floats free) [8, 14, 16].

Patient movement may ultimately worse the spatial resolution achievable at 1.5 T. The accuracy of routine MRI at 1.5 T in the evaluation of articular cartilage defects in the knee joint has therefore varied over a wide range [6, 15].The use of 3-T imaging systems is becoming widespread in clinical practice. The signal-to-noise ratio at 3 T is roughly double that at 1.5 T, which allows improvement in image quality and spatial resolution within a reasonable scan time [17, 19]. In addition, several advanced techniques for imaging cartilage with MRI, including T1 [26] and T2 weighted mapping [10] and diffusion-weighted imaging [4, 8] exploit the particular advantages that come with higher field strength. However, the disadvantages of high-field MR systems, such as more prominent flow and susceptibility artefacts, and greater magnetic field heterogeneity, need also to be considered [17]. Previous studies [9, 11, 14, 19] have shown improved diagnostic performance of 3-T as compared with 1.5-T systems in the detection of cartilage lesions. However, a direct comparison between 1.5- and 3-TMR images of the knee is needed to assess the actual improvement in diagnostic performance of 3-T MRI. To the best of our knowledge, no previous study in local health system here in Saudi Arabia has carried out for such this purpose, if we consider that MRI introduced earlier in health care system in our local society. Thus, the present study was performed to retrospectively compare the accuracy of routine MRI of the knee obtained at 1.5 and 3 T for patients to diagnose cartilage lesions and associated joint disorders at Taif city. Our hypothesis was that a routine MR protocol of the knee at 3 T can improve the detection and characterization of cartilage lesions within the knee joint as compared to a similar knee MR protocol performed at 1.5 T.

MATERIALS AND METHODS

A 100 patients sample were investigated at King Fiasal hospital in Taif city kingdom of Saudi Arabia KSA, other hospitals was excluded from data collection as they were not have two machines with our specification for the current research, the current hospital was pre-selected due to availability of 1.5 and 3 Tesla MRI machine. Patients with knee injuries was referred from orthopedic department to radiology imaging department from period of mid-February to mid-March 2019, data was collected according to authors distribution on this department on the day of clinical practice, inclusion criteria include all available knee images with their reports and excluded all missed images or report or even non-clear report for student's authors. Data collection sheet was designed to collect data using picture archiving and communication system PACS. Data collected were SNR, imaging weighting type, main report finding and other like patients bio data.

Written approval letter done from the ministry of health according to communication from author's university and referred to aforementioned hospital and this was a part of ethical research criteria for health research that involves human. Microsoft Excel program version 2010 has been used to perform analysis technique for variables across this study. Two different interpreter radiologists who have experience more than five years were reports these 100 images.

RESULTS AND DISCUSSION

100 Knee images were evaluated using 3.0T (60% patients) and 1.5 T (40%) field strength MRI machines. Of these there were 85-knee joint lesion, 34 patients (40%) of knee cartilage lesion were seen at femoral medial condyles and at patella.

For the two radiologists' readers the sensitivity was higher 80% for the detection of cartilage lesion of knee, all patients with cartilage lesion undergone arthroscopically for proven cartilage lesion. Consequently authors calculated true positive and true negative and different variables.

As by definition, the sensitivity of test is defined as ability to determine the patient cases correctly. To estimate it, we should calculate the proportion of true positive in patient cases. Mathematically, this can be stated by the following equation

$$Sensitivity = TP/TP + FN \quad \text{……………………..(1)}$$

Results will be shown as tables and figures and then discussed with aid of previous studies

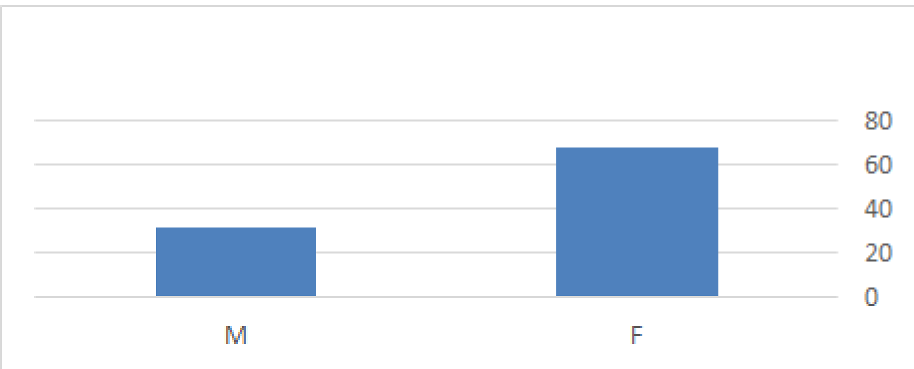

Fig-1: Gender distribution throughout study

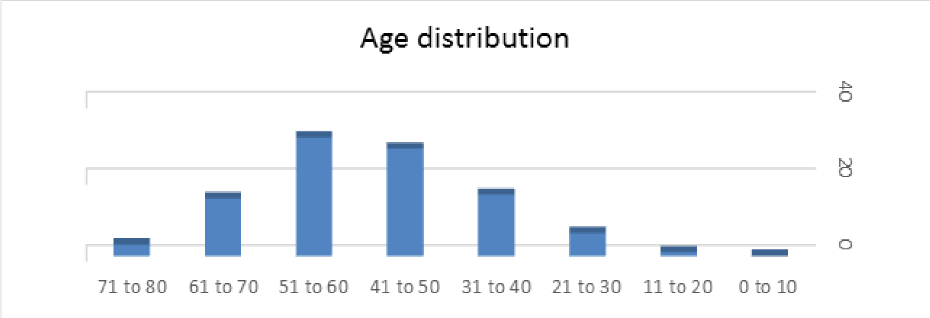

Fig-2: Age distribution

Table-1: Applied protocol for the knee used by 1.5 and 3.0 T MRI

Field strength (T)	Plane	TR ms	TE ms	FOV cm	SL mm	ETL	NEX	MAT Pixels
1.5	sag fs iw FSE	3,200	46	13	3	8	3	224 × 224
1.5	sag iw FSE	2,000	20	13	3	4	3	224 × 224
1.5	axial fs iw FSE	3,700	46	13	4	8	3	224 × 224
3.0	sag fs iw FSE	4,300	51	13	3	9	2	320 × 256
3.0	sag iw FSE	3,300	13.7	13	3	8	2	320 × 256
3.0	cor T1 FSE	675	15.4	13	4	5	2	320 × 256
3.0	axial fs iw FSE	4,300	51	13	4	9	2	320 × 256

TR repetition time, *TE* echo time, *FOV* field of view, *SL* slice thickness, *ETL* echo train length, *NEX* number of acquisitions, *MAT* matrix size in pixels, *sag* sagittal, *cor* coronal, *FSE* fast spin echo, *fs* fat-saturated.

Table-2: Sensitivity of diagnostic for all radiologists

MRI field strength	No of Knee lesion according to radiologist		Proven by arthroscopy	Sensitivity
1.5	25	11 for Rad 1	16	64%
		14 for Rad 2		
3	60	38 for Rad 1	48	80%
		22 for Rad 2		
Normal Knee diagnosed				
1.5	6	4 for Rad 1	0	100%
		2 for Rad 2		
3	9	4 for Rad 1	0	100%
		5 for Rad 2		

Rad = Radiologist

This study was conducted to find the value of 3 Tesla field strength in comparison to 1.5 field strength MRI machine at King Fiasal Hospital Taif.

According to graph 1 female patient was more frequent than male patients in this study 64% to 36% respectively and this may due to women have higher incidence of knee than men [19, 20]. Kaufman [21], suggested that gait differences between men and women partially explained the increased prevalence of osteoarthritis (OA) in women. This finding matches our finding accurately. In addition to that, local society of Saudi habits and obesity may enhance this finding, because female in Saudi Arabia as general have less chance to do exercise sport.

The most common age of knee disorder in this study was 51 to 60 years, this finding matched Keefe FJ *et al*. [22] who reported that the estimation incidence of diagnosed symptomatic knee OA was highest among adults aged 55 to 64, ranging from 0.37% per year for non-obese males to 1.02% per year for obese females. The estimated median age of knee OA diagnosis was 55 years.

The exposure factors (TR,TE) for protocol in 3T field strength are double the 1.5T this enhance the SNR and image quality as whole (noise reduction) which improve the visibility of higher contrast in addition to that matrix size was larger which will provide better details detection than narrow size which was associated with 1.5T. This finding match most finding of basic imaging physics in most references [22-25]. Sensitivity for detection of knee lesion was higher 80% for 3T and and less higher for 1.5T field strength, This finding match the study performed by Lutterbey G *et al*. [27]and study carried by Schoth *et al*. [26], as they concluded that 3.0 T MRI was superior for detecting and grading cartilage lesions compared to 1.5 T. Though a higher diagnostic confidence was found at 3.0 T, the false-positive rate was not decreased. Overall image quality at 3.0 T was rated superior to 1.5 T consistently by all two radiologists.

Conclusion

MRI at 3.0 T improved visualization of anatomical structures and improved diagnostic confidence compared to 1.5 T. This resulted in significantly better diagnostic sensitivity of knee lesion.

Recommendation

More study are required to detect specificity and accuracy as well as phantoms based study, to establish local protocol for imaging knee disorder that compatible with our local society.

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