European Journal of Therapeutics

DOI: 10.5152/EurJTher.2019.18051

Original Research

The Efficacy of 0.2 Tesla Open Magnetic Resonance Imaging Scanner in the Diagnosis of Anterior Cruciate Ligament Injury

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ABSTRACT

Objective: The aim of the present study was to search the efficiency of low-field (0.2 Tesla) open magnetic resonance scannerin the diagnosis of anterior cruciate ligament injury.

Methods: In the present study, 102 patients (54 males and 48 females; mean age 38.1±14 years) were collected from 562 cases who were referred to the radiology department from the orthopedic clinic due to the preliminary diagnosis of meniscopathy and ligamentous pathology and who had bone contusion on magnetic resonance imaging.

Results: Of the 102 patients, 87 (85.3%) had medial meniscus injury, 41 (40.2%) had lateral meniscus injury, 46 (45.1%) had anterior cruciate ligament injury, 9 (8.8%) had posterior cruciate ligament injury, and 93 (91.2%) had synovial fluid. Patients with anterior cruciate ligament injury were found to have 100% lateral compartment injury, 69% femoral lateral condyle contusion, and 76% tibial lateral plateau contusion.

Conclusion: It was concluded that the low-field (0.2 Tesla) open magnetic resonance scanner may be used efficiently to diagnose anterior cruciate ligament injury, as well as the pathological conditions in the knee.

Keywords: Anterior cruciate ligament injury, bone contusion, open low-field magnetic resonance scanner

INTRODUCTION

The main ligaments of the knee are the anterior and posterior cruciate ligaments and the medial collateral and lateral collateral ligaments. The most injured ligament of the knee is the anterior cruciate ligament. Although physical examination and bilateral direct knee radiography are used for evaluation of anterior cruciate ligament injury, the role of non-invasive imaging methods with high diagnostic value became important for pathologies requiring further examination.

Magnetic resonance imaging (MRI), which is reported with high accuracy rate on the knee joint, is preferred to diagnostic arthroscopy by many orthopedists (1). The quality of images acquired using an MRI has increased with the use of high-field magnets developed over time (≥1.5 Tesla) and advanced computer software, and the examination time has gradually decreased. Despite high-field scanner, as well as some advantages, such as longer scanning duration, low signal noise rate, insufficient number of thin slices, and low resolution (spatial resolution), low-field MRI scanners are most commonly used for diagnosis because of some reasons, such as better magnet homogeneity, relevant cost, and minimize claustrophobia handicap that appeared in closed gantry systems. Different resultshave been reported about the diagnostic accuracy of low-field MRI scanner in anterior cruciate ligament injury.

The aim of the present study was to detect the efficiency of low-field MRI scanner of 0.2 Tesla on anterior cruciate ligament injury in the knee joint and detection of other pathologies of the knee associated with anterior cruciate ligament injury.

METHODS

Overall, 562 cases who were referred from the orthopedics department to the MRI unit within the radiology clinic of our hospital due to the preliminary diagnosis of meniscopathy or ligamentous pathology between September 2007 and March 2009 were examined. A total of 102 (54 male and 48 female) patients who had pathological findings on MRI in the knee joint were included in this retrospective study. The mean age of the patients was 38.1±14 years. The cases were selected from patients without any history of trauma as assessed by an orthopedist in the orthopedics polyclinic and who presented clinical findings reminding meniscopathy or ligamentous pathology. Patients with rheumatoid arthritis, previous knee surgery, cardiac pacemaker, malignancy, and who are not

How to cite: Koç AS. The Efficacy of 0.2 Tesla Open Magnetic Resonance Imaging Scanner in the Diagnosis of Anterior Cruciate Ligament Injury. Eur J Ther 2019; 25(2): 104–8.

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Received: 14.10.2018 • **Accepted:** 01.03.2019

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Table 1. Demographic data of the patients

	Knee joint pathology (n=102)
Age (years)	38.1±14
Gender (Female/Male)	54/48

Table 2. MRI findings of the patients

Parameter	Knee joint pathology (n=102)
Medial femoral condyle contusion (n, %)	52 (51.0)
Lateral femoral condyle contusion (n, %)	46 (45.1)
Medial tibial plateau contusion (n, %)	65 (63.7)
Lateral tibial plateau contusion (n, %)	54 (52.9)
Medial meniscus injury (n, %)	87 (85.3)
Lateral meniscus injury (n, %)	41 (40.2)
Anterior cruciate ligament injury (n, %)	46 (45.1)
Posterior cruciate ligament injury (n, %)	9 (8.8)
Synovial fluid (n, %)	93 (91.2)
Medial collateral ligament injury (n, %)	7 (6.9)
Lateral collateral ligament injury (n, %)	9 (8.8)
Baker's cyst	14 (13.7)
Osteoarthritis (n, %)	13 (12.7)

MRI: magnetic resonance imaging

Figure 1. MRI T2A coronal image shows a tibial medial plateau contusion
MRI: magnetic resonance imaging

technically eligible for MRI were excluded from the study. The patients were informed about the procedure and possible complications (claustrophobia and possible consequences due to magnetic field in case of existence of any metallic instrument in the body). Informed consent was obtained from the patients. MRI examinations were performed in a 0.2 T low fieldstrength open MRI scanner (Hitachi Airis Mate, Hitachi Corp., Japan).

Two-dimensional gradient echo (GRE) axial images were obtained from the patients first for localization. In such imaging procedures, the parameters were as follows: repetition time, 100; echo time, 12; flip angle, 30°; slice thickness, 8 mm; slice interval, 9 mm; number of signal averages, 2(1); and matrix, 224×128. In MRI images, plan was first made through axial section for sagittal examination. Spin echo (SE) T1A, PDA, and fast spin echo (FSE) T2A slices on sagittal plane and then SE T1A, PDA and FSE T2A slices on coronal plane were obtained. Furthermore, axial and sagittal GRE images were added. The evaluation was performed by one radiologist both on the computer screen.

Statistical Analysis

All analyses were performed using Statistical Package for the Social Sciences 15.0 statistical software package (SPSS Inc.; Chicago, IL, USA). Continuous variables in the group data were expressed as mean±standard deviation. Categorical variables were presented as number and percentage. Comparison t test and variance analysis were used for parametric tests of univariate analysis, and Mann–Whitney U test and Kruskal–Wallis test were used for non-parametric tests according to the distribution of continuous variables in independent groups. Chi-square test was used for comparison of categorical variables. Multivariate logistic regression analysis was performed for significant changes as a result of univariate analyses for determination of the factors affecting anterior cruciate ligament injury. As a result of such analysis, an increase or a decrease of significant variables was presented as odds ratio according to the unit increase. A p value <0.05 was accepted as statistically significant.

RESULTS

The average age of 102 patients enrolled was 38.1±14 years including similar number of males and females (Table 1). In comparison with the pathological findings detected by MRI and age, as well as gender, patients with femur lateral condylar contusion were younger (33.6±12.8 and 41.7±13.9, p=0.003) and generally male (30 males and 16 females, p=0.001); there was no any significant association detected between other findings (p>0.05).

When patients with pathological MRI findings were evaluated, the most common pathological findings were synovial fluid and medial meniscus injury; and the least common pathological findings were medial collateral ligament, lateral collateral ligament, and posterior cruciate ligament injury. The number of patients with anterior cruciate ligament injury was 46 (45.1%) (Table 2).

Table 3. MRI findings associated with anterior cruciate ligament

		Anterior cruciate ligament injury			
Parameter		**No (56)**	**Yes (46)**	**kappa**	**p**
Medial femoral condyle contusion	None(50)	15	35	—0.487	<0.001
	Yes (52)	41	11		
Lateral femoral condyle contusion	None(56)	42	14	0,446	<0.001
	Yes (46)	14	32		
Medial tibial plateau contusion	None (37)	15	22	—0.203	0.028
	Yes (65)	41	24		
Lateral tibial plateau contusion	None (48)	37	11	0,415	<0.001
	Yes (54)	19	35		
Medial meniscus injury	None (15)	6	9	—0.082	0.209
	Yes (87)	50	37		
Lateral meniscus injury	None (61)	41	20	0.300	0.002
	Yes (41)	15	26		
Synovial fluid	None (9)	4	5	—0.034	0.509
	Yes (93)	52	41		

MRI: magnetic resonance imaging

Figure 2. MRI T2A coronal image shows tibial medial plateau and femoral medial condyle contusion
MRI: magnetic resonance imaging

Anterior cruciate ligament injury was found to be positively associated with medial femoral condyle contusion and medial tibial plateau contusion and negatively associated with lateral tibial plateau contusion and lateral meniscus injury (Table 3) (Figures 1–4).

A logistic regression analysis was performed for usability of MRI findings to detect the anterior cruciate ligament injury. When the parameters associated with anterior cruciate ligament injury were included in the analysis, there was an independent association between anterior cruciate ligament and contusion of lateral femoral condyle, medial femoral condyle, and lateral tibial plateau (Table 4).

DISCUSSION

The main finding of the present study was that low-field (0.2 Tesla) open magnetic resonance scanner may be used efficiently to diagnose anterior cruciate ligament injury and the pathological conditions in the knee.

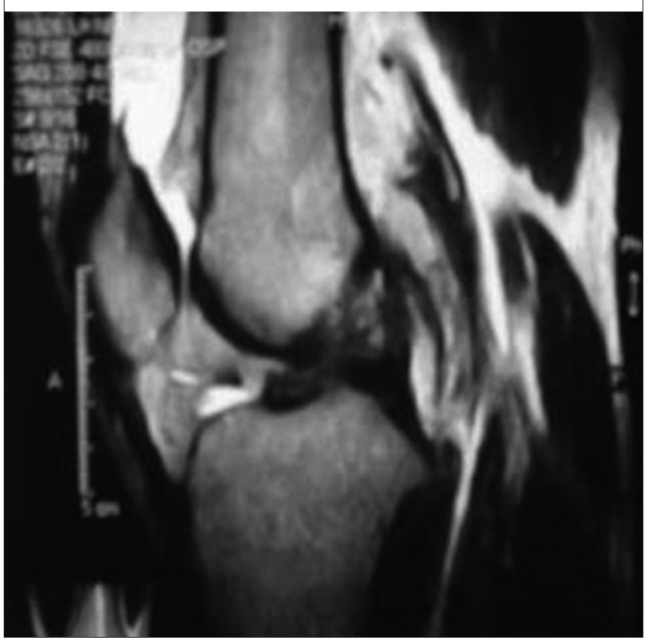
Among knee pathologies, anterior cruciate ligament injury, which is the second most common knee pathology, was detected in 46 (45.1%) patients in our study. MRI is the most valuable method to show anterior cruciate ligament directly, better non-invasive imaging of other soft tissues, and also for preoperative evaluation of an injured knee (2). The cruciate ligaments are stabilizers of the knee; and their evaluation has a specific importance. Anterior cruciate ligament is the most commonly affected ligament in knee traumas. Injury develops as secondary to large

Table 4. Regression analysis associated with anterior cruciate ligament injury

Parameter	Odds ratio	95% CI	p
Medial femoral condyle contusion	19.510	4.401-86.495	<0.001
Lateral femoral condyle contusion	0.054	0.012 - 0.242	<0.001
Lateral tibial plateau contusion	0.174	0.046 - 0.657	0.010

Figure 3. MRI T2A sagittal image shows anterior cruciate ligament injury

MRI: magnetic resonance imaging



traumas, and meniscus lacerations may accompany such injuries (3). If edema of soft tissue is added to diffuse or focal discontinuity of the ligament, anterior cruciate ligament rupture may be diagnosed. Anterior cruciate ligament injuries (ruptures on intraligamentary, femoral, and tibial connection sites) may be detected by MRI with an accuracy rate >80% (4). It was shown that anterior cruciate ligament injury is detected less in young patients, especially in children because of ligament laxity; and these patients may develop bone contusion only without any anterior cruciate ligament injury (5). In our study, there was no any difference with regard to age and gender between those with and without anterior cruciate ligament injury; and anterior cruciate ligament injury was detected independently from age. The possible cause for that may be the average age of the patients, which is 38 years in the present study.

The bone contusion in anterior cruciate ligament injury is detected at the posterior-lateral side of the tibial plateau and on the lateral femoral condyle just over the anterior horn of the lateral meniscus. Johnson et al. (6) showed that 80% of cases with anterior cruciate ligament injury have contusion of the lateral compartment. Furthermore, lateral tibial plateau contusion was detected on the lateral femoral condyle by 50% and on the lateral tibial plateau by 50%; contusion finding was detected on multiple zones in 30% of these patients (6). Similar to the previous study, Papalia et al. (7) showed contusion of lateral compartment by 70% in patients with anterior cruciate ligament injury. The same study detected that contusions of terminal sulcus on the lateral femoral condyle more specifically determine the anterior cruciate ligament injury. In the studies performed, the association between anterior cruciate ligament injury and contusion of the lateral femoral condyle and lateral tibial plateau was commonly connected to the mechanism creating lateral tibial rotation, as well as femoral medial rotation during flexion of the knee, namely, valgus stress. Such maneuver causes injury of the anterior cruciate ligament; frontal subluxation on the tibia relative to the femur and contusion of the terminal sulcus located on the posterior side of the lateral tibial plateau and medial part of the lateral femoral condyle (6 ,8). Snearly et al. (9) investigated bone contusion findings of adult patients without anterior cruciate ligament injury and detected bone contusion without anterior cruciate ligament injury in 28% of the patients. Similar to the previous study, in the present study, contusion finding on the lateral compartment was detected in 26% of patients without anterior cruciate ligament injury. In our study, lateral compartment injury was detected in 100% of patients with anterior cruciate ligament injury; contusion on the femoral lateral condyle and lateral tibial plateau was detected in 69% and 76%, respectively. Similarly, 100% ratio on bone contusion was shown in the study conducted by Kaplan et al. (10); lateral compartment contusion

Figure 4. MRI T2A sagittal image shows medial meniscus posterior horn injury

MRI: magnetic resonance imaging

was detected in all of 200 MRIs of patients with anterior cruciate ligament injury. Furthermore, the development of contusion on the lateral femoral condyle and lateral tibial plateau was shown as an independent indicator to detect the anterior cruciate ligament injury.

In addition, similar to the study conducted by Papalia et al. (7), contusion of the lateral femoral condyle specifically determined the anterior cruciate ligament injury. Another study supporting the findings of the present study was conducted by Spindler et al. (11), and they found a close association between anterior cruciate ligament injury and contusion of the lateral femoral condyle. In the present study, contusion on the femoral lateral condyle and lateral tibial plateau was detected in 69% and 76%, respectively. Although contusion of the lateral tibial plateau is more common in patients with anterior cruciate ligament injury, the statistical examination detected that contusion of the lateral femoral condyle is more associated with anterior cruciate ligament injury.

The present study has some limitations. Our study is a small-scale study for knee pathologies. Studies with larger patient series would provide more clear results. More objective findings might have been obtained if patients who had arthroscopy were included in the present study. Zeiss et al. (12) divided patients with anterior cruciate ligament injury according to partial and whole layer injury; lateral tibial plateau contusion was detected in 12% of patients with partial injury and 72% of patients with whole layer injury. Another study reported that the most common contusion detected in the anterior cruciate ligament injury was on the lateral tibial condyle by 82% (13). However, there was no any differentiation as partial or complete layer injury of the anterior cruciate ligament in the present study; all anterior cruciate ligament injuries were compared with contusion findings. Our study has shown that even 0.2 Tesla MRI examination in patients with claustrophobia and knee pathology may be useful in the evaluation of knee pathologies. However, owing to the fact that our study was performed between 2007 and 2009, a low Tesla MRI device was used. For this purpose, currently, open MRI with higher Tesla is used. Therefore, in our study, higher Tesla MRI could be used.

CONCLUSION

Low-field (0.2 Tesla) open magnetic resonance scanner may be used efficiently to diagnose anterior cruciate ligament injury, as well as the pathological conditions in the knee. Low-field (0.2 Tesla) open magnetic resonance scanner should be considered as a possible alternative for patients who cannot have high Tesla MRI because of claustrophobia.

Ethics Committee Approval: Author declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects" (amended in October 2013).

Informed Consent: Informed consent was not received because data analysis for the study was made retrospectively.

Peer-review: Externally peer-reviewed.

Acknowledgement: I would like to thank Dr. Bozkurt Gülek for his scientific support in preparing the manuscript.

Conflict of Interest: The author has no conflicts of interest to declare.

Financial Disclosure: The authors declare that this study has received no financial support.

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