The Value of Flexion MRI Acquisition in Detection of Meniscal Tears

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ABSTRACT

Aim: *The efficiency of MRI of the flexed knee was studied concerning meniscal lesion staging, existence of tears and meniscocapsulary separation (MCS).*

Method: *In our study with 50 cases, saggital TSE Pd/T2W sequences were acquired in flexion position in addition to routine MRI sequences in neutral position. Subtle or apparent tears and MCSs observed on neutral position acquisitions (NPA) were also evaluated with knee in flexion acquisitions (KFA) in order to evaluate additional diagnostic findings. Statistical evaluation was performed using Chi-square and reliability of medical diagnostic tests.*

Result: *There was no statistically significant difference between NPA and KFA concerning meniscal lesion grading ($p>0.05$). There was no statistically significant difference between NPA and KFA concerning tears due to signal increase extending to the joint surface. On the other hand, KFA contributed in tears due to MCSs (28,6%).*

Conclusion: *KFA is an applicable method in closed system MR devices, does not disrupt patient comfort and is not time consuming. Using this method, additional information can be acquired with high contrast resolution images. KFA seems to be a superior method to NPA in patients with suspected meniscal tears and especially in cases of MCS. Further studies with extended number of patients will increase the reliability of the results.*

Key words: *Arthroscopy, Magnetic resonance imaging, Meniscal tear*

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Menisküs Yırtıklarının Saptanmasında Fleksiyon MR Görüntülemenin Değeri

Amaç: *Dizin fleksiyon pozisyonunda çekilen Manyetik Rezonans Görüntüleme (MRG)'nin meniskal lezyonların evrelemesinde ve meniskokapsüler seperasyonun (MKS) saptanmasındaki etkinliğini araştırmak.*
Metod: *Çalışmamızda 50 olguda nötral pozisyondaki rutin diz MRG sekanslarına ilave olarak fleksiyon pozisyonunda, sagital eksende TSE Pd/T2 ağırlıklı sekans elde edilidi. Nötral pozisyon çekimlerinde (NPÇ) izlenen yırtık şüphesi, yırtık veya MKS fleksiyon pozisyon çekimlerinde de (FPÇ) değerlendirilerek ek tanısal bulgu araştırıldı. İstatistiki değerlendirmede Chi-square ve medikal tanı testleri kullanıldı.*
Bulgular: *Meniskal lezyon evrelemesinde NPÇ ile FPÇ arasında istatistiksel olarak (Chi-square) anlamlı bir fark bulunmadı (p>0.05). Meniskal yırtık tanısında ise artroskopi baz alındığında FPÇ ve NPÇ'nin duyarlılıkları sırasıyla %98-%88, doğruluk oranları sırasıyla %98-88 olarak bulundu. Eklem yüzeyine uzanan sinyal artışına bağlı yırtıklarda NPÇ ile FPÇ arasında istatistiksel olarak anlamlı fark bulunmazken, MKS'ye bağlı yırtıklarda FPÇ'nin katkı sağladığı (%28.6) görüldü.*
Sonuç: *FPÇ kapalı sistem MRG cihazlarında uygulanabilen, hasta konforunu bozmayan ve fazla zaman kaybına yol açmayan bir yöntemdir. Bu yöntemle yüksek kontrast rezolüsyonlu görüntülerle ek tanısal bilgiler elde edilebilmektedir. FPÇ, meniskal yırtık şüphesi ve de özellikle MKS olgularında NPÇ'ye göre üstün bir yöntem olarak görülmektedir. Çalışmanın daha geniş hasta grubu ile yapılması sonuçların güvenirliğini arttıracaktır.*
Anahtar kelimeler: *Artroskopi, Manyetik Rezonans Görüntüleme, Menisküs yırtığı*

INTRODUCTION

Magnetic resonance imaging (MRI) has been successfully used in the imaging of the knee since Reicher et al (1) had begun to use it in the detection of knee pathologies in 1985. The accuracy of MRI in meniscal lesions is high ranging from 77% to 98% in various studies (2-6). The minor discordances between arthroscopy and MRI is explained with mimicing of meniscal tears by normal anatomic structures or disability to see meniscal tears arthroscopically. It is especially difficult to determine meniscocapsulary separation (MCS) by arthroscopy. Kinematic MRI studies have been performed in order to increase the diagnostic success of MRI (7-15). The evaluation of meniscal deplacement can be done by kinematic MRI in the presence of meniscal tears. In flexion position the posterior horn and in extension position the anterior horn is compressed between femoral and tibial condyles, and due to the movement of the condyles the torn fragment is forced and displaced through the joint space (7-8). The close attachment of the medial meniscus to the medial collateral ligament limits the movement capability of the meniscus. This is a predisposing factor in medial meniscus injury.

Traumatic MCS forms a special type of meniscal tears. It is quite difficult to detect MCS by MRI. A distance of 5 mm or more between posterior horn of medial meniscus and the peripheral margin of tibial articular cartillage is accepted as a sign of MCS. From this point of view, Boxheimer et al (9) have reported in a kinematic MRI study that deplacements and fragments of meniscal tears are best visualised on examinations with knee in flexion position rather than in neutral position.

Kinematic MRI studies can usually be performed with open MRI systems, and this causes the contrast resolution to be low. Besides, the examination time is quite long. In this study we investigated the efficacy of KFA in the detection of meniscal tears and MCS in addition to standard NPA examinations on a 1.5 Tesla (T) MRI system.

MATERIALS AND METHODS

Among patients who applied to our radiology department for routine knee MRI examination between May 2006 and April 2007, we performed additional TSE Pd/T2 MRI sequences in saggital plane while the knee was in flexion position in patients whom we detected meniscal tear or doubt of tear during routine MRI examination. Among these, 50 patients (17 women, 33 men) were included into our study in whom meniscal tear was detected arthroscopically. The age of the patients ranged between 10-62 (mean:32,6±10,4). The MRI examinations were performed with 1.5 T MRI system (Siemens Magnetom Symphony, Erlangen, Germany). No special preparation was required from the patients before the MRI examination. The examinations were done in supine position. Routine neutral position examinations were done after covering the knee with a receiver coil while the knee was in extension and 15˚ external rotation. Later, KFA were acquired by the help of a non-ferromagnetic apparatus which was put below the knee to maintain the flexion position (Figure 1). Our receiver coil allowed a flexion angle of 30-50˚ (mean: 40˚) in relation with the patient weight. After GE T2A axial and coronal, TSE Pd/T2A saggital, and SE T1A coronal sequences had

***Figure 1**. Flexion apparatus and its use during MRI examination.*

been taken in neutral position, we got additional TSE Pd/T2A saggital sequences in flexion position. The additional sequences we got were increasing the examination time approximately a total of 5 minutes including patient preparation. The total examination time (neutral position+flexion position) was 20-25 minutes.

The MRI examinations were reported by two radiologists by common decision. The configuration of the meniscal tears, different localisations of tears in the same meniscus, the distribution of tears among menisci, and MCS were evaluated. While evaluating meniscal degeneration and tears, the grading system defined by Stoller et al was used (16). According to this grading system, grade-1 and grade-2 signal increases are defined as degeneration, and grade-3 and grade-4 signal increases are defined as tear. We included grade-3 and grade-4 tears into our study because only they could be detected arthroscopically. We evaluated MCS lesions among grade-3 tears. At first step, KFA was performed to look for additional findings to cases in which we thought about tears or subtle tears on routine NPA. The meniscal tears which were defined as absent (-) or present (+) were classified in two groups as signal increase reaching meniscus surface and MCS, respectively. The results were correlated with arthroscopy. Statistical analysis was done using Chi-square test and reliability of medical diagnostic tests.

RESULTS

In our study the MRI findings of 50 patients were evaluated in whom meniscal tear was detected arthroscopically. Meniscal tear was observed in 44 patients with NPA and in 49 patients with KFA. In a patient whom we interpreted to have grade-2 degeneration, meniscal tear was detected arthroscopically; and we regarded this case as false-negative. 40 of 41 medial meniscus tears and all of 9 lateral meniscus tears, and a total of 49 meniscal tears that have been detected on MRI were also confirmed arthroscopically. All of the medial meniscus tears were at the posterior horn. Eight of the lateral meniscus tears were localised at the posterior horn an one of them was at the anterior horn.

While in 43 of the patients (86%) NPA and KFA results were concordant, in 7 of them (14%) KFA detected higher grade meniscal lesion. One of the 43 patients that NPA and KFA displayed same results had grade-2 degeneration, 32 of them had grade-3 tear, and 10 of them had grade-4 tear. In 5 patients which NPA displayed grade-2 degeneration, KFA detected grade-3 meniscal tear (Figure 2). In 4 of these 5 patients grade-3 meniscal tear was reported due to MCS, and in one of them due to signal increase reaching joint surface. Besides, in 2 patients which NPA displayed grade-3 tear, KFA detected grade-4 tear (Figure 3). As a result, in 5 of the 50 patients (10%) only KFA could be able to detect meniscal tear, whereas in 2 patients (4%) we observed increase in the grade of tear by KFA. In one patient that arthroscopy revealed meniscal tear, MRI could not detect it.

On statystical analysis done by Chi-square test, there was no significant difference between NPA and KFA in

***Table 1**. Types of meniscal tears detected in NPA and KFA*

	Tear reaching joint surface	*MCS*	***Total***
Only KFA	*1*	*4*	*5*
Both NPA and KFA	*34*	*10*	*44*
Total	*35*	*14*	*44*

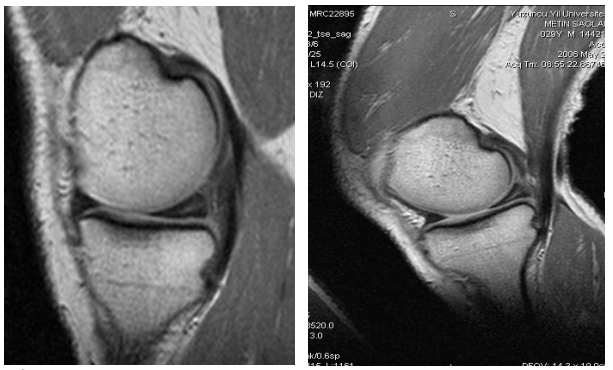

***Figure 2A,B**: Intrasubstance signal increase in medial meniscus posterior horn convenient with grade-2 degeneration is seen on NPA (A). On KFA (B), the signal is reaching capsular surface causing irregularity (Grade-3 tear).*

***Figure 3A,B**: Grade-3 tear on NPA (A) is evaluated as Grade-4 tear on KFA (B).*

meniscal lesion grading (p>0.05).

Meniscal tear reaching joint surface was detected in 34 (68%) of patients with NPA and in 35 (70%) of patients with KFA. In 14 patients (28%) MCS was detected with KFA; whereas only 10 of them were detected with NPA (Table 1). This means that 4 of 14 patients (28,6%) were detected only by KFA. While there was no significant difference between NPA and KFA in tears reaching joint surface, KFA displayed additional contribution in cases with MCS (28,6%). The sensitivity (and specificity) of KFA and NPA were 98% and 88%, respectively.

DISCUSSION

The dynamic properties of normal menisci during knee joint movement have been evaluated in different studies (7,9). The menisci are mobile, and permit anterior-posterior and medial-lateral movements during flexion and extension of the knee (8). The evaluation of meniscal deplacement in case of meniscal tear is possible especially with kinematic MRI examinations. In flexion position the posterior horn and in extension position the anterior horn is compressed between femoral and tibial condyles, and due to the movement of the condyles the torn fragment is forced and displaced through the joint space (7-8). Clinical signs of meniscal tears usually appear when the knee is in flexion position, and due to the thought that the torn meniscus or fragment may move, different kinematic MRI studies have been done to demonstrate meniscal tears and MCS better. These studies were performed with open MRI systems (0,5 T or less), and to the best of our knowledge, there isn't any study done with closed system MRI (1.5 T or more) while the knee is in flexion position. Besides, kinematic knee MRI studies are mostly done to evaluate patellofemoral joint discordance or to differentiate partial anterior cruciate ligament (ACL) rupture from total rupture, and rarely tried in meniscal lesions (7-15). The first kinematic MRI study to evaluate meniscal lesions and cruciate ligament lesions was done by Niitsu et al (10). In this study both sensitivity and specificity values of kinematic MRI had been found to be higher than conventional MRI examinations. In a study done by Boxheimer et al with 42 patients, deplaced meniscal tears had been better demonstrated with kinematic MRI while the knee was in flexion position (9).

The superiority of open MRI system is that more flexion can be maintained during the examination. On the other hand, when it is thought that it is not widespread, this is a disadvantage. Besides, the open MRI systems have low magnetic field power and this decreases the contrast resolution. With passive position technique of kinematic MRI examination, it is necessary to repeat the sequences in different angles of flexion, and this increases the examination time. On the other hand, with active movement technique, the examination is performed with ecoplanar imaging or fast GE sequences which decrease the contrast resolution. In our study, the examinations are performed with closed MRI system which has high magnetic field power (1.5 T) and high contrast resolution with an only one additional KFA sequence in order not to cause patient discomfort or too increased ex-

amination time. In most of the kinematic MRI studies (7,8,10-15), a flexion angle of 40-50˚ could be maintained, while in a study (9) a flexion angle reaching up to 90˚ was achieved. In our study, we could maintain a flexion angle between 30-50˚ (mean: 40˚), and this was the main limitation. But even with this degree of flexion additional diagnostic findings could be had. Another limitation was overweight patients in whom convenient KFAs could not be done. In our study, KFA altered the type of management in 5 patients (10%) and led to an indication of operation ($p<0.05$). In 2 patients (4%) increase in grade of meniscal tear was found with KFA although it did not alter the type of management and was not statistically significant ($p>0.05$).

Meniscal tear reaching joint surface was detected in 34 (68%) of patients with NPA and in 35 (70%) of patients with KFA. In 14 patients (28%) MCS was detected with KFA; whereas only 10 of them were detected with NPA (Table 1). This means that 4 of 14 patients (28,6%) were detected only by KFA. While there was no significant difference between NPA and KFA in tears reaching joint surface, KFA displayed additional contribution in cases with MCS (28,6%). Although following studies should be performed with increased number of patients, we found that KFA proved additional findings in MCS detection up to 8% (4/50) concerning all patients, and 28,6% (4/14) concerning MCS cases.

As a result, KFA seems to be a superior examination technique than NPA in patients with doubt of meniscal tear, especially in MCS cases.

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