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*Full Length Research Paper*

# The diagnostic value of 0.2 Tesla low-field open MR imaging in the detection of meniscal tears

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**Abstract**

**The purpose of this study was to investigate the diagnostic efficiency of 0.2 Tesla (T) low field-strength open MRI imaging in the diagnosis of meniscal tears of the knee. 44 knees of 44 patients who had applied to the Orthopedics department with several clinical complaints and physical findings regarding their knees were imaged by a low-field open MR scanner. The results were compared with those obtained from the arthroscopic examinations of the same patients, performed during the first week following their MRI examinations. MRI studies revealed medial meniscal tears in 33 (75 %), and lateral meniscal tears in 10 (22.70 %) cases. Arthroscopy proved medial meniscal tears in 32 (72.70 %), and lateral meniscal tears in 10 (22.70 %) of the cases, respectively. 3 false-positives and 2 false-negatives in the medial meniscal, and 2 false-positives and 2 false-negatives in the lateral meniscal series were detected. The sensitivity values were 93.75 % and 80 %, the specificity values were 75 % and 94.12 %, the accuracy values were 88.63 % and 90.90 %, the positive predictive values were 90.90 % and 80.80 %, and the negative predictive values were 81.81 % and 94.12 %, for the medial and lateral menisci, respectively. Our results have confirmed that low-field open MR scanners may be used effectively and reliably in the diagnosis and evaluation of meniscal tears of the knee.**

**Keywords:** Meniscopathy, meniscal tear, MRI, low-field MRI

## INTRODUCTION

The menisci are structures of critical importance in the knee joint. They play a major role in the biomechanics of the knee joint, and they also take part in the process of bearing weight. The menisci build the endurance potential of the knee, and they have a role in the process of absorption of blow forces to the knee joint. The menisci also share a fundamental part in the feeding and lubrication of the joint cartilage (Gershuni et al., 1989; Newman et al., 1993). Meniscal injuries ususally develop due to motion activities and they are the most frequent injuries encountered in the knee joint. The damage to the menisci may develop acutely, due to a sudden load on the joint; or chronically, due to repititive microtraumas.

The use of magnetic resonance imaging (MRI) in the imaging of the knee joint started in 1984. MRI has since been a fundamental imaging option in the evaluation of the pathological conditions of the knee joint (Stoller et al., 1990; Burk et al., 1990). Multiplanar imaging capability, advanced contrast creation between different tissue types, providing better anatomic details, and being a non-ionizing and noninvasive modality, are the most important advantages of MRI.

MRI is a very effective modality in the demonstration of intraarticular alterations due to knee injuries. MRI clearly depicts the morphology of meniscal tears and it helps in their classifications. It is also very helpful in the

| Number of patients | Minimum Age | Maximum Age | Mean Age | Std. Deviasyon |
|---|---|---|---|---|
| 44 | 18 | 64 | 38,66 | 12,904 |

**Table 1.** Age distribution and the mean age

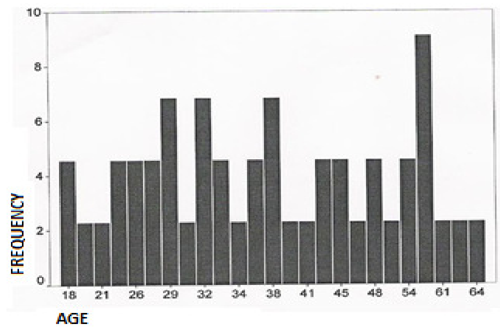


**Figure 1.** Age distribution of the patients

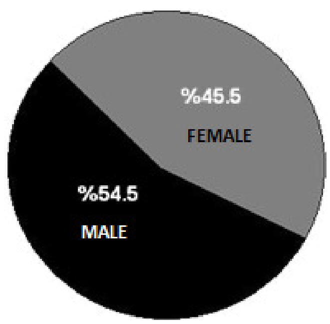


**Figure 2.** Gender distribution of the patients

decisive action on how to manage these tears arthroscopically (repair or meniscectomy) (Oei et al., 2007; Jee et al., 2003).

Thanks to the very fast development of high-field (1.5 and higher T) MR scanners and advanced software, image quality in MR imaging has increased conspicuously, and imaging times have been shortened. Despite their certain disadvantages such as longer imaging times, lower signal-to-noise ratios (SNR), unability to obtain very thin slices, and lower spatial resolution, low-field open MRI systems, too, have been successfully used in the imaging of the knee joint. Some of the advantages of these magnets are better magnet homogeneity, high economical advantage, and minimalized clostrophobia disadvantage when compared to closed bore systems. There are various reports on the diagnostic efficacies of these systems (Cevikol et al., 2004).

The purpose of this study was to compare the results of meniscal tear imaging performed in a 0.2 T low-field open MRI scanner with arthroscopic results, and evaulate the diagnostic efficacy of low-field MR imaging.

## MATERIALS AND METHODS

This study was carried out in the Radiology Department of the Numune Teaching and Research Hospital, Adana, Turkey. 44 patients who had applied to the Orthopedics Department for symptoms associated with meniscopathy were examined by a 0.2 T low-field open MRI scanner. The ages of the patients ranged between 18 and 64 years, and the mean age was 39 (Table 1 and Fig. 1). 24 patients were males and 20 were females (Figure 2).

The cases were selected from the patients who had applied to the Orthopedics Department with knee symp-

| | Number | Ratio (%) | Viable Ratio (%) | Total Ratio (%) |
|---|---|---|---|---|
| Negative | 11 | 25,0 | 25,0 | 25,0 |
| Positive | 33 | 75,0 | 75,0 | 100,0 |
| Total | 44 | 100,0 | 100,0 | |

**Table 2.** Number and ratio of medial meniscal tears detected on MRI.

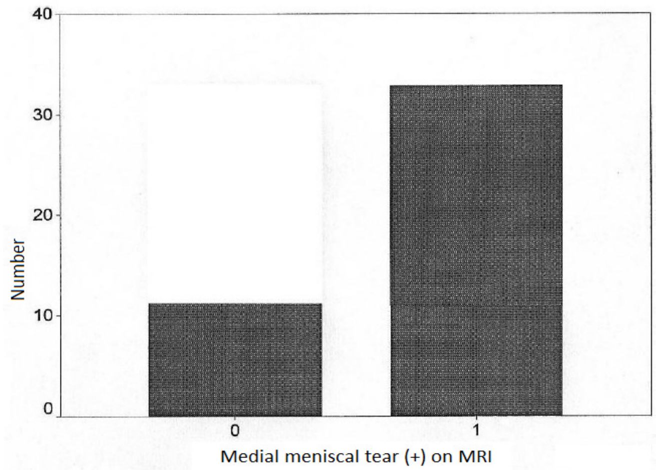


**Figure 3.** Medial meniscal tear (+) on MRI.

toms and whose physical examinations aroused the possibility of a meniscopathy.

MRI examinations were performed in a 0.2 T low-field open scanner. 2-dimensional gradient recalled echo (2D GRE) localizer sequences were obtained at the beginning of the examinations . Sagittal plans were made on the axial scans and spin echo T1-weighted (SE T1W), proton density weighted (PDW), and fast SE T2-weighted (FSE T2W) sequences were obtained sagitally. Then coronal sections were obtained with SE T1W, PDW, and FSE T2W sequences . In addition to these sequences, axial and sagittal T2*GRE sequences were administered.

The staging parameters defined by Stoller et al were administered for the evaluation of meniscal degenerations and tears (Stoller et al., 1990). According to this system, intrameniscal globoid signal increase was defined as Grade 1, intrameniscal linear signal incrase not abutting the articular surface as Grade 2, and intrameniscal signal increase showing contact with one or more articular surfaces as Grade 3. Grade 1 and Grade 2 signal increases were reported as degeneration, while Grade 3 signal increase was reported as meniscal tear.

Every knee was accepted as an individual case. All knees were listed vertically in a table. Four columns were created in this table. These comprised the following: the medial menisci, the lateral menisci, MR findings, and arthroscopic findings. Meniscal tear was coded as 1, and absence of a meniscal tear was coded as 0, for statistical purposes.

All patients underwent an arthroscopic evaluation during the first week following the MR examinations.

The results were evaluated by the Kappa test, and the accuracy, sensitivity, specificity, and the positive and negative predictive values were assessed.

## RESULTS

44 patients, of whom 24 were males and 20 females, were enlisted in this study. The ages of the patients varied between 18 and 64 years. The mean age was 39 years. All patients underwent MRI examinations of their knees in a 0.2 T low-field open MR scanner.

### Data about MRI-diagnosed medial meniscus tears

A medial meniscal tear was reported in 33 of the 44 patients (75 %) (Table 2, Figure 3).

### Data about arthroscopically-diagnosed medial meniscal tears

A medial meniscal tear was detected arthro-scopically, in 32 of the 44 patients (72.70 %) (Table 3, Figure 4).

| | Number | Ratio (%) | Viable Ratio (%) | Total Ratio (%) |
|---|---|---|---|---|
| Negative | 12 | 27,3 | 27,3 | 27,3 |
| Positive | 32 | 72,7 | 72,7 | 100,0 |
| Total | 44 | 100,0 | 100,0 | |

**Table 3.** Number and ratio of medial meniscus tears detected at arthroscopy.

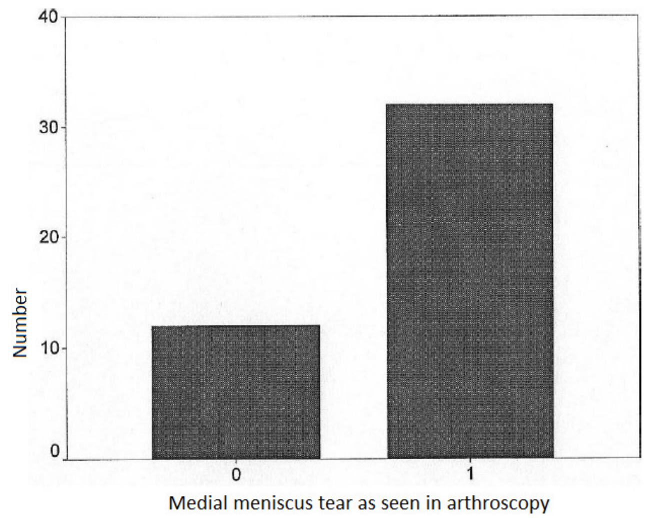


**Figure 4.** Medial meniscus tear as seen in arthroscopy.

| | Number | Ratio (%) | Viable Ratio (%) | Total Ratio (%) |
|---|---|---|---|---|
| Negative | 34 | 77,3 | 77,3 | 77,3 |
| Positive | 10 | 22,7 | 22,7 | 100,0 |
| Total | 44 | 100,0 | 100,0 | |

**Table 4.** Number and ratio of lateral meniscal tears detected at MRI.

## Data about MRI-diagnosed lateral meniscus tears

A lateral meniscal tear was reported in 10 of the 44 patients (22.70 %) (Table 4, Figure 5).

## Data about arthroscopically-diagnosed lateral meniscal tears

A lateral meniscal tear was detected arhroscopically, in 10 of the 44 patients (22.70 %) (Table 5, Figure 6).

## Cross tables

In this study, arthroscopic diagnosis was accepted as the gold standard, and MRI results were evaluated in comparison to it. The sensitivity, specificity, accuracy, and positive and negative predicitve values (PPV and NPV) for MRI diagnosis of meniscal tears were assessed.

The sensitivity for the medial meniscus was found to be 93.75 %, whereas the specificity was 75 %, the accuracy was 88.63 %, the PPV was 90.90 %, and the NPV was 81.81 %. As for the lateral meniscus, the following values were obtained: Sensitivity 80 %, specificity 94.12 %, accuracy 90.90 %, PPV 80 %, and NPV 94.12 %.

## DISCUSSION

The menisci had first been considered as a negligible part of the knee joint, and they were thought to be a remnant of the muscle tissues of the leg (Sutton, 1897;

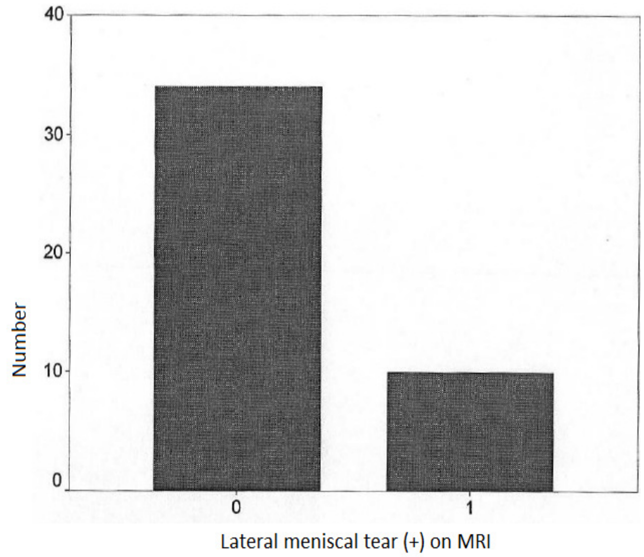


**Figure 5.** Lateral meniscal tear (+) on MRI.

| | Number | Ratio (%) | Viable Ratio (%) | Total Ratio (%) |
|---|---|---|---|---|
| Negative | 34 | 77,3 | 77,3 | 77,3 |
| Positive | 10 | 22,7 | 22,7 | 100,0 |
| Total | 44 | 100,0 | 100,0 | |

**Table 5.** Number and ratio of lateral meniscus tears detected at arthroscopy.

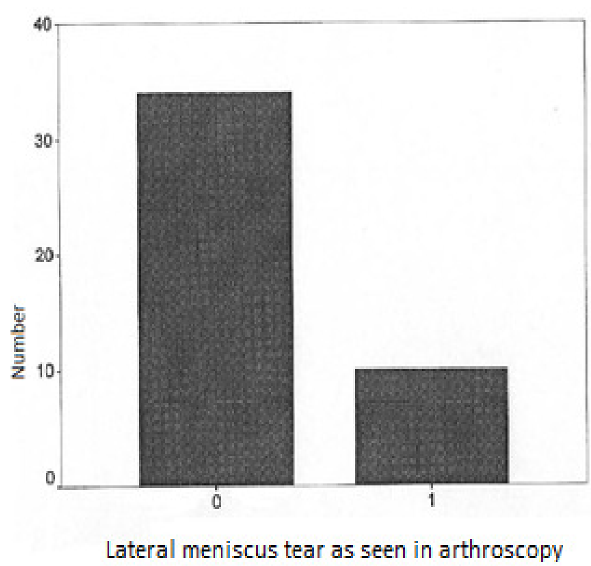


**Figure 6.** Lateral meniscus tear as seen in arthroscopy.

| | | Medial meniscus tear as seen in arthroscopy | | TOTAL |
|---|---|---|---|---|
| | | 0 | 1 | |
| Medial meniscal tear on MRI | 0 Number | 9 | 2 | 11 |
| | Medial meniscal tear (+) on MRI | 81,8% | 18,2% | 100,0% |
| | Medial meniscus tear as seen in arthroscopy | 75,0% | 6,3% | 25,0% |
| | 1 Number | 3 | 30 | 33 |
| | Medial meniscal tear (+) on MRI | 9,1% | 90,9% | 100,0% |
| | Medial meniscus tear as seen in arthroscopy | 25,0% | 93,8% | 75,0% |
| TOTAL | Number | 12 | 32 | 44 |
| | Medial meniscal tear (+) on MRI | 27,3% | 72,7% | 100,0% |
| | Medial meniscus tear as seen in arthroscopy | 100,0% | 100,0% | 100,0% |

**Table 6.** MRI / Arthroscopy cross evaluation for the medial meniscus. Tear positive (1); tear negative (0).

| | | Lateral meniscus tear as seen in arthroscopy | | TOTAL |
|---|---|---|---|---|
| | | 0 | 1 | |
| Lateral meniscal tear on MRI | 0 Number | 32 | 2 | 34 |
| | Lateral meniscal tear (+) on MRI | 94,1% | 5,9% | 100,0% |
| | Lateral meniscus tear as seen in arthroscopy | 94,1% | 20,0% | 77,3% |
| | 1 Number | 2 | 8 | 10 |
| | Lateral meniscal tear (+) on MRI | 20,0% | 80,0% | 100,0% |
| | Lateral meniscus tear as seen in arthroscopy | 5,9% | 80,0% | 22,7% |
| TOTAL | Number | 34 | 10 | 44 |
| | Lateral meniscal tear (+) on MRI | 77,3% | 22,7% | 100,0% |
| | Lateral meniscus tear as seen in arthroscopy | 100,0% | 100,0% | 100,0% |

**Table 7.** MRI/Arthroscopy cross evaluation for the lateral meniscus. Tear positive (1); tear negative (0).


**Figure 7.** Horizontal tear at the medial meniscus of the left knee. Sagittal T1W (A) and coronal T1W (B) MRI images. There is a septated cystic structure (parameniscal cyst) at the near vicinity of the posterior horn of the medial meniscus. The cyst appears hypointense on the coronal T1W image (B), whereas it is seen as a hyperintense structure on the T2W coronal (C) and T2*W axial (D) images. There is also an arthroscopic view (E).


**Figure 8.** Vertical longitudinal tear at the medial meniscus of the left knee. A. Sagittal, and B. Coronal , T1W serial images demonstrate the vertical longitudinal tear pattern at the posterior horn of the medial meniscus.

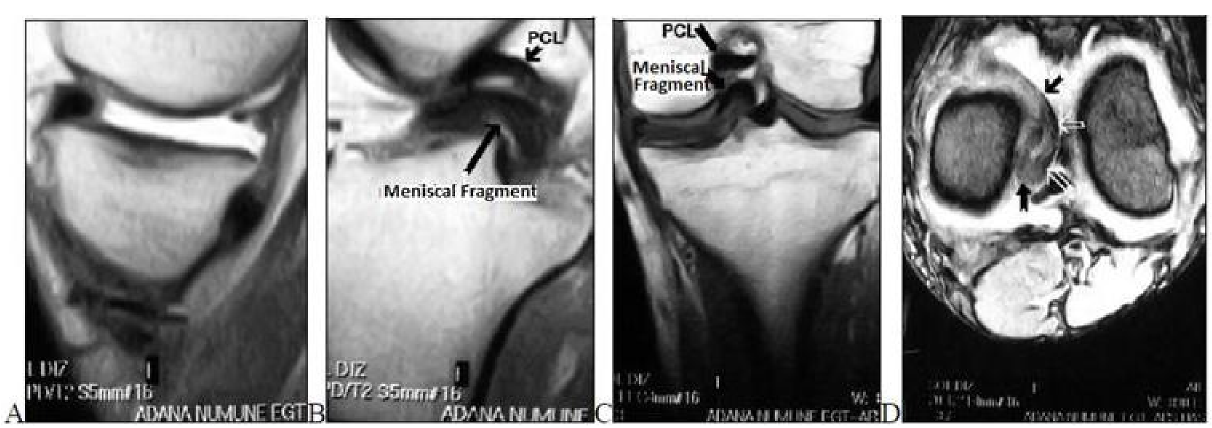


**Figure 9.** Bucket handle tear of the medial meniscus of the left knee. The PDW sagittal image shows the intrameniscal increased signal intensity (A). The T1W PDW sagittal image shows the pseudo PCL appearance (B). The T1W coronal (C) and the T2*W GRE images clearly depict the displaced meniscal fragment at the intercondylar notch (arrows).

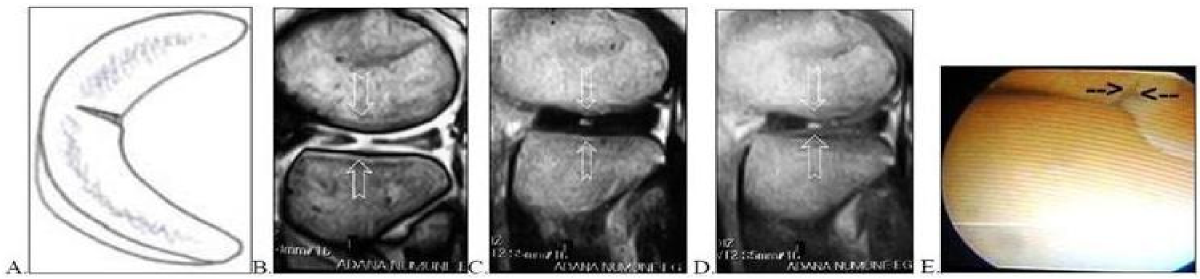

**Figure 10.** Peripherally located radial tear at the lateral meniscus. Schematic view (A); sagittal T2*W GRE view (B); sagittal T2W image (C); sagittal PDW image (D); arthroscopic image (E).

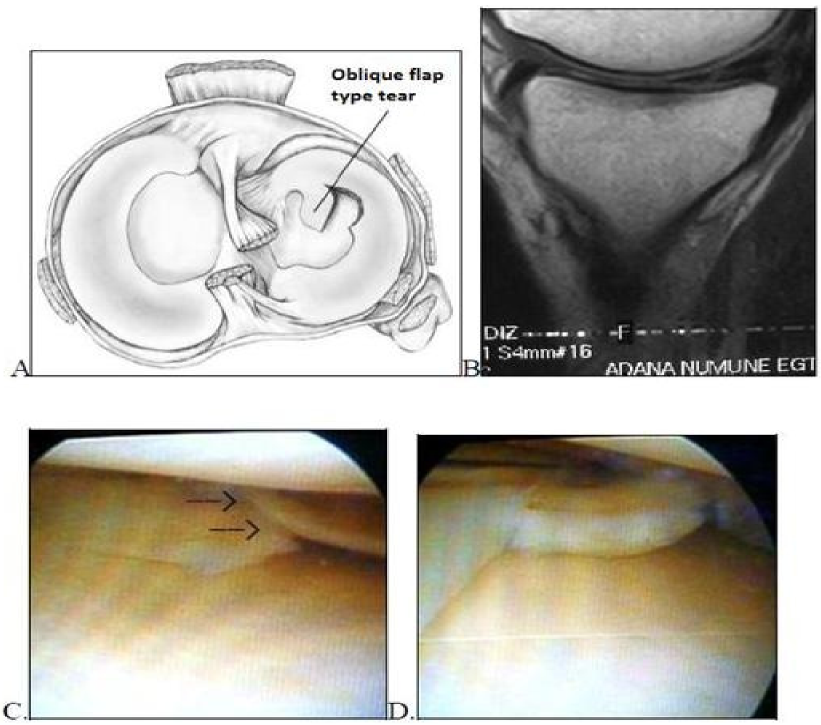


**Figure 11.** Oblique flap type tear. Schematic image (A); T1W sagittal image (B); arthroscopic image (C).


**Figure 12.** Meniscal fragment. Coronal PDW MR image shows the free meniscal fragment (arrows).

Jhonson et al., 1999). But today it is well known that menisci have an essential place in the complex biomechanics of the knee joint and also play an important role in maintaining the stability of the joint. The menisci also share an important role in the bearing, division, and absorption of weight loaded on the knee joint. They also have an important function in the vascular feeding of the articular cartilage (Gershuni et al., 1989; Newman et al., 1993; Spilker et al., 1992; Arnoczky et al, 1992; Burr et al., 1982).

Meniscal injuries are closely related to sportive activities and they are the most frequent injuries of the knee joint (Renstrom et al., 1990).

Meniscal tears may be classified into two groups according to their etiologies: traumatic and degenerative. Traumatic tears usually develop due to acute injuries. The patients are usually in the young age group, and they are usually active athletes (DeHaven et al., 1992). Acute injury usually develops when the femur rotates on the stabile tibia due to an axial loading, while the knee is in extension or flexion (Turek et al., 1984). An ACL tear, or less probably a PCL tear, may accompany the meniscal injury. The vertical longitudinal type tear is more frequent, but transverse and radial tears too, may be encountered (DeHaven et al., 1992).

On the other hand, degenerative tears usually develop following repeating microtraumas and they are usually due to the decay of the meniscal collagen. There is usually no chance of healing. These tears are usually seen as a horizontal clivage tear, or a flap or complex tear (DeHaven et al, 1992). Ligament injuries, diseases of the hip joint, degenerative joint disease, advanced age, trauma, intense sports activities, and septic arthritis are among the most prominent predisposing factors. The patients usually do not recognize their meniscal problems at the beginning, and the symptomatology appears late in the course of the disease (Washington et al., 1995).

MRI is the gold standard in the imaging of the intra and extraarticular components of the knee joint (Pietsch et al., 2006). In the evaluation of meniscal lesions, MRI diagnoses are compared against arthroscopy results. But still it is not fully clear if arthroscopy really is the fundamental gold standard in the evaluation of meniscal injuries. The accuracy rate of arthroscopy has been reported in different studies to be between 69 – 98 %. The most important advantage of arthroscopy over MRI is that it bears the option of direct intervention to the meniscal and other intraarticular tissues (Gumus et al., 2002). But, even though the complication rate is rather low, arthroscopy is still an invasive modality and when its operational prerequisites like laboratory studies and anesthesia are considered, it is an expensive method. MRI on the other hand, is noninvasive and considerably cheaper. Because of its high diagnostic accuracy, many orthopedic surgeons prefer MRI to arthroscopy today (Helms et al., 2002).

Meniscectomy and repair are the most frequently practiced surgical methods in the treatment of meniscal injuries (Rodkey et al., 2000). MRI supplies data about the properties of the tear in advance of surgery, such as its location, shape, depth, and extension (Rubin et al., 2000).

The T1W and PDW sequences are the most appropriate ones in the imaging of meniscal lesions. On the other hand, GRE sequences too, are very effective in meniscal imaging (Quinn et al., 1992; Kojima et al, 1996). But still the GRE sequence has its disadvantages in comparison to SE sequences. Its resolution capacity is lower, and it may lead to certain artifacts and signal exaggerations which may be mistaken for a tear (Carrino et al., 2002). Short TE sequences like T1W, PDW, and T2*GRE sequences are more sensitive and accurate than long TE sequences such as the T2W sequence, in the imaging and detection of meniscal damage (Crues et al., 1993). Because meniscal signal detection is diminished in long TE sequences, it is very hard and almost impossible detect meniscal injury with these sequences. This is why the T2W sequence is not preferred in meniscal imaging. Imaging must be performed on the sagittal and coronal planes. In addition to the sagittal and coronal planes, axial plane imaging too, is done in order to image the periarticular ligaments, the popliteal fossa, the patellar cartilage, and the patellofemoral joint.

Meniscal damage may be detected by means of high or low-field MR imaging (Cotten et al., 2000). High- and low-field MR imaging have been compared in various studies and no statistically significant differences have been found.

Cevikol et al compared the diagnostic efficacies of 0.35 T and 1.5 T MRI scanners in the diagnosis of meniscal tears. They found out that the accuracy rate of 1.5 T MR imaging was 94.7% in medial meniscal tears and 96.0 % in lateral meniscal tears. These values were 91.6 % and 93.7 %, for the 0.35 T MRI scanner, respectively. The authors reported that they found no statistically significant difference between the diagnostic efficacy rates of the 1.5 and 0.35 T scanners in terms of detecting meniscal tears. They concluded that low-field MRI scanners were as effective as high-field ones in this manner (Cevikol et al., 2004).

Ege et al conducted a similar study and studied the efficiency of 0.2 T low-field MR imaging in the diagnosis of meniscal tears. They studied 22 patients with medial, and 9 patients with lateral, meniscal tears. They found that the sensitivity and specificity of 0.2 T low field MR imaging for medial meniscal tears were 90 % and 78.5 %, consecutively. These values were 92.5 % and 77.7 % for the lateral meniscus (Ege et al., 2001).

In our study, we compared the diagnostic efficacy of 0.2 T low-field MRI imaging with that of arthroscopy. With this purpose, an open MRI scanner was utilized, and the accuracy, sensitivity, and specificity rates, together with the positive and negative predictive values, for the diagnosis of medial and lateral meniscal tears, were assessed. These values were then compared with those from the literature. MRI studies revealed medial meniscal tears in 33 (75 %), and lateral meniscal tears in 10 (22.70 %) cases. Arthroscopy proved medial meniscal tears in 32 (72.70 %), and lateral meniscal tears in 10 (22.70 %), of the cases respectively. 3 false-positives and 2 false-negatives in the medial meniscal, and 2 false-positives and 2 false-negatives in the lateral meniscal series were detected. The sensitivity values were 93.75 % and 80 %, the specificity values were 75 % and 94.12 %, the accuracy values were 88.63 % and 90.90 %, the positive predictive values were 90.90 % and 80.80 %, and the negative predictive values were 81.81 % and 94.12 %, in the medial and lateral menisci, respectively. Our results have confirmed that low-field open MRI scanners are as effective as high-field ones in meniscal imaging and they may be used effectively and reliably in the diagnosis and evaluation of meniscal tears of the knee.

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