



Accuracy of low-field MRI on meniscal tears

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ABSTRACT. This study aimed to verify the accuracy of low-field-intensity magnetic resonance imaging (MRI) in diagnosing meniscus tears. A total of 171 patients were examined through low-field-intensity MRI to detect meniscus injuries. These patients were then diagnosed through arthroscopy. Examination results were recorded and compared. The accuracy of the diagnosis for internal and external meniscus tears through low-field-intensity MRI was 95.91% and 95.91%, respectively, the sensitivities were 95.60% and 96.47%, respectively, and the specificities were 96.25% and 95.35%, respectively. Low-field-intensity MRI is an accurate and cost-effective method for diagnosing meniscus tears.

Key words: Meniscus; Tibia; MRI; Arthroscopy; Low field Intensity

INTRODUCTION

Magnetic resonance imaging (MRI) is an advanced and non-invasive examination method that is used to diagnose meniscus injuries. MRI has high resolution for soft tissues and can conduct multiple-direction imaging at arbitrary angles. This method can clearly show not only the structures and lesions of the meniscus, but also the surrounding ligament injuries, muscle injuries, and bone contusions. Therefore, MRI is widely used to diagnose meniscus injuries. In addition, the diagnostic value of MRI has been affirmed by radiologists and physicians in orthopedics departments because of the satisfactory accuracy and sensitivity of the method. However, most of the studies on the sensitivity and specificity of MRI in examining meniscus tears have been conducted with high-field-intensity MRI (commonly 1.5 T) (De Smet et al., 1994; Takeda et al., 1998; Ballard and Campbell, 2008), and most patients cannot afford the costs related to such examinations. Some previous reports (Kersting-Sommerhoff et al., 1995; Bottcher et al., 2010) have shown that low-field-intensity MRI, as a newly developed examination method, can be similarly used to diagnose meniscus injuries. Because it removes the unnecessary structures shown in high-field-intensity MRIs, low-field-intensity MRI substantially reduces the examination costs, and it is appropriate for wide clinical applications. MRI equipment with a 0.2 T low-field intensity that was made especially for the limbs was purchased for this study to examine meniscus injuries. Validation was subsequently conducted through arthroscopy to determine the diagnostic accuracy of MRI, and thus identify the clinical value and prospects of this examination method.

MATERIAL AND METHODS

General data

A total of 171 patients underwent both MRI examination and knee arthroscopy from October 2009 to December 2011. These patients included 44 males and 127 females and ranged in age from 11 to 84 years old, with a mean age of 45.8 years. A total of 96 cases of left knee joints and 75 cases of right knee joints were found. The time intervals between the MRI examination and the operation ranged from 2 to 30 days, and the mean duration was 10.2 days. All patients showed varying extents of acute or chronic joint pain. Vital signs included joint space tenderness, interlocking, and McMurray sign (+).

MRI examination

Sagittal and coronal plane imaging examinations were conducted with the four-limb osteoarticular imaging diagnosis instrument, Artoscan M (Artoscan 0.2 T, Esaote; Genoa, Italy) for all cases in this study. Meniscus tear injuries were confirmed on the basis of one of the following MRI findings: 1) abnormal linear high signals in the meniscus extending onto the meniscus plane, 2) less obvious meniscus wideness than the normal value (except for discoid cartilage tear) and obvious low signals migrating toward the intercondylar carina direction, and 3) meniscus deficiency occurring at the meniscus tissue site. This study was conducted in accordance with the Declaration of Helsinki and with approval from the Ethics Committee of the Second Affiliated Hospital of Soochow University. Written informed consent was obtained from all participants.

Diagnosis by arthroscopy

Stryker TV was used to monitor the arthroscopy for all patients who underwent the MRI examination. The operations were conducted under block anesthesia of the subarachnoid space. An arthroscope was inserted from the anterior external, anterior internal, and patellar upper incisions of the knee joint. Examinations of the anterior and posterior angles and the body of the internal and external menisci were conducted on the basis of a routine examination sequence. The lesion sites indicated by MRI were also explored critically, and the examined results were recorded in detail. Partial, subtotal, and total resections were also performed for the injured menisci.

RESULTS

The MRI examination results and the arthroscopy findings were recorded in detail and compared (the arthroscopy findings were taken as comparison standards) to obtain the true positive, false positive, true negative, and false negative counts of the internal and external meniscus injuries. The accuracy, sensitivity, specificity, positive prediction value, and negative prediction value of the internal and external meniscus injuries were calculated and results are shown in Table 1.

Table 1. Comparison of low-field intensity MRI and arthroscopy (cases).

Injured parts	True positive	False positive (%)	True negative (%)	False negative (%)	Sensitivity value (%)	Specificity	Accuracy	Positive prediction	Negative prediction value (%)
Internal meniscus	87	3	77	4	95.60	96.25	95.91	96.67	95.06
External meniscus	82	4	82	3	96.47	95.35	95.91	95.35	96.47

DISCUSSION

In cases of knee joint meniscus tears, joint fluid infiltration increases the amount of local free hydrogen ions, and high-intensity signals are present in MRI examination. Conversely, in the normal meniscus, free hydrogen ions are lacking, and low-intensity signals are present in the MRI scanning sequence (Cruet et al., 1987; Englund et al., 2008). Meniscus injury types mainly include bucket handle tear (the lack of normal meniscus morphology at the sagittal site, and the injured meniscus can migrate into the intercondyloidea fossa), level tear (a tear parallel to the tibial plateau appears in the layer), oblique tear (the most common type, in which the strip tear and the tibial plateau form a certain angle), radial tear (the tear has a radial shape), and compound injury (all of the above manifestations appear as a compound injury (Jee et al., 2003; Van Dyck et al., 2007; Long et al., 2010), and the local interface signal contrast is obvious).

Numerous studies have also suggested that high-field-intensity MRI is sensitive, enabling the accurate detection of meniscus tears (De Smet, 2012). However, this type of examination is often too expensive for most patients. In the present study, we used a four-limb osteoarticular imaging diagnosis instrument that was first introduced in China to diagnose the 171 cases of meniscus injuries. Arthroscopy is considered the gold standard in diagnosing meniscus tears to verify the accuracy of MRI diagnoses. The results showed that low-field-

intensity MRI had high accuracy, specificity, and sensitivity in diagnosing meniscus injuries. These results agreed with our original expectation that using low-field-intensity MRI for clinical examinations could benefit patients.

Some studies (Kersting-Sommerhoff et al., 1995; Franklin et al., 1997) compared the accuracy of low-field-intensity MRI for meniscus tear diagnosis with that of medium and high-intensity MRIs. Low-field-intensity MRI was found to provide sensitivity that was equivalent to or better than that of other MRIs.

Low-field-intensity MRI reduced the external interference caused by the excessive sensitivity of high-field-intensity MRI to fat, vessels, movements, and local tissue chemical changes, which potentially increased the diagnostic specificity and eliminated the emergence of false positive results. Therefore, low-field MRI showed advantages over high-field-intensity MRI. The present study confirmed this finding. Furthermore, low-field-intensity MRI is superior to high-field-intensity MRI in specific examinations (Kersting-Sommerhoff et al., 1995; Bottcher et al., 2010).

In this study, 7 cases were false positives. Meniscus tears were diagnosed because of the high signals generated around the ligamenta transversum genu (2 cases), popliteal muscle tendon sheath (1 case), and posterior menisiofemoral ligament (3 cases), and high signals were generated by the healed scar in 1 case with a peripheral tear of the meniscus. Errors in the experimental results are inevitable in this type of study because it was not a 'double blind' design, and the different radiologists and physicians involved in the orthopedics department have varying levels of clinical expertise and judgment abilities. Therefore, familiarizing oneself with the anatomical structures of the knee joint, understanding the running directions of the transverse and menisiofemoral ligaments, and shortening the time interval between the operation and the MRI examination are all necessary to eliminate false positive results. These injuries, especially the tears in the 1/3 blood supply area outside of the meniscus, would otherwise heal without treatment (Polly et al., 1988; Vaz et al., 2005; Ahn et al., 2012; Hegenscheid et al., 2012). A total of 2 cases of bucket handle tears and 2 cases of posterolateral corner injuries of the meniscus from the 7 false negative cases were misread by the radiologists and were not found through MRI. One case of a meniscus peripheral tear of the adjacent popliteal muscle tendon sheath, and 2 cases of typical lamellar meniscus tears were also not found. Therefore, poor knowledge of the radiologists diagnosing through MRI images can result in false positives or negatives. The practice level of the physicians conducting the arthroscopic operation also affects the percentage of false positives. For example, finding the internal posterior angle tears of the meniscus and the lower and edge tears of the meniscus is generally difficult. Finally, a true positive can be misread as a false positive, which increases the false positive rate (Khanda et al., 2008; Behairy et al., 2009). The consequences of a false positive finding are serious and can cause unnecessary arthroscopy or arthrotomy, which increases operation pains and economic burden for patients. Various possible complications could be generated because of unnecessary operations (De Smet and Tuite, 2006; Kijowski et al., 2011; Tokuda et al., 2012).

In this study, MRI equipment with a 0.2 T low-field intensity that was made especially for the limbs was purchased to examine meniscus injuries. Arthroscopy was then used in determining the diagnostic accuracy of MRI to evaluate the clinical value and prospects of this examination method. Our conclusion agrees with those of previous studies (Kersting-Sommerhoff et al., 1995; Bottcher et al., 2010). Low-field-intensity MRI substantially reduces examination costs by about 50%. It is also appropriate for wide clinical applications because

low-field-intensity MRI removes the unnecessary structures present in high-field-intensity MRI. Low-field-intensity MRI can accurately diagnose various types of meniscus injuries, since the radiologists are familiar with the anatomical structure of the knee joint, thoroughly understand the features of MRI, and reasonably apply the imaging parameters. Therefore, low field-intensity MRI can ultimately replace high-field-intensity MRI.

This study was limited to the examination and diagnosis of meniscus injuries. We will verify the clinical diagnostic value of MRI for skeletons, ligaments, articular cartilages, vessels, nerves, tendons, spinal cord lesions, and other structures in our future studies. The examination results will be compared with those of high-field-intensity MRI for use in clinical applications.

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