10.2478/abm-2010-0029

Asian Biomedicine Vol. 4 No. 2 April 2010; 215-222

Original article

Magnetic resonance imaging in the evaluation of meniscal tear

Numphung Numkarunarunrote[a], Anoma Sanpatchayapong[a], Pongsak Yuktanandana[b], Somsak Kuptniratsaikul[b]
[a]Department of Radiology, [b]Department of Orthopaedics, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand

Background: Magnetic resonance imaging (MRI) has been recognized as the imaging method for non-invasive evaluation of knee pathology, particular meniscus and ligaments.
Objective: Compare the sensitivity, specificity, and accuracy of MRI in the detection of meniscal tears with arthroscopy.
Material and methods: Twenty-seven patients who were diagnosed as meniscal tear on arthroscopy with preoperative MRI were included in this study between January 2003 and June 2008. MRI was performed with a 1.5 Tesla Signa Horizon Echospeed MRI for eight patients between January 2003 and June 2005 and a 1.5 Tesla Signa Excited HD MRI for nineteen patients between July 2005 and June 2008. The location of meniscal tear was evaluated by studying three areas: anterior horn, body and posterior horn. Sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of the anterior horn, body, posterior horn and overall meniscus were calculated.
Results: The sensitivity of MRI for detecting meniscal tears at the anterior horn, body, posterior horn, and overall medial meniscus was 42.9%, 87.5%, 94.1%, and 81.3%, respectively. The specificity was 95.0%, 84.2%, 81.8%, and 88.0%, respectively. The accuracy was 81.5%, 85.2%, 89.3%, and 85.4%, respectively. The PPV was 75.0%, 70.0%, 88.9%, and 81.2%, respectively. The NPV was 82.6%, 94.1%, 90.0%, and 88.0%, respectively. The sensitivity of MRI for detecting meniscal tears at the anterior horn, body, posterior horn and overall lateral meniscus was 0%, 100%, 85.7%, and 80.0%, respectively. The specificity was 100%, 100%, 90.5% and 97.2%, respectively. The accuracy was 96.0%, 100%, 90.5%, and 97.2%, respectively. The PPV was 100%, 75% and 80%, respectively. The NPV was 96.3%, 100%, 95.0%, and 97.2%, respectively.
Conclusion: MRI is a helpful technique to detect meniscal tear with different sensitivity and accuracy on the meniscal location.

Keywords: Arthroscopy, magnetic resonance imaging, meniscal tears

Magnetic resonance imaging (MRI) has been recognized as the best imaging method for non-invasive evaluation of knee pathology for two decades [1-3]. MRI can detect intra-articular soft tissue structures such as meniscus and other ligaments of the knee. Meniscal tears are a common abnormality that led to knee pain and is a frequent indication for knee arthroscopy [4]. Arthroscopy has been used as the gold standard and acts as reference in assessing other diagnostic tools. Previous literature reviewed accuracy of MRI in the evaluation of meniscal tears compared to arthroscopy. It ranged from 72.0-93.6% in lateral meniscal tears and 72.0-95.3% in medial meniscal tears [5-10].

In this study, we determined the accuracy of magnetic resonance imaging for the evaluation of meniscal tears performed at King Chulalongkorn Memorial Hospital. All patients underwent MRI and subsequent arthroscopy within one year. We analyzed the accuracy, common location and the common associated findings of meniscal tears.

Material and methods

This study was approved by the Ethics Committee of the Faculty of Medicine, Chulalongkorn University. The requirement for informed consent was waived.

Correspondence to: Numphung Numkarunarunrote, Department of Radiology, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand. E-mail: numphung36@yahoo.com

We retrospectively reviewed case notes of patients who were diagnosed as meniscus tear by arthroscopy with preoperative MRI between January 2003 and June 2008. We excluded patients whose operative notes and/or magnetic resonance imaging were incomplete or missing and those who had a time interval between preoperative MRI and arthroscopy of more than one year.

Between January 2003 and June 2005, MRI was performed with a 1.5 Tesla Signa Horizon Echospeed MRI with a knee coil for eight patients. The studies consisted of sagittal oblique spin echo proton density-weighted (TR/TE, 2140/30), sagittal oblique spin echo T2-weighted (TR/TE, 2140/90), coronal oblique spin echo T1-weighed (TR/TE, 540/10), coronal oblique fast spin echo T2-weighted with fat suppression (TR/TE, 5600/90), and axial fast spin echo proton density-weighted with fat suppression (TR/TE, 3600/13). MRI parameters were field of view, 14-16 cm; excitation range, 2-3; matrix size range, 256 x 192-224; section thickness, 4.0 mm; and inters lice gap, 2.0 mm.

In the remaining 19 patients, MRI was performed with a 1.5 Tesla Signa Excited HD MRI with a knee coil between July 2005 and June 2008. The studies consisted of sagittal oblique fast spin echo proton density-weighted (TR/TE, 3340/29.9), sagittal oblique fast spin echo T2 weighted with fat suppression (TR/TE,4300/80.6), coronal fast spin echo T1-weighted (TR/TE, 500/16.7), coronal fast spin echo T2 weighted with fat suppression (TR/TE, 4220/89.3), coronal oblique MPGR (TR/TE, 700/17) and axial fast spin echo proton density-weighted with fat suppression (TR/TE, 2960/23.8). parameter were field of view, 16-18 cm; excitation range, 2-3; matrix size range, 320-384 x 192-256; section thickness, 3.5 mm; and inters lice gap, 0.5 mm.

A meniscal tear was identified by MRI as with the one following criteria:

1. High intrameniscal signal extending to the superior or inferior surface of meniscus.

2. Foreshortening or absence of meniscus with or without visualized displaced fragment.

The location of meniscal tears was dividing into three areas: anterior horn, body and posterior horn of lateral, and medial meniscus in magnetic resonance imaging and arthroscopy.

The imaging was retrospectively evaluated by a musculoskeletal radiologist and a third-year radiology resident without knowing the athroscopic findings.

Two experienced orthopedists performed the arthroscopic procedure. The meniscal tear was considered to be torn if the tear can be displaced by probing. After arthroscopy, the orthopedists or attending orthopedic residents recorded the appearance and location of meniscal tear and other important findings in the operative note. We collected the data from the operative notes, verbal report from attending orthopedists or attending orthopedic residents or intraoperaitve videotapes.

We used the arthroscopy as the gold standard for the diagnosis of meniscal tears and for comparing the sensitivity of MRI. The MRI was considered true positive when it indicated meniscal tears and the tear is proven surgically and true negative when it indicates no tear and there is no tear on arthroscopy. It is false positive when it indicated tear and there is no tear on arthroscopy. It is false negative when it indicated no tear and there is tear on arthroscopy. From these results, sensitivity, specificity, accuracy, positive predictive value, and negative predictive value were calculated

Results

Twenty-seven patients were included in this study. Twenty-two patients were male and five patients were female. The age ranged from 18 to 74 years. The average age is 40.3 years. The MRI was completed between five days and 315 days before the arthroscopy (85.8 days in average).

We collected the data from operative notes for fifteen patients. In the rest 12 patients, we received the data from operative notes and verbal reports by the orthopedists or attending orthopedic residents. We also obtained additional intra-oprative videotapes of four patients.

MRI revealed 32 tears in the medial meniscus (76.0%) and 10 tears in the lateral menicus (24.0%) in twenty-seven patients. For 32 tears in medial meniscus, four were located at the anterior horn (10.0%), ten were located at the body (24.0%), and 18 were located at the posterior horn (43.0%). For ten tears in the lateral meniscus, two were located at the body (5.0%) and eight were located at the posterior horn (19.0%).

Arthroscopy revealed 32 tears of the medial meniscus (76.0%) and 10 tears of the lateral meniscus (24.0%) found in 27 patients. For 32 tears in the medial meniscus, seven were located at the anterior horn (17.0%), eight were located at the body (19.0%) and seventeen were located at the posterior horn (40.0%).

For ten tears in lateral meniscus, one was located at the anterior horn (2.0%), two were located at the body (5.0%) and seven were located at the posterior horn (17.0%).

Tears at the anterior horn of medial meniscus

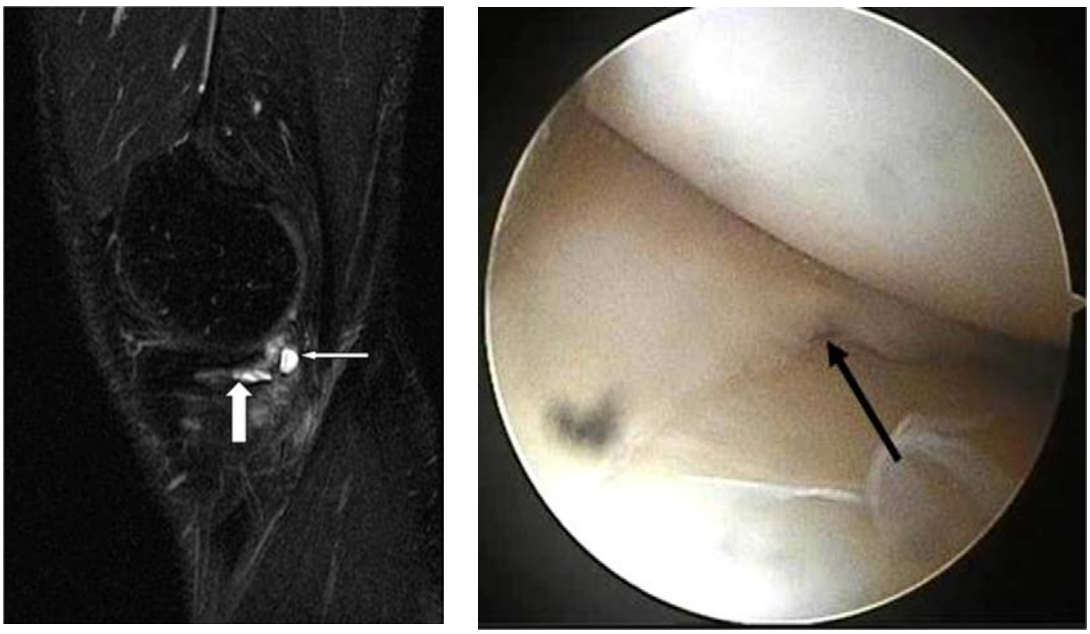
In seven patients, seven meniscal tears were found on arthroscopy, while MRI found three meniscal tears only. There were four false negative meniscal tears. One of four false negative meniscal tears was described in the operative note as a minimal tear. In another patient, a meniscal tear was found as flap tear on MRI, but not found on arthroscopy. In the remaining nineteen patients, there was no meniscal tear on MRI or arthroscopy.

Tears at the body of the medial meniscus

In eight patients, eight meniscal tears were found on arthroscopy, while MRI found only seven meniscal tears only. There was one false negative meniscal tear. In three patients, three meniscal tears were found on MRI, but not on arthroscopy. These false positive tears are characterized as horizontal tears on MRI. In the remaining sixteen patients, there was no meniscal tear on MRI and arthroscopy.

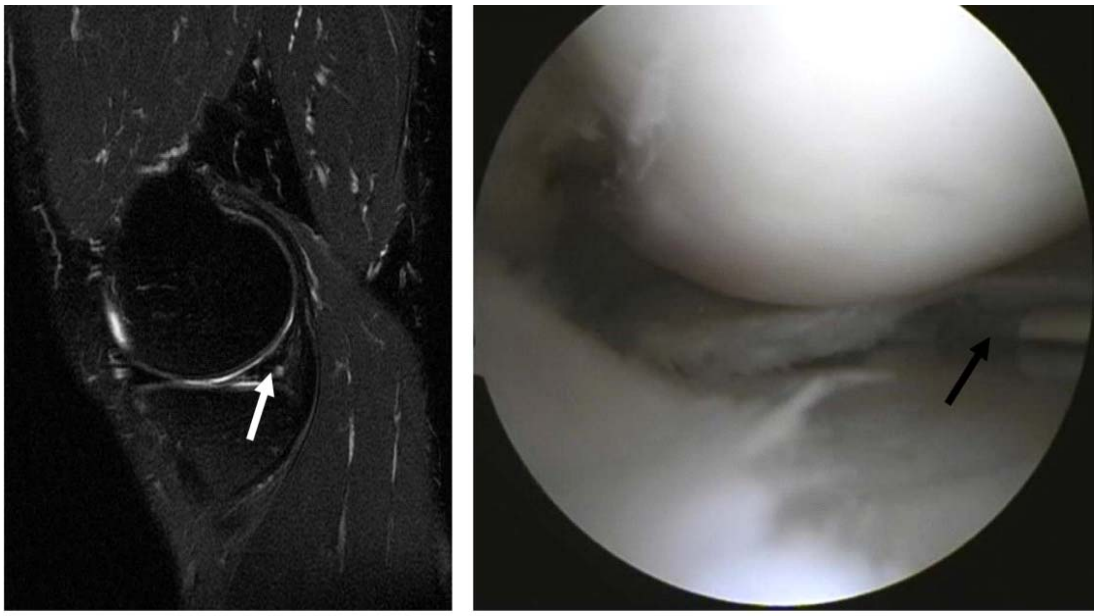
Tears at the posterior horn of the medial meniscus

In 16 patients, 16 meniscal tears were found on both MRI and arthroscopy (**Fig. 1** and **2**). In one of these 16 patients, one more meniscal tear was found on arthroscopy, but not found on MRI. Therefore, there was one false negative meniscal tear. It was described as small oblique tear on arthroscopy. In two other patients, two meniscal tears were found on MRI, but not found on arthroscopy. Two false positive tears were characterized as a flap tear and a horizontal tear. In remaining nine patients, there was no meniscal tear on MRI and arthroscopy.



(a) **(b)**

Fig. 1 A 53-years-old man. (**a**) A high intrameniscal signal extending to the inferior surface at posterior horn of medial meniscus on sagittal T2-weighted image with fat suppression (thick white arrow). (**b**) Knee arthroscopy demonstrating a meniscal tear (indicated by a black arrow) at the same region. Parameniscal cysts adjacent to torn meniscus on sagittal T2-weighted image with fat suppression (thin white arrow) was seen in (**a**).



(a) **(b)**

Fig. 2 A 52-years-old man. There was high intrameniscal signal extending to articular surface (indicated by a white arrow) at posterior horn of medial meniscus on sagittal T2-weighted image with fat suppression (**a**). Knee arthroscopy showed meniscal tear (indicated by a black arrow) at the same region (**b**).

The sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of MRI for detecting medial meniscal tears are demonstrated in **Table 1**. The sensitivity of MRI for detecting medial meniscal tears at the anterior horn, body, posterior horn, and overall medial meniscus is 42.9%, 87.5%, 94.1%, and 81.3%, respectively. The specificity is 95%, 84.2%, 81.8%, and 88%, respectively. The accuracy is 81.5%, 85.2%, 89.3%, and 85.4%, respectively. The PPV is 75%, 70%, 88.9%, and 81.2%, respectively. The NPV is 82.6%, 94.1%, 90%, and 88%, respectively.

Tears at the anterior horn of the lateral meniscus

In one patient, arthroscopy revealed one tear whereas MRI found no tear. This was a false negative meniscal tear. In another twenty-six patients, meniscal tear was not found in both MRI and arthroscopy.

Tears at the body of the lateral meniscus

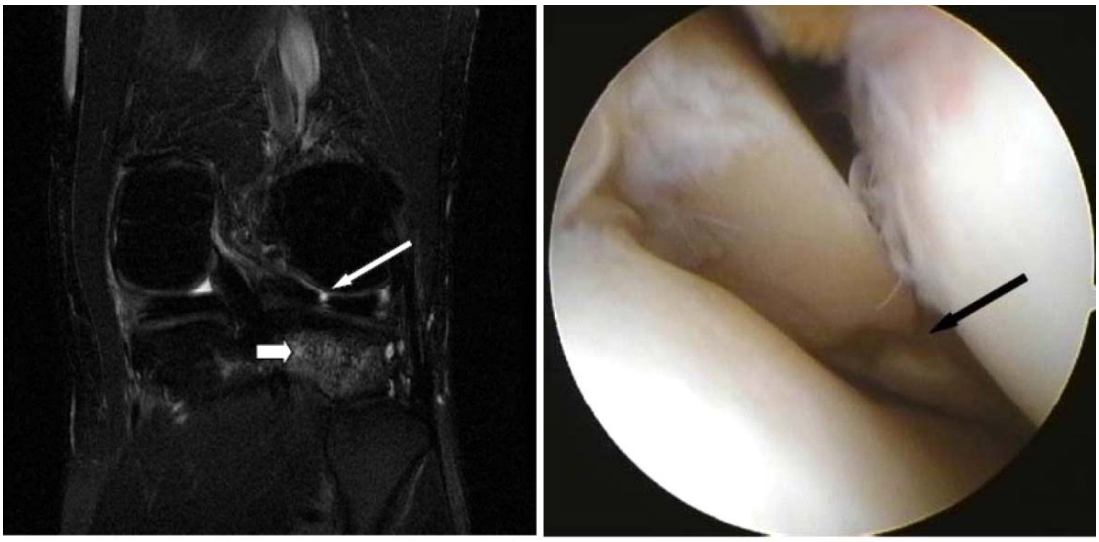
In two patients, two meniscal tears were found on MRI and arthroscopy. In another twenty-five patients, meniscal tear was not found on MRI and arthroscopy.

Tears at the posterior horn of the lateral meniscus

In seven patients, seven meniscal tears were found on arthroscopy while MRI found only six tears (**Fig. 3**). There was one false negative tear. In one of these seven patients, we also found another tear on MRI that was not found on arthroscopy. In another patient, one meniscal tear were seen on MRI while not seen on arthroscopy. In total, there were two false positive tears on the posterior horn of the lateral meniscus. These false positive tears were characterized as vertical longitudinal tears (and oblique tear. In the remaining nineteen patients, no meniscal tear was found on MRI and arthroscopy.

Table 1. Sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of MRI for medial meniscus.

	Sensitivity	Specificity	accuracy	PPV	NPV
Anterior horn	42.9%	95.0%	81.5%	75.0%	82.6%
Body	87.5%	84.2%	85.2%	70.0%	94.1%
Posterior horn	94.1%	81.8%	89.3%	88.9%	90.0%
Total	81.3%	88.0%	85.4%	81.2%	88.0%



(a) (b)

Fig. 3 A 21-years-old male. On coronal T2-weighted image with fat suppression (**a**) revealed radial tear at posterior of lateral meniscus (indicated by a thin white arrow). Knee arthroacopy (**b**) demonstrated a meniscal tear (indicated by a black arrow) at the same region. Bone bruise (thick white arrow) at posterioraspect of proximal tibia on coronal T2-weighted image with fat suppression (**a**) was shown.

The sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) of MRI for detecting lateral meniscal tears are demonstrated in **Table 2**. The sensitivity of MRI for detecting lateral meniscal tear at the anterior horn, body, posterior horn and overall lateral meniscus is 0%, 100%, 85.7% and 80.0%, respectively. The specificity is 100%, 100%, 90.5%, and 97.2%, respectively. The accuracy is 96.0%, 100%, 90.5%, and 97.2%, respectively. The PPV is -, 100%, 75.0%, and 80.0%, respectively. The NPV is 96.3%, 100%, 95.0%, and 97.2%, respectively.

Associated knee abnormalities on MRI findings that were identified included anterior cruciate ligament injury in 41.0% (11/27), posterior cruciate ligament injury in 7.0% (2/27)medial collateral injury in 48.0% (13/27), joint effusion in 70.0% (19/27), bone bruise in 33.0% (9/27), chondromalacia in 37.0% (10/27), meniscus cysts in 11.0% (3/27), discoid meniscus 7.0% (2/27), ganglion cyst in 7.0% (2/27) and baker cyst in 11.0% (3/27), meniscus extrusion in 4.0% (1/27).

Discussion

The meniscus protects the articular cartilage by acting as a buffer between the articular surfaces of the femur and tibia. The meniscus transmitted axial and torsional forces across the knee joint. The mobile menisci also transmit 50-90% of the load over the knee joint, depending on knee flexion angle, femoral translation, and rotation. The meniscus contributes to knee joint proprioception and probably to joint stability [11].

Meniscus injury or meniscal tear could occur from traumatic event on the knee, such as twisting, squatting, or cutting. Other cause is normal force on a degenerated meniscus, which also results in meniscus tear. This type tend of injury tends to occur in older people [12, 13]

Table 2. Sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of MRI for detecting lateral meniscus tear.

	Sensitivity	Specificity	accuracy	PPV	NPV
Anterior horn	0%	100%	96.0%	-	96.3%
Body	100%	100%	100%	100%	100%
Posterior horn	85.7%	90.5%	89.3%	75.0%	95.0%
Total	80.0%	97.2%	95.1%	80.0%	97.2%

According to the previous review [14], the most common location of meniscal tears was the posterior horn of meniscus. In our study, we also found that the posterior horn of medial meniscus was the most common location of meniscal tear. The second most common location of meniscal tear was the body of the medial meniscus. The least common location is anterior horn of lateral meniscus.

Diagnosis of meniscal tear is based on clinical history, physical examination, plain radiography and MRI. In our knowledge, increased signal intensity extends to articular surface of meniscus, foreshortening of meniscus and displaced meniscal fragment was the MRI findings that diagnosed to meniscal tear [15-17]. Currently, MRI has proven to be accuracy in evaluating meniscal tear ranging from 72.0-93.6% in lateral meniscal tear and ranging from 72.0-95.3% in medial meniscus tear compare to arthroscopy [5-9].

In our study, the sensitivity, specificity, and accuracy of the MRI was 81.3%, 88.0%, and 85.4% for the medial meniscus and 80.0%, 97.2%, and 95.1% for the lateral meniscus. This finding is consistent with other studies in previous mentioned literatures.

About the medial meniscus, the sensitivity of meniscal tear at anterior horn was lowest (42.9%), and at posterior horn was highest (94.1%). The specificity of anterior horn was highest (95.0%) and at posterior horn was lowest (81.8%). About the lateral meniscus, the sensitivity of meniscal tear at anterior horn was lowest (0%) and at body was highest (100%). The specificity of anterior horn and body was highest (100%) and at posterior horn was lowest (89.5%).

The zero percent of sensitivity of anterior horn at lateral meniscus may not be quite reliable because there was only one meniscal tear at that region. Our sample size was too small to detect sensitivity on anterior horn of lateral meniscus. Therefore, we rather believed that if there were more samples, sensitivity should increase.

According to Quin and Brown [18], MRI can miss small meniscal tears. In our study, the two false negative tears at anterior horn of medial meniscus and at posterior horn of lateral meniscus were described on arthroscopy as small tears. We claimed these two false negative tears were caused by limitation of the MRI in the detection of small meniscal tear, similar to Quin and Brown. For the rest six false negative tears, there was no explanation about the size of meniscal tears on operative notes. However, we believe they are missed by MRI because their sizes were small. The low sensitivity of anterior horns of meniscus may due to these small missed tears, which tend to occur on anterior horn more than other location.

Most false positive tears in our study were found on the posterior horn of the meniscus (50%). This was similar to Mink et al. [19]. They reported 47 false-positive results with MRI, 70% of which were in the posterior horn. Previous literature found two possible causes for these false-positive findings. The first cause may be that some meniscal tears are missed at arthroscopy. After reviewing arthroscopy videotapes, Quinn and Brown [18] noted that the arthroscopists often were unable to visualize directly areas of menisci that appeared to be torn on MRI images. These areas of the menisci could be evaluated only indirectly with a probe, and thus tears that were present and seen on MRI images may not be detected by the arthroscopist. A second cause for apparent false-positive findings on MRI images may be that healed tears can have persistent MRI signal that extends to the meniscal surface. According to Fischer et al. [20], they found healed tears in seven menisci that had MRI signal contacting the meniscal surface. Other investigators have shown that surgically repaired menisci may have signals contacting the surface after the tear has healed [21, 22]. In our study, we found two false positive tears that characterized as flap tears with medially displaced of meniscal fragment. Berg et al. [23] explained cause of false positive of this type of tear. They suggested osteophytes, ligament fragments, and loose bodies may mimic displaced meniscal fragment.

About associated knee abnormality by MRI findings, joint effusion was the most common finding. The other common findings were anterior cruciate ligament injury, posterior cruciate ligament injury, medial collateral ligament injury, bone bruise, chondromalacia, meniscus cyst, discoid meniscus, ganglion cyst, and Baker cyst. These associated knee abnormality were also reported previously [15, 21-28].

Despite the fact that this study has a limitation due to small number of patients, we believe it could become a baseline and give guidance for further studies.

Conclusion

Magnetic resonance imaging (MRI) was a helpful technique to detect meniscal tear depending on various sensitivity and accuracy from the meniscal location.

Acknowledgements

The authors would like to thank technician-team of MRI unit in the Department of Radiology of King Chulalongkorn Memorial Hosipital.

The authors have no conflict of interest to report.

References

1. Glashow JL, Katz R, Schneider M, Scott N. Double blind assessment of the value of magnetic resonance imaging in the diagnosis of anterior cruciate and meniscal lesions. J Bone Joint Surg (Am). 1989; 71: 113-9.
2. Fischer SP, Fox JM, Del PW, Friedman MJ, Snyder SJ, Ferkel RD. Accuracy of diagnoses from magnetic resonance imaging of the knee. J Bone Joint Surg (Am). 1991; 73:2-10.
3. Heron CW, Calvert PT. Three-dimensional gradient-echo MR imaging of the knee. Comparison with arthroscopy in 100 patients. Radiolology. 1992; 183: 839-44.
4. Scott WN. The knee. Missouri (USA):Mosby; 1994. p. 527.
5. Raunest J, Oberle K, Loehnert J, Hoetzinger H. The clinical value of magnetic resonance imaging in the evaluation of meniscal disorders. J Bone Joint Surg (Am). 1991; 73:11-6.
6. Winter K, Tregnning R. Reliability of magnetic resonance imaging for traumatic injury of the knee. New Zealand Medical J. 2005; 118:1-8.
7. Nikolaou VS, Chronopoulos E, Savvidou C, Plessas S, Giannoudis P, Efstathopoulos N, et al. MRI efficacy in diagnosing internal lesions of the knee: a retrospective analysis. J Trauma Manag Outcomes. 2008; 2:4.
8. Rappeport ED, Wieslander SB, Stephensen S, Lausten GS, Thomsen HS. MRI preferable to diagnostic arthroscopy in knee joint injuries. Acta Orthop Scand. 1997; 68:277-81.
9. Vaz DE, Camargo OP, Santana PJ, Valezi AC. Accuracy of magnetic resonance in identifying traumatic intraarticular knee lesions. Clinics. 2005; 60:445-50.
10. Aagaard H, Verdnj R. Function of the normal meniscus and consequences of meniscal resection. Scand J Med Sci Sports. 1999; 9:134-40.
11. Cannon WD, Morgan CD. Meniscal repair: II. Arthroscopic repair technique. J Bone Joint Surg. 1994; 76:294.
12. Hough AJ, Webber RJ. Pathology of the meniscus. Clin Orthop Relat Res. 1990; 252:32-40.
13. Canale ST, Beaty JH. Campbell's operative orthopaedics 11th ed. Pensylvania (USA):Mosby & Elsevier; 2008. p. 2421.
14. Stoller DW, Martin C, Crues JV, Kaplan CL, Mink JH. Meniscal tears: pathologic-correlation with MR imaging. Radiology. 1987; 163:731-5.
15. Wright DH, De Smet AA, Norris M. Bucket-handle tears of the medial and lateral menisci of the knee: value of MR imaging in detecting displaced fragments. Am J Radiology. 1995; 165:621-5.
16. Lecas LK, Helms CA, Kosarek FJ, Garret WE. Inferiorly displaced flap tears of the medial meniscus: MR appearance and clinical significance. Am J Radiology. 2000; 174:161-4.
17. Quinn SF, Brown TF. Meniscal tears diagnosed with MR imaging versus arthroscopy: how reliable a standard is arthroscopy. Radiology. 1991; 181:843-7.
18. Mink JH, Levy T, Creus JV. Tears of the anterior cruciate ligament and menisci of the knee: MRI imaging evaluation. Radiology. 1988; 167:769-74.
19. Fischer SP, Fox JM, Del PW, Friedman MJ, Snyder SJ, Fenkel RD. Accuracy of diagnoses from magnetic resonance imaging of the knee. J Bone Joint Surg. 1991; 73:2-10.
20. Fischer SP, Fox JM, Del PW, Friedman MJ, Snyder SJ, Fenkel RD. Accuracy of diagnoses from magnetic resonance imaging of the knee. J Bone Joint Surg. 1991; 73:2-10.
21. Wright DH, De Smet AA, Norris M. Bucket-handle tears of the medial and lateral menisci of the knee: value of MR imaging in detecting displaced fragments. Am J Radiology. 1995; 165:621-5.
22. Berg BV, Melghem J, Poilvache P, Maldague B, Lecouvet FE. Meniscal tears with fragments displaced in notch and recesses of knee: MR imaging with arthroscopic comparison. Radiology. 2005; 234:842-50.
23. Campbell SE, Sanders TG, Morrison WB. MR imaging of meniscal cyst: incidence, location, and clinical significance. Am J Radiology. 2001; 177:409-13.
24. Keene GC, Bikerstaff D, Rae PJ, Paterson RS. The natural history of meniscal tears in anterior cruciate ligament insufficiency. Am J Sports Med. 1993; 21: 672-9.
25. Paletta GA, Levine DS, O'Brien SJ, Wickiewicz TL. Patterns of meniscal injury associated with acute anterior cruciate ligament injury in skiers. Am J Sports

Med. 1992; 20:542-7.
26. Beall DP, Googe JD, Moss JT, Ly JQ, Greer BJ, Stapp AM, Martin HD. Magnetic resonance imaging of the collateral ligaments and the anatomic quadrants of the knee. Radiologic Clinics North America. 2007; 45: 983-1002.
27. Tarhan NC, Chung CB, Mohana-Borges AV, Hughes T, Resnick D. Meniscal tears: role of axial MRI alone and in combination with other imaging planes. Am J Radiology. 2004; 183:9-15.