False-Negative Meniscal Tear in MR Imaging Using Non Fat-Suppressed Techniques

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Abstract

Magnetic resonance (MR) imaging of menisci has a diagnostic accuracy of more than 90 per cent when the images are properly obtained. Errors in the interpretation of MR images may be related to many problems, resulting in false positive or false negative readings. We conducted this study to evaluate the prevalence of false negative results, using arthroscopy as gold standard. Matched MR imaging (performed before July 1997) and arthroscopic findings of the menisci in 63 consecutive patients were retrospectively reviewed separately by imaging planes and sequences used, by the site of tear, and by the site of meniscus (medial or lateral meniscus). The number and percentage of false-negative results were recorded. We found that with non fat-suppressed MR techniques, missed tear (false negative reading) of both menisci occurred predominantly in the meniscal body. The prevalence depends on imaging plane and sequence used. Among the techniques reviewed, sagittal T2-weighted (T2W) sequence had the highest prevalence of undetected meniscal tear.

Key word : Meniscus, MR Imaging, False-Negative

JAOVISIDHA S, POOKARNJANAMORAKOT C, APIYASAWAT P, ROJANAPLAKORN P, SIRIWONGPAIRAT P
J Med Assoc Thai 2001; 84: 242-246

Although the mean accuracy in the diagnosis of tears of each meniscus was 92 per cent (1), some errors still existed. Causes of false-positive magnetic resonance (MR) imaging interpretations included truncation artifact(2), vacuum phenomenon(3), the magic angle phenomenon(4), increased conspicuity of intrameniscal signal intensity (SI) at gradient echo imaging(5), misinter-

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pretation of normal anatomic structures and anatomic variants[6], and false-positive interpretation due to partial meniscectomy or changes after meniscal repair[7-10].

Many false-negative findings were of subtle tear of the peripheral posterior horns. These tears were particularly common on the lateral meniscus and were associated with tear of anterior cruciate ligament (ACL)[11]. This present study evaluated false-negative MR imaging findings of the menisci separately by parameters used and site of tear of each meniscus.

MATERIAL AND METHOD

Matched MR imaging and arthroscopic findings of the menisci in 63 consecutive patients were retrospectively reviewed separately by imaging planes and sequences used, by the site of tear (anterior horn, body [middle horn], or posterior horn), and by the site of meniscus (medial or lateral meniscus). The number and percentage of false-negative results were recorded. MR images were reviewed by a radiologist who had 5 years experience in musculoskeletal MR imaging (S.J.). Arthroscopy was performed by one orthopedic surgeon (C.P.) and was used as gold standard in this study.

All patients had undergone MR imaging before July 1997 with a 1.5-Tesla (T) superconducting imager (GE Medical Systems, Milwaukee, WI), with an extremity coil (GE Medical system) using the following techniques: sagittal spin-echo imaging in T1-weighted (T1W), proton-density (PD), and T2W imaging (400/17 ; 3600/20, 100 [repetition time/echo time msec]), section thickness 3 mm with a 1-mm section gap, matrix 256x192, three signal acquired ; coronal spin-echo imaging in T1W (450/60) and gradient-recalled echo (GRE) imaging (740/20; flip angle 25 degree), section thickness 3 mm with a 1-mm section gap, 256x192 matrix, three signal acquired.

Criteria for diagnosis of a tear were as follows: (*a*) presence of an area of increased intrameniscal SI that unequivocally touched a meniscus surface ; (*b*) contour irregularities with and without areas of increased SI (this included truncation of the meniscal apex); and (*c*) displacement of meniscal fragments[12].

RESULTS

Sixty-three consecutive patients (30 males and 33 females, aged from 18-65 years) were included. The interval between MR imaging and arthroscopy was 7-66 days. The indications for arthroscopy were ACL injury (n = 21), tear of one meniscus (n = 20), ACL injury with tear of one meniscus (n = 14) and knee pain not improved with conservative treatment (n = 8).

Table 1 reveals the number and percentage of missed meniscal tears by location and MR sequences used. For both menisci; the missed tear occurred predominantly at the meniscal body

Table 1. Percentage of undetected (false negative) meniscal tear.

	Anterior horn	Body	Posterior horn
Medial meniscus			
Sagittal T1	53 / 1 [1.9] [a,b]	53 / 2 [3.8]	19 / 0 [0]
Sagittal PD	40 / 1 [2.5]	38 / 1 [2.6]	17 / 0 [0]
Sagittal T2	60 / 1 [1.7]	55 / 3 [5.5]	33 / 1 [3.0]
Coronal T1	54 / 1 [1.9]	42 / 1 [2.4]	29 / 0 [0]
Coronal T2GRE	52 / 0 [0]	37 / 1 [2.7]	28 / 1 [3.6]
Lateral meniscus			
Sagittal T1	48 / 1 [2.1]	47 / 2 [4.3]	23 / 0 [0]
Sagittal PD	41 / 1 [2.4]	37 / 1 [2.7]	26 / 0 [0]
Sagittal T2	53 / 2 [3.8]	52 / 3 [5.8]	48 / 2 [4.2]
Coronal T1	47 / 1 [2.1]	39 / 1 [2.6]	39 / 0 [0]
Coronal T2GRE	48 / 1 [2.1]	41 / 1 [2.4]	42 / 1 [2.4]

[a] Number of cases read as normal in MR imaging / number of cases with tear detected by arthroscopy (false-negative MR finding) [percentage].

[b] In some cases, the tear involved more than one part of meniscus.

(middle horn), both at the inner (central) and peripheral portion. About 40 per cent of the tears were small and surgical manipulation was not required. Sagittal T2W sequence showed the highest percentage of missed lesion.

DISCUSSION

For tear of the lateral meniscus not detected at MR imaging, many occurred in the inner half of the menisci[13,14]. Justice et al[12], in the study of 561 arthroscopically proven MR imaging, reported that their largest category of errors was false negative findings of tears of the body and posterior horn of the lateral meniscus. Quinn et al[15] reported that among their 32 cases of false-negative MR imaging ; 62.5 per cent occurred in the posterior horn, 22 per cent in the body, 15.5 per cent in the anterior horn; 59 per cent occurred in the lateral meniscus and 41 per cent in the medial meniscus. Seventeen per cent[12] and 47 per cent[15] of undetected tears were small and stable and partial meniscectomy was not required. However, some authors[11] stated that one type of false-negative finding of lateral meniscus was subtle tear of the peripheral posterior horns, which was associated with tear of the ACL. This present study corresponds to these reports. We found that the majority of false-negative findings of the lateral meniscus were at the meniscal body (middle horn), both at the inner (central) and peripheral portion, ranging from 2.4-5.8 per cent depending on the plane and sequence used. False-negative readings were more common than false-positive readings in the lateral meniscus[13,16] approximately three to one. Up to 11 per cent of all lateral meniscal tears were not visible by MR imaging even in retrospect[17].

For medial meniscus; false-negative and false-positive interpretations were equally common [12,13], and most of the missed medial tears were small, stable, and did not require treatment. Four per cent of medial meniscal tear could not be found retrospectively[18]. Our study revealed missed medial tears in the meniscal body (2.4-5.5%), posterior horn (0-3.6%), and anterior horn (0-2.5%) in order of prevalence, respectively.

This present study also found that among all sequences and planes of imaging used, sagittal T2W sequence had the highest incidence of undetected tear of the meniscus. This is not an unexpected finding, because most abnormal meniscal signals are recognized on short-TE images without corresponding abnormality on T2W images[13]. However, if the high signal persists on T2W images, a tear can be diagnosed with higher specificity.

The limitations of this study were the limited imaging sequences. We did not review the images with fat suppression. If fat is inhomogeneously suppressed, it is more difficult to interpret than those without fat suppression. Additionally, with a low field (0.064 T) or mid field (0.3 to 0.5 T) MR machine, there is more chance to obtain inhomogeneously fat-suppressed images than with a high-field machine (1.0-2.0 T). However, fat-suppressed techniques are now routinely used in MR knee study in our hospital.

In conclusion, with non fat-suppressed MR techniques, missed tear of both menisci occurred predominantly in the meniscal body. The prevalence depends on the imaging plane and sequence used. Among the techniques reviewed, sagittal T2W sequence had the highest prevalence of undetected meniscal tear.

(Received for publication on August 16, 2000)

REFERENCES

1. Bonamo J, Saperstein A. Contemporary magnetic resonance imaging of the knee: the orthopedic surgeon's perspective. Magn Reson Imaging Clin N Am 1994; 2: 481-95.
2. Turner D, Rapoport M, Erwin H, et al. Truncation artifact: a potential pitfall in MR imaging of the menisci of the knee. Radiology 1991; 179: 629-33.
3. Shogry M, Pope T. Vacuum phenomenon simulating meniscal or cartilaginous injury of the knee at MR imaging. Radiology 1991; 180: 513-5.
4. Peterfy C, Janzen D, Tirman P, et al. "Magic angle" phenomenon: a cause of increased signal in the normal lateral meniscus on short-TE MR images of the knee. AJR Am J Roentgenol 1994: 163: 149-54.
5. Quinn SF, Brown TF, Szumowski J. Menisci of the knee: radial MR imaging correlated with arthroscopy in 259 patients. Radiology 1992; 185: 577-80.
6. Firooznia H, Golimbu C, Rafii M. MR imaging of the menisci: fundamentals of anatomy and pathology. Magn Reson Imaging Clin N Am 1994; 2: 325-47.
7. Smith D, Totty W. The knee after partial meniscectomy: MR imaging features. Radiology 1990: 176: 141-4.
8. Deutsch AL, Mink JH, Fox JM, Friedman MJ, Howell SM. The postoperative knee. Magn Reson Q 1992; 8: 23-54.
9. Deutsch AL, Mink JH, Fox JM, et al. Peripheral meniscal tears: MR findings after conservative treatment or arthroscopic repair. Radiology 1990; 176: 485-8.
10. Farley TE, Howell SM, Love KF, Wolfe RD, Neumann CH. Meniscal tears: MR and arthrographic findings after arthroscopic repair. Radiology 1991; 180: 517-22.
11. De Smet AA, Graf B. Meniscal tear missed on MR imaging: relationship to meniscal tear patterns and anterior cruciate ligament tears. AJR Am J Roentgenol 1994; 162: 905-11.
12. Justice WW, Quinn SF. Error patterns in the MR imaging evaluation of menisci of the knee. Radiology 1995; 196: 617-21.
13. Rubin D. MR imaging of the knee menisci. Radiol Clin North Am 1997; 35: 21-44.
14. Mink JH, Levy T, Crues JV III. Tears of the anterior cruciate ligament and menisci of the knee: MR imaging evaluation. Radiology 1988; 167: 769-74.
15. Quinn SF, Brown TF. Meniscal tears diagnosed with MR imaging *versus* arthroscopy: how reliable a standard is arthroscopy. Radiology 1991; 181: 843-7.
16. Fischer SP, Fox JM, Del Pizzo W, et al. Accuracy of diagnosis from magnetic resonance imaging of the knee: a multi-center analysis of one thousand and fourteen patients. J Bone Joint Surg 1991; 73A: 2-10.
17. Winalski CS, Aliabadi P, Wright RJ, Shortkroff S, Sledge CB, Weissman BN. Enhancement of joint fluid with intravenous administered gadopentetate dimeglumine: techniques, rationale, and implication. Radiology 1993; 187: 179-85.
18. De Smet AA, Tuite MJ, Norris MA, et al. MR diagnosis of meniscal tears: analysis of causes of errors. AJR Am J Roentgenol 1994; 163: 1419-23.

ผลลบลวงในการแปลผลการฉีกขาดของหมอนรองกระดูกข้อเข่าด้วยภาพที่สร้างจากคลื่นแม่เหล็กไฟฟ้า

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การตรวจหมอนรองกระดูกข้อเข่าด้วยเครื่องสร้างภาพจากคลื่นแม่เหล็กไฟฟ้า (MRI) สามารถให้ผลที่แม่นยำเกินกว่าร้อยละ 90 ถ้าหากภาพนั้นสร้างจากเทคนิคที่เหมาะสมและผู้แปลผลมีความชำนาญ การแปลผลผิดอาจเกิดจากสาเหตุหลาย ๆ อย่างทั้งในแง่ผลบวกลวง (false positive) และผลลบลวง (false negative) ได้ทำการศึกษาผลลบลวงในการแปลผลการฉีกขาดของหมอนรองกระดูกข้อเข่า โดยเปรียบเทียบภาพ MRI (ที่เข้ารับการตรวจก่อนเดือนกรกฎาคม 2540) กับการส่องกล้องในข้อเข่าซึ่งกระทำในเวลาต่อมาในผู้ป่วย 63 ราย พบว่าเมื่อศึกษาโดยแยกแยะตามเทคนิคที่ใช้ตรวจและตามตำแหน่งต่างๆของหมอนรองกระดูกข้อเข่า ผลลบลวงของ MRI จะพบบ่อยที่สุดที่ช่วงกลางของหมอนรองกระดูกข้อเข่า ทั้งทางด้านใน (central portion) และทางด้านนอก (peripheral portion) อย่างไรก็ตาม ร้อยละ 40 ของจำนวนนี้ การฉีกขาดเป็นรอยเล็กและไม่จำเป็นต้องได้รับการรักษาโดยการผ่าตัด ส่วนเทคนิคที่ให้ผลลบลวงมากที่สุดในการศึกษานี้คือ sagittal T2-weighted sequence ดังนั้น การแปลผลการฉีกขาดของหมอนรองกระดูกข้อเข่าจึงควรพิจารณาถึงเทคนิคที่ใช้ตรวจด้วย

คำสำคัญ : หมอนรองกระดูกข้อเข่า, การตรวจด้วยคลื่นแม่เหล็กไฟฟ้า, ผลลบลวง

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จดหมายเหตุทางแพทย์ ฯ 2544; 84: 242-246

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