Skeletal Radiol (2009) 38:149–156
DOI 10.1007/s00256-008-0600-y

SCIENTIFIC ARTICLE

Retears of postoperative knee meniscus: findings on magnetic resonance imaging (MRI) and magnetic resonance arthrography (MRA) by using low and high field magnets

Paolo Cardello · Carlo Gigli · Alessandra Ricci · Leonardo Chiatti · Nicola Voglino · Enrico Pofi

Received: 23 May 2008 / Revised: 12 September 2008 / Accepted: 12 September 2008 / Published online: 10 October 2008

Abstract
Purpose The purpose of this study was to determine the diagnostic performance of magnetic resonance (MR) obtained with intra-articular contrast medium in the evaluation of recurrent meniscal tears using low-field extremity-only and high-field whole-body magnets.
Materials and methods Postoperative standard MR examinations and MR arthrographies of 95 knees were reviewed. Patients experiencing pain and disability after meniscal repair underwent standard MR and MR arthrography (Gadoterate meglumine 0.0025 mmol/ml) on both a 0.2-T and 1.5-T magnet. In 52 of 95 patients, second-look arthroscopy was performed; in the remaining 43 of 95 patients, clinical follow-up was used as the standard of reference. Sensitivity, specificity, positive and negative predictive values as well as accuracy of MRI/MR arthrographic signs as meniscal morphologic changes and the presence of contrast medium tracking into the tear at T1- and T2-weighted sequences in the detection of recurrent meniscal tears were determined.
Results All MR and MR arthrograpic signs were sensitive in the detection of recurrent tears (range 80–91%). Abnormal meniscal morphology had low specificity [26% (13/50)] for both the 0.2-T and 1.5-T scanner, whereas accuracy was 55% (52/95) and 57% (54/95), respectively. The presence of contrast medium within the meniscus substance on T2-weighted images had higher value of specificity [84% (42/50)] and accuracy [84% (80/95)] by using low field strength magnet than by using high field strength magnet [74% (37/50) and 81% (77/95), respectively]. Whereas, the increased intrameniscal signal intensity extending to the meniscal surface at T1-weighted sequences after intra-articular contrast medium administration had lower specificity and accuracy on 0.2-T images [84% (42/50) and 82% (78/95), respectively] than on 1.5-T images [90% (45/50) and 88% (84/95), respectively].
Conclusion A diagnosis of recurrent meniscal tear in a previously arthroscopically repaired meniscus can be made both on 0.2-T and 1.5-T magnets on the basis of increased signal on T2-weighted and T1-weighted images in the presence of intra-articular contrast material.

Keywords Meniscal repair · MR arthrography · Knee MR · Arthrographic study · Low-field MR

Purpose

Peripheral meniscal tears undergo surgical repair with a high rate of success. However, some patients experience residual or recurrent pain and disability as presence of locking, catching or giving way after surgery [1–7]. The role of magnetic resonance imaging (MRI) in these patients is to distinguish intact menisci from residual tears, recurrent

P. Cardello (✉) · E. Pofi
Department of Radiodiagnostic, Belcolle Hospital,
Street Sammartinese snc,
Viterbo, Italy
e-mail: p.cardello@virgilio.it

C. Gigli · N. Voglino
Division of Knee Surgery and Arthroscopy,
Department of Orthopedics and Traumatology, Belcolle Hospital,
Viterbo, Italy

A. Ricci · L. Chiatti
Department of Medical Physics, Belcolle Hospital,
Street Sammartinese snc,
Viterbo, Italy

tears being at the site of repair and tears occurring at a new location [8–12].

The purpose of this study was to determine the diagnostic performance of MRI/magnetic resonance arthrography (MRA) in the evaluation of recurrent meniscal tears using low-field extremity-only and high-field whole-body magnets.

Materials and methods

Patients

The study was approved by the Hospital Research Ethics Review Committee, and informed consent was obtained.

One hundred and eighty-four consecutive patients with peripheral meniscal had been treated with bioabsorbable arrows (Polysorb Meniscal Stapler XLS, Tyco USS, USA) during a 3-year period between July 2003 and July 2006. Eighty-nine patients returned to normal activity within 3–6 months without pain and disability. The remaining 95 patients had persistent or recurrent pain and disability after meniscal repair. There were 52 male and 43 female patients with an average age of 42 years and an age range of 22–63 years.

In all 95 patients, postoperative standard MR and MR arthrography were performed during the same session within 5–12 months after surgery.

The patients with evidence of recurrent or residual tears and tear at a location other than the old repair site underwent second-look arthroscopy (52/95). Patients without evidence of meniscal tear were followed clinically up to 16 months after meniscal repair (43/95).

MR imaging protocol

MR images were obtained with a 0.2-T extremity-only magnet (Artoscan Esaote, Genoa, Italy) using a standard knee coil and with a 1.5-T magnet (Symphony Siemens, Erlangen, Germany) and using a dedicated phased array during the same session.

On the 0.2-T magnet, the following protocol was used: sagittal and coronal T1-weighted spin echo sequences (TR/TE=840/26 ms); sagittal, coronal and axial T2-weighted turbo spin echo sequences (TR/TE=3,000/80 ms) with contiguous 4-mm-thick sections, field of view 200×200 mm, matrix 256×256; coronal T1-weighted gradient echo high-resolution sequence (TR/TE=580/16 ms FA 75°) with contiguous 4-mm-thick-sections, field of view 180×180 mm, matrix 288×256. On the 1.5-T magnet, the corresponding parameters were: sagittal and coronal T1-weighted spin echo sequences (TR/TE=420–771/12 ms), with and without fat suppression; sagittal and axial T2-weighted turbo spin echo sequences (TR/TE=3800/90 ms) with 3-mm slice thickness, interslice gap 0.7 mm, field of view 170×170 mm, matrix 512×512; coronal T2-weighted gradient echo sequence (TR/TE=60/18 ms FA 20°) with 4-mm slice thickness, interslice gap 0.2 mm, field of view 170×170 cm, matrix 256×256.

MR arthrography was subsequently performed using 20–40 ml of a Gadoterate meglumine (Dotarem, Guerbet, Aulnay-sous-Bois, France) solution (3.75 mmol/l). A 22- or 20-gauge needle was placed close to the centre of the retropatellar cartilage using a supralateral approach. Care was taken not to introduce air into the joint and to drain the effusion before injecting the contrast material. After contrast medium injection, the knee was exercised by extending and bending continuously for 5 min before imaging was repeated. Prior to the MR examination, an elastic bandage was wrapped around the suprapatellar region in an attempt to increase the amount of contrast around the menisci. No complications were encountered as haematoma and allergic reactions, delayed infections, haemarthrosis and synovitis. After contrast medium administration, each patient was examined first with the 1.5-T magnet, followed by the 0.2-T magnet during the same session.

The 1.5-T MR arthrographic protocol included: sagittal and coronal T1-weighted spin echo sequences (TR/TE=420–770/12 ms), with and without fat-suppression; sagittal and coronal T2-weighted turbo spin echo sequences (TR/TE=3800/90 ms), with fat-suppression and with 3-mm slice thickness, interslice gap 0.7 mm, field of view 170×170 mm, matrix 512×512. The 0.2-T MR arthrographic protocol included: sagittal T1-weighted 3D gradient echo sequence (TR/TE=50/16 ms FA 65°) with 1.1-mm slice thickness, filed of view 200×200 mm, matrix 256×256; sagittal and coronal T1-weighted spin echo sequences (TR/TE=840/26 ms); sagittal T2-weighted turbo spin echo sequence (TR/TE=3000/80 ms) with contiguous 4-mm-thick sections, field of view 200×200 mm, matrix 256×256.

Image interpretation

All MR and MR arthrographic examinations were interpreted separately by two musculoskeletal radiologists in comparison with MR images obtained before surgical repair and clinical findings. In case of disagreement, a consensus was reached.

Based on previously published criteria [8–12], a meniscal tear was diagnosed as follows:

(a) inner margin rounded or mild notching (defect less than one fourth the thickness of the meniscus), detached meniscal fragment;

(b) increased intrameniscal signal intensity similar to that of joint fluid extending to the meniscal articular surface at T2-weighted turbo spin echo sequences; and
(c) abnormal communication of the contrast medium from the joint into the substance of the meniscus at T1-weighted spin echo sequences.

Full-thickness tear was assessed by the presence of intrameniscal contrast material extending through the entire length or depth of the meniscus. Large partial-thickness tear was assessed by the visualisation of imbibition of contrast mixture into a tear cleft involving more than one third of the meniscus length or height, whereas the extension of contrast medium through less than one third of the fibrocartilage length and height was considered normal finding.

The patients who fulfilled the MR diagnostic criteria of recurrent tear underwent second-look arthroscopy within 2 weeks. The arthroscopic criteria for a normal postoperative meniscus were the presence of a smooth meniscal remnant without mobile or displaced meniscal fragment and without meniscal separation. Superficial change with smooth contour irregularities was not considered to indicate abnormality. The arthroscopic criteria for a recurrent or new meniscal tear included the identification of an unstable meniscal fragment, flap tear or extensive meniscal cleavage.

The subjects without MR evidence of retear were followed clinically up to 16 months after meniscal repair. The disappearance of symptoms and normal findings at physical examination were considered to represent the standard of reference for a normal postoperative meniscus.

Statistical analysis

Statistical analysis of the collected data was performed using statistical software SPSS (SPSS, Chicago). The evaluation of the sensitivity, specificity, positive and negative predictive values and accuracy of each MR sign assessed in the evaluation of a recurrent meniscal tear was included. A separate analysis was performed evaluating data collected using 1.5-T and 0.2-T magnets. Statistical analysis was completed by calculating the odds ratio with 95% confidence interval and the chi-square of each MR and MR arthrographic imaging sign to determine the best MR sign of recurrent tear after repair with bioabsorbable arrows.

Inter-observer variability was evaluated using κ value analysis.

Results

There were 45 of 95 patients with and 50 of 95 patients without retears. The diagnosis of retears was proven arthroscopically in 43 of 95 patients and clinically in two of 95 patients.

Table 1 demonstrates the true and false positives and negative results according to field strength and MR criterion.

0.2-T MRI/MR arthrographic findings

In 41 patients (43.1%) with second-look arthroscopy positive for recurrent tears or with knee pain and disability 16 months later the surgical repair, MRI/MRA displayed the presence of notch or inner border rounded; in 37 subjects (38.9%), the abnormal meniscal morphology was not associated with positive arthroscopy or persistent pain. Normal fibrocartilage shape at MRI/MRA was confirmed by second-look procedure or by resolution of clinical complain in 13 patients (13.7%), but was not observed in the remaining four subjects (4.3%) who presented persistent pain or recurrent tear at arthroscopic evaluation.

The presence of contrast medium tracking into the tear at T1-weighted sequences was confirmed by positive second-look arthroscopy or by persistent joint line pain and clicking, respectively, in 36 patients (37.9%; Fig. 1a–c), whereas it was associated with negative arthroscopic evaluation or disappearance of pain and disability in eight subjects (8.4%; Fig. 3a). Moreover, the lack of increased intrameniscal signal intensity at T1-weighted sequences was associated with negative second-look arthroscopy or clinical recovery in 42 patients (44.2%; Fig. 2a) and with symptomatic discomfort or recurrent tears at orthopaedic surgical procedures in nine patients (9.5%).

T2-weighted sequences showed abnormal communication of the contrast mixture from the joint into the substance of the meniscus in 38 patients (40%) who presented recurrent tears at second-look arthroscopy or complain of joint disease (Fig. 1d) and in eight subjects (8.4%) without pain at follow-up or with negative surgical orthopaedic evaluation. The same sequences did not find the presence of

Table 1 Arthroscopic and clinical follow-up related with MRI/MR arthrographic signs

	0.2 T			1.5 T		
	MS	T1	T2	MS	T1	T2
TP	41	36	38	39	39	40
FP	37	8	8	37	5	13
FN	4	9	7	6	6	5
TN	13	42	42	13	45	37

TP true positive value, *FP* false positive value, *FN* false negative value, *TN* true negative value, *MS* meniscal shape changes, *T1* presence of contrast medium tracking into the tear at T1-weighted sequences, *T2* presence of contrast medium tracking into the tear at T2-weighted sequences

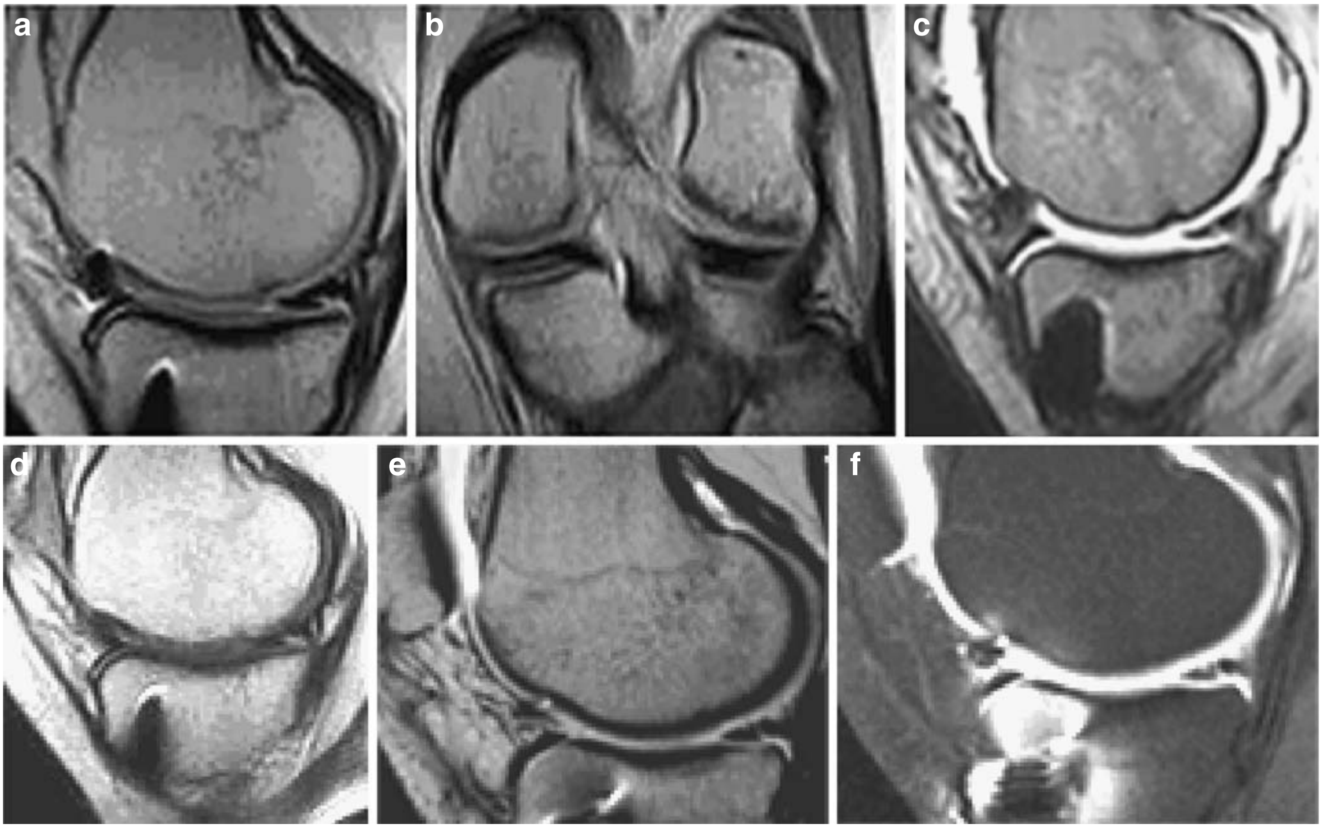

Fig. 1 Recurrent meniscal tear of the posterior horn of the medial meniscus after preservation surgery at MR arthrographic imaging 0.2-T magnet: sagittal and coronal T1-weighted SE images (**a**, **b**), sagittal T1-weighted 3D GE image (**c**), sagittal T2-weighted TSE image (**d**); 1.5-T magnet: sagittal T1-weighted SE image (**e**), sagittal T1-weighted fat suppressed SE image (**f**). MRA displays a notching of the medial meniscus with irregular contour and demonstrates linear region of increased signal intensity that represents contrast material leaking cleft within the posterior horn of the medial meniscus, a finding indicating recurrent tear. These findings were confirmed at second-look arthroscopy

intrameniscal contrast material in 42 patients (44.2%), as confirmed by negative second-look arthroscopy and drastic reduction of knee pain (Fig. 2b), and in seven subjects (7.4%) characterised by positive arthroscopic evaluation or persistent joint pain.

1.5-T MRI/MR arthrographic findings

The presence of notch or inner border rounded was found in 39 patients (41%) with second-look arthroscopy positive for recurrent tears or with knee pain and disability 12 months after the surgical repair; in 37 subjects (38.9%), the meniscal morphologic changes were not associated with positive arthroscopy or persistent pain. The MRI/MR arthrographic absences of morphologic abnormalities were confirmed by second-look procedure or by resolution of joint pain and disability in 13 patients (13.7%), but were not reported in the remaining six subjects (6.4%) who presented persistent pain or recurrent tear at arthroscopic evaluation.

The extension of gadoterate mixture into the meniscal tear at T1-weighted sequences was confirmed by positive second-look arthroscopy or by persistent joint line pain and disability in 39 patients (41%; Fig. 1e,f), whereas it was associated with negative arthroscopic procedure or resolution of pain in five subjects (5.3%; Fig. 3b,c). The lack of fluid entering the meniscal substance at T1-weighted sequences was associated with negative second-look arthroscopy or recovery in 45 patients (47.3%; Fig. 2c–e) and to symptomatic disease or recurrent tear at orthopaedic arthroscopic evaluation in six subjects (6.4%).

T2-weighted sequences permitted relief of abnormal communication of the contrast medium into the fibrocartilage substance of the meniscus in 40 patients (42.1%) who presented retears at second-look arthroscopy or complain of joint disease and in 13 subjects (13.7%) asymptomatic at follow-up or negative at arthroscopic procedure. T2-weighted sequences evaluated the absence of intrameniscal contrast medium in 37 patients (38.9%), as confirmed by negative second-look arthroscopy and disappearance of joint pain (Fig. 2f), and in five subjects (5.3%) who presented recurrent tear at arthroscopic evaluation or persistent knee pain and disability.

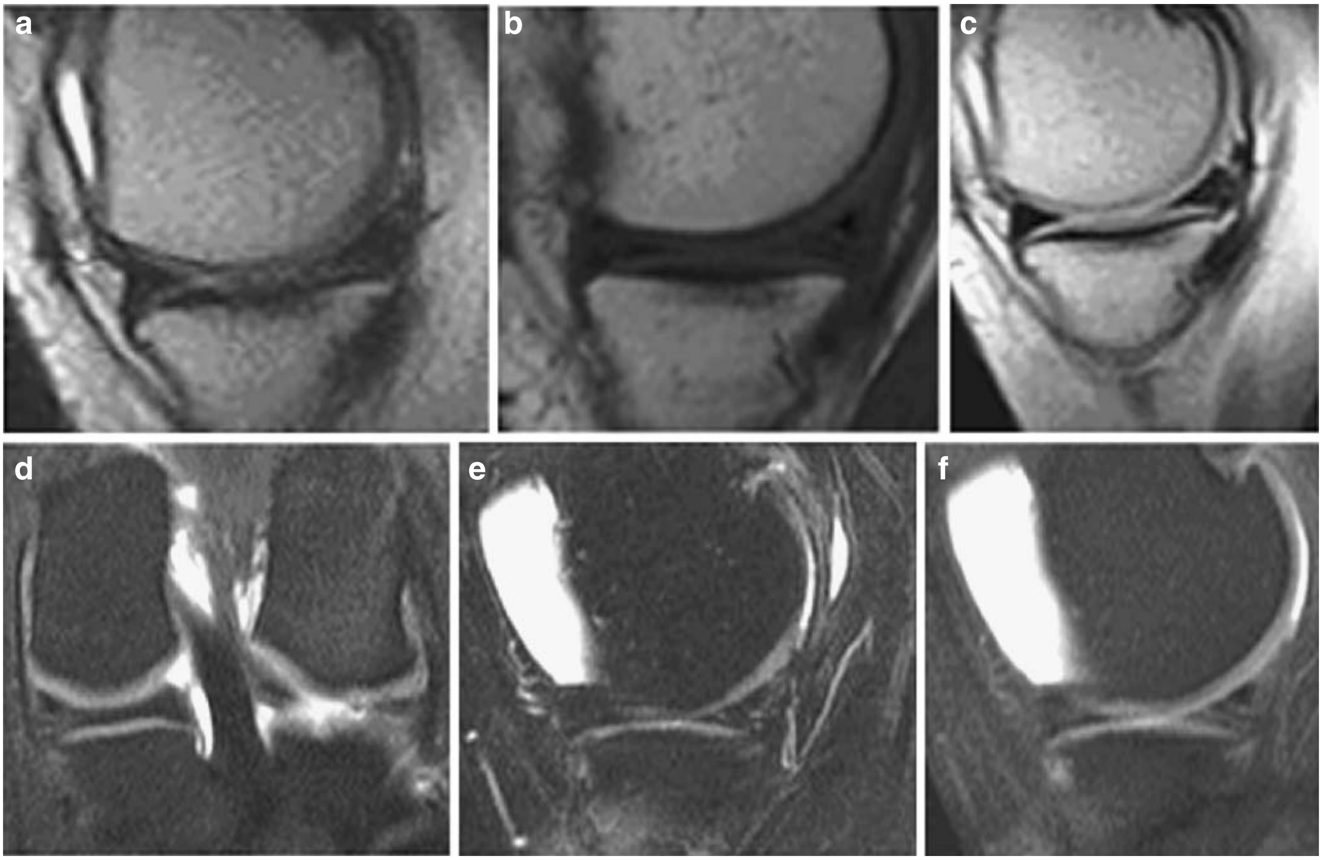

Fig. 2 Meniscal signal intensity changes after preservation surgery later 8 months at MRI/MRA. 0.2-T magnet: sagittal T1-weighted SE image after contrast injection (**a**), sagittal T2-weighted TSE image after intra-articular gadoterate mixture administration (**b**); 1.5-T magnet: sagittal T1-weighted SE image without contrast medium (**c**), sagittal and coronal T1-weighted fat-suppressed SE images after intra-articular contrast mixture (**d**, **e**), sagittal T2-weighted fat-suppressed TSE image after intra-articular gadoterate injection (**f**). MRA displays abnormal signal intensity referred to as "intrameniscal signal conversion" without recurrent tear

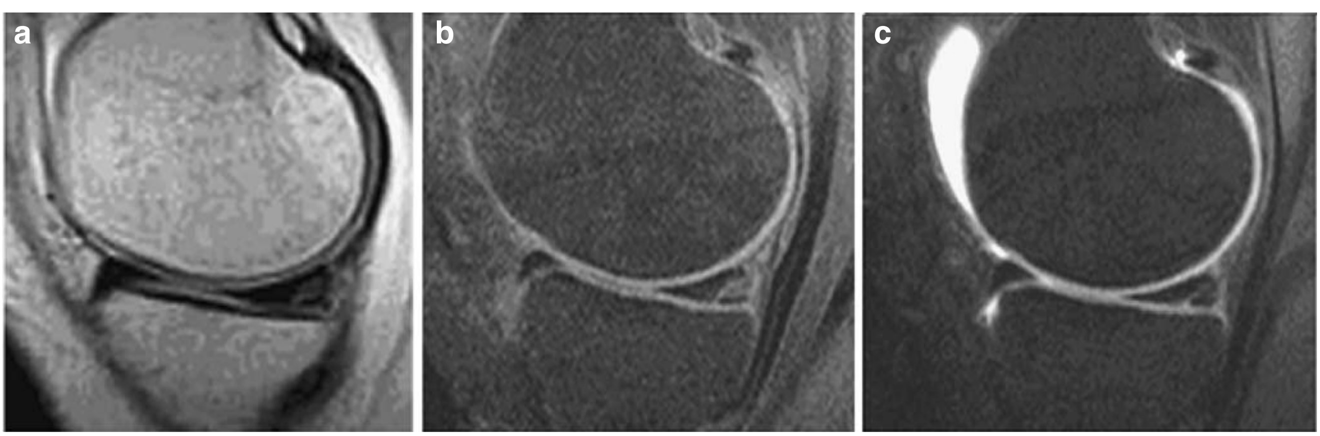

Fig. 3 False positive recurrent meniscal tear at MRI/MRA. 0.2-T magnet: sagittal T1-weighted SE image after contrast injection (**a**); 1.5-T magnet: sagittal T1-weighted fat-suppressed SE image before intra-articular contrast mixture (**b**), sagittal T1-weighted fat-suppressed SE image after intra-articular gadoterate administration (**c**). MRA shows the presence of intrameniscal contrast medium involving more than one third of the posterior horn of the medial meniscus. Both readers interpreted this enhancement as a recurrent tear, but a fibrovascular scar tissue was found at second-look arthroscopy

Table 2 Diagnostic performance of three MRI/MR arthrographic signs in assessment of recurrent knee meniscal tears using 0.2-T and 1.5-T magnets

	MS		T1		T2	
	0.2 T	1.5 T	0.2 T	1.5 T	0.2 T	1.5 T
Sensitivity (%)	87	91	80	87	84	89
Specificity (%)	26	26	84	90	84	74
Positive predictive value (%)	51	53	82	89	83	75
Negative predictive value (%)	68	76	82	88	86	88
Accuracy (%)	55	57	82	88	84	81

MS meniscal shape changes, *T1* presence of contrast medium tracking into the tear at T1-weighted sequences, *T2* presence of contrast medium tracking into the tear at T2-weighted sequences

Table 2 demonstrates the resulting sensitivities, specificities, predictive values and accuracies of each MR sign. Meniscal morphologic changes were sensitive but not specific for the diagnosis of retears. Contrast tracking into the meniscal substance was similarly sensitive but far more specific and accurate than abnormalities of meniscal form. With regard to contrast leakage, 0.2-T images performed slightly superior to 1.5-T images on T2-weighted sequences and slightly inferior on T1-weighted sequences. No significant differences were found in diagnostic accuracy among the abnormal signal at T2-weighted sequences and abnormal signal at T1-weighted sequences using both magnets.

The obtained results stocked up from the cross-tabs analysis, showed in Table 3, revealed as the best MR sign of meniscal recurrent tear the presence of gadolinium mixture involving more than one third of the meniscus length and height at T2-weighted sequences when we performed 0.2-T MR examinations and T1-weighted sequences when we used 1.5-T magnet.

Readers had an agreement of 95% (κ=0.89) for all MR signs.

Discussion

A selective approach to the meniscal tears has been evolved with the goal of preserving the meniscus, as an alternative to partial meniscectomy, with its documented deleterious effects on articular cartilage. The menisci have got important roles in shock absorption, maintenance of joint congruity and functional stability, increasing the area of load transmission within the knee to help preserve the hyaline articular cartilage. Since the meniscus has an important functional role in the knee, the problem of how to preserve it after injury has arisen. Meniscal repair procedures are associated with the best outcome for linear, vertical or oblique tears in the periphery of the meniscus due to proximity to the vascular supply, and arthroscopically guided techniques have been developed for larger peripheral tears with an unstable segment through the use of suture, staples, darts and bioabsorbable arrows to promote fibrovascular scar and successful healing. In our institution, meniscal repair, performed using bioabsorbable arrows, is less practised than partial meniscectomy because of the limited group of patients who are eligible, the higher short-term morbidity and the longer postoperative recovery time. Peripheral tears heal with fibrovascular scar tissue within 10 weeks, and the human meniscus has been demonstrated to be healed within 4–6 months. Return of activity is usually allowed within 3–6 months [1–7, 12–15].

Following meniscal repair, patients may present with persistent or recurrent symptoms. Before the advent of MR/MR arthrographic images, the diagnostic evaluation of the meniscal findings included conventional arthrography or repeated surgical exploration. Currently, MR and MR arthrographic imaging is a consolidated method to differ-

Table 3 Results of the analysis of cross-tabs of MRI/MR arthrographic signs in assessment of recurrent meniscal tear

	MS		T1		T2	
	0.2 T	1.5 T	0.2 T	1.5 T	0.2 T	1.5 T
Odds Ratio (OR)	2.28	3.60	21.00	58.50	28.50	22.77
CI (95%)	0.79–6.64	1.08–12.02	7.34–60.09	16.56–206.63	9.44–86.07	7.40–70.07
Chi-square	2.38	4.72	39.02	55.99	44.43	37.98
p value	0.12	0.03	0.00	0.00	0.00	0.00

MS meniscal shape changes, *T1* presence of contrast medium tracking into the tear at T1-weighted sequences, *T2* presence of contrast medium tracking into the tear at T2-weighted sequences entiate intra-articular causes of pain, such as ligamentous, cartilaginous, osseous abnormalities, and possible residual or recurrent and new meniscal tears in postoperative time as described in literature. The distinction between recurrent and residual tears was of no clinical importance in the management of a patient with recurrent symptoms after meniscal surgery, and the tears are indistinguishable on the basis of imaging findings alone.

Applegate et al., in 1993, performing both conventional MR imaging and MRA in each patient, showed that the sensitivity, specificity and accuracy to identify postoperative meniscal tears were, respectively, 89%, 86% and 88% for MRA. Katz et al., in 1996, reported improved accuracy in differentiating postoperative meniscal changes from recurrent tears using MRA. Sciully et al., in 1999, compared four imaging techniques (conventional arthrography, conventional MR, MRA with iodinated contrast material and MRA with gadolinium-based contrast material) in each patient and showed that gadolinium-enhanced MRA was the most accurate imaging method for the diagnosis of meniscal recurrent tears (92%), with technical advantages including lower viscosity of gadolinium than synovial fluid allowing imbibition into small clefts, utilisation of T1-weighted pulse sequences with their favourable signal-to-noise ratio and intra-articular pressure allowing separation of otherwise apposed torn meniscal edges. Direct arthrography in the study of White et al., in 2002, had a sensitivity of 90%, specificity of 78% and accuracy 85%, whilst in a study of Vives et al. in 2003, intra-articular contrast MR had a sensitivity of 91.7%, specificity of 100% and an overall accuracy of 92.9% [16–20].

Other authors disagreed with these concepts, as Magee et al., in 2003, who stated that patients with less than 25% meniscal resection do not need MRA because the findings were useful in making a diagnosis in a minority of the patients. De Smet et al., in 2005, argued that MR imaging has a comparable accuracy to MRA and would be the preferred study in the setting of meniscal repair [21–22].

This study performed postoperative MR/MR arthrographic images within 5–12 months of the arthroscopic repair in symptomatic patients using low field magnet (0.2 T) and high field magnet (1.5 T) and then compared images, clinical findings and arthroscopic results.

The healing of meniscal tears is found to contain cellular fibrovascular scar tissue; remodelling of this scar tissue to a normal appearing fibrocartilage may not occur. As a rule, the postoperative meniscus shows an area of increased intrameniscal signal intensity extending to the articular surface without the presence of the contrast mixture intrasubstance at T1- and T2-weighted sequences, referred to as “intrameniscal signal conversions”. We showed 40 (42.1%) cases of intrameniscal signal conversion with various morphologies and all without signs of recurrent tears after contrast medium injection. In three patients (3.1%), meniscus showed improvement with diminished conspicuity of abnormal signal intensity at T1- and T2-weighted images on the postoperative MR imaging but, in compliance with Arnoczky et al., still markedly different from the normal meniscal tissue. Histological studies have demonstrated that scar tissue eventually modulates into a fibrocartilage-like tissue with increased cellularity and vascularity of the repaired tissue; complete maturation of the scar tissue into a fibrocartilage that is indistinguishable from normal meniscus has never been demonstrated [9–16].

The criteria used for diagnosis of a recurrent or new tear are: signal intensity similar to that of gadolinium on T1-weighted images or to that of fluid on T2-weighted images that extend trough the meniscus, meniscal morphologic changes and identification of displaced meniscal fragments. In some patients, the presence of intrameniscal contrast mixture involving less than one third of the meniscus length and height, according to literature, has been considered normal [19, 23–25]. In positive patients (34.7%), we observed that all signs have high sensitivity. The increased intrameniscal signal intensity extending to the meniscal surface on T2-weighted images gives the most accuracy in assessing recurrent or residual meniscal tear using a 0.2-T magnet. The finding of intrameniscal gadolinium entering the crevice of meniscal tear on T1-weighted imaging is the most specific and accurate of the signs assessed by performing examination with 1.5-T magnet; these results disagree with the study of White et al. [19] who observed increased intrameniscal signal intensity extending the meniscal surface on T2-weighted images to be the most specific sign assessed and to have the highest positive predictive value for recurrent and residual meniscal tear. In addition, the same results of our study do not share the report of Recht’s work which affirmed the findings of high signal intensity joint fluid extending into a cleft within the meniscal substance on T2-weighted images to be specific but not sensitive signs of a return meniscus [26].

In nine cases (9.4%), MR/MR arthrographic images demonstrated gadoterate mixture entering approximately as or more than one third of the postoperative meniscus length or height and was diagnosed recurrent tear: In these subjects, second-look arthroscopy displayed intrameniscal scar and granulation tissue that simulated a recurrent tear. This group of patients constitutes the greater difficulty and challenge in the diagnosis of recurrent tear after peripheral meniscal suture [2, 11, 27, 28].

An abnormal shape has much lower specificity (26%) and accuracy (55% and 57%, respectively) in menisci with repeat tears using low and high field strength magnets. This supports the finding reported by Lim and Totty that the diagnosis of repeat tears of meniscal segments with marked contour irregularity should be made cautiously since this irregularity can mimic a tear [29, 30].

The results of the study are limited. (1) A shortcoming is that the knowledge of MRI/MR arthrographic findings may have influenced the clinical decision either to proceed or not to proceed to arthroscopy and thus created a selection bias in favour of a positive meniscal pathologic entity in patients proceeding to second-look arthroscopy and possibly a bias in the arthroscopic evaluation of the meniscus. (2) The use of arthroscopy and clinical findings as the standards of reference for evaluation of meniscal tear has intrinsic limitations for subjective variability among individual arthroscopists and orthopaedics in the diagnostic assessment of a possible recurrent and new meniscal tear. (3) Last but no least, shortcoming is the limited number of postoperative menisci that were studied and, consequently, the 95% CIs are large.

Conclusion

A diagnosis of recurrent meniscal tear can be made both on 0.2-T and 1.5-T images on the basis of increased signal on T2-weighted and T1-weighted images in the presence of intra-articular contrast material.

References

1. Quinby JS, Golish SR, Hart JA, Diduch DR. All-inside meniscal repair using a new flexible, tensionable device. Am J Sports Med 2006; 34: 1281–1286.
2. Johnson MJ, Lucas GL, Dusek JK, Henning CE. Isolated arthroscopic meniscal repair: a long-term outcome study (more than 10 years). Am J Sports Med 1999; 27: 44–49.
3. Spindler KP, McCarty EC, Warren TA, Devin C, Connor JT. Prospective comparison of arthroscopic medial meniscal repair technique. Am J Sports Med 2003; 31: 929–934.
4. Majewski M, Stoll R, Widmer H, Müller W, Friederich NF. Midterm and long-term results after arthroscopic suture repair of isolated, longitudinal, vertical, meniscal tears in stable knees. Am J Sports Med 2006; 34: 1072–1076.
5. Voloshin I, Schmitz MA, Adams MJ, DeHaven KE. Results of repeat meniscal repair. Am J Sports Med 2003; 31: 874–880.
6. Ellermann A, Siebold R, Buelow JU, Sobau C. Clinical evaluation of meniscus repair with a bioabsorbable arrow: a 2 to 3-year follow-up study. Knee Surg Sports Traumatol Arthrosc 2002; 10: 289–293.
7. Kurzweil PR, Tifford CD, Iagnacio EM. Unsatisfactory clinical results of meniscal repair using the meniscus arrow. Arthroscopy 2005; 21: 905.
8. Yoshida S, Recht MP. Postoperative evaluation of the knee. Radiol Clin North Am 2002; 40: 1133–1146.
9. Gopez AG, Kavanagh EC. MR Imaging of the postoperative meniscus: repair, resection and replacement. Semin Muscoloskelet Radiol 2006; 10: 229–240.
10. Muellner T, Egkher A, Nikolic A, Funovics M, Metz V. Open meniscal repair: clinical and magnetic resonance imaging findings after twelve years. Am J Sports Med 1999; 27: 16–20.
11. White LM, Kramer J, Recht MP. MR imaging evaluation of the postoperative knee: ligaments, menisci, and articular cartilage. Skelet Radiol 2005; 34: 431–452.
12. Mustonen AOT, Tielinen L, Lindahl J, Hirvensalo E, Kiuru M, Koskinen SK. MRI of menisci repaired with bioabsorbable arrows. Skelet Radiol 2006; 35: 515–521.
13. Scott GA, Jolly BL, Henning CE. Combined posterior incision and arthroscopic intra-articular repair of the meniscus. J Bone Jt Surg Am 1986; 68: 847–861.
14. Arnoczky SP, Cooper TG, Stadelmeir DM, Hannafin JA. Magnetic resonance signals in healing menisci: an experimental study in dogs. Arthroscopy 1994; 10: 552–557.
15. Arnoczky SP, Warren RF. The microvasculature of the meniscus and its response to injury. Am J Sports Med 1983; 11: 131–141.
16. Applegate GR, Flannigan BD, Tolin BS, Fox JM, Del Pizzo W. MR diagnosis of recurrent tears in the knee: value of intraarticular contrast material. AJR Am J Roentgenol 1993; 161: 821–825.
17. Katz LD, Lynch R, Ruwe P, Jokl P, Kelley J. MR arthrography of the knee in the post-operative meniscus in patients with knee pain. Radiology 1996; 201: 169.
18. Sciulli RL, Boutin RD, Brown RR, et al. Evaluation of the postoperative meniscus of the knee: a study comparing conventional arthrography, conventional MR imaging, MR arthrography with iodinated contrast material, and MR arthrography with gadolinium-based contrast material. Skelet Radiol 1999; 28: 508–514.
19. White LM, Schweitzer ME, Weishaupt D, Kramer J, Davis A, Marks PH. Diagnosis of recurrent meniscal tears: prospective evaluation of conventional MR imaging, indirect MR arthrography, and direct MR arthrography. Radiology 2002; 222: 421–429.
20. Vives MJ, Homesley D, Ciccotti MG, Schweitzer ME. Evaluation of recurring meniscal tears with gadolinium-enhanced magnetic resonance imaging. Am J Sports Med 2003; 31: 868–873.
21. Magee T, Shapiro M, Rodriguez J, Williams D. MR arthrography of postoperative knee: for which patients is it useful? Radiology 2003; 229: 159–163.
22. De Smet AA. Imaging and MR arthrography for diagnosis of recurrent tears in the postoperative meniscus. Semin Muscoloskelet Radiol. 2005; 9: 116–124.
23. Farley TE, Howell SM, Love KF, Wolfe RD, Neumann CH. Meniscal tears: MR and arthrographic findings after arthroscopic repair. Radiology 1991; 180: 517–522.
24. Deutsch AL, Mink JH, Fox JM, et al. Peripheral meniscal tears: MR findings after conservative treatment or arthroscopic repair. Radiology 1990; 176: 485–488.
25. De Smet AA, Horak DM, Davis KW, Choi JJ. Intensity of signal contacting meniscal surface in recurrent tears on MR arthrography compared with of contrast material. AJR Am J Roentgenol 2006; 187: 565–568.
26. Recht MP, Kramer J. MR imaging of the postoperative knee: a pictorial essay. RadioGraphics 2002; 22: 765–774.
27. McCauley TR. MR imaging evaluation of the postoperative knee. Radiology 2005; 234: 53–61.
28. Toms AP, White LM, Marchall TJ, Donnell ST. Imaging the postoperative meniscus. Eur J Radiol 2005; 54: 189–198.
29. Lim PS, Schweitzer ME, Bhatia M, et al. Repeat tear of postoperative meniscus: potential MR imaging signs. Radiology 1999; 210: 183–188.
30. Totty WG, Matava MJ. Imaging the postoperative meniscus. Magn Reson Imaging Clin N Am 2000; 8: 271–283.