Published in final edited form as:

Skeletal Radiol. 2017 October ; 46(10): 1353–1360. doi:10.1007/s00256-017-2695-5.

MRI CHARACTERISTICS OF TORN AND UNTORN POST-OPERATIVE MENISCI

Richard Kijowski, M.D.,

Department of Radiology, University of Wisconsin School of Medicine and Public Health, 600 Highland Avenue, Madison, Wisconsin 53792-3252, Phone: 608-265-3247, FAX: 608-263-5112

Humberto Rosas, M.D.,

Department of Radiology, University of Wisconsin School of Medicine and Public Health, 600 Highland Avenue, Madison, Wisconsin 53792-3252, Phone: 608-265-2762, FAX: 608-263-5112

Adam Williams, M.D., and

Radiology and Imaging Consultants, 1400 East Boulder Street, Phone: 719-365-5853, FAX: 719-365-5853

Fang Liu, Ph.D.

Department of Radiology, University of Wisconsin School of Medicine and Public Health, 600 Highland Avenue, Madison, Wisconsin 53792-3252, Phone: 608-265-9387, FAX: 608-263-5112

Abstract

Objective—To compare magnetic resonance imaging (MRI) characteristics of torn and untorn post-operative menisci.

Methods—The study group consisted of 140 patients with 148 partially resected menisci who were evaluated with a repeat knee MRI examination and subsequent repeat arthroscopic knee surgery. Two musculoskeletal radiologists retrospectively assessed the following MRI characteristics of the post-operative meniscus: contour (smooth or irregular), T2 line through meniscus (no line, intermediate signal line, intermediate-to-high signal line, and high fluid-like signal line), displaced meniscus fragment, and change in signal pattern through meniscus when compared to baseline MRI. Positive predictive values (PPV) and negative predictive values (NPV) were calculated using arthroscopy as reference standard.

Results—All 36 post-operative menisci with no T2 line were untorn at surgery (100% NPV), while 46 of 79 post-operative menisci with intermediate T2 line, 16 of 18 post-operative menisci with intermediate-to-high T2 line, and 14 of 15 post-operative menisci with high T2 line were torn at surgery (58.2%, 88.9%, and 93.3% PPV respectively). Additional MRI characteristics associated with torn post-operative meniscus at surgery were irregular meniscus contour (85.7%

Correspondence to: Richard Kijowski.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

There is no acknowledgement of grants, disclosures, or other assistances for the manuscript. The manuscript was performed with approval for our Institutional Review Board.

PPV), displaced meniscus fragment (100% PPV), and change in signal pattern through meniscus (99.4% PPV).

Conclusions—Post-operative menisci with no T2 signal line were untorn at surgery. The most useful MRI characteristics to predict torn post-operative menisci at surgery were change in signal pattern through meniscus compared to baseline MRI and displaced meniscus fragment followed by high T2 line through meniscus, intermediate-to-high T2 line through meniscus, and irregular meniscus contour.

Keywords

Meniscus; Meniscectomy; Post-Operative; MRI

INTRODUCTION

Meniscus tears are a common cause of knee pain and one of the most frequent indications for arthroscopic knee surgery [1]. While tears in the peripheral vascularized zone of the meniscus may undergo surgical repair, the vast majority of meniscus tears are treated with partial meniscectomy [2, 3]. Clinical outcome following partial meniscectomy is generally good especially in the younger patient population [4–7]. However, many individuals sustain subsequent knee injuries or have persistent pain following surgery which requires additional evaluation to exclude the possibility of a re-tear of the post-operative meniscus.

Magnetic resonance imaging (MRI) is a cost-effective and non-invasive method to evaluate the meniscus in patients with knee pain. MRI has high sensitivity and specificity for detecting meniscus tears in patients without prior knee surgery [8]. However, diagnostic performance is considerably lower in individuals following partial meniscectomy since the conventional criteria used to diagnose a meniscus tear cannot necessarily be applied to the post-operative meniscus [9–16]. For example, partial meniscectomy may result in distortion of the normal meniscus morphology. Furthermore, intra-substance meniscus signal may extend into the articular surface when a portion of the meniscus has been resected which may simulate a meniscus tear [17].

Various studies have investigated the usefulness of MRI for evaluating the post-operative meniscus [9–16]. However, these studies have been limited by small patient populations, inclusion of patients with both meniscus repair and partial meniscectomy, and selection bias as the vast majority of patients had a pre-operative clinical diagnosis of a torn post-operative meniscus. Furthermore, few previous studies have investigated the usefulness of various MRI findings to determine the presence or absence of a torn post-operative meniscus [13]. Thus, this study was performed to retrospectively compare the MRI characteristics of surgically confirmed torn and untorn menisci in a large number of patients who had undergone prior partial meniscectomy.

METHODS

Subjects

The retrospective study was performed in compliance with Health Insurance Portability and Accountability Act (HIPAA) regulations, with approval from our Institutional Review Board, and with a waiver of informed consent. A review of Current Procedural Terminology (CPT) codes was performed to identify 541 patients who had undergone two arthroscopic surgeries on the same knee at our institution between January 1, 2005 and July 1, 2015. The medical records of these patients were reviewed to determine whether or not they met the following inclusion criteria of the study: 1) a history of prior partial meniscectomy performed at the time of the first arthroscopic surgery, 2) a history of a second arthroscopic surgery performed on the same knee, and 3) an MRI examination performed on the same knee within a six month time period prior to the second arthroscopic surgery. The study group consisted of 140 patients with 148 partially resected menisci who met these inclusion criteria. Eight patients had partial meniscectomies performed on both menisci at the time of the first arthroscopic surgery.

MRI Examination

All 140 patients in the study group were imaged on the same 1.5T or 3.0T MRI scanner (Signa HDx, GE Healthcare, Waukesha, Wisconsin; N=99 patients imaged at 1.5T and N=41 patients imaged at 3.0T) using an 8-channel phased-array extremity coil (Precision Eight TX/TR High Resolution Knee Array, Invivo, Orlando, Florida). All MRI examinations consisted of an axial frequency selective fat-suppressed T2-weighted fast spin-echo sequence (TR/TE: 3800ms/88ms at 1.5T and 4050ms/85ms at 3.0T), a coronal intermediate-weighted fast spin-echo sequence (TR/TE: 1800ms/20ms at 1.5T and 3.0T), a coronal frequency selective fat-suppressed T2-weighted fast spin-echo sequence (TR/TE: 3200ms/50ms at 1.5T and 3.0T), a sagittal intermediate-weighted fast spin-echo sequence (TR/TE: 1800ms/20ms at 1.5T and 3.0T), and a sagittal frequency selective fat-suppressed T2-weighted fast spin-echo sequence (TR/TE: 4200ms/80ms at 1.5T and 4000ms/80ms at 3.0T). All sequences were performed with a 14 cm field of view, a matrix of 256×224 at 1.5T and 384×224 at 3.0T, a slice thickness of 2mm or 3mm with an inter-slice gap between 0.2mm and 1.0mm, a bandwidth between 20kHz and 41kHz, an echo train length between 3 and 15, and two or three signal averages.

Arthroscopic Knee Surgeries

The first and second arthroscopic knee surgeries in all 140 patients in the study group were performed by one of three orthopedic sports medicine specialists at our institution who had between 10 years and 25 years of clinical experience and who were aware of the findings of the MRI examination at the time of surgery. The orthopedic surgeons routinely inspect all areas of the medial and lateral meniscus both visually and with a surgical probe at arthroscopy to assess the extent of meniscal injury. The surgeons document in their surgical reports the pre-operative clinical diagnosis of the patient, the presence or absence of a tear within the medial and lateral meniscus, and the method of treatment of any meniscus tear detected at surgery. The surgical reports of the first arthroscopic surgery of all patients were reviewed to confirm that a partial meniscectomy was performed at the time of the initial

surgery. The surgical reports of the second arthroscopic surgery of all patients were reviewed to determine the pre-operative clinical diagnosis of the patient and whether the post-operative meniscus was torn or unorn.

Review of MRI Examination

The MRI examinations of all 140 patients in the study group performed prior to the second arthroscopic surgery were retrospectively reviewed independently by two fellowship-trained musculoskeletal radiologists with 11 and 13 years of clinical experience who were blinded to the clinical and surgical findings to determine the following MRI characteristics of the post-operative meniscus: 1) contour of the remaining partially resected meniscus (smooth contour or irregular contour), 2) presence of a line of increased signal through the meniscus extending into the articular surface on intermediate-weighted images, 3) presence of a line of increased signal through the meniscus extending into the articular surface on T2-weighted images, 4) signal intensity of the T2 signal line through the meniscus (no T2 signal line, intermediate T2 signal line defined as signal intensity between meniscus and cartilage signal, intermediate-to-high T2 signal line defined as signal intensity between cartilage and fluid signal, and high T2 signal line defined as signal intensity similar to fluid), 5) total number of coronal and sagittal images on which the T2 signal line through the meniscus was visualized (less than five images or five or more images), 6) extent of the T2 signal line through the meniscus (less than 75% through total meniscus vertical dimension or more than 75% through total meniscus vertical dimension), 7) presence of a displaced meniscus fragment, and 8) change in the signal intensity pattern through the meniscus defined as new meniscus contour abnormality or a new line of increased signal through the meniscus extending into the articular surface on intermediate-weighted or T2-weighted images in regions of the meniscus that appeared normal on the baseline MRI examination performed prior to the first arthroscopic surgery, which was available in 115 of the 140 patients in the study group. When the two radiologists disagreed on a particular characteristic of the post-operative meniscus, a consensus review of the MRI examination was performed to make the final interpretation with the help of a third fellowship-trained musculoskeletal radiologist with 10 years of clinical experience as needed.

Statistical Analysis

All statistical analysis was performed using MATLAB software (MATLAB 2010b, MathWorks Inc, Natick, MA). Kappa value was used to assess the inter-observer agreement between radiologists for determining the MRI characteristics of the post-operative meniscus. Inter-observer agreement was assessed according to the recommendations of Landis and Koch in which a kappa value of 0.00 to 0.20 indicates slight agreement, a value of 0.21 to 0.40 indicates fair agreement, a value of 0.41 to 0.60 indicates moderate agreement, a value of 0.61 to 0.80 indicates substantial agreement, a value of 0.81 to less than 1.00 indicates near perfect agreement, and a value of 1.00 indicates perfect agreement [18].

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the various MRI characteristics of the post-operative meniscus for detecting a surgically confirmed torn post-operative meniscus was calculated. When calculating sensitivity, specificity, PPV, and NPV for the signal intensity of the T2 signal line through

the meniscus, the signal intensities needed to be grouped into three individual MRI negative finding and MRI positive finding categories in order to meet the definitions of the statistical parameters: 1) no T2 signal line as MRI negative finding and intermediate T2 signal line, intermediate-to-high T2 signal line, or high T2 signal line as MRI positive finding, 2) no T2 signal line or intermediate T2 signal line as MRI negative finding and intermediate-to-high T2 signal line or high T2 signal line as MRI positive finding, and 3) no T2 signal line, intermediate T2 signal line, or intermediate-to-high T2 signal line as MRI negative finding and high T2 signal line as MRI positive finding. However, the PPV for the individual signal intensities of intermediate T2 signal line, intermediate-to-high T2 signal line, and high T2 signal line were able to be calculated. These PPV values were calculated for all menisci, menisci in patients with a pre-operative clinical diagnosis of a torn post-operative meniscus, and menisci in patients without a pre-operative clinical diagnosis of a torn post-operative meniscus. The PPV values were also calculated for menisci evaluated on a 1.5T scanner and menisci evaluated on a 3.0T scanner.

RESULTS

The study group consisted of 93 males and 48 females with an age range between 16 years and 64 years and an average age of 40.6 years. Of the 140 patients in the study group, the pre-operative clinical diagnosis for the second arthroscopic knee surgery was a torn post-operative meniscus in 77 patients, an anterior cruciate ligament tear in 33 patients, and a torn meniscus which had not undergone prior partial meniscectomy in 30 patients. There were 83 partially resected medial menisci and 65 partially resected lateral menisci. Of the 148 partially resected menisci, 76 were found to be torn and 72 were found to be untorn at the second arthroscopic surgery. Forty-five of the torn post-operative menisci were in the medial meniscus and 31 of the torn post-operative menisci were in the lateral meniscus.

Table 1 shows the kappa value for inter-observer agreement between radiologists for assessing the various MRI characteristics of the post-operative meniscus. There was substantial to near perfect inter-observer agreement for assessing all MRI characteristics of the post-operative meniscus with kappa values ranging between 0.72 for the total number of coronal and sagittal images on which the T2 signal line through the meniscus was visualized and 0.92 for change in the signal intensity pattern through the meniscus on intermediate-weighted or T2-weighted images when compared to the baseline MRI examination.

Table 2 shows the diagnostic performance of the various MRI characteristics for detection of a torn post-operative meniscus. A change in the signal intensity pattern through the meniscus on intermediate-weighted or T2-weighted images when compared to the baseline MRI examination was the most useful MRI characteristic for detection of a torn post-operative meniscus with high specificity and sensitivity (Figure 1). The presence of an irregular meniscus contour (Figure 2), a line of increased T2 signal extending into the articular surface on 5 or more images, and a displaced meniscus fragment had high specificity but low sensitivity for detection of a torn postoperative meniscus. The presence of a line of increased signal through the meniscus extending into the articular surface on intermediate-weighted and T2-weighted images had high sensitivity but low specificity for detection of a torn post-operative meniscus.

The signal intensity of the T2 line extending through the meniscus was useful for detection of a torn post-operative meniscus, especially if there was no T2 signal line, an intermediate-to-high T2 signal line, or a high T2 signal line (Figure 3–Figure 7). All 36 menisci with no T2 signal line were found to be untorn at surgery (100% NPV with 95% confidence interval of 90.3% and 100%), while 46 of 79 menisci with an intermediate T2 signal line (PPV of 58.2% with 95% confidence interval of 46.6% and 69.2%), 16 of 18 menisci with an intermediate-to-high T2 signal line (PPV of 88.9% with 95% confidence interval of 65.3% and 98.6%), and 14 of 15 menisci with a high T2 signal line (PPV of 93.3% with 95% confidence interval of 68.0% and 99.8%) were found to be torn at surgery. The PPV of a post-operative meniscus with an intermediate, intermediate-to high, and high T2 signal line was 69.4% (95% confidence interval of 54.6% and 81.8%), 92.3% (95% confidence interval of 64.0% and 99.8%), and 100% (95% confidence interval of 71.5% and 100%) respectively when the pre-operative clinical diagnosis was a torn post-operative meniscus and 40.0% (95% confidence interval of 22.6% and 59.4%), 80.0% (95% confidence interval of 28.4% and 99.5%), and 75.0% (95% confidence interval of 19.4% and 99.4%) respectively when the pre-operative clinical diagnosis was not a torn post-operative meniscus. . The PPV of a post-operative meniscus with an intermediate, intermediate-to high, and high T2 signal line was 52.8% (95% confidence interval of 38.6% and 66.7%), 92.9% (95% confidence interval of 66.1% and 99.8%), and 90.9% (95% confidence interval of 58.7% and 99.8%) respectively when the meniscus was evaluated on a 1.5T scanner and 70.8% (95% confidence interval of 48.9% and 87.4%), 75.0% (95% confidence interval of 19.4% and 99.4%), and 100% (95% confidence interval of 39.8% and 100%) respectively when the meniscus was evaluated on a 3.0T scanner.

DISCUSSION

Our study has shown that the absence of a line of increased signal through the meniscus extending into the articular surface on intermediate-weighted and T2-weighted images was a reliable MRI finding of an untorn post-operative meniscus. The 100% sensitivity of this MRI finding for detection of a torn post-operative meniscus was higher than values previously reported in the literature. Lim and associates reported 88% sensitivity for a line through the meniscus on intermediate-weighted images [13], while White and associates reported 76% and 84% sensitivity for a line through the meniscus on intermediate-weighted and T2-weighted images respectively for detection of a torn post-operative meniscus [14]. However, these studies were performed several years ago using less advanced MRI scanners and coils. Thus, the higher number of false negative findings may be the result of greater difficulty in determining whether signal within a post-operative meniscus extended into the articular surface due to reduced tissue contrast and lower in-plane and through-plane spatial resolution. A recent study by Magee and associates reported 75% sensitivity for a line of increased signal through the meniscus extending into the articular surface on either intermediate-weighted or T2-weighted images for detection of a torn post-operative meniscus. However, only four out of the 100 post-operative menisci evaluated with MRI in this study were found to be untorn at arthroscopy [16].

Our study has shown that an intermediate T2 signal line extending into the articular surface of a post-operative meniscus is a nonspecific MRI finding which confirms the results of

previously published studies [9–16]. However, no previous study has included a large enough number of patients with surgically confirmed torn and untorn post-operative menisci to determine the exact clinical significance of this finding. Our study found that an intermediate T2 signal line through a post-operative meniscus had a PPV of 58.2% for detection of a meniscus re-tear which indicates that the finding is almost equally present in torn and untorn post-operative menisci. When an intermediate T2 signal line is identified through a post-operative meniscus, the clinical history of the patient should be taken into consideration as the PPV of this finding in our study increased from 40.0% when the pre-operative clinical diagnosis was not a torn post-operative to 69.4% when the pre-operative clinical diagnosis was a torn post-operative meniscus.

Our study has shown that various MRI findings have high specificity for detection of a torn post-operative meniscus. In particular, a line of intermediate-to-high signal or high signal through the meniscus extending into the articular surface on T2-weighted images was a reliable MRI finding of a torn post-operative meniscus with 95.8% specificity. Previous studies by Lim and associates [13] and Applegate and associates [11] reported 88% and 90% specificity respectively for the presence of high fluid-like T2 signal line through the meniscus for detection of a torn post-operative meniscus. However, no previous study has investigated the usefulness of an intermediate-to-high T2 line signal through the meniscus as an MRI finding of meniscus re-tear. A line of intermediate-to-high T2 signal through the meniscus likely represents partial volume averaging between joint fluid and torn meniscus fibers and had a similar high PPV in our study for detection of a torn post-operative meniscus as a high fluid-like T2 signal line through the meniscus. Our study has also shown that additional MRI findings have high specificity for detection of a torn post-operative meniscus including an irregular meniscus contour, a line of increased T2 signal extending into the articular surface on 5 or more images, and a displaced meniscus fragment. Unfortunately, these highly specific MRI finding were relatively insensitive and were not present in many torn post-operative menisci in our study.

The most useful MRI characteristic for detection of a torn post-operative meniscus in our study was a change in the signal intensity pattern through the meniscus on intermediate-weighted or T2-weighted images when compared to the baseline MRI examination which had a sensitivity of 85.7% and a specificity of 98.2%. This emphasizes the importance of having the baseline MRI examination available for comparison when evaluating patients with a post-operative meniscus. New meniscus contour abnormality or a new line of increased signal through the meniscus extending into the articular surface in regions of the meniscus that appeared normal on the baseline MRI examination may also be due to the fact that the initial MRI examination underestimated the true extent of the meniscus tear or that the surgeon debrided some untorn meniscal tissue in order to create a smooth meniscus margin. However, the near perfect specificity of this MRI finding for detection of a torn post-operative meniscus in our study indicates that this was not the case at least in our patient population. Thus, our results strongly suggest that any change in the signal intensity pattern through a post-operative meniscus should be considered to represent a meniscus re-tear.

MRI arthrography is currently used at many institutions to evaluate the post-operative meniscus. While MRI arthrography is more invasive and expensive than conventional MRI, it has been shown to provide improved diagnostic performance for detection of a torn post-operative meniscus [11, 14–16]. The presence of high gadolinium-like signal within a post-operative meniscus on fat-suppressed T1-weighted images is a highly specific finding of a torn meniscus on MRI arthrography. However, a previous study by De Smet and associates has shown that 41% of patients with a surgically confirmed torn post-operative meniscus had signal intensity within the meniscus extending into the articular surface which was lower than the signal intensity of gadolinium contrast [19]. Thus, similar to the presence of a line of intermediate T2 signal extending into the articular surface on conventional MRI, diagnosis of a torn post-operative meniscus on MRI arthrography is challenging in the common scenario when the intra-meniscus signal intensity is not as bright as gadolinium contrast. Nevertheless, the use of MRI arthrography should be considered for post-operative menisci with equivocal findings on conventional MRI as the presence of high gadolinium-like signal within the meniscus would allow for a definitive diagnosis of re-tear.

Our study has several limitations. One limitation was the retrospective study design. Another limitation was the presence of selection bias as not all patients with a post-operative meniscus evaluated with MRI at our institution underwent subsequent arthroscopic knee surgery and were included in our study group. In addition, many of the MRI characteristics of the post-operative meniscus, especially the signal intensity of the T2 signal line through the meniscus, are rather subjective and may be difficult to reliably assess. Although there was high inter-observer agreement for determining the presence or absence of the various MRI characteristics of the post-operative meniscus in our study, both reviewers were experienced musculoskeletal radiologists. Thus, it is not known whether less experienced radiologists would achieve the same high inter-observer agreement for evaluating the post-operative meniscus. A final limitation of our study was that arthroscopy is considered to be an imperfect reference standard for determining the presence or absence of meniscus tear [20].

In conclusion, our study has shown that various MRI findings are useful for distinguishing between a torn and untorn post-operative meniscus. The absence of a line of increased signal through the meniscus on intermediate-weighted and T2-weighted images is a highly sensitive finding, while the presence of a line of intermediate-to-high signal or high fluid-like signal through the meniscus on T2-weighted images is a highly specific finding for a torn post-operative meniscus. However, the presence of a line of intermediate signal through the meniscus on T2-weighted images is a nonspecific finding which can be seen almost equally in both torn and untorn post-operative menisci. In this circumstance, one needs to look for additional MRI findings with high specificity such as the presence of an irregular meniscus contour, a line of increased T2 signal extending into the articular surface on 5 or more images, a displaced meniscus fragment, or a change in the signal intensity pattern through the meniscus when compared to the baseline MRI examination and take into account the clinical history of the patient to determine whether there is a high likelihood of meniscus re-tear.

References

1. Garrett WE Jr, Swiontkowski MF, Weinstein JN, et al. American Board of Orthopaedic Surgery Practice of the Orthopaedic Surgeon: Part-II, certification examination case mix. The Journal of bone and joint surgery American volume. 2006; 88:660–667. [PubMed: 16510834]
2. Abrams GD, Frank RM, Gupta AK, Harris JD, McCormick FM, Cole BJ. Trends in meniscus repair and meniscectomy in the United States, 2005–2011. The American journal of sports medicine. 2013; 41:2333–2339. [PubMed: 23863849]
3. Montgomery SR, Zhang A, Ngo SS, Wang JC, Hame SL. Cross-sectional analysis of trends in meniscectomy and meniscus repair. Orthopedics. 2013; 36:e1007–1013. [PubMed: 23937745]
4. Bolano LE, Grana WA. Isolated arthroscopic partial meniscectomy. Functional radiographic evaluation at five years. The American journal of sports medicine. 1993; 21:432–437. [PubMed: 8346759]
5. Hulet CH, Locker BG, Schiltz D, Texier A, Tallier E, Vielpeau CH. Arthroscopic medial meniscectomy on stable knees. J Bone Joint Surg Br. 2001; 83:29–32. [PubMed: 11245533]
6. Burks RT, Metcalf MH, Metcalf RW. Fifteen-year follow-up of arthroscopic partial meniscectomy. Arthroscopy. 1997; 13:673–679. [PubMed: 9442319]
7. Scheller G, Sobau C, Bulow JU. Arthroscopic partial lateral meniscectomy in an otherwise normal knee: Clinical, functional, and radiographic results of a long-term follow-up study. Arthroscopy. 2001; 17:946–952. [PubMed: 11694926]
8. Oei EH, Nikken JJ, Verstijnen AC, Ginai AZ, Myriam Hunink MG. MR imaging of the menisci and cruciate ligaments: a systematic review. Radiology. 2003; 226:837–848. [PubMed: 12601211]
9. Smith DK, Totty WG. The knee after partial meniscectomy: MR imaging features. Radiology. 1990; 176:141–144. [PubMed: 2353083]
10. Farley TE, Howell SM, Love KF, Wolfe RD, Neumann CH. Meniscal tears: MR and arthrographic findings after arthroscopic repair. Radiology. 1991; 180:517–522. [PubMed: 2068321]
11. 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 American journal of roentgenology. 1993; 161:821–825. [PubMed: 8372768]
12. 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. Skeletal radiology. 1999; 28:508–514. [PubMed: 10525794]
13. Lim PS, Schweitzer ME, Bhatia M, et al. Repeat tear of postoperative meniscus: potential MR imaging signs. Radiology. 1999; 210:183–188. [PubMed: 9885605]
14. 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. [PubMed: 11818609]
15. Ciliz D, Ciliz A, Elverici E, Sakman B, Yuksel E, Akbulut O. Evaluation of postoperative menisci with MR arthrography and routine conventional MRI. Clinical imaging. 2008; 32:212–219. [PubMed: 18502349]
16. Magee T. Accuracy of 3-Tesla MR and MR arthrography in diagnosis of meniscal re-tear in the post-operative knee. Skeletal radiology. 2014; 43:1057–1064. [PubMed: 24752876]
17. McCauley TR. MR imaging evaluation of the postoperative knee. Radiology. 2005; 234:53–61. [PubMed: 15564389]
18. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977; 33:159–174. [PubMed: 843571]
19. De Smet AA, Horak DM, Davis KW, Choi JJ. Intensity of signal contacting meniscal surface in recurrent tears on MR arthrography compared with that of contrast material. AJR American journal of roentgenology. 2006; 187:W565–568. [PubMed: 17114506]
20. Quinn SF, Brown TF. Meniscal tears diagnosed with MR imaging versus arthroscopy: how reliable a standard is arthroscopy? Radiology. 1991; 181:843–847. [PubMed: 1947108]

Figure 1.

44 year old male with a surgically confirmed torn post-operative body and anterior horn lateral meniscus. (A) Coronal intermediate-weighted fast spin-echo image on the baseline MRI examination shows signal abnormality extending into the articular surface of the body of the lateral meniscus consistent with a tear (arrow). (B and C) Corresponding coronal and sagittal intermediate-weighted fast spin-echo images show a normal appearing anterior horn of the lateral meniscus (arrows). (D) Coronal intermediate-weighted fast spin-echo image on the follow-up MRI examination performed prior to the second arthroscopic surgery shows abnormal morphology of the body of the lateral meniscus consistent with prior partial meniscectomy. (E and F) Corresponding coronal and sagittal intermediate-weighted fast spin-echo images show new signal abnormality extending into the articular surface of the anterior horn of the lateral meniscus consistent with a re-tear (arrows).

Figure 2. 37 year old male with a surgically confirmed torn post-operative posterior horn medial meniscus. Sagittal fat-suppressed T2-weighted fast spin-echo image shows abnormal morphology of the posterior horn of the medial meniscus consistent with prior partial meniscectomy. The remaining meniscus has an irregular contour with an intermediate T2 signal line of signal intensity between meniscus and cartilage signal extending into the articular surface (arrow).

Figure 3. 33 year old female with a surgically confirmed untorn post-operative posterior horn medial meniscus. Sagittal fat-suppressed T2-weighted fast spin-echo image shows abnormal morphology of the posterior horn of the medial meniscus consistent with prior partial meniscectomy. The remaining meniscus has a smooth contour with absence of a line of increased T2 signal extending into the articular surface (arrow).

Figure 4. 42 year old male with a surgically confirmed untorn post-operative posterior horn medial meniscus. Sagittal fat-suppressed T2-weighted fast spin-echo image shows abnormal morphology of the posterior horn of the medial meniscus consistent with prior partial meniscectomy. The remaining meniscus has a smooth contour with an intermediate T2 signal line of signal intensity between meniscus and cartilage signal extending into the articular surface (arrow).

Figure 5. 34 year old male with a surgically confirmed torn post-operative posterior horn medial meniscus. Sagittal fat-suppressed T2-weighted fast spin-echo image shows abnormal morphology of the posterior horn of the medial meniscus consistent with prior partial meniscectomy. The remaining meniscus has a smooth contour with an intermediate T2 signal line of signal intensity between meniscus and cartilage signal extending into the articular surface (arrow), which is nearly identical in appearance to the intermediate T2 signal line through the meniscus in the patient in Figure 4 who had a surgically confirmed untorn post-operative meniscus. An intermediate T2 signal line through a post-operative meniscus is a nonspecific MRI finding which can be seen in both torn and untorn menisci.

Figure 6. 39 year old female with a surgically confirmed torn post-operative posterior horn lateral meniscus. Sagittal fat-suppressed T2-weighted fast spin-echo image shows abnormal morphology of the posterior horn of the lateral meniscus consistent with prior partial meniscectomy. The remaining meniscus has a smooth contour with an intermediate-to-high T2 signal line of signal intensity between cartilage and fluid signal extending into the articular surface (arrow).

Figure 7.

26 year old male with a surgically confirmed torn post-operative posterior horn lateral meniscus. Sagittal fat-suppressed T2-weighted fast spin-echo image shows abnormal morphology of the posterior horn of the medial meniscus consistent with prior partial meniscectomy. The remaining meniscus has a smooth contour with a high fluid-like T2 signal line extending into the articular surface (arrow).

TABLE 1

Kappa value for inter-observer agreement between radiologists for assessing the various MRI characteristics of the post-operative meniscus.

MRI Characteristics	Kappa Value (95% Confidence Intervals)
Contour	0.81 (0.70–0.90)
Presence of Intermediate Line	0.90 (0.80–0.99)
Presence of T2 Line	0.91 (0.84–0.99)
Signal Intensity of T2 Line	0.81 (0.71–0.91)
Number of Images T2 Line Visualized	0.72 (0.63–0.83)
Extent of T2 Line	0.76 (0.65–0.89)
Displaced Fragment	0.82 (0.66–0.94)
Change From Prior MRI	0.92 (0.85–0.99)

TABLE 2

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the various MRI characteristics for detection of a torn post-operative meniscus.

MRI Characteristics	Diagnostic Performance (95% Confidence Intervals)			
	Sensitivity	Specificity	PPV	NPV
Irregular Contour	47.4% (35.7%–59.2%)	91.7% (82.8%–96.9%)	85.7% (71.5%–94.6%)	62.2% (52.3%–71.5%)
Intermediate Line	100% (95.3%–100%)	38.9% (27.6%–51.1%)	63.3% (52.3%–71.5%)	100% (87.7%–100%)
Any T2 Line	100% (95.3%–100%)	50.0% (38.0%–62.0%)	67.9% (58.4%–76.4%)	100% (90.3%–100%)
Intermediate-High or High T2 Line	40.4% (27.6%–54.2%)	95.8% (78.9%–99.9%)	90.9% (75.7%–98.1%)	60.0% (50.5%–69.0%)
High T2 Line	18.4% (10.5%–29.0%)	98.6% (92.5%–99.9%)	93.3% (68.1%–99.8%)	34.3% (23.4%–46.6%)
T2 Line on Five or More images	65.8% (54.0%–76.3%)	69.4% (51.9%–83.7%)	82.0% (70.0%–90.6%)	49.0% (34.8%–63.4%)
T2 Line 75% through Meniscus	50.0% (38.3%–61.7%)	52.8% (35.5%–69.6%)	69.1% (55.2%–80.9%)	33.3% (21.4%–47.1%)
Displaced Fragment	27.7% (18.0%–39.1%)	100% (95.0%–100%)	100% (83.9%–100%)	56.7% (47.6%–65.5%)
Change From Prior MRI	85.7% (75.3%–92.9%)	98.2% (90.5%–99.9%)	99.4% (91.2%–99.9%)	84.6% (73.5%–92.4%)