Meniscal problems: to repair and to replace

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Intraobserver and interobserver agreement of MRI for reparability of peripheral meniscal tears. What criteria do really matter?

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ABSTRACT

Background: Prediction of meniscus reparability is useful for surgeons to optimise surgical scheduling and to inform patients about postoperative management.

Purpose: Determination of the intra- and interobserver agreement of three magnetic resonance imaging (MRI) criteria for reparability: a peripheral rim smaller than 4 mm, a tear longer than 10 mm and homogenous aspect of meniscal tissue.

Study design: Cohort study (diagnosis)

Methods: In two rounds with an interval of at least 6 weeks, 3 orthopaedic surgeons and 3 musculoskeletal radiologists studied the preoperative MRI scans of 63 patients with a longitudinal full-thickness medial or lateral meniscal tear. All patients had an arthroscopic meniscal repair. The blinded images were evaluated measuring the tear length and rim width and meniscal aspect was classified. Agreement was calculated using the linear weighted Kappa coefficient (κ) and the intraclass correlation coefficient (ICC). Examiner agreement strength was defined according to the guidelines of Landis and Koch.

Results: Intraobserver agreement was poor to good (κ 0.12 – 0.72) for the classification of the meniscal aspect and decreased in lateral meniscal tears. The interobserver agreement for meniscal aspect was mainly poor to fair (κ 0.09 – 0.53). The intraobserver reliability for measurement of the length of the meniscal tear was moderate to excellent (ICC 0.51 – 0.80) for all observers in both rounds and moderate to good (ICC 0.59 – 0.73) for measurement of the peripheral rim width. The interobserver agreement on tear length and rim width was moderate in both rounds (ICC 0.58 and 0.50 in round 1 and 0.50 and 0.50 in round 2, respectively).

Conclusions: Tear length and rim width are the only two measurements with moderate to good agreement. However, these measurements do not predict reparability of a longitudinal meniscal tear on MRI images.

INTRODUCTION

Preserving meniscal tissue and thereby saving meniscal function decreases the risk of premature osteoarthritis after meniscectomy.[13,19] For that reason, meniscal repair is preferable above partial meniscectomy in the treatment of meniscal tears whenever possible. Preoperative knowledge about the reparability of a meniscal tear can be an important step in the management of meniscal tears, where it can help to inform patients about their treatment, postoperative management and it helps surgeons to optimise surgical scheduling. Intraoperative criteria for meniscal repair are based on factors like tear length, tear instability and tear type.[10] The International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) classification of meniscal tears was developed to classify tear depth, rim width, location, tear pattern, and quality of the tissue based on intraoperative findings and provides sufficient interobserver reliability to evaluate the outcome after meniscal treatment.[1] Magnetic Resonance Imaging (MRI) is currently used on a routine base to diagnose ligament injury or meniscal tears of the knee with high sensitivity and specificity.[12] Using MRI to predict reparability is far less established. Criteria for meniscal repair based on MRI were first stated by Matava in 1999. The tear length of longitudinal or bucket handle tears, the distance from tear to meniscosynovial junction, tear location and minimal damage were considered important parameters for meniscal repair.[10] Criteria for prediction of meniscal reparability based on MRI for only medial bucket handle meniscal tears were further prescribed by Thoreux based on anatomical knowledge and surgical experience. They enlarged the criteria based on distance from tear to meniscosynovial junction (rim width) and defined the minimal damage of the inner and peripheral meniscal fragments.[20] Finally, criteria for reparability of both medial and lateral longitudinal full-thickness meniscal tears were defined. A tear was considered reparable when it met all of the following criteria: (1) a bucket handle rim segment less than 4 mm wide; (2) tear length of $\geq$ 1 cm, regardless of the total tear length; and (3) minimal damage to the inner and peripheral meniscal fragments (described as generated low signals or isosignals compared with the normal contralateral meniscus of the same knee, thereby demonstrating the absence of degenerative tears).[11] These three criteria on reparability are used for both medial and lateral longitudinal full-thickness meniscal tears, but were never validated. Useful criteria on reparability should have good intraobserver and interobserver agreement. Therefore, we performed an observational study to determine intra- and interobserver agreement on meniscal reparability for longitudinal, peripheral meniscal tears based on MRI among both orthopaedic surgeons and musculoskeletal radiologists.

According to our knowledge the ISAKOS classification system was never used to describe tear morphology based on MRI images. We evaluated the usefulness of the ISAKOS classification in classifying meniscal tears on MRI. We hypothesized that the three above mentioned MRI criteria and the ISAKOS classification have good to excellent (weighted Kappa (κ) ≥ 0.61) intra- and interobserver agreement.

MATERIALS AND METHODS

Patients

We retrospectively reviewed the preoperative MRI images of 63 consecutive patients, who underwent an arthroscopic meniscal repair of a longitudinal, peripheral meniscal tear between June 2008 till August 2011. The study included 45 (71%) men and 18 women with a median age of 24 years (Inter Quartile Range (IQR), 18 – 31 years). No revision cases were included in our study. Thirty-eight out of 63 (60%) patients had a medial meniscal tear, of which 22 were displaced. Twelve of the 25 patients with a lateral meniscal tear, had a displaced meniscal tear. The Medical Ethical Review Board decided that approval for this study was not necessary.

Patient evaluation

Multiple attempts (maximal five) were made, to contact all 63 patients by telephone during summer 2014. All medical records were checked for postoperative radiographic examinations, reoperations and complications. If patients could be reached, they were asked to complete questionnaires about their medical history, especially about any possible reoperation or radiographic examination elsewhere. Patients were not evaluated in the outpatient clinic. The criteria for failure were partial or (sub)total meniscectomy of the previous sutured meniscus or failure (re-tear or partial healing) proven by radiological examination (MRI or Computed Tomography (CT) arthrography).

Surgical technique

At arthroscopy, criteria for meniscal repair were: a vertical tear in red zone or red-white zone (vascularized peripheral zone of the meniscus), a tear length > 1 cm, and non-degenerative, homogenous meniscal tissue. A millimeter ruler to measure tear length and rim width was not available. The standard procedure for isolated meniscal repair included rasping of the peripheral rim and meniscus, suturing the posterior horn with all-inside sutures and the middle section with inside-out sutures, and drilling holes in the intercondylar notch to provide blood and growth factors.

MRI technique

MRI examinations were performed using a 1.5 Tesla (T) Siemens Avanto MRI scanner in 12 patients, a 1.5 T Siemens Magnetom Essenza MRI scanner in 22 patients, and a 1.5 T Siemens Harmony MRI scanner in 29 patients (all Siemens Medical Systems, Erlangen, Germany). For all examinations, a 16 cm field of view was used and patients were scanned in supine position using a phased array knee coil. The examinations performed on the Magnetom Essenza MRI scanner included coronal and sagittal T2-weighted images and with repetition times (TR) of 800 to 1130 ms and echo times (TE) of 27 ms, slice thickness (ST) was 4 mm with a gap/slice spacing (SS) of 0.8 mm, and a matrix size of 384 x 234. On the Siemens Avanto MRI scanner a coronal and sagittal T2 Medic were performed with a TR of 700 ms, TE of 23 ms, ST of 4 mm with a SS of 0.8 mm and a matrix size of 320 X 256. The protocol on the Siemens Symphony included a coronal and sagittal T2 Medic with a TR of TR of 976 to 997 ms, TE of 27 ms, ST of 4 mm and a SS of 0.8mm and a matrix size of 256 x 156, and 320 x 216 respectively. The examinations performed on the Siemens Harmony scanner included a coronal and sagittal T2 Medic having a TR of 867 ms, TE of 26 ms, ST of 4 mm, SS of 0.8 mm and matrix size of 256 x 179.

Image evaluation

Review of images was performed on a Picture Archiving and Communication System (PACS) workstation (GE Healthcare, Hoevelaken, Netherlands). Three orthopaedic surgeons and three musculoskeletal radiologists independently evaluated the MRI images in two rounds. The orthopaedic surgeons had 17 years, 8 years and 6 years of experience. The radiologists had 22 years, 20 years and 11 years of experience in musculoskeletal imaging. The observers were aware of the patients' meniscal injury, but had no additional information about the MRI report, patients' demographics, clinical findings and orthopaedic treatment. They were blinded for the fact that only repaired longitudinal, peripheral meniscal tears were included. After the first review session the patients' MRI images were shuffled randomly and evaluated for a second time. The minimal interval between the two observation rounds had to be at least six weeks.

The observers were asked to measure the width of the peripheral rim and the length of the meniscal tear in millimeters (mm), and to describe the aspect of the meniscal tissue and tear morphology to determine intraobserver and interobserver agreement on meniscal reparability using the following criteria: (1) a bucket handle rim segment less than 4 mm wide; (2) tear length of $\geq$ 1 cm, regardless of the total tear length; and (3) minimal damage to the inner and peripheral meniscal fragments. Tear length was measured by counting the number of slices on which the tear was seen multiplied by the slice thickness in mm. The distance from the meniscosynovial junction to the meniscal tear as seen on the sagittal and coronal MRI images were estimated using standard ruler divided in mm increments. Aspect of the meniscal tissue of the inner and peripheral meniscal tear fragments was compared with the normal, contralateral meniscus of the same knee to determine homogeneity (low signals or isosignals). Meniscal aspect was scored as homogeneous (low signal) or heterogeneous (high signal). Tear morphology was classified by the ISAKOS classification: longitudinal-vertical (extension of this tear is a bucket handle tear), horizontal, radial, vertical flap, horizontal flap, and complex.[1] With six items in the ISAKOS classification for meniscal tears, 63 patients included in this study was enough to get a reliable intraobserver and interobserver agreement.[4]

At the end all observers were asked to answer a key question, whether they would perform a meniscal repair or not, based on their own experience and daily practise and not (only) based on the given three criteria.

Statistics

Data of tear length and rim width were tested for normality. We evaluated the mean length of peripheral rim and meniscal tear length scored by each examiner for both rounds. A weighted Kappa (κ) coefficient was performed to determine consistency among observers for categorical data. For both rounds the Fleiss' Kappa was calculated to show the overall agreement for the six observers. For continuous data, including tear length and peripheral rim width, the intraclass correlation coefficient (ICC) using a 2-way random effects model was calculated to estimate intra- and interobserver reliability.[18] Wilcoxon signed rank test was used to compare paired data between groups. The strength of examiner agreement was defined according to the guidelines of Landis and Koch as follows: poor, $\kappa \leq 0.20$; fair, $\kappa = 0.21$ to 0.40; moderate, $\kappa = 0.41$ to 0.60; good, $\kappa = 0.61$ to 0.80; and excellent, $\kappa = 0.81$ to 1.00.[9] A Student's T-test was used to calculated statistical differences in rim width and tear length between meniscal repair failures and survivors. Statistical analysis was performed using SPSS statistical software (version 20, SPSS Inc, Chicago, IL).

RESULTS

Our study population of 63 patients contained slightly more patients with a displaced meniscal tear (n = 34) than with a non-displaced tear (n = 29), and slightly more medial tears (n = 38) than lateral tears (n = 25). Twenty-two of 38 (58%) medial meniscal tears were displaced and 12 of 25 (48%) lateral meniscal tears were displaced.

Time interval between the two observation rounds varied from 3 months to 5.5 months. According to the measurements and reviews of the observers, 35% to 60% (average 48%) of the patients met all three MRI criteria for reparability. This percentage was lower than the average of 61.4% measured with the key question on meniscal repair of patients considered suitable for meniscal repair according to the 'key question'.

Meniscal Aspect

Results of intraobserver agreement on meniscal aspect were evaluated for all patients and results are shown in Table 1. Intraobserver agreement for orthopaedic surgeons was moderate to good, while the radiologists had a poor to moderate intraobserver agreement of the meniscal aspect, all results are shown in Table 1. Intraobserver agreement did not change when dividing the tears on bases of displacement: displaced tears versus non displaced tears. Intraobserver agreement, was higher for medial tears compared to lateral tears. Interobserver agreement on meniscal aspect in both rounds was fair with a Fleiss' Kappa of 0.34 and 0.31, in respectively round 1 and 2. Kappa coefficient varied from 0.15 to 0.53 in round 1 and 0.09 to 0.53 in round 2 (Table 2).

Table 1. Intraobserver agreement of the meniscal aspect in all patients, in patients divided by tear displacement (displaced versus non displaced) and in patients divided by knee compartment (medial versus lateral).

	All tears (n = 63)			
	κ	95% CI		
OS 1	0.63	0.53 – 0.73		
OS 2	0.72	0.63 – 0.80		
OS 3	0.42	0.31 – 0.54		
Rad 1	0.30	0.20 – 0.41		
Rad 2	0.12	0.08 – 0.16		
Rad 3	0.41	0.25 – 0.56		
	Displaced tears (n = 34)		Non displaced tears (n = 29)	
	κ	95% CI	κ	95% CI
OS 1	0.64	0.50 – 0.77	0.61	0.45 – 0.77
OS 2	0.71	0.59 – 0.83	0.73	0.61 – 0.85
OS 3	0.30	0.12 – 0.47	0.52	0.36 – 0.68
Rad 1	0.31	0.19 – 0.44	0.30	0.12 – 0.49
Rad 2	0.07	0.02 – 0.13	0.18	0.13 – 0.23
Rad 3	0.46	0.25 – 0.66	0.34	0.11 – 0.58
	Medial tears (n = 38)		Lateral tears (n = 25)	
	κ	95% CI	κ	95% CI
OS 1	0.63	0.50 – 0.75	0.60	0.42 – 0.78
OS 2	0.68	0.56 – 0.80	0.76	0.63 – 0.89
OS 3	0.44	0.28 – 0.60	0.36	0.17 – 0.55
Rad 1	0.52	0.39 – 0.65	0.06	-0.08 – 0.19
Rad 2	0.11	0.06 – 0.16	0.09	0.03 – 0.16
Rad 3	0.42	0.24 – 0.60	0.34	0.04 – 0.63

OS = Orthopaedic Surgeon; Rad = Radiologist. κ = Kappa coefficient. 95% CI = 95% Confidence Interval.

Table 2. Interobserver agreement of the meniscal aspect and tear type in both observation rounds (round 1 and round 2).

	Meniscal aspect				Tear type			
	Round 1		Round 2		Round 1		Round 2	
	κ	95% CI	κ	95% CI	κ	95% CI	κ	95% CI
OS 1 vs OS 2	0.53	0.43 –0.63	0.38	0.27 – 0.50	0.30	0.17 – 0.43	0.38	0.22 – 0.54
OS 1 vs OS 3	0.46	0.36 – 0.55	0.24	0.14 – 0.34	0.25	0.12 – 0.38	0.31	0.06 – 0.57
OS 2 vs OS 3	0.45	0.34 – 0.56	0.53	0.44 – 0.63	0.41	0.28 – 0.54	0.49	0.26 – 0.69
Rad 1 vs Rad 2	0.39	0.28 – 0.51	0.16	0.12 – 0.20	0.06	-0.05 – 0.17	0.03	-0.01 – 0.08
Rad 1 vs Rad 3	0.31	0.18 – 0.41	0.24	0.14 – 0.34	0.09	-0.03 – 0.15	0.03	-0.06 – 0.11
Rad 2 vs Rad 3	0.24	0.13 – 0.36	0.10	0.07 – 0.13	0.10	-0.03 – 0.23	0.04	0.02 – 0.05
OS 1 vs Rad 1	0.49	0.33 – 0.55	0.34	0.23 – 0.46	0.04	-0.07 – 0.15	0.01	-0.09 – 0.11
OS 1 vs Rad 2	0.37	0.25 – 0.49	0.20	0.16 – 0.23	0.17	0.15 – 0.29	0.07	-0.0 – 0.161
OS 1 vs Rad 3	0.37	0.27 – 0.48	0.28	0.16 – 0.40	0.01	-0.09 – 0.19	0.05	0.03 – 0.07
OS 2 vs Rad 1	0.19	0.10 – 0.29	0.26	0.14 – 0.39	0.10	-0.00 – 0.20	0.17	0.06 – 0.27
OS 2 vs Rad 2	0.38	0.27 – 0.49	0.12	0.08 – 0.16	0.10	0.00 – 0.20	0.19	-0.00 - 0.38
OS 2 vs Rad 3	0.22	0.14 – 0.30	0.30	0.20 – 0.39	0.21	0.10 – 0.32	0.55	0.32 – 0.78
OS 3 vs Rad 1	0.22	0.14 – 0.30	0.26	0.15 – 0.37	0.24	0.12 – 0.36	0.18	0.07 – 0.29
OS 3 vs Rad 2	0.43	0.33 – 0.53	0.10	0.06 – 0.15	0.25	0.20 – 0.39	0.12	0.01 – 0.22
OS 3 vs Rad 3	0.15	0.09 – 0.22	0.09	0.02 – 0.16	0.27	0.13 – 0.41	0.38	0.10 – 0.66
Fleiss' Kappa	0.34		0.31		0.19		0.19	

OS = Orthopaedic Surgeon; Rad = Radiologist. κ = Kappa coefficient. 95% CI = 95% Confidence Interval.

Rim width and tear length

Intraobserver reliability for meniscal tear length and the peripheral rim width was moderate to excellent for all observers in both rounds. Absolute values and the intraclass correlation coefficients are shown in Table 3. In all except five (0.007%) observations, tear length was measured longer than 1 cm. Interobserver agreement on tear length was moderate (ICC round 1 = 0.58 and ICC round 2 = 0.52). Interobserver agreement on rim width was moderate (ICC round 1 = 0.50 and ICC round 2 = 0.50).

Tear type

In two rounds, the right tear type (a longitudinal tear as described intraoperatively) was scored in 85.5% of the cases (Table 4). The number of correct scored tear types was slightly higher in the group of orthopaedic surgeons compared to the group of radiologists (89.2% versus 81.7%, p = 0.09). A horizontal meniscal tear was the second most scored tear type. The intraobserver reliability for tear type using the ISAKOS classification for meniscal tears was poor to moderate, as shown in Table 4. Interobserver agreement on tear type in both rounds was poor with a Fleiss' Kappa of 0.19 in both rounds. Kappa coefficient varied from 0.01 to 0.41 and 0.03 to 0.55, in respectively round 1 and round 2 (Table 2).

Table 3. Intraobserver agreement of the tear length and of the peripheral rim in both rounds. Tear length and rim width (median and interquartile range (IQR)) in millimeters.

	Tear length[1]	Tear length[2]	ICC	95% CI	Peripheral rim width[1]	Peripheral rim width[2]	ICC	95% CI
OS 1	28.8 (24.0 – 33.6)	33.6 (28.8 – 33.6)	0.51	0.19 – 0.70	3.8 (2.5 – 4.4)	3.7 (3.1 – 4.5)	0.72	0.57 – 0.73
OS 2	38.4 (28.8 – 43.2)	38.4 (28.8 – 43.2)	0.71	0.57 – 0.82	3.8 (2.5 – 4.9)	3.8 (2.3 – 4.7)	0.73	0.59 – 0.83
OS 3	33.6 (24.0 – 38.4)	33.6 (28.8 – 38.4)	0.80	0.70 – 0.88	3.1 (1.9 – 4.0)	3.2 (1.9 – 4.1)	0.73	0.59 – 0.83
Rad 1	33.6 (28.8 – 43.2)	28.8 (28.8 – 38.4)	0.58	0.39 – 0.72	2.8 (1.5 – 4.0)	3.6 (2.2 – 4.8)	0.64	0.46 – 0.77
Rad 2	33.6 (24.0 – 38.4)	33.6 (24.0 – 38.4)	0.79	0.68 – 0.87	3.0 (2.0 – 4.0)	3.4 (2.2 – 4.1)	0.59	0.40 – 0.73
Rad 3	28.8 (24.0 – 33.6)	28.8 (24.0 – 33.6)	0.51	0.30 – 0.67	3.0 (2.0 – 4.0)	3.6 (2.8 – 4.7)	0.69	0.54 – 0.80

1 = round 1, 2 = round 2. OS = Orthopaedic Surgeon; Rad = Radiologist. ICC = intraclass correlation coefficient. 95% CI = 95% Confidence Interval.

Table 4. Tear morphology. Absolute numbers and average percentage (%) of correct estimates of tear morphologic type by examiner in two rounds and intraobserver agreement on tear morphology using the ISAKOS classification.

Longitudinal tear (n = 63)					
	Round 1	Round 2	%	κ	95% CI
OS 1	54	59	89.7	0.17	0.03 – 0.31
OS 2	49	59	85.7	0.40	0.26 – 0.54
OS 3	55	61	92.1	0.34	0.16 – 0.52
Rad 1	46	44	71.4	0.51	0.39 – 0.62
Rad 2	54	58	85.7	0.20	0.05 – 0.35
Rad 3	50	60	88.1	0.19	0.06 – 0.33
Average			85.5		

OS = Orthopaedic Surgeon; Rad = Radiologist. κ = Kappa coefficient. 95% CI = 95% Confidence Interval.

Failure

Median follow-up was 52 months (IQR, 45 – 58 months). Data of 57 patients were available for evaluation (90.5%). Up to date personal data of 4 patients were not available, so they could not be reached by phone or mail, not even after contacting their general practitioner. One patient was excluded because he did not speak Dutch or English and therefore was unable to complete our Dutch or English evaluation. One patient did not return the questionnaires.

In these 57 evaluable patients 14 meniscal repairs failed (25%). No significant differences in tear length and rim width were found between the groups of patients with or without a failed meniscal repair for all observers. Intraobserver agreement of tear length varied from moderate to good (0.46 – 0.80) for patients with a failed meniscal repair and varied from fair to good for patients with an intact meniscal repair (0.34 - 0.76). Intraobserver agreement on rim width varied from moderate to good for both groups (0.49 – 0.74 and 0.52 – 0.78). Interobserver agreement on tear length was fair (ICC round 1 = 0.29 and ICC round 2 = 0.27) for the failed meniscal repairs and moderate to good for meniscal repair survivors (ICC round 1 = 0.59 and ICC round 2 = 0.63). Interobserver agreement on rim width was moderate to good (ICC round 1 = 0.47 and ICC round 2 = 0.66) for the failed meniscal repairs and moderate (ICC round 1 = 0.42 and ICC round 2 = 0.47) for meniscal repair survivors.

DISCUSSION

The results of this study showed that meniscal aspect has poor intraobserver and interobserver agreement. Furthermore, rim width and tear length have moderate to good intra- and interobserver agreement. For that reason, rim width and tear length may be more valuable criteria for reparability of longitudinal meniscal tears on MRI, especially because the meniscal aspect is not only influenced by meniscal damage.

In our study, agreement on meniscal aspect was low especially in lateral meniscal tears. Sensitivity is shown to be related to the location and tear pattern for the lateral meniscus, with peripheral longitudinal tears involving the posterior third of the meniscus demonstrating the lowest sensitivities.[16] False-negatives are more common in the lateral meniscus as well, especially with tears of the posterior horn or if less than one-third of the meniscus is involved.[5] High signal intensity in the body of the meniscus in MRI is a well-established criterion for diagnosing a meniscal tear or degeneration. However, an increased signal in the posterior horn of the lateral meniscus can be due to the magic-angle phenomenon rather than to meniscal degeneration or a meniscal tear.[15] Given the very specific criteria based on signal-intensity on MRI to predict spontaneously healing,[8] using criteria based on signal-intensity to predict reparability instead of meniscal healing may be difficult to use as well. All this can be an explanation for the low agreement on this item, so we have to conclude that a heterogeneous or high MRI signal of the axial part of the meniscus does not compromise arthroscopic reparability.

The displaced fragment of a bucket handle meniscal tear can have a high-intensity signal, which changes to low after reduction of the meniscus to its original position and may therefore be described as degenerative.[7] Low agreement on meniscal aspect in both patients with a displaced and without a displaced bucket handle tear and the possibility to wrongly assess a displaced fragment as degenerative, are two other reasons why meniscal aspect is less valuable as a criterion for reparability.

As mentioned earlier, according to our observers 48% of the patients met all three MRI criteria for reparability. Median measured rim width varied little from 2.8 to 3.8 mm in our study. When using rim width with the cut-off point of 4 millimeters, 68.2% of our would have a reparable meniscus. Of course, enlarging the criterion rim width in millimeters will increase this amount of patients. However, this remains controversial based on meniscal size and blood supply. Capillaries are penetrated in up to 25% of the lateral meniscus and in up to 30% of the medial meniscus.[2] Together with the size of medial and lateral meniscus in people without osteoarthritis measured on MRI, using the central 5 MRI slices representing the meniscus body, a peripheral rim of 3 mm is expected to have good blood supply. Probably for this reason a maximum distance of 3 mm from tear to meniscosynovial junction was chosen as criterion in other studies.[3,10,17] When we would have used this cut-off point of 3 mm in our study population, only 42.2% of the patients would have met this criterion. Matava and co-workers were uncertain about reparability of meniscal tears having a peripheral rim width of 3 to 5 mm, but they did not find those tears irreparable.[10] All of this makes the use of rim width as a criterion for reparability doubtful. Despite the moderate to excellent agreement, only there 68% of the patients in this study met this criterion. Increasing the rim width is not consistent with meniscal vascular anatomy, while decreasing rim width will lead to a large population who will wrongly be rejected for a meniscal repair based on MRI images.

The meniscal tear length gives an indication about its stability and is an important criterion for meniscal repair. In all except five out of 756 observations, tear length was measured longer than 1 cm. This confirms the inclusion criteria for this study.

We have found an average of 85.5% correct scored tears using the ISAKOS classification for meniscal tears, which we find a reasonable score. Radiologists are less familiar with the ISAKOS classification, which could be a possible explanation for their lower score (81.7%) compared to the orthopaedic surgeons (89,2%). A horizontal meniscal tear was the second most scored tear type in this patient group with only longitudinal tears. If a tear appeared in an oblique configuration, this may be scored as a horizontal, instead of a longitudinal tear, this could have decreased the number of correct scored tears. The low intra- and interobserver agreement suggests that the use of this classification is not valuable for describing tear morphology on MRI.

There are two possible explanations for the higher score on reparability according to the key question (61%) compared to the score based on meeting all three MRI criteria (48%). First, because of the consequences of a lateral meniscectomy,[14] the threshold performing a meniscal repair might be lower when facing a lateral meniscal tear. Second, patient's young age, indirectly given by the presence of open epiphysis on MRI, may influence the decision about reparability because of the consequences of (partial) meniscectomy in the young patient.

There was no significant difference in tear length and rim width between the group with a failed meniscal repair and the group without a failed meniscal repair, which contradicts an eventually low threshold for meniscal repair in some patients in this study population. Together with the fair to good interobserver agreement on tear length and a moderate to good agreement on rim width between these two groups, we can conclude that the criteria tear length and rim width measured on MRI cannot predict survival of a meniscal repair.

Our study has some limitations. We were unable to consistently correlate the observers' estimation of tear length and minimum distance from the meniscosynovial junction with actual intraoperative measurements because this information was occasionally missing from the operative records. Software to measure the precise tear length on MRI in three dimensions, using X, Y, Z coordinates, was lacking and is not used on a routine base. Calculation tear length by multiplying number of slices with slice thickness does not give the exact tear length. On the other hand is it a reliable way with a moderate to excellent observer agreement. Three MRI scanners were used in this study. All were 1.5 Tesla using the same slice thickness and gap/slice spacing, but they slightly differ in repetition times, echo times and matrix size. Finally, we used these 1.5T scanners, while the improved resolution on 3T scanners now more and more used, may improve predicting meniscal reparability in the future. However, Grossman et al showed no improvements in the sensitivity of 3T MRI for detecting meniscal tears when compared with 1.5T scanners.[6]

CONCLUSION

A tear length and a rim width are the only two measurements with good agreement. However, these measurements do not predict reparability of a longitudinal meniscal tear on MRI images. Based on the function of the meniscus, and the deleterious biomechanical and long-term clinical effect of removing part of the meniscus, we advise to always consider meniscal repair first and take the risk of failure when facing a longitudinal, peripheral meniscal tear on MRI.

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