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Original Article

Is MR imaging correlated with mid-term clinical results after arthroscopic all-inside meniscal repair?

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Abstract

Aim: To research the correlation between clinical and radiological results after arthroscopic meniscus repair with all-inside suture technique and to assess the magnetic resonance imaging (MRI) diagnostic value on previously repaired meniscus.

Materials and Methods: Fifty-two patients were included in the study.All-inside suture technique with a Fast-Fix suture device was used for all patients. After at least 24 months follow-up, the affected knee was checked with 1.5 Tesla MRI if there was an additional pathology or the meniscal pathology persisted with criteria of Crues et al. International Knee Documentation Committee (IKDC) and Lysholm scores were used for evaluation of the functional status of patients. Barrett's criteria wascriteria were used for failure rates and clinical improvement. Correlation between clinical results and MRI findings were investigated.

Results: The mean follow-up was 39.6 (range, 24–60) months. The mean age was 31.4 (range, 21–45) years. At the last time follow up the mean IKDC and Lysholm scores were improved significantly (p<0.001). Healing in RR zone tears were significantly better than for the RW zone according to the clinical scores (p=0.02). MRI had one false negative and 11 false positive resultsresult when compared with the clinical results. In radiological results, repairs after at least 8 weeks were different from early repairs and had significantly higher failure rates (p=0.01).

Conclusion: Clinical examination and radiological investigation for meniscal healing with 1.5 Tesla MRI gave significantly different healing and failure rates (p=0.006).Evaluating a previously repaired meniscus with MRI is controversial.

Keywords: Meniscus; correlation; clinical examination; all inside; magnetic resonance imaging; results.

INTRODUCTION

The biological function of the meniscus has been well defined, as resisting shear stress, tension and compression to the knee joint, also having a role in load transmission, load bearing and shock absorption (1). Meniscal injury is currently a well-recognized source of knee dysfunction. Meniscal repairs suggested instead of meniscectomy to preserve these functions and arthroscopic meniscal repair has become a widely applied method in orthopedic surgery (2). Outside-in (4), Inside-out (3) and all-inside repair (5) techniques are various methods used in arthroscopic meniscus repair. All-inside repair technique is frequently used today requiring easy application, shorter surgical time and less complication rates (5). Clinical evaluation, radiologic methods and second-look arthroscopy were used to assess the repaired meniscus. In a recent study Miao et al. (6) suggested thorough clinical evaluation and supportive radiological studies in the repaired meniscus evaluation. Second-look arthroscopy is an expensive and invasive method so that it is more commonly used for ongoing symptoms, (7). Evaluation of a repaired meniscus with MRI is controversial where it is a reliable method to diagnose a meniscal lesion (8-10). MRI may be considered as a good diagnostic tool in evaluating meniscus healing with its non-invasive and easily accessible feature, but edematous or fibrous tissues can produce pathological signals and cause misinterpretation in healing (11,12). Sensitivity of 92% and specificity

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of 99% have been reported by combining several MRI sequences (6,13,14). Repaired meniscus evaluation is very important for the activity status of patients (15,16). The aim of this current study was to compare the clinical and radiolgical results of repaired meniscus with Fast-Fix meniscal fixators and identify the MRI characteristics. So we investigated if the MRI findings with 1.5 Tesla T2 serial had a correlation with clinical results.

MATERIAL and METHODS

Patients

160 patients undergoing all-inside arthroscopic meniscus repair at the Department of Orthopedics and Traumatology, Erciyes University Hospital, Kayseri, Turkey between January 2008 and October 2013 were evaluated retrospectively. All operations were performed by the same surgeon. Fifty-two randomly selected patients (50 males, 2 females) who had attended follow-up visits on a regular basis also underwent MRI examination to identify MRI characteristics of meniscus repair were included in this study. Fast-Fix repair system (Smith & Nephew Inc, Andover, MA) was used in all operations. A mean of 2.2 (range, 1–4) suture devices were used for meniscal repair.Patient demographics and surgical reports were recorded (Table 1). The inclusion criteria were as follows: undergoing arthroscopic meniscal surgery with/without anterior cruciate ligament (ACL) reconstruction, bucket handle or vertical-longitudinal meniscal tears, meniscal tears of 15 to 35 mm in length and in Red-Red (RR) or Red-White (RW) zones, having undergone 1.5 Tesla MRI at least 24 months after the operation, and use of the single-bundle method with hamstring tendon autografting in ACL repairs (if present). Exclusion criterias were: previous knee surgery; degenerative osteoarthritis; less than 2 years of follow-up; knee joint infection; major cartilage defects; BTB (bone-tendon-bone) or double-bundle hamstring autografting for ACL reconstruction; meniscal tears greater than 35 mm; degenerative meniscal tears; genu varum or genu valgum deformities, The patients who did not show adequate adherence to the rehabilitation program or follow-up assessments were also excluded.

MRI evaluation protocol

52 patients were examined at least 24 months after surgery by MRI. 1.5-T MRI scanner (Intera, Phlips Medical Systems, Best, the Netherlands) was used for radiologic examination with a dedicated knee coil. Imaging sequences were examined, including sagittal and coronal proton-density-weighted turbo spinecho (repetition time/echo time 900/35 msec, field of view [FOV] 160 mm, matrix 256×256, slice thickness 3 mm), sagittal and coronal T2 fast field echo (repetition time/echo time 500/14 msec, FOV 160 mm matrix 256×256, slice thickness 3 mm, flip angle 25°), and axial T2 weighed turbo skinecho spoiled invertion recovery (repetition time/ echo time 5200/60, FOV 160 mm matrix 256×256, slice thickness 3 mm). An independent radiologist blinded to patients' data and clinical evaluation examined the MRIs. Crues et al.'s criteria (17) was used for meniscal signal alterations classification as Grade 0: normal meniscus – low signal intensity; Grade 1: irregularly marginated intrameniscal signal-not connected to the articular surface; Grade 2: linear signal-not connected to the articular surface; Grade 3: linear signal intensity- connected to the articular surface. Using the criteria of Crues et al., a failed meniscus repair was considered as grade-3 signal- linear signal intensity- connected to the articular surface whether to the tibial or the femoral site.

Surgical method

Same surgeon performed all the operations. FasT-Fix suture anchors (Fast-FixTM 360, Smith &Nephew, Andover, MA, US) were used in all operations with all-inside technique. During the operation, after the arthroscope was placed within the knee through the anterolateral port, the suprapatellar bursa was inspected with the knee extended, and then the patello-femoral joint was accessed to examine the congruity between the joint surfaces and integrity of patello-femoral joint. The scope was shifted to the medial joint space while the knee was at 90-degree flexion, and an anteromedial portal was accessed, where a hook was placed. Following the examination of the medial joint, the cruciate ligaments were assessed. Then, the arthroscope was advanced to the lateral joint space, and this space was examined. All intra-articular structures were checked with a probe before any intervention was performed. After the meniscal disorder was defined, a probe was used for evaluating the mean length of the meniscal tear, and then a repair was carried out using the all-inside suture technique. In all patients with ACL rupture, autografting with semitendinosus and gracilis harmstring tendons was performed. The single-bundle method was used for all reconstructions. At the completion of surgery, the joint space was irrigated and a negative-pressure surgical drain was placed within the joint.Postoperative ice application was performed, and the surgical drain was removed 24 hours after surgery.

Rehabilitation protocol

Patients were allowed to mobilize with crutches partial loadbearing until week 5 due to protecting repaired menisci. Isometric quadriceps and hamstring exercises were performed on the first postoperative day. Also, using a CPM device, movements were begun on the first postoperative day. After week 3, quadriceps exercises with weights were initiated. Full mobility was started after 6 weeks, and full loadbearing was allowed after 8 weeks. Return to sports activities was allowed after 4 months.

Assessments

Before the operation all the patients had been examined clinically with Lysholm (18) and International Knee Documentation Committee (IKDC) scores (19). MRI was used for radiological investigation. Postoperative clinical improvement was measured by the clinical scores. IKDC status was graded as A, B, C, or D. Healing status of the repaired meniscus was evaluated using Barrett's criteria [20], where the absence of joint tenderness, effusion, and locking as well as the presence of a negative McMurray test were considered as an indicative for healed meniscus. A negative outcome in any of the scoring or examination measures was considered clinical failure. The assessments performed at the last follow-up visit were taken into account for the final evaluation. MRI of the affected knee after at least 24 months follow-up was checked to see if the meniscal pathology persisted with the criteria of Crues at al. On the basis of this study, we investigated the correlation between MRI findings and clinical results.

Statistical analysis

Statistical analysis was performed using SPSS version 15 software program for Windows. Mean and Standard deviation (SD) or median and range were calculated as measures of central location and spread of data. Failure incidence in subgroups of patients with different characteristics was compared using chi-squared test. MRI findings with clinical results were compared using McNemar and Kappa statistics. One-way analysis of variance (ANOVA, Tukey's studentized range test) was used for analyzing the time difference between operation and MRI. Since the data were not normally distributed nonparametric tests were used. Statistical significance was considered as p value<0.05. The hospital research ethics committee approved the study.

RESULTS

Clinicalresults

The mean tear length was 20 mm (range, 15–-35). The mean Lysholm and IKDC scores were significantly improved at the last follow up when compared with the baseline scores (p<0.001) (Table 2). Three patients (5.7%) were IKDC B, 9 (17.3%) were IKDC C, and 40 (77%) were IKDC D preoperatively. Postoperatively, these scores improved to 34 patients (65.3%) who were IKDC A, 7 (13.4%) who were IKDC B, 8 (15.6%) who were IKDC C, and 3 (5.7%) who were IKDC D. RR zone tears were significantly beter than RW zone clinically (p=0.02), but there were no significant differences for repair time, concurrent ACL reconstruction, tear length, and side of the tear (p>0.05) (Table 3). At the last follow up of the 52 patients (50 males and 2 females), 49 (94.3%) had no complaints, which was rated as clinical success. There became clinical failure in 3 patients (5.7%) according to the Lysholm, IKDC scores and Barrett's criteria. All examinations were performed by one sports medicine doctor who was blinded about the MRI results. Patients who were successful at the last follow-up clinical examination had reached their activity levels after 4 months postoperatively.

Imaging results

Before surgery, all patients had vertical-longitudinal meniscal tears at least a grade 3 lesion according to Crues et al.'s criteria.After the operation at a mean follow-up of 39 months (range, 24–60), on 1.5 Tesla MRI, 9 patients showed no signal alteration. Fourteen patients had grade 1 alteration, 16 had grade 2, and 13 had grade 3 alteration. In grade 3 lesions, a re-rupture was detected fluid entering the meniscus or creating an intrameniscal signal with high intensity (Table 4). Ten of the grade 3 lesions were located medially and 3 laterally with radiological imaging. Subchondral edema in the medial femoral condyle was detected in two patients, but only one had a clinical complaint. Three patients had chondral degeneration of the femoral condyle without any complaint. An additional Baker cyst was identified in one patient. A slight joint effusion was detected in 5 patients and in one patient there was a plenty of effusion in the knee joint. The mean time length from surgery to imaging was summarized in Table 4. There was no statistically significant difference between the MRI grades according to the time difference between operation and MRI (p>0.05).

There was no evidence of foreign body reactions with chronic inflamation or formation of granuloma during the study period.

Correlation between clinical and imaging results

Failure rates for clinical and imaging results were significantly different from each other (p=0.006). The failure rate with MRI was higher 13 patients (25%) than clinical examination 3 patients (5.7%). MRI had one false negative and 11 false positive results compared with the clinical results (Table 5).

Table 1. Demographic data of patients

Categotry	Variables
No. of paients(n)	52
Age(mean+sd)	31.4+6.9
ACL reconstruction	
With n(%)	38(72.1)
Without n(%)	14(27.9)
Zone of tears	
R/W n(%)	18(34.6)
R/R n(%)	34(65.4)
Gender	
Male n(%)	50(96.2)
Female n(%)	2(3.8)
No. of repaired menisci	52(100)
Right knee n(%)	32(61.5)
Left knee n(%)	20(38.5)
Medial meniscus n(%)	37(71.2)
Lateral meniscus n(%)	15(28.8)
Duration of follow-up (months)(mean+sd)	39.6+12.2
Trauma to surgery (months)(mean+sd)	6.7+6.1

Table 2. Functional Results			
Evaluation method	Preoperative scores	Postoperative scores	p value
Lysholm score (mean+sd)	51.4+10.6	91.3+13	<0.001(*)
IKDC score Median(Range)	4(2-4)	1(1-4)	<0.001(**)

*: Independent Samples T Test
**: Wilcoxon Signed Ranks Test

Table 3. Clinical and radiological failure rates according to the subgroups					
	No. of tears n(%)	Clinical failure No. of tears n(%)	P Value(*)	Radiological failure No. of tears n(%)	P Value(*)
Time of repair					
<8 weeks	23(44.2)	2(66.6)	0.58	2(15.4)	0.01
>8 weeks	29(55.8)	1(33.4)		11(84.6)	
ACL reconstruction					
With	38(72.1)	2(66.6)	0.86	5(38.5)	0.48
Without	14(27.9)	1(33.4)		8(68.5)	
Zone of tears					
R/W	18(34.6)	3(100)	0.02	6(46.2)	0.33
R/R	34(65.4)	0(0)		7(53.8)	
Length of tears					
<25 mm	36(69.2)	1(33.4)	0.24	7(53.8)	0.18
>25 mm	16(30.8)	2(66.6)		6(46.2)	
Tear side					
Medial	37 (71.2)	2 (66.6)	0.86	10(76.9)	0.73
Lateral	15 (28.8)	1 (33.4)		3(23.1)	
Knee side					
Right knee	32 (61.5)	2 (66.6)	0.85	10(76.9)	0.32
Left knee	20 (38.5)	1 (33.4)		3(23.1)	

*: Chi-Square Tests
ACL: Anterior cruciate ligament

Table 4. Comparison of MRI grades and clinical results					
	MRI Grade				
	Grade 0	Grade 1	Grade 2	Grade 3	P value(*)
Time from surgery to MRI (months)(mean+sd	37.7+11.0	30.4+13.0	30.3+16.1	35.2+15.2	0.73
Clinical results					Total
Symptomatic n(%)	-	1(33.3)	-	2(66.7)	3(100)
Asymptomatic n(%)	9(18.4)	13(26.5)	16(32.7)	11(22.4)	49(100)

*:One-wayAnova test, MRI: magnetic resonance imaging

Table 5. Clinical vs Radiologic Results				
MRI results (postoperative)		Healed menicsi (n)	Failed menisci (n)	Total (n)
Clinical results (postoperative)	No symptomes	38	11	49
	Symptomatic	1	2	3
Total(n)		39	13	52

Mc Nemar, p:0.006

DISCUSSION

The most important finding of this study was that clinical examination and radiological investigation for meniscal healing gave significantly different healing and failurerates in the mid-term after all-inside arthroscopic meniscal repair(p=0.006).The failure rate of meniscal repair with MRI was higher than clinical examination (25% vs 5.7%). According to the findings of this study the MRI's diagnostic value is controversial in evaluating previously repaired menisci.

Meniscus injury is now a well-known source of knee dysfunction. Meniscus repair is preferred over meniscectomy to preserve function, and arthroscopic meniscus repair is one of the most common orthopedic procedures (2). There may be other associated pathologies with meniscal injury, most commonly acl injury, which may than result in osteoarthritis [21]. Therefore, the importance of protecting meniscus and acl and radiological evaluation of these patologies is very important. All-inside repair with meniscal fixators requiring simpler surgical techniques is widely used today (5). Clinical evaluation, radiologic methods and second-look arthroscopy were used to assess the repaired meniscus. In a recent study Miao et al. (6) suggested thorough clinical evaluation and supportive radiological studies in the repaired meniscus evaluation. Second-look arthroscopy is an expensive and invasive method so that it is more commonly used for ongoing symptoms (7). Evaluation of a repaired meniscus with MRI is controversial where it is a reliable method to diagnose a meniscal lesion (8-10). MRI may be considered as a good diagnostic tool in evaluating meniscus healing with its non-invasive and easily accessible feature, but edematous or fibrous tissues can produce pathological signals and cause misinterpretation in healing (11,12). It is important to evaluate the meniscal status after all-inside meniscal repair with meniscal fixators, whether healed or not, for guiding the patient's activity levels (15,16). In the short term several studies have confirmed the limitation of conventional MRI in evaluating the repaired meniscus whether healed or not (6,22-24).On the other hand, sensitivity of 92% and specificity of 99% have been reported by combining several MRI sequences (6,13,14).

It is shown that a man's meniscus healed by 4 months [25]. Also, in experimental studies nearly complete repair of a meniscus has been seen at 8 weeks, however complete repair of the meniscus has been seen by 6 months (23=. So from the operation to postoperative MRI, assessment is an important factor for investigating the repaired menisci. Initial fibrovascular tissues and later mature fibrocartilagenous scar produceincreased signal intensity on MRI. Hantes et al. (15), using indirect MRI, radiogically assessed the healing process of the meniscal repair at 3, 6, and 12 months after the operation. They found a significant reduction without disappearance of this hypersignal occurred from 3 to 12 months, and suggested that the meniscal healing process lasted for at least 12 months. In another study Miao et al. (6) emphasized that MRI diagnostic accuracy correlated positively with the follow-up time in repaired meniscus. Mustonen et al. [26] found satistically significant difference between the grade 0 (36 months) and grade 3 groups (14 months) according to the time difference between the operation and MRI, they reported a highest incidence of meniscus with a grade 3 signal was seen in patients where the surgery had been performed within the last 18 months. In this current study, MRI was performed at least 24 months after the surgery and found no significant difference between the distributions of grades according to the time of MRI after surgery.

With a significantly longer follow-up time (mean, 37.7 months), the clinical and radiological outcome of 52 repaired menisci using the all-inside suture tecnique with a Fast-Fix suture device is evaluated in this study. The clinical success rates in our series was 94.3% according to the Barrett'scriteria et al. (20), and radiological success was 75% according to Crues et al. criteria (17). Radiological and clinical success rates with a Fast-Fix device have been reported as 82–92% [6,27-30]. In this current study the clinical results were similar to these findings with the Fast-Fix technique [28-30]. No adiological grading was identified between the radiological grading and clinical outcomes in this comparison study. Nine patients showed no signal alteration, 14 had a grade, 16 had a grade 2, and 13 had a grade 3 signal alterations, respectively. In 11 patients with good clinical outcome high radiological grades were identified. As we have shown in our comparisons, we believe that it is very difficult to distinguish between scar tissue and a fully healed meniscus using MRI examinations,

Eggli et al. (31), performing 25 MRI scans after meniscal repair with outside-in technique after a mean follow-up of 7.5 years reported that there was a discrepancy between clinical and MRI findings. They identified persistent grade 3 or 4 lesions in 96% of the successfully repaired menisci. Similarly, Steenbrugge et al. (32) reported mucoid degeneration or scarring within the site of inside-out meniscal repair in 46% of patients with good clinical results after 13 years. Muellner et al. (11) performed MRI nearly 13 years after open meniscal repair among 19 patients. No signal alterations were observedin 4 patients, in 5 patients grade 2 signals were observed, and in 10 patients grade 3 signal alterations were observed on repaired side. In these series, the surgical techniques were different from our all-inside technique, but the results were consistent with ours. Additionally, in a long term study Pujol et al. (16) investigated the MRI features of the all-inside repaired meniscus in 23 patients using a 1.5-T MRI. They reported no meniscal signal alteration in 3 patients (13%), a vertical signal in 7 (30%), a horizontal signal in 9 (39%), and a complex tear in 4 (17.5%) with MRI examinations. There were several abnormal vertical and/or horizontal hypersignals after arthroscopic all-inside meniscal repair on the repaired side on MRI examination after 10 years postoperatively. Thus it was suggested that MRI was not suitable for sensing for repaired meniscus even after a long-term follow-up because of the initial fibrovascular tissues and later mature fibrocartilagenous scar tissues producing abnormal signals.

Some studies demonstrated that using T1-weighted or proton-density-weighted MR images it was not possible to diagnose a recurrent tear after previous repaired meniscus. In both the healed and recurrent tear the intrameniscal signal contacting the surface is identical. De Smet [33] demonstrated that the identification of the meniscus fragment or fluid signal intensity entering the meniscus on fat-saturated proton density or T2-weighted images was specific for the detection of recurrent meniscus rupture after repair.Sensitivities with fat-saturated fast SE proton-density- and T2-weighted images (13,14) (96 to 100%) are higher than with the older techniques of SE T2-weighted images [34] (60 to 75%). De Smet [33], based on the studies of White et al. (13) and Applegate et al. [34], also suggested that if the patient was known to have meniscus repair without meniscus resection, MRI might have a comparable accuracy with MR arthrography.Both Magee et al. [35] and Kececi et al. [36] do not agree with this conclusion.Keçeci et al.[36] reported that direct MR arthrography was considered to be a more reliable method for assessing the status of the postoperative meniscus and that MR arthrography appeared to be an invasive procedure compared to conventional MRI, but was less invasive than second-look arthroscopy and supported the idea that many unnecessary procedures might be avoided with MR arthrography.

Although the diagnostic value of MRI on repaired meniscusis controversial in the literature we used 1.5 T MR imaging of sagittal T2-weighed fast field echo, sagittal proton-density-weighted turbo spin echo, axial T2-weighted turbo skin echo spoiled invertion recovery, coronal T2-weighed fast field echo with fat saturation, and coronal proton-density-weighted turbo spin echo with fat saturation to assess the healing status for all meniscus repairs. To verify meniscal healing after artroscopic all-inside meniscal repair, Hoffelner et al. [37] investigated the correlation between clinical and radiological results using 3 T MRI and found that imaging with a 3-Tesla MRI after meniscal repair provides good but not definitive reliability on meniscus healing. Therefore, it has no advantage compared to 1.5-T MRI.

Recent advances in MRI technology (proton density images, higher fluid sensitivity, rapid suppression of fat suppression, etc.) and their applications in the field of arthroscopic knee surgery invalidate the older technology and offer both non-invasive and more accurate diagnostic methods. However, new investigations should be conducted to prove the reliability of newer MR imaging in the postoperative meniscus. In addition to its role in diagnosis, second-look arthroscopy is still the gold standard method for evaluation of the repaired meniscus offering treatment opportunity.

There were some limitations of our study. It was retrospective in nature and follow-up time was short. Besides we used symptomatic improvement as a clinical outcome measure to evaluate the success rate and we were not able to perform arthroscopy or MR arthrography in these patients to accurately analyze our results. Therefore, further prospective long term studies are needed to clarify the diagnostic value of MRI in previously repaired menisci.

CONCLUSION

Clinical examination and radiological investigation for meniscal healing with 1.5 Tesla MRI gave different healing and failure rates in the mid-term after all-inside arthroscopic meniscal repair, and this was statistically significant (p=0.006).The failure rate of meniscal repair with MRI was higher than clinical examination (25% vs 5.7%). According to the findings of this study the diagnostic value of MRI was controversial in evaluating previously repaired meniscus.

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