Available online at www.medicinescience.org

ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2020;9(3):692-9

Are clinical outcomes and failure rate following meniscal repair for vertical-longitudinal tears age-dependent

Erdal Uzun, Ahmet Guney

Erciyes University Faculty of Medicine, Department of Ortopedics and Traumatology, Kayseri, Turkey

Received 01 May 2020; Accepted 18 May 2020
Available online 17.08.2020 with doi: 10.5455/medscience.2020.05.071

Abstract

This study aimed to compare the clinical outcomes and failure rate following meniscal repair for vertical-longitudinal tears between patients 40 years of age or older and patients younger than 40 years. Between 2008 and 2016, 134 patients with vertical longitudinal meniscal tear repair (121 males and 13 females) were included in the study. Patients were divided into two main groups according to age: <40 years (Group 1); >40 years (Group 2). The clinical status of patients was evaluated by the Visual Analog Scale (VAS), Tegner, Lysholm, and International Knee Documentation Committee (IKDC) scores, Barrett's criteria were used to assess meniscal healing. Patient and tear characteristics, operative features were also investigated. The mean follow-up time was 57.8 ± 13.0 months (range, 24-84 months). There was a significant improvement in clinical scores in both groups (p <0.001), however, there was no difference between the groups (p>0.05). Failure was noted in 8 patients (8.9%) in group 1, 4 patients (9.1%) in group 2 (p>0.05). Time to failure was significantly lower in the older-aged group (p=0.040). Red-white (RW) zone tears, Body Mass Index (BMI) (kg/m2) and late repairs (>2 months) were found to be significantly higher in failed repairs (p=0.005, p=0.020, p=0.042, respectively). Clinical outcomes following arthroscopic repair for vertical-longitudinal meniscal tears do not differ in terms of age. Especially peripheral tears should be repaired in the early period because of their better healing potential regardless of age.

Keywords: Age, clinical, failure, meniscal repair

Introduction

Many factors such as tear location, tear chronicity, tear type and extent, patient age, suture technique, and associated injuries may affect the result when considering a meniscal repair. Several studies suggested that meniscal repair results are better for longitudinal, acute, and peripheral vascular tears and in young patients with stable knees [1,2]. However, in the literature confusing results have been reported evaluating meniscal repair in patients 40 years of age or older; some reported less favorable results in patients over age 40 [3,4], whereas other studies have suggested no difference in clinical outcomes concerning age group [5-9]. To the best of our knowledge, there is no study comparing the effect of the age on clinical outcomes following vertical-longitudinal meniscal tear repair between the patients over 40 years of age and younger in the literature. We hypothesized that the outcomes over the age of 40 would probably be worse. This current study aimed to compare the clinical outcomes and failure rate following arthroscopic vertical-longitudinal meniscal tear repair between patients 40 years of age or older and patients younger than 40 years.

Materils and Methods

Patients

A total of 390 patients underwent arthroscopic meniscal repair between 2008-2016 in our clinic. One hundred thirty-four of these who were operated on for vertical longitudinal meniscal tears and attended follow-up visits regularly were retrospectively evaluated and included in the study. The patients were divided into two main groups: group 1 included 90 patients (82 males, 8 females) younger than 40 years of age, and group 2 included 44 patients (39 males, 5 females) 40 years of age or older. The inclusion criteria were a meniscal tear after trauma or sports injury, repair of an isolated vertical-longitudinal tear in the length of 15 to 35 mm, red-red (RR), or red-white (RW) zone tears. History of previous knee surgery; less than two years of follow-up; additional pathologic conditions (e.g., cartilage defect of grade 2

***Coresponding Author:** Erdal Uzun, Erciyes University Faculty of Medicine, Department of Ortopedics and Traumatology, Kayseri, Turkey,
E-mail: nuzuladre@gmail.com

or above according to the Outerbridge classification [10]; a tear length over 35 mm; tears other than vertical-longitudinal in shape; instability of patellofemoral joint or lower extremity deformity; diabetes or rheumatoid conditions were the exclusion criteria. Also excluded were patients who did not show adequate adherence to the rehabilitation program or follow-up assessments. Excluded patients are summarized in Figure. Our institutional review board approved the study (No. 2016/193).

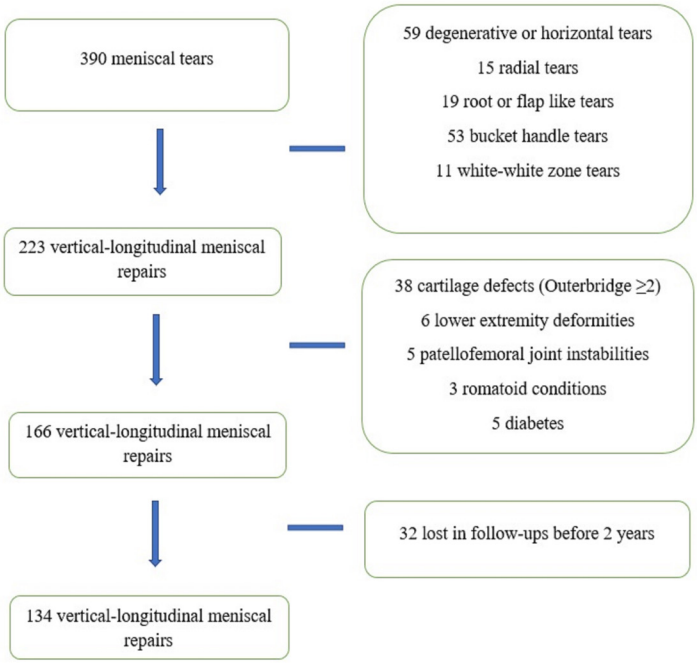

Figure. Study Flowchart and Patient Exclusion Details

Surgical method

All patients were operated on under general or spinal anesthesia. Routine anteromedial and anterolateral portals were used for all operations. Meniscal tears and other intraarticular pathologies were determined to examine all the knee compartments. An arthroscopy probe was used to measure the tear length. Knee side (right, left), tear side (medial, lateral), and localization (RR, RW zones) were recorded. RR zone was considered as tears within 2 mm of the menisco-capsular area, where the RW zone was considered as 2–4 mm from the menisco-capsular area [11]. Meniscal rasping was performed as an adjunct procedure to stimulate healing at the time of the repair. Depending on the tear location, an all-inside suture or a hybrid method (outside-in with all-inside) was performed. In all repairs, an oblique or vertical suture configuration was used. The posterior horn tears and meniscus tears including meniscal body were repaired using the all-inside technique, however, an additional outside-in suture (the hybrid method) was used for tears extending to the anterior horn. The all-inside technique was performed using Fast-Fix suture (Fast-Fix™ 360, Smith & Nephew, Andover MA, US), whereas outside-in method was performed using #0 Polydioxanone suture (PDS) (Ethicon) sutures. A mean of 2.5 (range, 1 to 5 sutures) Fast-Fix sutures and 1.9 (range, 1 to 3 sutures) PDS (Ethicon) sutures were used in meniscal repairs. In patients with anterior cruciate ligament tear, a single bundle reconstruction was performed with a hamstring autograft.

Postoperative rehabilitation

On the first day following the operation, isometric quadriceps and hamstring exercises were performed. Also, a continuous passive motion (CPM) machine device was used for the range of motion exercises allowing up to 90 degrees on the first day after the operation. When the patients could perform a straight leg raise and flex the knee to 90 degrees, they were discharged. In the third week, quadriceps exercises were started with weights as much as the patient could tolerate. Patients were mobilized with support and partial loading until week five to protect the repaired menisci. Full mobility was started six weeks after surgery, and a full load was allowed after eight weeks. A walk to jog progression was started at the 10th week and a return to running at four to six months. As early as four to six months postoperatively return to pre-injury activities was allowed.

Assessments

The clinical scores and failure rate were used as primary outcome measures. Evaluation of the factors possibly affecting the failure rate was also used as secondary outcome measures. All patients had been examined clinically with the Visual Analog Scale (VAS), ranging from 0 to 10; 0 = no pain to 10 = worst pain ever; the Lysholm score [12]; the Tegner Activity Scale [13] and the International Knee Documentation Committee (IKDC) subjective knee evaluation form [14] - graded as A (normal), B (nearly normal), C (abnormal), or D (severely abnormal)- before the operation. For the preoperative radiological investigation, magnetic resonance imaging (MRI) had been used for all patients. For postoperative and follow-up assessments, the change in the clinical scores was evaluated. Also, the healing status of the meniscus was assessed using Barrett's criteria [5], where the absence of joint tenderness, effusion, and locking as well as the presence of a negative McMurray test were considered indicative of a healed meniscus. Clinical failure was considered when an unfavorable outcome in any of the scoring or examination measures occurred. Tear characteristics (location, length, chronicity, side), repair technique, suture configuration, body mass index (BMI), chondral status at the time of the repair, and smoking habits were also investigated in terms of failure status.

Statistical analysis

Statistical analysis was performed using SPSS version 22.0 for Windows (IBM Inc. Chicago, IL, USA). Distribution of normality was tested using the Shapiro–Wilk test. Independent samples t-test was used for normally distributed data for the comparisons of variables between the two cohorts with independent samples. Nonparametric tests were used if the data were not normally distributed. For intergroup comparisons of continuous variables, the Mann–Whitney U test or Kruskal–Wallis test were used depending on the group numbers compared, and for intragroup comparison, the Wilcoxon test was used. The chi-square test was used for the categorical data comparison. Fischer exact test was used when the chi-squared test requirements were not met. The level of statistical significance was set at p-value <0.05.

Results

The clinical characteristics and demographic data of patients are summarized in Table 1.

Table 1. Patient demographics, tear characteristics, and operative features according to the study group

		Total (n=134)	(<40 age) Group(n=90)	(>40 age) Group (n=44)	P Value
Age (year)		31.8 ± 9.8	25.4 ± 4.6	44.0 ± 3.9	0.000
BMI (kg/m2)		26.4 ± 3.2	26.5 ± 3.0	26.3 ± 3.6	0.816
Number of suture used	Female	13 (9.7)	8 (6.0)	5 (3.1)	0.649
	Operative time (minutes)	121 (90.3)	82 (61.2)	39 (29.7)	
Operative time (minutes)	Right	59 (44.0)	40 (29.9)	19 (14.2)	0.520
	Left	75 (56.0)	50 (37.3)	25 (18.7)	
Number of suture used	Medial	93 (69.4)	62 (46.3)	31 (23.1)	0.853
	Lateral	41 (30.6)	28 (20.9)	13 (9.7)	
Operative time (minutes)	≤8 weeks	69 (51.5)	46 (34.3)	23 (17.2)	0.523
	>8 weeks	65 (48.5)	44 (32.8)	21 (15.7)	
Number of suture used	Red-Red	74 (55.2)	52 (38.8)	22 (16.4)	0.253
	Red-White	60 (44.8)	38 (28.4)	22 (16.4)	
Operative time (minutes)	<25 mm	82 (61.2)	56 (41.8)	26 (19.4)	0.434
	>25 mm	52 (38.8)	34 (25.4)	18 (13.4)	
Number of suture used	Nonsmokers	83 (62.9)	54 (40.3)	29 (21.6)	0.320
	Smokers	51 (38,1)	36 (26.9)	15 (11.2)	
Operative time (minutes)	All-inside	76 (56.7)	54 (40.3)	22 (16.4)	0.273
	Hybrid	58 (43.3)	36 (26.9)	22 (16.4)	
Number of suture used	Oblique mattress	44 (32.8)	34 (25.4)	14 (10.4)	0.081
	Vertical mattress	90 (67.2)	56 (41.8)	30 (22.3)	
Operative time (minutes)	No	95 (70.9)	66 (49.3)	29 (21.6)	0.245
	Yes	39 (29.1)	24 (17.9)	15 (11.2)	
Number of suture used	No	64 (47.8)	44 (48.9)	20 (45.5)	0.709
	Yes	70 (52.2)	46 (51.1)	24 (54.5)	
Operative time (minutes)	Regional	76 (67.2)	50 (37.3)	26 (19.4)	0.421
	General	58 (32.8)	40 (29.9)	18 (13.4)	
Number of suture used	Anterior 2/3	58 (43.3)	37 (27.6)	21 (15.7)	0.140
	Posterior 2/3	25 (18.7)	21 (15.7)	4 (3.0)	
	Posterior 1/3	51 (38.1)	32 (23.9)	19 (14.2)	
Number of suture used		3.3 ± 1.3	3.2 ± 1.2	3.6 ± 1.4	0.061
Operative time (minutes)		37.3 ± 10.6	36.1 ± 9.6	39.7 ± 12.1	0.065

Data are reported as mean ± SD or n (%). Bolded P value indicates a statistically significant difference between groups (P < 0.05). BMI, Body mass index.

Table 2. Clinical Outcome Scores According to the Study Group.

Evaluation method	Total	(<40 age) Group	(>40 age) Group	P Value
Time to failure (months)	21.9 ± 8.9	25.5 ± 8.0	14.7 ± 6.5	0.040
Failed repairs (n/%)	12 (9.0)	8 (8.9)	4 (9.1)	0.969
Follow-up time (months)	57.8 ± 13.0	57.5 ± 13.4	58.4 ± 12.4	0.690
VAS score (mean+sd)				
Preop	6.2 + 1.4	6.2 + 1.5	6.4 + 1.2	0.488
Postop	2.7 + 1.6	2.7 + 1.5	2.9 + 1.6	0.414
Pre-post difference	-3.4 + 2.3	-3.5 + 2.3	-3.4 + 2.2	0.895
Pre-post difference p	**<0.001**	**<0.001**	**<0.001**	
Tegner score (mean+sd)				
Preop	3.3 + 0.6	3.3 + 0.6	3.3 + 0.6	3.3 + 0.6
Postop	7.5 + 1.2	7.5 + 1.2	7.5 + 1.2	7.5 + 1.2
Pre-post difference	4.1 + 1.4	4.1 + 1.4	4.1 + 1.4	4.1 + 1.4
Pre-post difference p	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Lysholm score (mean+sd)				
Preop	50.0 + 8.4	51.5 + 8.5	47.0 + 7.7	**0.005**
Postop	90.0 +12.9	90.2 + 12.4	89.7 + 14.3	0.836
Pre-post difference	40.0 + 13.8	38.7 + 12.7	42.6 + 15.7	0.129
Pre-post difference p	**<0.001**	**<0.001**	**<0.001**	
IKDC score - median (range)				
Preop	4(2–4)	4(2–4)	4(2–4)	0.193
Postop	1(1–4)	1(1–4)	1(1–4)	0.983
Pre-post difference	-2 ((-3) – 1)	-2 ((-3) – 1)	-2 ((-3) – 1)	0.441
Pre-post difference p	**<0.001**	**<0.001**	**<0.001**	

VAS: Visual Analog Scale, IKDC: International Knee Documentation Committee. Bolded P value indicates a statistically significant difference between groups (P <0.05)

Table 3. Patient demographics, tear characteristics, and operative features according to the failure status

		Failure (+) (n=12)	Failure (-) (n=122)	P Value
Age (year)		29.6 ± 7.9	31.7 ± 9.9	0.481
BMI (kg/m2)		26.6 ± 3.3	24.4 ± 1.4	0.020
Sex (n/%)	Female	0 (0.0)	13 (9.7)	0.234
	Operative time (minutes)	12 (9.0)	109 (81.3)	
Affected Knee side (n/%)	Right	4 3.0)	55 (41.0)	0.434
	Left	8 (6.0)	67 (50.0)	
Torn meniscus (n/%)	Medial	6 (4.5)	87 (64.9)	0.126
	Lateral	6 (4.5)	35 (26.1)	
Time of repair (n/%)	≤8 weeks	3 (2.2)	68 (50.7)	0.042
	>8 weeks	9 (6.7)	54 (40.3)	
Zone of tears (n/%)	Red-Red	2 (1.5)	72 (53.7)	0.005
	Red-White	10 (7.5)	50 (37.3)	
Length of tears (n/%)	<25 mm	10 (7.5)	72 (53.7)	0.099
	>25 mm	2 (1.5)	50 (37.3)	
Smoking habits (n/%)	Nonsmokers	6 (4.5)	77 (57.5)	0.372
	Smokers	6 (4.5)	45 (33.6)	
Repair technique (n/%)	All-inside	9 (6.7)	67 (50.1)	0.164
	Hybrid	3 (2.2)	55 (41.0)	
Suture configuration (n/%)	Oblique mattress	6 (4.5)	42 (31.3)	0.185
	Vertical mattress	6 (4.5)	80 (59.7)	
Grade I cartilage degeneration (n/%)	No	7 (5.2)	88 (65.7)	0.315
	Yes	5 (3.7)	34 (25.4)	
Number of suture used	No	6 (4.5)	58 (52.5)	0.871
	Yes	6 (4.5)	64 (47.5)	
Anesthesia type	Regional	4 (3.0)	72 (53.7)	0.087
	General	8 (6.0)	50 (37.3)	
Tear region (n/%)	Anterior 2/3	3 (2.2)	55 (41.0)	0.782
	Posterior 2/3	3 (2.2)	22 (16.4)	
	Posterior 1/3	6 (4.5)	45 (33.6)	
Number of suture used		3.1 ± 1.1	3.3 ± 1.3	0.618
Operative time (minutes)		37.5 ± 10.7	37.3 ± 10.6	0.960

Data are reported as mean ± SD or n (%). Bolded P value indicates a statistically significant difference between groups ($P < 0.05$). BMI, Body mass index

The mean follow-up time was 57.8 ± 13.0 months (range, 24–84 months). There was no significant difference between the patients younger than 40 years of age versus patients 40 years or older according to preoperative clinical and functional scores except the Lysholm score. Postoperative scores were significantly increased in both groups compared to the baseline ($p<0.001$). However, postoperative clinical and functional scores and improvement in scores were not statistically different between the groups ($p>0.05$) (Table 2). The overall meniscal repair failure rate at the last follow-up was 9% (12/134). The meniscal repair failure rate was 8.9% (8/90) in the younger group and 9.1% (4/44) in the older group. The mean time to failure was found to be significantly shorter in older patients (14.7 ± 6.5 vs. 25.5 ± 8.0, $p=0.040$). MRI evaluation was performed for failed repairs and observed that; vertical tears were transformed into complex, bucket handle or flap style tears in 7 patients (4 patients in the younger group, 3 patients in the older group), and we performed subsequent meniscectomy of the repaired meniscus in these patients. The remaining 5 patients (4 patients in the younger group, 1 patient in the older group) underwent a repeated meniscal repair. Symptom-free patients could return to their preoperative activity levels after six months postoperatively. When patient characteristics were evaluated according to the failure status, RW zone tears, BMI, and late repairs (>2 months) were found to be significantly higher in failed repairs ($p=0.005$, $p=0.020$, $p=0.042$, respectively) (Table 3).

Discussion

The most important finding of this current study was that the clinical outcomes and failure rate following arthroscopic meniscal repair for vertical-longitudinal tears did not differ between patients 40 years of age or older and patients younger than 40 years.

Meniscal repair for acute, longitudinal, peripheric vascular zone tears in young individuals with stable knees was reported to have the most successful results [1,2]. Previous studies demonstrated age as a predictor of meniscal repair failure, as older patients are more likely to fail than younger patients [3,4,15-17], whereas some revealed that the failure rate does not vary with patient age [5,6,9,18-21]. There are a small number of studies in the literature, evaluating the clinical outcomes following meniscal repairs in patients older than 40 years [5-7,9]. In previous short-term studies, the meniscal repair was recommended regardless of age after obtaining successful radiological and clinical outcomes in patients older than 40 years [5,6]. Also, recent long-term studies supported these findings, revealing no difference according to the age [7,9]. Consistent with these results, we found no significant difference in clinical and functional outcomes and also failure rate (9.1% vs. 8.9%) between the younger and older age groups. In this study the meniscal repair failure rate by age of >40 years was also consistent with a recent review reporting the meniscal repair failure rate as 10% (15/148) in the patient aged >40; 9% (5/59) in vertical-longitudinal tear and 9% (6/66) in peripheral, completely vascular tear [21].

Clinical and functional scores, the failure rate on clinical assessment, failure determined from second-look arthroscopy, and radiologic outcomes were used as assessment criteria for evaluating meniscal healing [7,9,22,23]. Some authors revealed that assessing meniscal healing in routine clinical practice was not feasible using second-look arthroscopy or MRI investigation of every patient, so the physical examination was still considered an easily available assessment tool, and this might be supplemented with imaging studies when needed [24]. In this current study, we used clear evidence of clinical failure and clinical scores as evaluation criteria and supported with MRI investigation. Several studies using the failure rate as the primary outcome measure after meniscal repair involve a postoperative follow-up duration of up to two years [18,25,26]. In the present report, the mean follow-up was 57.8 ± 13.0 months (range, 24-84 months), which can be considered adequate for the assessment of meniscal healing.

In the literature, as well as age, tear characteristics (location, length, chronicity, side, pattern), repair technique, suture configuration, chondral status at the time of the repair, BMI, anterior cruciate ligament reconstruction and smoking habits were investigated as potential risk factors that may affect failure status [4-9,18-21,27-35]. The effect of meniscal tear chronicity on the failure rate of meniscal repair is controversial. Most authors have found no effect of tear chronicity on meniscal repair failure [6,9,18-20,27,28]. However, some authors support the negative effect of the tear chronicity on meniscal healing [4,5]. The failure rate in this study was significantly lower in meniscal tears repaired within 2 months after injury: three (2.2%) vs. nine (6.7%). Barret et al. [5] supported the idea that meniscal tear location rather than the patient age determines the potential for successful meniscal repair. In contrast, Noyes et al. [6] reported a healing rate of 87% in avascular zone repair of patients 40 years and older and recommended preserving meniscal tissue whenever possible. Some authors have found no significant difference in healing rates for tear location (RR vs. RW) [18,27-29]. However, similar to the findings of Barret et al., we found that RR zone tears were associated with decreased failure risk. In the literature, different results have emerged in studies evaluating BMI and meniscal repair results [30-32]. Some studies support the idea that BMI is not associated with meniscal repair outcomes [30,32]. However, Laurenson et al. [31] reported that BMI>25 emerged as a significant factor of poor prognosis. In this study, we found higher BMI values in patients with failed repairs.

Eggli et al. [4] observed that tear-length favorably influences meniscal healing (<25 mm, 82% (23 of 28) vs. >25 mm, 71% (17 of 24)). However, like several studies, we found no significant effect of tear length on meniscal repair results in vertical longitudinal meniscal tear [5,9,27-29]. Some authors reported that smoking negatively influenced meniscal healing [33,34]. In contrast, some other studies found that smoking did not affect meniscal healing [30,31]. Likewise, we found no significant effect of smoking on clinical results. Lateral meniscus tears have been reported to have better healing potential than medial meniscus tears because of higher biomechanical loads on the medial meniscus [3], whereas several studies reported no association between repair laterality and failure rate [5-8]. Our results were in concordance with the latter findings. Also, we found no association of repair technique, suture configuration, chondral status at the time of the repair with increased failure risk in line with the recent review [21].

Heterogeneous patient selection, short-term results, lack of comparison group, and the lack of preoperative patient-reported outcomes were the limitations of the studies in the literature evaluating the effect of an age older than 40 years on meniscal failure [5-7,9]. In this current study, we comparatively evaluated the

outcomes of arthroscopic meniscal repair for vertical-longitudinal tears between patients aged 40 years or older and patients younger than 40 years. The strengths of our study were the evaluation of a homogenous tear type (vertical-longitudinal) and the presence of a comparison group with pre- and postoperative patient-reported outcomes.

This study has several limitations. First, this study was retrospective although we used the prospectively collected data of patients without loss of follow-up. Second, at least a two-year follow-up may be enough to evaluate the failure rate; nevertheless, long-term functional and radiologic outcomes may differ, and more accurate results may be obtained with longer follow-up. The third limitation may be the absence of a radiological or second-look arthroscopic evaluation of all patients. The proportion of patients with asymptomatic failed repairs is unknown – we might exclude asymptomatic failures. Prospective long-term follow-up studies with larger cohorts are needed to evaluate the effect of age on meniscal repair results.

Conclusion

Clinical scores and failure rates following arthroscopic meniscal repair for vertical-longitudinal meniscal tears do not differ in terms of age. We suggest meniscal repair and meniscal tissue protection in patients with vertical-longitudinal meniscal tears regardless of age. Especially peripheral tears should be repaired in the early period because of their better healing potential.

Acknowledgments
This research did not receive any financial support, technical and other assistance of importance for the study.

Conflict of interests
The authors have no conflicts of interest to declare.

Financial Disclosure
All authors declare no financial support.

Ethical approval
Ethics committee approval was received for this study from School of Medicine Clinical Research Ethics Committee of Erciyes University.(No. 2016/193).

References

1. Henning CE. Arthroscopic repair of meniscus tears. Orthopedics United States. 1983;6:1130–2.
2. Noyes FR, Heckmann TP, Barber-Westin SD. Meniscus repair and transplantation: a comprehensive update. J Orthop Sports Phys Ther. 2012;42:274–90.
3. Buseck MS, Noyes FR. Arthroscopic evaluation of meniscal repairs after anterior cruciate ligament reconstruction and immediate motion. Am J Sports Med. 1991;19:489–94.
4. Eggli S, Wegmuller H, Kosina J, et al. Long-term results of arthroscopic meniscal repair. An analysis of isolated tears. Am J Sports Med. 1995;23:715–20.
5. Barrett GR, Field MH, Treacy SH, et al. Clinical results of meniscus repair in patients 40 years and older. Arthroscopy. 1998;14:824–9.
6. Noyes FR, Barber-Westin SD. Arthroscopic repair of meniscus tears extending into the avascular zone with or without anterior cruciate ligament reconstruction in patients 40 years of age and older. Arthroscopy. 2000;16:822–9.
7. Steadman JR, Matheny LM, Singleton SB, et al. Meniscus suture repair: minimum 10-year outcomes in patients younger than 40 years compared with patients 40 and older. Am J Sports Med. 2015;43:2222–7.
8. Everhart JS, Magnussen RA, Poland S, et al. Meniscus repair five-year results are influenced by patient pre-injury activity level but not age group. Knee.2020;27:157-64.
9. Poland S, Everhart JS, Kim W, et al. Age of 40 Years or Older Does Not Affect Meniscal Repair Failure Risk at 5 Years. Arthroscopy. 2019;35:1527–32.
10. Outerbridge re. The etiology of chondromalacia patellae. J Bone Joint Surg Br. 1961;43–B:752–7.
11. Cannon WDJ, Vittori JM. The incidence of healing in arthroscopic meniscal repairs in anterior cruciate ligament-reconstructed knees versus stable knees. Am J Sports Med. 1992;20:176–81.
12. Tegner Y, Lysholm J, Lysholm M, et al. A performance test to monitor rehabilitation and evaluate anterior cruciate ligament injuries. Am J Sports Med. 1986;14:156–9.
13. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clin Orthop Relat Res. 1985;(198):43–9.
14. Irrgang JJ, Ho H, Harner CD, et al. Use of the International Knee Documentation Committee guidelines to assess outcome following anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 1998;6:107–14.
15. Abrams GD, Frank RM, Gupta AK, et al. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. Am J Sports Med. 2013;41:2333–9.
16. Bach BRJ, Dennis M, Balin J, et al. Arthroscopic meniscal repair: analysis of treatment failures. J Knee Surg. 2005;18:278–84.
17. Lyman S, Hidaka C, Valdez AS, et al. Risk factors for meniscectomy after meniscal repair. Am J Sports Med. 2013;41:2772–8.
18. Kalliakmanis A, Zourntos S, Bousgas D, et al. Comparison of arthroscopic meniscal repair results using 3 different meniscal repair devices in anterior cruciate ligament reconstruction patients. Arthroscopy. 2008;24:810–6.
19. Fok AWM, Yau WP. Early results of all-inside meniscal repairs using a pre-loaded suture anchor. Hong Kong Med J = Xianggang yi xue za zhi. 2013;19:124–8.
20. Majeed H, Karuppiah S, Sigamoney KV, et al. All-inside meniscal repair surgery: factors affecting the outcome. J Orthop Traumatol. 2015;16:245–9.
21. Everhart JS, Higgins JD, Poland SG, et al. Meniscal repair in patients age 40years and older: A systematic review of 11 studies and 148 patients. Knee. 2018;25:1142–50.
22. Ahn JH, Wang JH, Yoo JC. Arthroscopic all-inside suture repair of medial meniscus lesion in anterior cruciate ligament--deficient knees: results of second-look arthroscopies in 39 cases. Arthroscopy. 2004;20(9):936–45.
23. Kubiak G, Fabis J. Clinical results of meniscus repair. Ortop Traumatol Rehabil. 2010;12:28–40.
24. Miao Y, Yu J-K, Ao Y-F, et al. Diagnostic values of 3 methods for evaluating meniscal healing status after meniscal repair: comparison among second-look arthroscopy, clinical assessment, and magnetic resonance imaging. Am J Sports Med. 2011;39:735–42.
25. Brillante MJ, Diduch DR, Lunardini DJ, et al. Meniscal repair using an all-inside, rapidly absorbing, tensionable device. Arthroscopy. 2008;24:779–85.
26. Kise NJ, Drogset JO, Ekeland A, et al. All-inside suture device is superior to meniscal arrows in meniscal repair: a prospective randomized multicenter clinical trial with 2-year follow-up. Knee Surg Sports Traumatol Arthrosc. 2015;23:211–8.
27. Kotsovolos ES, Hantes ME, Mastrokalos DS, et al. Results of all-inside meniscal repair with the FasT-Fix meniscal repair system. Arthroscopy. 2006;22:3–9.
28. Rothermel SD, Smuin D, Dhawan A. Are Outcomes After Meniscal Repair Age Dependent? A Systematic Review. Arthroscopy. 2018;34:979–87.
29. Nepple JJ, Dunn WR, Wright RW. Meniscal repair outcomes at greater than five years: a systematic literature review and meta-analysis. J Bone Joint Surg Am. 2012;94:2222–7.
30. Moses MJ, Wang DE, Weinberg M, et al. Clinical outcomes following surgically repaired bucket-handle meniscus tears. Phys Sportsmed. 2017;45:329–36.
31. Laurendon L, Neri T, Farizon F, et al. Prognostic factors for all-inside meniscal repair. A 87-case series. Orthop Traumatol Surg Res. 2017;103:1017–20.
32. Jiang EX, Abouljoud MM, Everhart JS, et al. Clinical factors associated with successful meniscal root repairs: A systematic review. Knee. 2019;26:285–91.

33. Haklar U, Donmez F, Basaran SH, et al. Results of arthroscopic repair of partial- or full-thickness longitudinal medial meniscal tears by single or double vertical sutures using the inside-out technique. Am J Sports Med. 2013;41:596–602.

34. Blackwell R, Schmitt LC, Flanigan DC, et al. Smoking increases the risk of early meniscus repair failure. Knee Surg Sports Traumatol Arthrosc. 2016;24:1540–3.

35. Gormeli G, Gormeli CA, Sevimli R, Karakaplan M, Aslanturk O. Knee osteoarthritis after ACL injury: does early reconstruction prevents posttraumatic osteoarthritis. J Turgut Ozal Med Cent. 2015; 22: 276-7.