Long-Term Outcome After Arthroscopic Meniscal Repair Versus Arthroscopic Partial Meniscectomy for Traumatic Meniscal Tears

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Background: The influence of standard meniscus treatment strategies regarding osteoarthritic progress, function, and sports activity has not been estimated in a direct long-term comparison.

Hypothesis: Meniscal repair compared with partial meniscectomy (partial meniscal resection) decreases osteoarthritic changes and reduces the effect on sports activity in the long-term follow-up.

Study Design: Cohort study; Level of evidence, 3.

Methods: Eighty-one patients with an arthroscopic meniscus shape–preserving surgery after isolated traumatic medial meniscal tear (repair: n = 42; meniscectomy: n = 39) were examined clinically (Lysholm score, Tegner score) and radiologically (Fairbank score, compared with the uninjured knee); the follow-up was divided into midterm (3.4 years; n = 35) and long term (8.8 years; n = 46). Additionally, the influences of the preoperative sports activity level and age at surgery were evaluated.

Results: In the long-term follow-up, no osteoarthritic progress was detectable in 80.8% after repair compared with 40.0% after meniscectomy (*P* = .005) with significant benefit for the ''young'' subgroup (*P* = 0.01). The preinjury activity level was obtained in 96.2% after repair compared with 50% after meniscectomy (*P* = .001). The function score revealed no significant difference between these strategies (*P* = .114). The athletes showed a significantly reduced loss of sports activity after repair compared with the athletes after meniscectomy (*P* = .001).

Conclusion: Arthroscopic meniscal repair offers significantly improved results for isolated traumatic meniscal tears regarding the long-term follow-up in osteoarthritis prophylaxis and sports activity recovery compared with partial meniscectomy.

Keywords: meniscal repair; long-term results; osteoarthritis; arthroscopic surgery

The changes in "pivoting" sports activities in the past few decades have resulted in increased injury rates of the meniscal structures (1.5 million injuries in Germany per year) and present more common problems for surgical treatment.[7] These demands shifted the emphasis in meniscal surgery regarding the return to previous sports activity level as well as osteoarthritis prophylaxis.[48] The tear type allows a meniscal repair only in 5% and in 70% to 80% with a concomitant anterior cruciate ligament (ACL) reconstruction.[12,16] The meniscal shape and the orientation of the fibrocollagen structures enable optimal weightbearing and shock absorption regarding joint congruence and stability.[40] Evaluating the role of meniscal integrity for the instantaneous intra-articular pressure distributions on a human cadaveric model showed that the contact areas and the peak local contact stress increased significantly with the loss of meniscal tissue and seemed to be directly related to the amount of fibrocartilage resection.[4,11,20] In particular, the preservation of the meniscal rim appears important for the postoperative axial pressure distribution of the meniscus.[32]

Since the first open meniscal repair,[3] several fixation methods and materials for the arthroscopic repair of meniscal tears have been described with varying healing

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TABLE 1
Exclusion Criteria for Patient Review

Postoperative interval <2 years	Preoperative osteoarthritis Fairbank Grade 3 or 4
Patellar dislocation	Preoperative limitation of range of motion
Osteochondral lesions	Preoperative varus or valgus deviation >5°
Bony fractures	Lesion of the central or peripheral nervous system
Ligament insufficiency	Knee surgery before
Simultaneous injury of medial and lateral meniscus	Any kind of infection
Bilateral knee injury	Noncompliant rehabilitation
Postoperative reinjury except the meniscus	Fatty meniscus degeneration
	Atraumatic tear/negative trauma history

rates from 64% to 97%.[1,13,24,38,48] The recent literature offers numerous repair techniques with less morbidity and simplified tools to reach the different locations. The variety of the meniscal healing success rates seems to be influenced more by the rupture zone[20,26] and joint stability[9,30,38,46] and less by the choice of implant or by the suture technique[5,41,48] or by the injury-to-surgery time interval.[28,48]

In combination with ACL reconstruction, the benefit of meniscal repair therapy for athletes regarding osteoarthritis prophylaxis and sports activity resumption has been demonstrated.[§] The purpose of the present study was to measure the midterm and long-term outcome after meniscal repair compared with the partial meniscectomy in stable knees regarding osteoarthritic progress, loss of knee function, and influence on sports activity.

MATERIALS AND METHODS

Patients

All patients with a history of knee trauma and isolated medial meniscal surgery between 1996 and 2001 were reviewed retrospectively and invited for an examination. The exclusion criteria are shown in Table 1. Of all meniscus surgeries, 112 patients were eligible after applying the specific exclusion criteria, and 81 were examined at the radiological and clinical standardized follow-up. The 81 patients consisted of 42 patients with a meniscal repair (16 women, 26 men; mean ± SD, 31.29 ± 11.61 years) and 39 patients with partial meniscectomy (12 women, 27 men; 32.54 ± 10.60 years). These groups were subdivided according to time of follow-up (midterm follow-up: 2-5 years; long-term follow-up: 5-8 years). The influence of the "preinjury sports activity level" and "age at surgery" was recorded by defined subgroups. The preinjury Tegner sports activity was used to divide the patients into "athletes" (recreational sports 5 or more times per week; repair: n = 31; meniscectomy: n = 28) and "nonathletes" (repair: n = 11; meniscectomy: n = 11). The age at surgery was used to divide the patients into group "young" (≤30 years; n = 45) and group "old" (>30 years; n = 36).

[§]References 1, 24, 29, 30, 34, 38, 46, 48.

Arthroscopic Procedure

All patients underwent a physical examination and standardized radiological diagnostics (conventional radiograph and magnetic resonance imaging [MRI]). The indications for the repair or partial resection procedure were not randomized and depended on the rupture type. The meniscal repair was performed in full-thickness and vertical longitudinal tears greater than 1 cm in length or bucket-handle tears in the red-red to the red-white zone. The indications for the arthroscopic partial meniscectomy were ruptures in the white-white zone, and all tears were considered as nonrepairable due to their type and size.

All arthroscopic surgeries were performed under general or spinal anesthesia using a 4-mm/30° angle optic without a special leg positioner. Before the meniscal inside-out suture (meniscus repair needles set with PDS 2-0; Arthrex, Naples, Florida) at the rupture zone, capillary bleeding was generated. For the partial meniscectomy, the different angulate punch instruments were used (Arthrex), and the rupture zone was resected, taking into account the semilunar meniscal shape.

For the rehabilitation regimen after meniscal repair, the application of range of motion (ROM) limiting braces allowed 60° of flexion and 0° of extension with weightbearing restricted to full extension for 4 weeks after surgery; during the 5th to 6th week 90° of flexion and 0° of extension were allowed. Patients underwent physiotherapeutic treatment with passive joint motion, isometric muscle exercises in the closed chain. After 6 weeks pain-adapted weightbearing with full range of motion and approach to the former specific sports were allowed. For the partial meniscectomy group, the rehabilitation regimen included pain-adapted weightbearing with limited ROM of 90° of flexion and 0° of extension for two weeks after surgery without any braces. Physiotherapeutic treatment was performed with full range of joint motion, isometric muscle exercises in the closed chain. Four weeks after surgery the resumption of the former specific sports was allowed. Persisting dysesthesias or repeat surgery at the previously treated part of the meniscus with intraoperative sign of nonhealing were defined as "specific failure" of the arthroscopic meniscal treatment.

Scoring Systems

All patients were examined regarding the osteoarthritis progression, the sports activity, and the general knee function. The Fairbank classification[18] was applied for evaluating the osteoarthritis progression: Grade 0 = no signs of osteoarthritis; Grade 1 = subchondral sclerosis; Grade 2 = changes of the femoral condyles or tibial osteophytes; and Grade 3 = high-grade osteoarthritis with narrowness of the joint space >50%. The radiographs of both knee joints (anteroposterior and lateral view in standing position) were compared to each other by an independent radiologist blinded to each case. The uninjured side was defined as the

TABLE 2
Midterm Results Comparing Repair Group Versus Partial Meniscectomy Group Regarding Osteoarthritis Progress, Sports Activity, and General Knee Function[a]

		Age at Surgery, y	Time of Follow-up, y	Osteoarthritis Fairbank Grade	Tegner Sports Activity Level Loss	Lysholm Function
Repair (n = 16)	Mean	31.5	3.44	0.00	−0.08	92.75
	SD	12.09	1.21	0.00	0.25	6.78
Partial resection (n = 19)	Mean	34.79	3.42	−0.05	−0.16	91.47
	SD	12.09	1.12	0.23	0.50	7.08
P value		NS (.41)	NS (.97)	NS (.36)	NS (.63)	NS (.76)

[a]SD, standard deviation; NS, not significant.

control. Progress of osteoarthritis was considered as positive when a difference in the Fairbank score was detectable compared with the uninjured knee. The Tegner sports activity score[47] was used as the functional score. Sports activity reduction was defined as a difference between the preinjury sports level compared to the status at follow-up. With the Lysholm score,[33] the patients' subjective opinion of function and the presence or absence of signs of instability at the time of follow-up were recorded.

Statistical Analysis

The determined parameters were compared statistically by the matched-pairs Wilcoxon test (comparison between injured vs noninjured side; comparison of different times of follow-up), the Wilcoxon-Mann-Whitney test (comparison of meniscal repair vs partial meniscectomy), and the Spearman test and the Fisher exact test (measurement of correlations) using the software BIAS (Biometric Analysis of Samples 8.4.2; Epsilon, Frankfurt Main, Germany). The level for statistical significance was set to an α level of $P \leq .05$.

RESULTS

In the scoring systems, all 81 patients benefited from the surgery. The length of the posttraumatic symptoms until surgery was retrospectively, not reliably, measurable. In 40 of 42 repaired cases, there was a longitudinal rupture, and in 2 of 42 cases, a bucket-handle injury. A partial meniscectomy was performed in 33 of 39 for a longitudinal rupture, in 4 of 39 for a bucket-handle tear, and in 2 of 39 for a flap rupture. All patients had negative meniscus signs (Steinman test I or II, McMurray test[31]) and showed a sufficient capsule-ligament complex without instability at time of follow-up.

Success Rate and Complications

In the repair group, there were 6 revision surgeries within the first 13 months; 3 of them were associated with new trauma, and 3 were without any reasonable cause. In 2 posttraumatic cases, a new meniscal repair was performed in another part of the meniscus, and in 4 cases after initial meniscal repair, a partial meniscectomy was necessary. Two patients without a new trauma showed intraoperatively a nonhealing meniscal repair and were defined as specific failure. Another patient reported persisting dysesthesias in the region of the saphenous nerve at the long-term follow-up. In the partial meniscectomy group, there were 4 revision surgeries after trauma within the first 36 months. In 2 cases, a new rupture at another part of the same meniscus occurred. In 2 cases, a persisting lesion at the former resection zone was detected and recorded as an insufficient initial partial meniscectomy. All patients with revision surgeries had stable ligament conditions but showed positive meniscal test findings before revision surgery. The success rate after meniscal repair was 85.71% (36 of 42), and after partial meniscectomy, it was 89.74% (35 of 39).

Meniscal Repair Versus Partial Meniscectomy

The midterm examinations (3.43 ± 1.14 years; n = 35) comparing the two meniscal procedures showed no significant differences regarding osteoarthritis progress, no loss of sports activity, and no deficit of knee function (Table 2). The long-term data (8.83 ± 2.62 years; n = 46) after meniscal repair surgery revealed no significant changes ($P = .063$) regarding the osteoarthritis progression. In contrast, after partial meniscectomy, a highly significant osteoarthritis deterioration was detectable ($P = .0005$) (Table 3). In the repair group, 80.79% showed no radiological signs of osteoarthritis progression; in the partial meniscectomy group, only 40% ($P = .005$) were unchanged (Table 4). Measuring the sports activity loss, the statistical analysis revealed no significant influence of the meniscal repair ($P = .982$) in contrast to a highly significant loss in sports activity level after partial meniscectomy ($P = .0009$) (Table 5). In the repair group, 96.15% reached the preinjury sports activity level in contrast to only 50.00% in the partial meniscectomy group ($P = .001$). There was no significant difference in the Lysholm function score between groups ($P = .114$) (Table 5).

Influence of Sports Activity Level and Age at Surgery

For the athlete subgroups, there was a significant loss of sports activity level in the partial meniscectomy group

TABLE 3
Long-Term Results of Repair Group Versus Partial Resection Group Regarding Osteoarthritic Changes Compared With the Opposite Uninjured Knee (Control)[a]

		Age at Surgery, y	Time of Follow-up, y	Osteoarthritis Fairbank Difference	Osteoarthritis Fairbank Control	Osteoarthritis Fairbank Postoperative	*P* Value
Repair (n = 26)	Mean	31.15	8.58	−0.19	0.27	0.46	NS (.063)
	SD	11.55	2.66	0.40	0.53	0.58	
Partial resection	Mean	30.40	9.15	−0.6	0.55	1.15	.0005
(n = 20)	SD	9.36	2.60	0.50	0.69	0.75	
P value		NS (.96)	NS (.30)	.005			

[a]SD, standard deviation; NS, not significant.

TABLE 4
Fairbank Grade of Osteoarthritis in Percentages After Midterm and Long-Term Follow-up

	Midterm (3.43 ± 1.14 y)			Long-Term (8.83 ± 2.62 y) *P* = .005		
	Grade 0	Grade 1	Grade 2	Grade 0	Grade 1	Grade 2
Repair	100.00%	0%	0%	80.79%	19.23%	0%
Partial resection	94.74%	5.26%	0%	40.00%	60.00%	0%

TABLE 5
Long-Term Results of the Lysholm Function Score and the Tegner Sports Activity Score Comparing Repair Group Versus Partial Resection Group[a]

		Lysholm Function	Preinjury Tegner Sports Activity Score	Follow-up Tegner Sports Activity Score	Tegner Sports Activity Score Change	*P* Value
Repair (n = 26)	Mean	91.54	5.50	5.46	0.04	NS (.98)
	SD	8.95	1.53	1.50	0.19	
Partial resection (n = 20)	Mean	88.35	6.25	5.30	0.95	.005
	SD	8.02	1.55	1.69	1.19	
P value		NS (.11)			.0002	

[a]SD, standard deviation; NS, not significant.

(–1.06 ± 1.24; *P* = .004). After the repair procedure, there was no significant difference (0.06 ± 0.24; *P* = 1.000). In the repair group 94.4% reached the preinjury sports activity level at the long-term follow-up; only 43.75% of the partial meniscectomy group reached the preinjury level (*P* = .001). There was no correlation between preinjury sports activity level and postoperative osteoarthritic progression in the 2 groups (repair: *P* = .257; meniscectomy: *P* = .474). Furthermore, there was a protective effect against the osteoarthritis progression after repair compared with the meniscectomy detectable in the "young" subgroup (≤30 years; 23.89 ± 4.54 years) (*P* = .01). In the "old" subgroup (>30 years; 42.39 ± 7.13 years), there was no protective effect (*P* = .161).

DISCUSSION

Both meniscal repair and partial meniscectomy procedures are the standard therapies for meniscal treatment. Therefore, the present study describes the clinical and radiological benefit of meniscal repair versus partial meniscectomy after isolated traumatic medial meniscal rupture. All osteoarthritis factors except the meniscal rupture were excluded by the study design (Table 1). Additionally, the rupture type makes repair feasible in only 5% of all meniscal lesions.[12,16] Even the potential influences of the medial and lateral side[10] were excluded by restricting the study to medial menisci only. These preselective criteria of the present study generated the untypical distribution of repairable and nonrepairable meniscal ruptures with equal basic meniscal rupture types in both groups.

Neither negative clinical meniscal test results nor the MRI allow prediction of complete healing.[35,37,38] Any radiological diagnosis is less sensitive compared with second-look arthroscopy for evaluation of meniscal healing. Via second-look arthroscopy after arthroscopic meniscal repair, it has been shown that the absence of clinical meniscal signs in 84% consisted of 65% "completely" healed and 19% "incompletely" healed meniscal repairs.[37] Studies with MRI[38] and spiral computed tomography

TABLE 6
Literature Review After Meniscal Repair Ordered by Time of Follow-up[a]

Study Group	Year of Publication	Patients	Follow-up	Surgical Technique	Healing Rate	Healing Determined By	Combined ACL Rupture	Control Group
Pujol et al[38]	2008	53	6 mo retrospective	Arthroscopic/ outside-in, all-inside	82% (58% complete, 24% incomplete)	Arthro-CT	Yes	No
Ahn et al[1]	2004	39	19 mo retrospective	Arthroscopic/ all-inside	97%	Second-look arthroscopy	Yes	No
Haas et al[23]	2005	37	24.3 mo prospective	Arthroscopic/ all-inside	86%	Clinical	Yes	No
Morgan et al[36]	1991	74	— retrospective	Arthroscopic/ outside-in	84% (65% complete, 19% incomplete)	Second-look arthroscopy	Yes	No
Mariani et al[34]	1996	22	28 mo retrospective	Arthroscopic/ outside-in	77%	Clinical, MRI	Yes	No
Hanks et al[24]	1991	45	4 y retrospective	Arthroscopic/ all-inside	90%	Clinical	Yes	N = 29 open meniscus suture
Venkatachalam et al[49]	2001	59	5 y retrospective	Arthroscopic/ all-inside	66%	Clinical	No	No
Tuckman et al[47]	2006	133	5.2 y retrospective	Arthroscopic/ outside-in, all-inside	64%	Telephone interview	Yes	No
Eggli et al[15]	1995	52	7.5 y retrospective	Arthroscopic	90%	Clinical, MRI	No	No
Present study	2009	42	8.5 y retrospective	Arthroscopic/ inside-out	86%	Clinical, radiograph	No	N = 39 arthroscopic partial resection
Majewski et al[33]	2006	88	10 y retrospective	Arthroscopic/ outside-in	73%	Clinical, radiograph	No	No
Muellner et al[37]	1999	22	12.9 y retrospective	Open meniscus suture	87%	Clinical, MRI	Yes	No
Rockborn and Messner[42]	2000	30	13 y retrospective	Open meniscus suture	77%	Clinical, radiograph	No	N = 30 arthroscopic partial resection

[a]ACL, anterior cruciate ligament; CT, computed tomography; MRI, magnetic resonance imaging.

arthrography[39] described success rates of 91% to 92% after arthroscopic meniscal repair. The success rate seemed to depend less on the applied repair technique and more on the meniscal region[49] and ligamentous stability.[13] Additionally, there are "silent failures" in which the meniscal repair failed with recurrence of symptoms but no apparent cause.[34] In the present study in 7.1% (3 of 42) of silent failures after repair, a secondary partial meniscectomy was required. Our specific failure analysis of these cases showed no obvious causes or new trauma. Similar to Morgan et al,[37] we recorded the absence of clinical symptoms as a successful repair. The meniscal healing success rate after meniscal repair was 85.7% (36 of 42) and after partial meniscectomy was 89.7% (35 of 39), confirming literature data[||] (Table 6). At the time of follow-up, all examined patients showed negative meniscal signs. The absence of symptoms may describe the quantity of meniscal repair, but the quality of the meniscal healing remained unclear.

The biomechanical advantages of the meniscus-preserving procedures have been examined in detail.[4] The incidence of osteoarthritis seems to depend on the range of meniscal tissue resection.[2] The securely and reproducibly arthroscopic measurement of the injured meniscal tissue amount respective of the partial meniscectomy is difficult. The percentage of the ruptured meniscal tissue and the influence on the clinical and radiological outcome of the meniscal treatment remained unclear in all clinical follow-up investigations of the literature review as well as in the present study. In combination with ACL reconstruction, the protective effect of the arthroscopic meniscal repair versus partial meniscectomy has been described several times,[29,30] independent of the meniscal repair technique.[22] Interestingly, isolated open meniscal repair offered no benefit regarding osteoarthritis prophylaxis compared with the isolated arthroscopic partial meniscectomy.[43] With long-term follow-up, only a few studies described the success rate of the isolated arthroscopic

[||]References 8, 15, 19, 23, 24, 34, 38, 48.

meniscal repair in the absence of a control procedure.[15,34,50] Majewski et al[34] described an increased degree of osteoarthritic changes in 25% after meniscal repair compared with the uninjured control knee. For isolated arthroscopic partial meniscectomy, the literature review revealed osteoarthritis progression rates up to 53%.[8,19,27] The authors of the present study are not aware of a study directly comparing the meniscal repair versus the partial meniscectomy after traumatic meniscal tear (Table 6).

Excluding all concomitant osteoarthritis-inducing factors aside from meniscal injury (Table 1), the present data displayed the significant increased general status after meniscal repair compared with the partial meniscectomy. The influence of injury-to-surgery interval in the present study was not reliably assessable by the applied retrospective study design but was previously shown not to affect surgical outcome.[48] For the radiological osteoarthritis progression, the radiological evaluation of the uninjured contralateral knee of the patients[34,42,43] or a healthy knee of a control group[2] was established and assumed to exclude the physiological osteoarthritis progression. Compared with the uninjured contralateral knee, in the present study after meniscal repair, there were no osteoarthritic changes detectable in 80.79%, but after partial meniscectomy, only in 40% (Table 4). This osteoarthritis incidence after meniscal repair confirmed the findings of Majewski et al[34] who found 25% compared with the uninjured control knee. Osteoarthritic changes were recorded in 19% after arthroscopic meniscal repair. We presume these degenerative changes were due to decreased tissue quality after meniscal repair with incomplete healing or by the meniscal scar tissue.[25,36,50] This rate of osteoarthritic progression after meniscal repair (Tables 3 and 4) seemed to be comparable with the incomplete healing rate (19%-24%) shown in studies with second-look arthroscopy after arthroscopic meniscal repair[37] or arthro–computed tomography follow-up.[39] The repaired meniscal tissue may have decreased biomechanical qualities inducing degenerative changes. The extent of meniscal healing seemed to be increased in the "young" meniscal tissue; therefore, our data showed a significantly decreased osteoarthritis progression in the young population group compared with the older patients.

Electromyographic midterm studies showed persisting deficits after partial meniscectomy with decreased quadriceps femoris strength and sports activity.[14,17,21,44] The arthroscopic meniscal repair enabled a muscular recovery without any sports activity loss.[45] The arthroscopic meniscal repair allowed professional athletes (Tegner score $\geq$7) in 86% and recreational athletes (Tegner score $\geq$6) in 100% to return to the preinjury sports activity level.[30] The long-term sports activity of the athletes showed the recovery of preinjury status after meniscal repair in 94.4%. After partial meniscectomy, the previous level was reached in the athlete group in only 43.8%, analogous to previous data after isolated partially lateral meniscectomy in the stable athlete's knee[6] (Table 5). The Lysholm score recorded the daily function without sports ability and instability symptoms. So the impairments of the Tegner sports activity differences were not reflected in the Lysholm score; both groups showed similar data.

The choice of surgical procedure was not randomized but instead based on the type of tear. This has to be seen as a limitation of the present study. So principally, the present study measured the differences of 2 surgical treatment strategies indicated by the different types of meniscal injuries. The isolated influence of the meniscal rupture type was not assessable in the present study design. A randomized study design evaluating meniscal repair versus partial meniscectomy in principally repairable meniscal ruptures would enable the isolated comparison of both procedures but would not be ethically realizable. It is assumed that a partial meniscectomy in a "repairable" meniscal rupture would result in an increased meniscus tissue loss with more osteoarthritic changes compared with the present partial meniscectomy group.[2]

The meniscal repair procedure has to be seen as the more complex therapy with specific complications and higher perioperative expenses as well as extended rehabilitation compared with the partial meniscectomy. The present study showed significant benefits for osteoarthritis prophylaxis and sports activity resumption after the more complex meniscal repair therapy compared with the partial meniscectomy in a long-term follow-up.

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