P. Rockborn
K. Messner

Long-term results of meniscus repair and meniscectomy: a 13-year functional and radiographic follow-up study

P. Rockborn · K. Messner (✉)
Sports Medicine,
Faculty of Health Sciences,
Linköping University,
58185 Linköping, Sweden
e-mail: KarMe@ort.liu.se
Tel.: +46-11-224140
Fax: +46-13-224434

Abstract This study investigated the long-term outcome of common meniscus treatment (meniscectomy, repair). A consecutive series of 30 patients with open meniscus repair were compared retrospectively to 30 patients who had an arthroscopic partial or subtotal meniscectomy. The groups were matched according to sex, age, meniscus lesion, and follow-up time. The patients were aged 13–43 years at the time of operation; all had intact cruciate ligaments, and none had had previous surgery on the knee. Patients were reexamined at a mean of 13 years after the operation. In addition, for a subgroup of 22 matched pairs, data were available from a 7-year follow-up. Four of the repaired menisci did not heal, and another three reruptured during the 13-year follow-up; these menisci were all excised (23%). Meniscal remnant surgery was needed in 6 cases (20%) after initial meniscectomy. At the 13-year follow-up there was no difference between the groups in knee function, subjective complaints, or manual findings. Almost 90% of the patients in both groups had no knee problems during daily activities. At the late follow-up radiographic signs for bone spurs, sclerosis, or flattening of the femoral condyle were found in around half of the cases in each group. Three patients (10%) with initial repair and 8 (27%) with meniscectomy had minor joint space reduction, but no patient had more severe radiographic changes. After 7 years (subgroup) joint space reduction was more common after initial meniscectomy than after repair ($P < 0.05$). After 13 years the incidence and severity of arthrosis did not differ significantly between the two groups, even when only the successful repairs were compared to meniscectomy ($P = 0.06$).

Key words Meniscus treatment · Long-term results · Knee function · Radiographic osteoarthrosis

Introduction

The role of the knee menisci as load-sharing and cartilage-protective structures has been demonstrated experimentally [11, 32] and confirmed clinically by the high incidence of radiographic signs for premature arthrosis in long-term evaluations after open total meniscectomy [10, 16, 17, 30]. Since then emphasis has been put on meniscal preserving treatment such as partial meniscectomy or, if possible, repair [8, 9, 12, 13, 15]. Partial meniscectomy results in a lesser stress increase on cartilage than does total meniscectomy during in vitro conditions [5], and a repaired peripheral longitudinal meniscal tear leads to a similar stress distribution in the knee than that seen with an intact meniscus [3]. Hence, as anticipated from these studies, the senior author found in a 7-year follow-up evaluation that patients with initial repair had a better knee function and less radiographic signs for premature arthrosis than patients treated with arthroscopic meniscec-

tomy [29]. On the longer term the superiority of meniscal repair above meniscectomy should even become more prominent.

Thus the purpose of this study was to reexamine patients with initial meniscal repair or arthroscopic meniscectomy after 13 years with functional and radiographic evaluations.

Patients and methods

Between 1978 and 1983 approximately 200 meniscus injuries were diagnosed yearly at our Department (900 arthroscopies/year). At that time arthroscopic partial meniscectomy was the treatment of choice in most instances, but open repair was performed in cases with longitudinal tear in the outer vascularized meniscal rim with no signs for tissue degeneration. The arthroscopic findings were recorded on a standard protocol which had been introduced to create a detailed database for the purpose of research [18]. Meniscal lesions were classified as radial, longitudinal, horizontal-cleavage, bucket handle, or flap tears. The size of the rupture and the amount of tissue removed at meniscectomy were recorded by hand on a schematic drawing. In addition, the degree of cartilage degeneration on femoral and tibial condyles, patella, and patellar groove was graded according to a modified Outerbridge classification (grade 1, soft, discolored or superficial cartilage fibrillation; grade 2, fragmentation of cartilage; grade 3, erosion of cartilage to subchondral bone) [20].

From the protocols of the years 1978–1983 all patients ($n = 33$) with intact cruciate ligaments who underwent meniscus repair were selected and traced; three refused reexamination. To the remaining 30 patients with repair (repair group) we were able to retrospectively match 30 patients from the other protocols who had a meniscectomy during the same time period (meniscectomy group). Only patients with intact cruciate ligaments and no major other concomitant injuries except for the meniscus were selected. The patients were matched according to sex, age (within 5 years), site of meniscus lesion (medial, lateral), and follow-up time (within 5 years). No patient in the repair group had any previous surgery on either knee. Four patients in the meniscectomy group had undergone open meniscectomy on the other knee before the index operation, but no one had previous surgery on the concerned knee. Each group consisted of 24 men and 6 women. The mean age was 26 years (range 13–43 years) at index surgery. In each group 21 medial and 9 lateral menisci were treated (Table 1). Nine experienced knee surgeons were involved in the meniscus sutures; five of these performed the meniscectomies.

Table 1 Initial patient characteristics

	Repair group ($n = 30$)	Meniscectomy group ($n = 30$)	P
Age (years)	26	26	n.s.
Medial/lateral (n)	21/9	21/9	
Preoperative activity (Tegner), median (range)	7 (3–9)	6.5 (3–9)	n.s.
Levels 4–10 (%)	97	77	< 0.05
Time from injury to surgery (weeks), median (range)	19 (0–104)	18 (0–370)	n.s.
Traumatic injury (n)	22	20	n.s.
Follow-up time I (years)	6.9	6.8	n.s.
Follow-up time II (years)	13.7	12.9	< 0.05

Table 2 Type of meniscus tear and cartilage grading at initial arthroscopy (after [20])

	Repair group	Meniscectomy group
Meniscus tear		
Radial	0	1
Longitudinal-vertical	30	18
Intrameniscal	10	10
Meniscocapsular	19	0
Bucket handle	1	8
Horizontal-cleavage	0	7
Flap	0	4
Cartilage changes[a]		
Grade 0	24	13
Grade 1	5	15
Grade 2	1	2
Grade 3	0	0

[a] More patients in the meniscectomy group had changes than in the repair group ($P < 0.05$)

Repair group

All tears were longitudinal, 2–4 cm long, and located in the peripheral third of the meniscus (vascularized zone) or at the capsular attachment (Table 2). In one case a bucket handle tear was reduced and then repaired. Two patients had an associated tear of the medial collateral ligament, one patient a tear of the posterior oblique ligament, and another a tear of the lateral collateral ligament. These ligament injuries were sutured or stapled during the same session. The meniscus was repaired by an open technique according to Hamberg et al. [13]. Briefly, a posteromedial skin incision was made with the knee flexed to about 60°. Vertical arthrotomy was carried out along the dorsal edge of the posterior oblique ligament. After débridement of the tear surfaces until bleeding, the tear was fixed to the capsular ring by two to four vertical nonresorbable sutures. In case with lateral meniscal injury the tear was usually repaired through an arthrotomy posterior to the lateral collateral ligament. In one case the lateral collateral/popliteal ligament complex was detached with a bone fragment, and in another two the iliotibial band to facilitate the approach. After the procedure the knee was immobilized in a plaster cast at 20° of flexion for 5 weeks. After the immobilization period, motion and weight-bearing were successively trained under physiotherapeutic supervision. Sports were not allowed before 2 months after the operation. The patients were managed by the physician until full recovery.

Meniscectomy group

All 15 partial and 6 subtotal medial meniscectomies and the 7 partial and 2 subtotal lateral meniscectomies were carried out arthroscopically. Subtotal meniscectomy was defined as extended resection of the posterior, middle, and anterior horns leaving only a small remnant at the periphery. A resection which left one-half or more of the meniscal body intact was defined as partial meniscectomy. None of the patients had an associated ligament tear. Onehalf of the patients were treated as outpatients; the remaining patients stayed at the hospital between 12 and 24 h for reasons unrelated to arthroscopy. Full weight bearing was allowed immediately after the procedure, and a written exercise program was prescribed for home training. The patient was controlled at a single occasion by the physician.

Follow-up examinations

Patients were reexamined a mean of 13 years (range 11–17) after the index operation. In a subpopulation of 22 pairs of patients (subgroup), results from a 7-year (range 6–10) follow-up examination were available. The 7-year follow-up evaluation was carried out by the senior author (K.M.), and the 13-year follow-up evaluation by the first author (P.R.), who were both experienced orthopedic surgeons at time of evaluation.

At both follow-up examinations knee function was assessed by the Lysholm score [19]. The activity levels 1 year after operation and at the various follow-ups were graded by the 11-point Tegner scale [31]: levels 0–3 correspond to daily activities without any sports, levels 4 and 5 to physical fitness activities, level 6 to participation in active individual sports such as squash, tennis and down hill skiing, and levels 7–10 to competitive team sports. At both occasions all knees were examined manually, which included tests for range of motion, stability, meniscal pathology, patellofemoral disorder, and thigh muscle atrophy. Knee stability was further evaluated by instrumented measurement of sagittal tibial displacement at 20°of knee flexion with a laxity tester (Orthopedic Systems, Hayward, Calif, USA) using a 90-N load.

In addition, at the 13-year follow-up evaluation the patient's own subjective assessment of knee function was recorded using a visual analogue scale ranging from 0 to 100, 0 indicating no disability and 100 severe disability [28]. Thigh muscle strength was estimated as described by Appel [2]. For this purpose the patient in single stance was asked to squat as far down as possible such as to be able to rise again without support. The angle between the extended and the reached squatting position was measured. The test was performed on both legs. Furthermore, varus-valgus alignment of the femorotibial axes was measured in the standing patient. The knee alignment was defined as varus when the space between the medial knee condyles exceeded the space between the ankle malleoli, and vice versa in a valgus knee.

Radiographic examination

At both follow-up evaluations anteroposterior radiographs of each knee were taken in a slightly flexed, weight-bearing position as described by Ahlbäck [1]. All radiographs from both occasions were reviewed blindly by the senior author. Radiographic changes were graded according to Fairbank [10] and Ahlbäck [1] and classified as: grade 0, no changes; grade 1, Fairbank changes such as ridge formation, flattening of the femoral condyles and sclerosis, but no joint space reduction; grade 2, joint space reduction (minimum 50%) with or without Fairbank changes (Ahlbäck grade I); grade 3, joint space obliteration (Ahlbäck grade II).

Joint fluid analysis

At 13-year follow-up examination 26 patients in the repair group and 28 in the meniscectomy group volunteered for a joint fluid aspiration of the operated knee. No knee had obvious effusion before injection. First, an undiluted joint fluid sample was aspirated under sterile conditions. Then 20 ml sterile physiological saline solution was injected intra-articularly; the patient was encouraged to flex and extend the knee ten times to provide a mixture between the saline and joint fluid and then as much as possible of the diluted joint fluid was aspirated. A diluted sample was obtained from all knees; an undiluted sample was obtained from 23/26 knees in the repair group and from 21/28 knees in the meniscectomy group. The amount of aspirated fluid was measured and the sample stored at –20 °C until analyzed. Proteoglycan fragments were quantified as sulfated glycosaminoglycans by precipitation with Alcian blue, using chondroitin-6-sulfate as standard [4]. The procedure of joint fluid aspiration and radiographic examination was approved by the local ethics committee.

Statistics

For nonparametric data (Lysholm score, Tegner scale, radiographic score) the Mann-Whitney U test was used for analysis of group differences, and the Wilcoxon signed rank test for analysis of repeated measurements in the same patient. For parametric data (operation-time, sick-leave, range of motion, angles at muscle strength measurements, stability) the paired t test was used for analysis of repeated measures and the unpaired t test for group differences. Differences in proportions (radiographic grading, cartilage grading at arthroscopy) between the two groups were assessed with the chi-square test. The statistical evaluation was performed with aid of Statistica software (Statsoft, Tulsa, Okla., USA).

Results

Initial group characteristics

Before injury more patients in the repair group participated regularly in recreational or competitive sport activities (levels 4–10 according to Tegner) than in the meniscectomy group ($P < 0.05$; Table 1). The time from injury to surgery was similar in the two groups. At index arthroscopy patients treated by meniscectomy had more signs for cartilage degeneration (mostly surface fibrillation) in the concerned knee compartment than patients with repair ($P < 0.05$; (Table 2). The surgical time was longer in the repair group (72 ± 45 min,) than in the meniscectomy group (49 ± 22 min; $P < 0.05$). Sick leave was also longer in the repair group (13 ± 5 weeks) than in the meniscectomy group (1.5 ± 1 weeks; $P < 0.001$). In addition, patients with repair had more postoperative outpatient visits (median 4, range 0–9) than patients with meniscectomy (median 1, range 0–8; $P < 000.1$). Patients with meniscus repair had a slightly longer overall follow-up than those with meniscectomy ($P < 0.05$; Table 1).

Failure rate and repeated surgery

The frequency of repeat surgery of the concerned meniscus was similar in the two groups. Four repairs of a medial meniscus did not heal (14%) and were excised within 1-2 years after initial treatment. Another three repairs (one lateral, two medial) ruptured during the follow-up period and were excised at 3, 5, and 14 years after the initial operation. One rerupture occurred after a minor trauma. In the other two cases the symptoms arose gradually. The total failure rate ($n = 7$) 13-years after meniscus repair was 23%. One patient in the repair group sustained a traumatic rupture of the anterior cruciate ligament 11 years after the initial injury. A patella tendon reconstruction was performed 8 months before the 13-year follow-up evaluation. Another three patients (10%) in this group had an arthroscopic meniscectomy of the other knee during the follow-up period.

In the meniscectomy group six patients (20%) had repeated surgery of the concerned meniscus because of in-

sufficient primary resection or rupture of the remnant, all within 3 years after the index operation. In this group seven patients underwent arthroscopic partial meniscectomy in the other knee during the follow-up period.

Knee function and activity

After 13 years the median Lysholm score was 95 (range 69–100; max. 100) in the repair group and 95 (range 75–100) in the meniscectomy group. Also, the patient's own assessment of knee function on the visual analogue scale was similarly high in the two groups. Fifty-two patients (87%) had no problems during daily activities (Lysholm score > 84 points), and 39 (65%) had a normal knee function (Lysholm score > 94 points). According to the patient's own assessment, 15 patients (25%) had no knee problems during activities, and 32 patients (53%) had minor problems (2–20 mm on the visual analogue scale). Two patients in the repair group had major com-

plaints (> 60 mm), but none in the meniscectomy group had major problems.

Knee function had not changed between 7 and 13 years in the two subgroups, when studied longitudinally. Patients with repair had median Lysholm scores of 97 (range 87–100) after 7 years and 97 (range 69–100) after 13 years, and patients with meniscectomy had scores of 95 (range 64–100) and 95 (range 75–100) at the respective follow-ups. There were also no group differences in knee function at any of the follow-ups. The activity level declined in both groups between 7 and 13-year follow-up evaluations ($P < 0.05$). After 7 years the two groups had a similar activity level, but after 13 years the activity level was higher in the repair group ($P < 0.01$; Fig. 1).

Manual examination

At the 13-year follow-up patients in the two groups had similar values for range of motion, instrumented evaluation of sagittal tibial displacement, angles during muscle strength testing, and knee joint alignment (Table 3). No patient had a range of motion deficit compared to the other knee exceeding 6° for extension or 10° for flexion. Thigh muscle circumference, angles at the muscle strength measurement, and sagittal knee displacement at instrumented evaluation did not differ between concerned and other knee or between groups. In no case did the sagittal displacement exceed 3 mm compared to the other knee, including the case with reconstruction of the anterior cruciate ligament. Six patients in the repair group complained of joint line tenderness, and one of these had a positive sign for meniscal pathology. Three patients in the meniscectomy group had joint line tenderness, but none had specific symptoms for meniscal remnant pathology. Two patients in each group complained of patellofemoral tenderness.

At longitudinal observation of the subgroups there was no change in range of motion or amount of sagittal displacement over time.
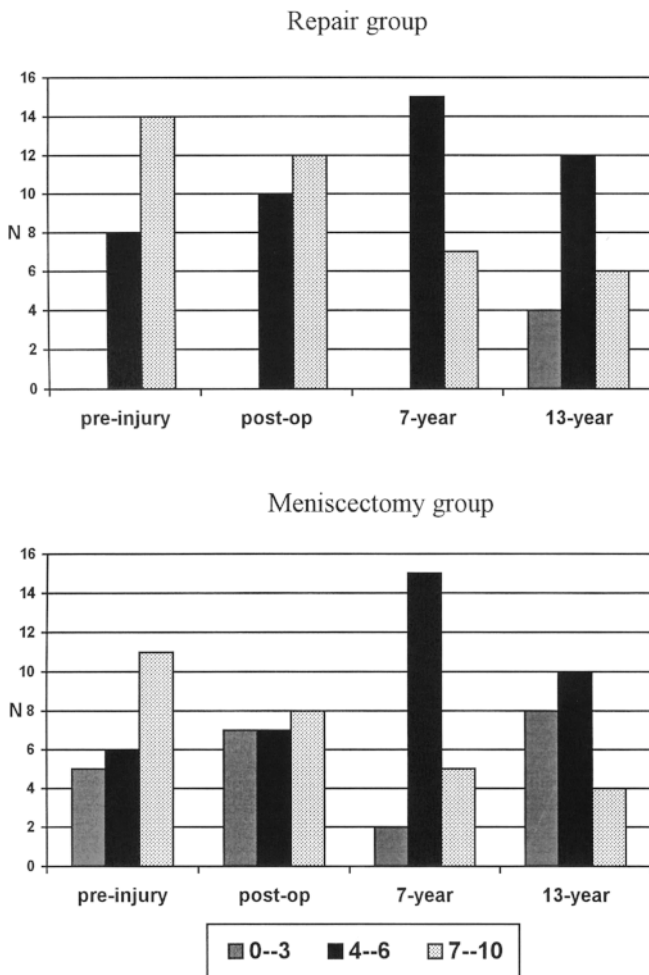
Fig. 1 Tegner activity level in the subgroups ($n = 44$) before injury, postoperatively, at 7- and 13-year follow-ups

Table 3 Physical examination at the 13-year follow-up

	Repair group	Meniscectomy group	P
Range of motion (°)	147 ± 6	143 ± 7	n.s.
Angle during muscle strength testing (°)	114 ± 20	110 ± 24	n.s.
Total sagittal displacement (mm)	3.3 ± 1.4	3.5 ± 1.7	n.s.
Knee joint alignment (n)			n.s
Varus	11	11	
Valgus	11	12	
Neutral	8	7	

Table 4 Radiographic changes after 13 years

| Arthrosis grade	Repair group				Meniscectomy group (n = 30)	
	All (n = 30)		Successful repair (n = 23)			
	n	%	n	%	n	%
0	17	57	15	65	15	50
1	10	33	7	30	7	23
2	3	10	1	4	8	27

Table 5 Radiographic changes in the subgroups (n = 44) 7 and 13 years after meniscus repair and meniscectomy

Arthrosis grade	Repair group				Meniscectomy group			
	7 years (n = 22)		13 years (n = 22)		7 years (n = 22)		13 years (n = 22)	
	n	%	n	%	n	%	n	%
0	21	96	14	64	12	55	10	45
1	1	5	6	27	6	27	4	18
2	0	0	2	9	4	18	8	36

Radiographic findings

At the 13-year follow-up 17 patients in the repair group (57%) had normal radiographic findings, 10 (33%) had grade 1 arthrosis, and 3 (10%) had grade 2 arthrosis. Two of the patients with grade 2 arthrosis had had meniscectomy within the first years after repair because of non-healing. Fifteen patients in the meniscectomy group (50%) had normal radiographic findings, 7 (23%) had a grade 1 arthrosis, and 8 (27%) a grade 2 arthrosis. There was no significant difference between the groups concerning incidence or severity of arthrosis, even when only patients with successful repairs were compared to patients of the meniscectomy group ($P = 0.06$; Table 4). No patient developed more severe radiographic changes than a grade 2 arthrosis.

Only a single patient in the subgroup with initial repair had signs of radiographic arthrosis after 7 years (grade 1), but between 7 and 13 years radiographic signs for arthrosis developed in seven patients of this group ($P < 0.05$; Table 5, Fig. 2). Four of these patients had had the repaired meniscus excised. In the meniscectomy group (subgroup), six patients had a grade 1 arthrosis and four a grade 2 arthrosis after 7 years. In this group five knees had developed radiographic signs of arthrosis or had radiographically deteriorated between the two follow-up evaluations (Table 5, Fig. 2). After 7 years arthrosis was more common after initial meniscectomy than after repair ($P < 0.05$), but there was no longer a significance difference between the groups in incidence and severity of arthrosis after 13 years.
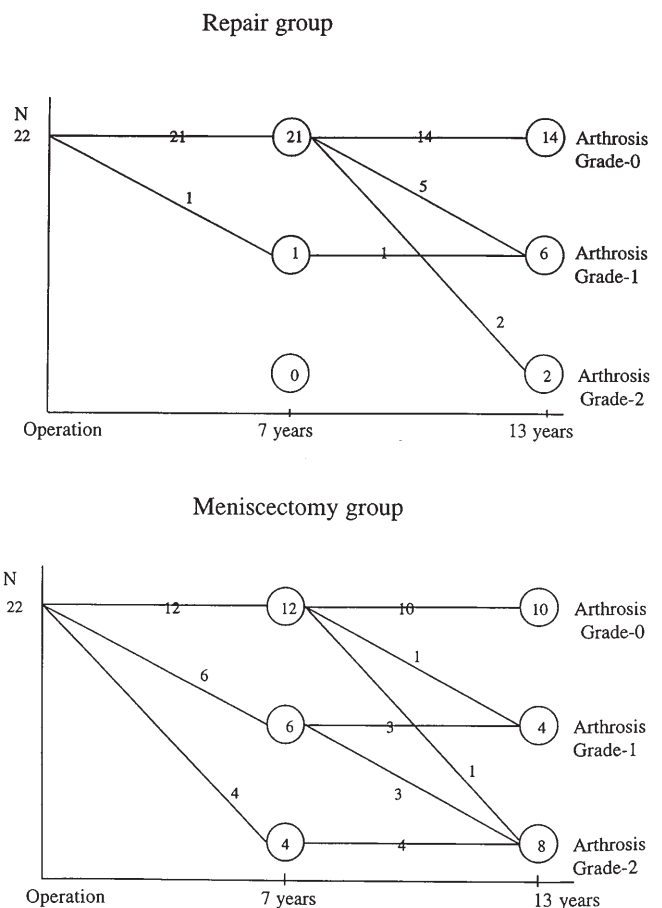
Fig. 2 Development of radiographic changes over 13 years in 22 matched pairs of patients after meniscus repair and meniscectomy

There were no differences in knee function, subjective evaluation, radiographic signs of arthrosis, range of motion, muscle strength, or knee laxity between medial and lateral compartment surgery in any of the groups, or between medial repair and medial meniscectomy, or lateral repair and lateral meniscectomy.

Joint fluid analysis

The concentration of proteoglycan fragments in undiluted (43 ± 19 µg/ml after repair, 50 ± 29 µg/ml after meniscectomy) or diluted samples (15 ± 7 µg/ml, and 16 ± 9 µg/ml, respectively) did not differ between groups, and there was no correlation of this parameter with the degree of arthrosis as seen on radiographs.

Discussion

The most startling finding in the present study was that arthrosis developed in a number of patients with initial re-

pair, thus the superiority of repair compared to arthroscopic meniscectomy was no longer as evident after 13 years as it had been after 7 years. Of course most of the patients in the repair group who developed arthrosis between the two follow-up occasions had underwent meniscectomy because of nonhealing or a rerupture of the repaired meniscus. The repair group as a whole had also a somewhat longer overall follow-up. Nevertheless, a subsequent deterioration in the cartilage protecting effect of a repaired meniscus must be considered in the long term because of early and late failures. The treatment alternative for a peripheral longitudinal rupture would be total meniscectomy. This treatment has been shown in many long-term follow-up evaluations to lead to a higher incidence and severity of arthrosis than arthroscopic meniscectomy or repair, as presented here [16, 17]. Thus the failures after repair which account for most of the arthrosis in this group should not be an argument against repair of peripheral ruptures.

Comparison of the patient group with meniscal repair to a group of patients with arthroscopic meniscectomy whom we selected to elucidate the effects of meniscal repair has its obvious defaults, since there was no randomization between the groups. The type of meniscal rupture and quality of meniscal tissue were decisive for the choice of a specific treatment. Meniscectomies were carried out in cases with obviously degenerative intrasubstance tears, meanwhile repairs were performed exclusively in menisci with peripheral longitudinal tears in the vascularized zone with good-tissue quality and macroscopically intact cartilage. In addition, in half of the cases with meniscectomy as initial treatment some cartilage fibrillation was present at time of treatment pointing to a beginning cartilage disease. This initial group difference may explain the comparably obvious difference in arthrosis which was found after 7 years. However, none of patients with initial cartilage degeneration developed an advanced degree of arthrosis or major subjective symptoms in a 13-year perspective. Similarly, we found in a previous investigation that preexisting cartilage fibrillation at the time of treatment did not lead to functional and radiographic deterioration 13 years after arthroscopic meniscectomy compared to cases with macroscopically intact cartilage [25].

Cases with a longitudinal peripheral meniscus rupture as required for repair may also have had a different trauma history than cases with intrasubstance ruptures and tissue degeneration which were treated by meniscectomy. The higher number of concomitant ligament injuries in the repair group may point to a more violent trauma than in patients who underwent meniscectomy. Conversely, the relatively high incidence of previous meniscal surgery in the other knee of patients with meniscectomy underlines the degenerative character of the meniscal tear in this group and may also be responsible for the relatively high incidence of arthrosis in these knees. Nevertheless, the possible differences in initial trauma severity may in the long term have affected the susceptibility for arthrosis in the two groups and may be therefore partly responsible for the conspicuous increase in arthrosis between 7 and 13 years which we noted in the repair group. It has also been suggested earlier that some knees with isolated repairable meniscal tears have biomechanical abnormalities or previously unidentifiable impairment in joint configuration which predispose a meniscus to tear initially [6]. It also has been demonstrated that meniscal tissue degeneration is generally present in cases with isolated meniscus rupture, even in those with vertical longitudinal rupture which occurred after a significant trauma [27]. Thus the patients with repairable menisci may have had some degenerative joint disease even from the beginning. Finally, it should be noted that a repaired meniscus may not function as well as a normal one under in vivo conditions. It has been shown experimentally that the scar in the repair area does not have normal meniscal tissue characteristics [14, 22]. This abnormal tissue may adversely affect the load-bearing properties of the meniscus and make it also more vulnerable to degeneration. By this process the late failures after repair, which occurred up to 14 years after the initial procedure, are easily explained. However, the risk of meniscal tear generally increases with age, which is demonstrated by the rather high incidence of degenerative meniscal ruptures in the other knee of both patient groups.

Despite a relatively high incidence of arthrosis after repair and meniscectomy over the years, only two patients complained of major symptoms during activities at the late follow-up investigation. All others had a good to excellent knee function and were able to participate in sporting activities. The general trend for a decrease in activity involvement over time especially concerning team or other strenuous sports may be explained partly by a natural decline in an aging population. The fact that patients with repair after 13 years were more active in sports than patients with meniscectomy may be explained by a personal preference which was obvious from the beginning. The high functional scores during a more active sport participation in the repair group than in patients with meniscectomy underlines the beneficial effect of the repair procedure.

The high functional scores in both groups despite radiographic change in a number of cases may be explained by the generally low degree of arthrosis in this 13-year perspective. We found a similar low-grade arthrosis after arthroscopic meniscectomy with comparable follow-up, even in cases which had some initial cartilage fibrillation [24, 25]. In the absence of major ligament insufficiency as demonstrated by manual and instrumented evaluations, the development of arthrosis seemed to be very slow after either initial meniscal treatment, and did not yet result in a major joint destruction or subjective symptoms, nor did the manual examination suggest deteriorated knee function in either of the treatment groups. It has been shown

previously that the time delay between meniscal surgery and clinical symptoms of arthrosis may be rather long in patients, who sustain injury and treatment at young age [23]. In the present study the patients had a mean age of only 26 at initial treatment, and radiographic signs for arthrosis did indeed progress with time and may eventually become clinically symptomatic.

Concentration of protoglycan fragments in joint fluid has been suggested as marker for cartilage disease [7, 21]. The concentration of this marker depends on cartilage mass, depletion of cartilage molecules, release, and clearance of the fragments from joint fluid. It has also been found to vary with the time of the day and activity [26]. The clinical relevance of this marker when analyzed only at a single occasion may therefore be questionable, and the reason for the lack of correlation between this marker and the radiographic findings in the present study.

In view of the rather high early and late failure rate after meniscal repair, the potential of repair to avoid or significantly reduce the incidence of arthrosis in the long term does not seem as clear as previously suggested. The high functional scores and rather low incidence of arthrosis after arthroscopic meniscectomy must be weighted against the inconvenience of long rehabilitation and long sick leave after repair in a case with a centrally located repairable meniscus, in which arthroscopic partial meniscectomy could be the treatment alternative.

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