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The arrow versus horizontal suture in arthroscopic meniscus repair

A prospective randomized study with arthroscopic evaluation

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Abstract In a prospectively randomized study including 68 patients, the results of inside-out horizontal meniscus suturing were compared to meniscus repair using the meniscus arrow. 96% of the patients underwent re-arthroscopy after 3–4 months. Only lesions in the red/red or red/white areas were included. Patients were treated with a hinged brace for 9 weeks. 30 patients had an isolated bucket-handle lesion. In 19 cases the repair was done in conjunction with an ACL reconstruction and in 19 cases the repair was performed in an ACL-insufficient knee. The two groups were comparable. Operating time in the arrow group was one half that of the suture group. Of 65 re-arthroscopies, 91% of the patients had healed or partially healed in the arrow group compared to 75% in the suture group (P = 0.11). In only 50% of the non-healed cases was this clinically suspected prior to control arthroscopy. The difference between healing in ACL-reconstructed and ACL-insufficient knees was not significant. Two patients in the suture group had a deep infection. There were no serious neurovascular injuries. Five patients in the suture group and two patients in the arrow group had symptoms in the saphenous nerve area. All patients had some synovial irritation at control arthroscopy but no severe reactions to suture or arrows were seen. Short-term results with meniscus arrows, based on healing and evaluated by second-look arthroscopy, seem promising.

Key words Meniscus repair · Biodegradable · Meniscus arrow · Meniscus lesion · Arthroscopic repair

Introduction

Today, the repair of suitable meniscus lesions is universally accepted. In 1993 we reported, in this journal, a new method for this procedure [1] using an “arrow” made of polylactic acid. The failure strength of the meniscus arrow compared to horizontal suturing has previously been reported [2]. The new all-inside method using the arrow was developed to overcome the risk of serious neurovascular injuries using arthroscopically assisted outside-in or inside-out techniques [12] and to shorten the operating time by eliminating the need for joint capsule exposure during these procedures. Introduction of the all-inside meniscus arrow technique with less potential deleterious side effects might lead to an increased number of suitable lesions being repaired. This might, in turn, decrease the risk of partial and total meniscectomies, which in many studies have been shown to increase the risk of secondary arthritis [7, 9, 11]. The aim of the present prospective randomized study was to compare the healing rate for the new system with that of a commonly used inside-out suturing technique, using the Acufex double-barrel system, with re-arthroscopy as an endpoint.

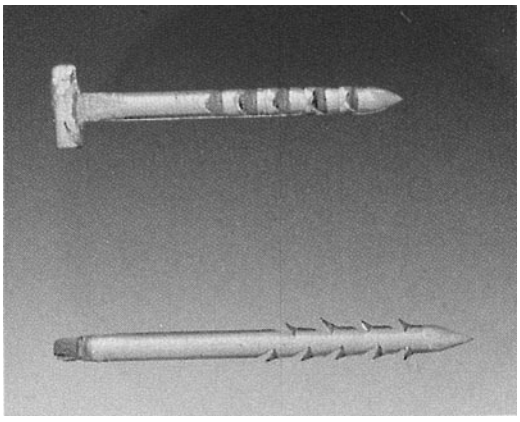

Fig. 1 The meniscus arrow

Table 1 Criteria used for patient inclusion in the study

Inclusion criteria	Procedure
Between 18 and 40 years	Randomization (see text)
Reliable patients (no abuse)	Video
Full-thickness rupture > 10 mm in length	Scarification (rasp)
Less than 6 mm from the capsule	5–10 mm between fixation points
No former ipsilateral meniscus surgery	Exposure of knee joint capsule (suture group only)
No complex ruptures	Postfixation video
No arthroscopic arthritis	Re-arthroscopy 3–4 months after repair
Informed consent prior to surgery	

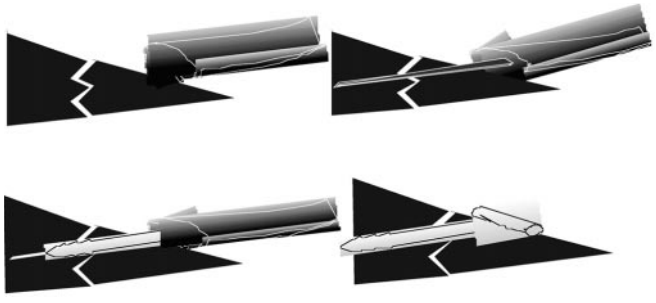

Fig. 2 The operative technique with the meniscus arrow

Materials and methods

Sixty-eight patients with longitudinal vertical meniscus lesions ("bucket-handle lesions" – displaced or in situ) were randomized (after informed consent) to either arthroscopically assisted inside-out suture repair with the Acufex double-barrel system (Maxon –0 suture), or to repair with the all-inside procedure using the meniscus arrow (Fig. 1). Inclusion criteria are shown in Table 1. After arthroscopic verification of a longitudinal vertical meniscus lesion (LVML), patients were randomized in separate groups according to whether they had an ACL-sufficient or ACL-insufficient knee (total ACL rupture). No patients with posterior cruciate ligament ruptures were included. The study was approved by the local ethics committee.

The operative procedure was identical for both groups except for joint capsule exposure, which was obviously only necessary in the suture group (Table 1) where there was a risk for neurovascular entrapment when sutures were tied on the capsule. The operative technique using the meniscus arrow has previously been described by Albrecht-Olsen et al. [1] and is summarized in Fig. 2. The lesion is freshened with a rasp; the bucket-handle is reduced; the appropriate cannula is introduced into the knee and placed on the surface of the meniscus. A specially designed needle is pushed through the cannula and into the meniscus to prepare a hole. The needle is then pulled back and an arrow of appropriate length is pushed through the cannula to the surface of the meniscus. A long piston is mounted on a reciprocating instrument and, with this, the arrow is hammered into the meniscus. The procedure is repeated until proper fixation is obtained. In this study, only arrows of 13 mm or 16 mm length were used. The main reason for comparing this new system to the horizontal suture placement using the double-cannula was that the latter procedure was the standard procedure in our department and, in fact, probably the most widely used system in Europe.

Postoperatively, patients with stable knees were treated with a two-point Don Joy brace (30–60°) for 5 weeks without weight-bearing, followed by 4 weeks with increasing weight-bearing and a range of motion (ROM) of 20–90°. The brace was then removed and the patients were instructed not to squat for 3 months; jogging was commenced after three months and cutting sports (which require fast changes in running direction) after 6 months.

Thirty-eight patients, who were found to have a concomitant ACL rupture (19 were reconstructed concomitantly), changed into a four-point Don Joy brace after 2 weeks. At this time, the ACL-reconstructed patients were seen by a physiotherapist and passive ROM, from 0–90°, was started. When not with the physiotherapist, the brace was set at the ROM mentioned above. After 9 weeks, the 38 patients began an ACL rehabilitation program. Otherwise, all patients followed the same regimen. The distribution of patients with stable and unstable knees is seen in Table 2. Only patients with high demands in sports or labor, or with instability during daily living activities, had an ACL reconstruction. No unstable knees were reconstructed on the basis of LVML alone.

Patients were seen at 2, 5 and 9 weeks postoperatively, and were checked for neurological problems, infection, swelling and

Table 2 Distribution of lesions in the groups

	Isolated lesions		Unstable knee with concomitant ACL reconstruction		Unstable knee – no ACL reconstruction	
	Medial meniscus	Lateral meniscus	Medial meniscus	Lateral meniscus	Medial meniscus	Lateral meniscus
Suture group	9	6	5	4	7	3
Arrow group	8	7	5	5	8	1
n = 68	30		19		19	

ROM levels. At 3–4 months, re-arthroscopy was performed in 65 patients after informed consent. Menisci were then defined as healed if there was no residual tear left and as partially healed if there was a residual cleft less than 10 mm and the meniscus was otherwise stable to probing. All other arthroscopic cases were defined as non-healed.

Clinical healing was defined by the absence of pain at the joint line, no locking and no effusion. The operations were performed by seven different surgeons and all operations and second-looks were recorded on video.

Fishers exact test was used for comparison of binomial data between the arrow and the suture groups. Ordinal and interval data were compared by the Mann-Whitney test (Wilcoxon two-sample rank sum test for unpaired data). The calculation of *P* values was performed using the program Statxact, (statistical software for exact nonparametric inference, CYTEL, Cambridge, Mass.).

Results

Repair

A total of 65 patients underwent re-arthroscopy. Two patients in the suture group and one patient in the meniscus arrow group did not want a re-arthroscopy. They were all symptom-free. Thus, the material consisted of 33 patients in the group repaired with meniscus arrows and 32 in the group repaired with sutures. There was no statistical difference between the two groups concerning the following parameters: sex, age, meniscus injured, median length of lesion, median distance from joint capsule and number of repair points. There was a significantly longer time from injury to repair in the meniscus arrow group (Table 3).

Median operating time for the repair procedure alone was 30 min in the meniscus arrow group and 60 min in the suture group ($P = 0.00001$, Mann-Whitney test).

Thirty patients had an isolated LVML, 19 patients had an unstable knee and had an ACL reconstruction performed at the time of meniscus repair, and 19 patients had an unstable knee which was not reconstructed at the time of meniscus repair. The distribution is shown in Table 2.

At re-arthroscopy after 3–4 months, 30 patients were healed or partially healed in the arrow group and 24 in the suture group ($P = 0.11$, Fisher's exact test). The distribution is seen in Table 4. Eight menisci in the suture group (25%) and three in the arrow group (9%) had not healed. In all, 17% of 65 menisci were not healed. All these menisci were excised. Three patients were symptom-free and clinically healed but did not want re-arthroscopy.

Only one non-healed meniscus in the arrow group and four in the suture group were detected clinically at the time of re-arthroscopy. leaving six of the non-healed menisci undetected at this time. We found that it was clinically impossible to judge whether a meniscus was partially healed 3–4 months after repair.

At re-arthroscopy, 18 of 19 patients who had a concomitant ACL reconstruction had healed, whereas only 12 of 17 patients who were ACL-insufficient had healed at 3–4 months. Though there was a tendency towards better healing in the ACL-reconstructed group, it was not significant ($P = 0.08$, Fisher's exact test).

There were no statistical differences in healing (total and partial) between arrows and sutures in the subgroups with isolated lesions, lesions in ACL-reconstructed knees and lesions in ACL-insufficient knees ($P = 1.0$, $P = 0.42$, $P = 0.29$, respectively; Fisher's exact test).

Complications

Two patients in the suture group suffered deep infection. One patient with an isolated bucket-handle lesion returned 5 days after surgery with fever and a swollen knee. Primary repair was unproblematic. An arthroscopic synovectomy was performed and the meniscus was resected. All sutures were removed. The patient recovered without further complications. The other patient had an ACL-reconstruction done at the time of repair. At 2 weeks, there was superficial infection at the suture site. At 3 weeks, the patient returned with a deep infection. In this case, meniscus repair

Table 3 Comparison of repair results in the meniscus arrow group and the suture group

Demographic data	Meniscus arrow group	Suture group	*P* value
Male/female ratio	26/8	29/5	0.53[b]
Median age (years)	26.5 (18–37)	25.5 (18–40)	0.52[c]
Medial/lateral meniscus	21/13	21/13	1.0[b]
Median length of lesion (range)	25.0 mm (12–40)	25.1 mm (15–40)	0.89[c]
Median distance from capsule (range)	1.9 mm (0–4)	2.1 mm (0–4)	0.58[c]
Median number of repair points	3.9 (2–8)	3.3 (1–6)	0.14[c]
Time from injury to repair:[a] < 2 months	14	23	–
2 months–1 year	6	8	–
> 1 year	13	3	0.01[c]
Median duration of meniscus repair (range)	30.3 min (10–90)	59.8 min (25–120)	< 0.01[c] (0.00001)
Swelling at 5 weeks postoperatively	18	19	1.0[b]

[a] One patient without data concerning time from injury to repair in the arrow group
[b] Fisher's exact test
[c] Mann-Whitney test (Wilcoxon two-sample rank sum test for unpaired data)

Table 4 Results assessed by re-arthroscopy at 3–4 months

All patients	Arrows	Sutures
Healed	27	18
Partially healed	3	6
Not healed	3	8
No re-arthroscopy	1	2

was complicated by a long lesion and a long operating time (80 min for the meniscus repair, total operating time 3.5 h). Arthroscopic synovectomy was performed and part of the meniscus was removed. Both patients were among the non-healed patients in the suture group. Cultures revealed *Staphylococcus aureus* in both cases. The original surgery was performed by two different surgeons.

Two patients in the arrow group had intermittent pain problems along an infrapatellar nerve branch, probably because a tip of an arrow protruded through the capsule in both cases. In one case, symptoms subsided after 5 weeks; in the other case the arrow tip was cut off under local anesthesia and the pain disappeared. In this case, the peripheral nerve branch was seen riding over the tip of the arrow.

In the suture group, five patients had symptoms in the saphenous nerve area. In two cases, pain along the nerve subsided after 2 weeks. In three cases, problems persisted after 3 months. One had pain along the nerve, one had annoying dysesthesia along the nerve and one had hyposensibility in the saphenous nerve innervation area below the knee.

There were no serious neurovascular injuries in the study, but several other patients had transient paresthesia around incisions for arthroscopy or ACL reconstruction not related to meniscus repair. There were no severe intra-articular adverse reactions to arrows or sutures during the period from primary operation to re-arthroscopy, but all patients had some synovial irritation at re-arthroscopy. Eighteen patients in the suture group and 19 in the arrow group had some swelling in the operated knee at the 5 week follow-up ($P = 1.0$, Fisher's exact test) (Table 4).

At re-arthroscopy, one patient had a small impression in the femoral cartilage opposite one of the arrows, but the cartilage surface was intact and the patient had no symptoms.

Discussion

Most reported results of meniscus repair have been based on clinical evaluation alone [5, 17, 18] but some authors have argued that a non-symptomatic knee is no guarantee for meniscus healing [3, 19]. This method of defining meniscus healing will therefore lead to an unrealistically high rate of success. In our study, we found it quite impossible to assess whether a patient had healed fully or only partially. At 3–4 months, we even found clinical assessment of healing difficult in cases where re-arthroscopy showed no healing. Tenuta and Arciero found that five of ten arthroscopically verified failures were asymptomatic (average observation time 11 months) [19]. It therefore seems that a true healing rate should not be based on clinical evaluation alone.

To our knowledge, there are no previous clinical prospective randomized studies comparing various repair methods and only a few studies which included re-arthroscopy have been performed [16, 19]. Tenuta and Arciero [19] performed re-arthroscopy on 84% of their patients and found that 81% of these had healed or partially healed (44 of 54). Out of 54 patients, 40 had their repairs done in conjunction with an ACL reconstruction, which is recommended by several authors as the best environment for successful repair [14, 16]. This group had a 90% healing rate compared to only 57% in the group of patients with isolated lesions. Some authors have performed re-arthroscopy on a part of the patient population for various reasons and have made an estimation of meniscus repair success [14]. DeHaven et al. [6], having perfomed re-arthroscopy on 33% of the patients found that 79% had a successful open vertical repair (within 2 mm from the capsule) with a mean follow-up of 11 years. In their study, 66% of the patients had had a primary or secondary cruciate reconstruction. In our study, only 28% of the patients had a concomitant reconstruction and, although there was a tendency towards increased healing rate in the ACL-reconstructed group, this difference was not significant and we found no statistically significant increase in healing between reconstructed and ACL-insufficient knees. This might be explained by a type two error.

At 3 months, we found an overall healing rate of 83% at re-arthroscopy (96% of repairs re-examined). The timing of re-arthroscopy as early as 3 months after repair might be discussed. At this time, patients had not yet returned to former activities. However, that was actually one of the reasons for doing it so early. After re-arthroscopy, we could then inform patients about whether they could increase their activities. Moreover, we would not expect that at this time an unhealed meniscus would have any spontaneous potential to heal anyway. Finally, it would seem less ethical to prospectively plan for re-arthroscopy with a patient at 1 year postoperatively when most patients would probably be symptom-free.

In our study, 45% of patients had had their lesion for more than 2 months and 24% had had their lesion for more than 1 year; most of the latter were in the arrow group. Some authors have found that the rate of successful repair is inversely correlated to the time from injury to repair [18]. Other authors reason that chronicity leads to more complex tears and this will, in turn, minimize the rate of healing success. They argue that this is the reason for worse results in the chronic group [4].

Some experimental studies have shown that the failure strength with vertically oriented sutures is superior to that

with horizontal ones [13, 15], which can be explained by the predominance of semicircular fibers. Consequently, some authors use vertical sutures whenever possible [5, 16]. Whether the experimental data have any clinical relevance is unknown. In any case, we have found it very difficult to orient sutures vertically in the posterior horn of the medial meniscus. We compared this new all-inside repair method with the widely used horizontal repair system using a double-barrel from Acufex. As suture material, we used Maxon-0 sutures. Whether sutures should be absorbable or non-absorbable is also debated but there are no clinical data supporting the superiority of one over the other [10].

Our postoperative treatment was rather restrictive, but was in accordance with the literature at the time of protocol planning and the regimen was the same for repairs with sutures and arrows. In the past few years, rehabilitation programs for meniscus repair have become increasingly aggressive, as have ours, with seemingly no change in the clinical healing rate. Still, there is no consensus on the postoperative management for repairs, and regimens range from no splinting and free motion to 6 weeks in full extension and no weight-bearing.

Severe synovitis and foreign-body reaction have been observed with the use of absorbable products [8]. No severe reactions were seen during the 3–4 month postoperative period of this study. In many cases, patients had slight synovitis but there were no differences among the two groups. The synovitis is possibly explained by the healing response and the response to synovial scarification during the repair process and other surgical procedures, such as ACL reconstruction. No synovial biopsies were investigated in this study.

As the arrows are made of self-reinforced material, which is hard, it might be suspected that the arrows would harm the nearby or opposite cartilage. We have, therefore, followed this particular issue very closely. As mentioned above, we only observed one case in which the cartilage surface was intact, but there was a small indentation opposite to one of the arrows. That cartilage deformation was only seen in one case is probably explained by the fact that the arrow heads are impacted into the meniscus surface during insertion. This is in contrast to the result after insertion in most animal menisci, which are hard, where the arrow head will protrude onto the surface.

We have no explanation for the high rate of deep infection in the suture group (6%). In one case, the repair was done in combination with an ACL reconstruction and the procedure was prolonged due to a bucket-handle lesion extending into the anterior horn of the meniscus. The other case was a straightforward repair. None of the patients had any known immune deficiency.

Although we were very meticulous in the exposure of the knee joint capsule before tying the suture knots, five patients had symptoms in the saphenous nerve area, in two cases only transiently. Also, two patients in the arrow group had nerve irritation as the tip of an arrow irritated one of the infrapatellar branches. In one case, the tip was removed through a small incision under local anesthesia. Both patients had very slim extremities and a shorter arrow should have been used, but at the time the shortest arrow was 13 mm long. Consequently, a 10 mm arrow has been designed.

No serious injuries to neurovascular structures where seen in this study and the potential risk should be further minimized with the arrows, as this method is an all-inside procedure.

Our results showed that the arrow procedure is much faster than suturing. In fact, procedure time was reduced by 50%. In cases where the primary goal is an ACL reconstruction, meniscus repair with arrows will add only a short time to the total procedure. Theoretically, the shorter operation time and the fact that capsular exposure is superfluous might minimize the risk of infection.

An obvious risk of using an easier and faster repair system would be a tendency towards more doubtful repairs of lesions that would otherwise have been resected, e.g., complex lesions, repairs of horizontal cleavage lesions, flap lesions and lesions in the white/white area for which the arrow system is not designed. This could, of course, lead to an overall lower healing rate.

The initial results using the meniscus arrow seem promising and the short-term results, evaluated by re-arthroscopy of 96% of the repairs, are at least comparable to those of horizontal suturing. Subsequently, we have found that this all-inside technique also allows surgery under local anesthesia, which we now use increasingly for these procedures.

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