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Arthroscopic meniscal repair: a comparative study between three different surgical techniques

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Abstract The purpose of this prospective study was to evaluate and compare the results of arthroscopic meniscal repair using three different techniques. Between January 2002 and March 2004, 57 patients who met the inclusion criteria underwent an arthroscopic meniscal repair. The outside-in technique was used in 17 patients (group A), the inside-out in 20 patients (group B), while the rest of the 20 patients (group C) were managed by the all-inside technique using the Mitek RapidLoc soft tissue anchor (Mitek Surgical Products, Westwood, MA, USA). Anterior cruciate ligament (ACL) reconstruction was performed in 29 patients (51%). The criteria for clinical success included absence of joint line tenderness, locking, swelling, and a negative McMurray test. The minimum follow-up was one year for all groups. The mean follow-up was 23 months for group A, 22 months for group B, and 22 months for group C. All meniscal repairs were considered healed according to our criteria in group A, while 19 out of 20 repairs (95%) healed in group B. Finally 7 of 20 repairs (35%) were considered failures in group C and this difference was statistically significant in comparison with other groups. The time required for meniscal repair averaged 38.5 min for group A, 18.1 min for group B, and 13.6 min for group C. Operation time for meniscal repair in group A was statistically longer in comparison with other groups. There were no significant differences among the three groups concerning complications. According to our results, arhtroscopic meniscal repair with the inside-out technique seems to be superior in comparison with the other methods because it offers a high rate of meniscus healing without prolonged operation time.

Keywords Meniscal repair · Outside-in · Inside-out · All-inside technique

Introduction

Arthroscopic meniscal repair is the treatment of choice for peripheral longitudinal meniscal tears in young patients. Today, there are three arthroscopic techniques for meniscal repair: the inside-out and outside-in suturing techniques [28, 30] and the all-inside technique, which uses biodegradable products and was developed originally by Albrecht-Olsen et al. [2] in 1993. Since then, a plethora of absorbable devices such as arrows [3, 20], screws [17], and anchors [4, 22] have been developed that allow for all-inside meniscal repair.

The use of all-inside meniscal repair systems has been increasing dramatically in the last years mainly because it is technically less demanding and easier for the surgeon in comparison with suturing methods. In United States, in 1996, only 3.3% of meniscal repairs were performed with the meniscus arrow, while in 1998, this increased to 34.4% [20]. In addition, these devices theoretically reduce the operative time and

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avoid the risk of neurovascular complications [3]. However, very few studies comparing the suturing techniques with the all-inside meniscal repair systems are available in the literature in order to draw useful conclusions [3, 32, 33]. Furthermore, all these studies compare the inside-out technique with the absorbable arrows. To our knowledge, comparative studies between suturing techniques and any of the new absorbable devices, which are commonly used for meniscal repair, have not been published.

Therefore, we designed this prospective randomized study to evaluate and compare the clinical results and complications of arthroscopic meniscal repair in a consecutive series of patients using three different techniques: the inside-out and outside-in suturing techniques, and the all-inside technique using the Mitek RapidLoc soft tissue anchor (Mitek Surgical Products).

Materials and methods

In our department, from January 2002, all patients with suspicion of a meniscal tear (based on clinical examination and magnetic resonance imaging (MRI)) were asked to enroll in the study if they met the following criteria: (a) longitudinal full thickness tear greater than 10 mm in length, (b) location of the tear less than 6 mm from the meniscocapsular junction, (c) no former meniscus surgery, (d) no evidence of arthritis during arthroscopy, and (e) fixation of the meniscus using only one technique (no hybrid fixation). Anterior cruciate ligament (ACL) deficient knees were reconstructed, using patella tendon or semitendinosus autograft, at the time of the meniscal repair. Three surgeons experienced in arthroscopic knee surgery performed the operations. Between January 2002 and March 2004, 62 patients who met the inclusion criteria underwent an arthroscopic meniscal repair and were included in the study. However, five of them were reluctant to come in for the clinical evaluation at the latest follow-up and, therefore, they were dropped from the study, leaving 57 patients.

The randomization procedure was performed using closed envelopes that contained one of the three letters (A, B, C). Letter A corresponds to the outside-in technique, letter B to inside-out technique, and letter C to all-inside technique. The circulating nurse opened a randomly selected envelope just before meniscal repair if the lesion was suitable for repair. Institutional Review Board approval was obtained before initiating the study. All patients gave their informed consent to participate.

Surgical techniques

General anesthesia or a combined femoral and sciatic nerve block was used in all patients. After diagnostic arthroscopy, the morphology of the meniscus tear was determined. The tear length and the rim width were recorded at the time of surgery. In case of a dislocated bucket-handle tear, reduction was performed. In all cases, tear edges were freshened with a meniscus rasp and shaver. Multiple perforations in meniscus rim and capsule to produce vascular channels and encourage bleeding in order to stimulate healing response were carried out with microfracture awls. For the outside-in technique, we used 18-guage long needles. The needle is inserted from outside the knee joint and advanced through the torn parts of the meniscus. Then, a No. 2-0 PDS absorbable suture is advanced through the needle and retrieved from the anteromedial or anterolateral portal (depending on the side of the torn meniscus). The needle is withdrawn leaving the suture into the joint. The free limbs of another 2-0 PDS absorbable suture are advanced through the tip of a second needle and exited through the other end of the needle. Thus, a loop is created at the tip of the needle. The second needle is inserted into the joint again through the torn parts of the meniscus 4–5 mm apart from the first needle. The free limbs of the suture are pushed forward delivering the loop into the joint. The needle is withdrawn and the loop is then retrieved from the same portal. The single suture is loaded into the loop and the surgeon pulls the free ends of the suture loop creating a PDS loop over the meniscus. A 5 mm incision is performed between the suture limbs (the insertion points of the needles) and both limbs are retrieved through this incision. Finally, after dissection of the subcutaneous tissues down to the joint capsule, the suture is tied.

For the inside-out technique, we used the Zone Specific II meniscal repair system (Linvatec, Largo, FL, USA). The system consists of six prebent canullae in order to give access to all areas of meniscus. Double-armed needles with preattached 2-0 Ethibond were used for meniscal suturing. A posteromedial or posterolateral incision of 1.5 cm was used to protect the neurovascular structures while placing sutures (usually two sutures) in the posterior horn of the menisci. Minor skin incision was used for the other areas to tie the sutures over the capsule.

For the all-inside technique, we used the Mitek RapidLoc soft tissue anchor (Mitek Surgical Products). The system consists of three components: a soft tissue anchor (back-stop), a connecting suture, and a ''top hat'' that compresses the tear again the back-stop. The

implant is preloaded onto a needle. There are three available needle angles (0, 12, and 27°). The needle with the implant is loaded into the meniscal applier (a gun shaped device) and advanced into the joint through the meniscus tear. By pressing the trigger of the applier, the back-stop is delivered to the meniscocapsular junction. The needle and the applier are then withdrawn from the joint and a knot pusher is used to compress the top-hat (and the meniscal tear) against the back-stop.

Evaluation methods

Preoperatively, diagnosis of meniscal tear was based on clinical examination; special attention was paid to signs of meniscal tear, such as, locking, tenderness on palpation of the joint line, presence or absence of effusion, and meniscal tests like McMurray and Apley tests. In addition, all patients underwent MRI evaluation preoperatively. Knee laxity was measured with the KT 1000 Arthrometer (MED metric, San Diego, CA, USA). Postoperatively (as well as preoperatively) all patients were evaluated by the same examiner (V.Z). Evaluation was performed with the International Knee Documentation Committee (IKDC) knee evaluation form. In addition, using Barrett's criteria [9], a repaired meniscus was considered healed if there was no joint line tenderness, effusion, and a negative McMurray's test at the latest follow-up. If one or more of these parameters was present, the result was classified as a failure.

Postoperatively, all patients (isolated meniscal repair and meniscal repair with an ACL reconstruction) used a hinged brace, and motion was restricted between 0 and 60° for the first 3 weeks with partial weight bearing, followed by another 3 weeks with increase of range of motion between 0 and 90°, and progression to full weight bearing by the sixth postoperative week. Jogging was permitted after the tenth postoperative week and full activity at 5 months.

Statistics

Differences between the groups of patients were evaluated with one way analysis of variance (ANOVA) and Bonferroni multiple comparison test for the continuous parametric variables. The Kruskal–Wallis *H*-test (K independent samples) was used to detect significant differences between groups for ordinal nonparametric variables and the Fisher's exact test for proportions. When a significant difference was detected, the Pearson chi-square test was performed for comparison of the groups one by one. The data were analyzed with the SPSS statistical package (SPSS Version 12, Chicago, IL, USA). The level of significance was set at $p < 0.05$.

Results

The outside-in technique was used in 17 patients (group A), the inside-out technique in 20 patients (group B), while 20 patients were managed by the all-inside technique (group C). All patients returned for a complete follow-up on May–June 2005. The minimum follow up was 12 months for all patients. The mean follow-up period was 23 months for group A (range 19–37 months), 22 months for group B (range 17–36), and 22 months for group C (range 17–35).

The three groups were comparable in terms of age, gender, chronicity, location (rim width), side (medial, lateral), and length of the tear. However, only 5 patients in group C underwent a simultaneous ACL reconstruction and this difference was detected as statistically significant in comparison with the other groups (Table 1).

At the last follow-up, no patient in group A was found to have symptoms of meniscal tear according to our criteria. Thus, the healing rate in this group was 100%. One patient in group B sustained a retear of his repaired (bucket handle tear) medial meniscus tear, 5 months after the index operation during deep knee flexion. The patient presented with a locked knee in the emergency department but he declined further treatment. The rest of the patients had no symptoms. Thus, the healing rate in this group was 95%. Seven patients in group C had tenderness on joint line palpation. These repairs were considered failures according to our criteria. Four of these patients were performed in conjunction with an ACL reconstruction. These four knees were clinically stable after ACL reconstruction with no signs or history of instability. Five of them had a positive McMurray sign. In addition, all these patients were limited or gave up sports activities. Thus, the healing rate in this group was 65% and this difference was statistically significant in comparison with the two other groups (Table 2).

The time required for meniscal repair averaged 38.5 min for group A (range 25–55), 18.1 min for group B (range 10–22), and 13.6 min for group C range (8–20). The time for meniscal repair was significantly longer in group A in comparison with the two other groups. No statistically significant difference was found between groups B and C. The number of sutures used averaged 3.4 (2–6) for group A, 3.6 (2–7) for group B, and 2.2 devices (1–4) for group C. One patient from group A and three patients from group B developed a

Table 1 Demographic data of the patients and condition of meniscal tears

	Group A (17)	Group B (20)	Group C (20)	*P* value (A vs. B)	*P* value (A vs. C)	*P* value (B vs. C)
Age	28.5	28	25.02	1.00	0.443	0.610
Length of tear (mm)	28.8	27.75	25.05	1.00	0.379	0.755
Gender (F/M)	4/13	4/16	5/15	1.00	0.680	1.00
Chronicity (> 3 weeks/ < 3 weeks)	14/3	16/4	15/5	1.00	1.00	1.00
Meniscus side (medial/lateral)	14/3	17/3	17/3	1.00	1.00	1.00
Location of tear (red/red, red/white)	16/6	12/8	13/7	1.00	1.00	1.00
ACL reconstruction (yes/no)	10/7	13/7	5/15	0.745	0.05	0.025

saphenous neuropathy after surgery. However, all patients had complete resolution of their symptoms within 4 months. Removal of RapidLoc device at the time of surgery was necessary in one case because the ''top hat'' of the implant impinged against the medial femoral condyle during knee motion. We had no cases of arthrofibrosis or infection in this series.

Preoperatively, according to the IKDC evaluation form, 15 knees (88%) were characterized as abnormal or severely abnormal and two knees as near normal (12%) in group A. In group B, all knees were characterized as abnormal or severely abnormal, and in group C, 19 knees (95%) were characterized as abnormal or severely abnormal and one knee as near normal (5%). Postoperatively, all knees were considered normal or near normal in group A, and 19 of 20 knees (95%) were characterized as normal or as near normal in group B, according to the IKDC evaluation form. Thirteen of 20 knees (65%) were characterized as normal or as near normal in group C, according to the IKDC evaluation form. The distribution of abnormal and severe abnormal cases within the groups was the same with the distribution of failures of healing. Therefore, both the healing rate and the postoperative IKDC evaluations shared the same statistics.

All knees were considered stable with an average side-to-side difference of 1.8 mm in maximum-manual KT-1000 arthrometer testing.

Discussion

The use of meniscal repair devices-implants that allow for all-inside meniscal repair has been increasing in popularity in the recent years [20]. Today, a plethora of devices for all-inside meniscal repair are available with a success rate ranging from 75 to 90% [3, 4, 16, 17, 20, 22]. However, only three published studies comparing the ''gold standard'' suture repair technique with the meniscus arrow are available. None of the other newer devices have been compared to the traditional techniques.

In this study, the traditional ''outside-in'' and ''inside-out'' suturing techniques are compared with a new meniscal repair device-implant. To the best of our knowledge, this is the first comparative study between both suturing techniques and an all-inside device. According to our results, the success rate for both suturing techniques is very high (100% for the outside-in technique and 95% for the inside-out technique). In contrast, the success rate was 65% for the all-inside technique with the Mitek RapidLoc implant (Mitek Surgical Products). The success rate was significantly higher for both suturing techniques in comparison with the all-inside technique, while the difference between the two suturing techniques was not statistically significant. The clinical result was used to determine the success rate in our study. We acknowledge of course that this is an indirect evaluation of meniscal healing and this is a limitation of our study like in the majority of similar studies. However, second-look arthroscopy is rarely possible because of cost and ethical considerations. Furthermore, based on two excellent studies [1, 25], we believe that the meniscus of an asymptomatic patient after meniscal repair is completely or at least partially healed. In both of these studies, it has been proved that clinical examination accurately predicted all failures in second look arthroscopy, with no false

Table 2 Comparison between the three groups for time and effectiveness of the procedure

	Group A (17)	Group B (20)	Group C (20)	*P* value (A vs. B)	*P* value (A vs. C)	*P* value (B vs. C)
Healing rate yes/no (%)	17/0 (100%)	19/1 (95%)	13/7 (65%)	1.00	0.009	0.044
Duration (min)	38.5 (25–55)	18.1 (10–22)	13.6 (8–20)	< 0.01	< 0.01	0.145
IKDC preop AB/CD	2/15	0/20	1/19	0.204	0.584	1.00
IKDC postop AB/CD	17/0	19/1	13/7	1.00	0.009	0.044

positives. More specifically, Ahn et al. [1] who used exactly the same criteria for clinical assessment for meniscal healing as in our study, found that among 38 asymptomatic patients, the menisci healed completely or partially as verified on second-look arthroscopy. The only patient who had clinical signs of failure was found to have a failed repair on second-look arthroscopy. Therefore, we think that our clinical evaluation reflects the status of the meniscus after repair.

The high clinical success rate with the suturing techniques is similar to the success rates of other series [9, 24–27, 29], ranging from 85 to 100%. We had a high failure rate (35%) with the Mitek RapidLoc implant in comparison with other studies with meniscal repair devices. The success rate for the Meniscal Arrow ranged from 88 to 95% according to most recent studies [3, 20, 33]. The healing rate with the T-Fix system has been reported to be nearly 90% [4]. Laprell et al. [22] reported a success rate of 86% with the Mitek meniscal repair system. However, comparison is not always possible because several study groups use different evaluation systems. It appears that conventional suturing techniques, although more technically demanding, allow a meticulous repair of the meniscus as they provide compression across the tear site, and the fixation strength is higher in comparison with the vast majority of implant fixators. More specifically, Barber et al. [8] reported that the fixation strength of vertical and horizontal sutures is higher in comparison with the Mitek RapidLoc implant. Probably, these are the main reasons for the different results between suturing techniques and the device used in this study.

There were no differences among the three groups regarding age, gender, chronicity, location (rim width), side (medial, lateral), and length of the tear. The only significant difference was that less number of patients in the all-inside group underwent a simultaneous ACL reconstruction. This may have had an impact on our results because, according to some studies, the healing rate of meniscal repair is higher when a simultaneous ACL reconstruction is performed [7, 14]. However, the distribution of failures within the all-inside group was higher in the ACL reconstructed patients and this indicates that ACL reconstruction is probably not an important factor in this group of patients. Other authors also found no significant difference in their results between isolated meniscal repairs and concominant ACL reconstruction [3, 17, 35]. Horibe et al. [19] found better healing rate in isolated tears than in tears associated with ACL reconstruction. In addition, De Haven et al. [13] reported that they had only 4% failures in isolated meniscal repairs with rim width less than 3 mm and, according to their opinion, rim width is the primary factor for a successful repair and not simultaneous ACL reconstruction.

Theoretically, the use of all-inside meniscal repair systems offers two main advantages: reduction of both the risk of serious neurovascular complications and operative time. However, today, no data exist in the literature to support the superiority of these devices in comparison with the suturing techniques. Three comparative studies (inside-out technique versus arrow) have been published up to date [3, 32, 33]. Two of them [32, 33] do not report any data regarding the operative time, whereas in the third study, Albrecht-Olsen et al. [3] reported that meniscal repair with arrows was 50% faster than suturing (without providing any specific data in their results). We found that the time required for meniscal repair was significantly longer for the outside-in method in comparison with the other two methods. The all-inside technique was faster than the inside-out method but this difference was not statistically significant. Perhaps this was due to the use of a small posterior incision for the most posterior sutures.

Four patients in both suturing groups developed saphenous neuropathy but all had complete resolution of their symptoms without permanent functional impairment. Our results are in accordance with other series regarding both the percentage and the type of complications [5, 6, 34]. It seems that the most common complication of the suturing techniques is the development of saphenous nerve neuroapraxia. Barber [6] and Stone et al. [34] reported 22 and 10% saphenous nerve neuroapraxia, respectively in their studies which resolved in all patients. Austin and Sherman [5] reported a 7% saphenous neuropathy in their series with spontaneous resolution of the symptoms in all but one patient.

A RapidLoc had to be removed in one case because of impingement of the implant against the medial femoral condyle. Chondral injuries after arthroscopic meniscal repair using the Mitek RapidLoc device have been already reported [12, 15]. Many other types of complications like broken implants [11], migration of the implants [10], cystic hematoma formation [18], nerve irritation [3], and aseptic synovitis [31] have been reported after meniscal fixation with implants. Probably, inappropriate insertion, wrong implant size, and early degradation are among the several factors which are responsible for these types of complications. These types of complications have not been reported with the suturing techniques in the literature, similar to the findings of our series.

Based on our results, we believe that meniscal repair with sutures is still the ''gold standard'' to which all other techniques must be compared. Suturing techniques are clinically documented since there are available studies with long-term follow-up (10 years) and high success rates. In contrast, studies using meniscal arrows, with a medium or long-term follow-up, reported high failure rates (28–30%) and deterioration of the clinical results [21, 23]. Our preferred method for meniscal repair is the inside-out technique since it provides a high rate of meniscus healing without prolonged operation time.

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