



OUTSIDE-IN SINGLE LOOP SUTURE TECHNIQUE PROVIDES SUCCESSFUL LONG-TERM RESULTS IN PATIENTS TREATED FOR LONGITUDINAL MENISCUS TEARS: AVERAGE 4-YEAR FOLLOW-UP

DIŞTAN İÇE TEK HALKALI DİKİŞ TEKNİĞİ, LONGİTUDİNAL MENİSKÜS YIRTIĞI NEDENİYLE TEDAVİ EDİLEN HASTALARDA BAŞARILI UZUN VADELİ SONUÇLAR SAĞLAMAKTADIR: ORTALAMA 4 YILLIK TAKİP

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ABSTRACT

Introduction: In our study, we aimed to evaluate the mid- and long-term follow-up results of the outside-in meniscus repair technique in the treatment of longitudinal meniscus tears.

Methods: Patients who underwent surgery for meniscus repair using outside-in meniscus repair technique between June 2010 and June 2023 were retrospectively analyzed. The range of motion (ROM), the Lysholm Knee Score (LKS) and the Cincinnati Knee Rating System (CKRS) were used for postoperative functional assessment. The Henning classification system were used for the radiological evaluations for meniscal healing status.

Results: Ninety patients (38F/52M) were included in the study. The mean age was 28.2±6.9 years and the follow-up time was 58.4±38.8 months. The mean LKS increased from 44.1±1.4 to 90.4±8.1 and the mean CKRS score from 19.2±3.5 to 28.1±3.2. ($p<0.01$ and $p<0.01$, respectively) The McMurray test was found as positive in 62 patients before the operation and in 14 patients at the last examination. According to the Henning classification, improvement was observed in 86 patients.

Conclusion: We have found that the radiological and functional results of meniscal repairs performed with the single-loop outside-in repair technique are almost perfect in the majority of patients. Considering our results, we believe that the outside-in repair technique is a method that can be safely used for meniscal body, anterior horn and bucket-handle tears.

Keywords: Arthroscopic meniscus repair, outside-in repair, single loop technique

ÖZET

Giriş: Çalışmamızda, dıştan içe menisküs onarım tekniğiyle ameliyat ettiğimiz longitudinal menisküs yırtıklarının orta ve uzun vadeli takip sonuçlarını değerlendirmeyi amaçladık.

Yöntemler: Haziran 2010 ile Haziran 2023 arasında dıştan içe menisküs onarım tekniğiyle menisküs yırtığı tamiri yapılan hastalar retrospektif olarak analiz edildi. Ameliyat sonrası fonksiyonel değerlendirme için eklem hareket aralığı (EHA), Lysholm Knee Score (LKS) ve Cincinnati Knee Rating System (CKRS) kullanıldı. Menisküs iyileşmesinin radyolojik olarak değerlendirilmesi için Henning sınıflandırma sistemi kullanıldı.

Bulgular: Çalışmaya 90 hasta (38K/52F) dahil edildi. Ortalama yaş 28,2±6,9 yıl ve takip süresi 58,4±38,8 aydı. Ortalama LKS 44,1±1,4'ten 90,4±8,1'e ve ortalama CKRS skoru 19,2±3,5'ten 28,1±3,2'ye yükseldi. (sırasıyla $p<0,01$ ve $p<0,01$) McMurray testi ameliyattan önce 62 hastada pozitif olarak bulunurken ve son muayenede 14 hastada pozitif olarak bulundu. Henning sınıflandırmasına göre 86 hastada iyileşme gözlemlendi.

Sonuç: Tek loop dıştan içe onarım tekniği kullanılarak yapılan menisküs onarımlarının radyolojik ve fonksiyonel sonuçlarının hastaların büyük kısmında mükemmel yakın sonuçlandığını gördük. bulgularımız ışığında menisküs gövde, ön boynuz ve kova sapı yırtıklarında dıştan içe onarım tekniğinin güvenle kullanılabilecek bir yöntem olduğunu düşünmekteyiz.

Anahtar kelimeler: Artroskopik menisküs onarımı, dıştan içe tamir, tek halka tekniği

INTRODUCTION

Menisci are essential structures for a healthy knee joint, contributing to stabilization, aiding lubrication, protecting against compressive forces, and enhancing tibiofemoral congruency (1). Roughly 50 to 70% of total weight is transmitted through the menisci, which aids in conserving the viability of the articular cartilage (2,3).

Meniscal pathology has been observed in approximately one out of every seven patients presenting to orthopedic clinics with knee-related complaints (4). Notably, meniscal conditions may present with a variety of etiologies, including

degeneration, discoid morphology, and acute meniscal tears.

Arthroscopic meniscus repair was first described by Ikeuchi et al. in 1979 (5). Over the years, with increasing experience in arthroscopic surgery and industrial development, techniques have been described that can be divided into four main categories: Inside-Out, Outside-In, All-Inside and Hybrid, although no clear superiority over the other techniques has been demonstrated (6,7). Historically, the gold standard for meniscal repair was the inside-out technique, but this was associated with risks to the

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neurovascular structures (8–10). The outside-in technique was developed to reduce the risks of these injuries and is commonly used for tears of the meniscal body and/or anterior horn of the meniscus (2,11,12).

The aim of this retrospective study is to evaluate the medium- to long-term clinical outcomes of outside-in meniscal repair. We hypothesized that meniscal repair using the outside-in technique would lead to favorable mid- to long-term outcomes as reflected by improvements in patient-reported outcomes (PROs).

Material and Method

Approval was obtained from the Ethics Committee of the Bilecik Seyh Edeabali University School of Medicine before the start of the study (decision number 332000, date: 21/05/2025). Informed consent was obtained from the patients who agreed to participate in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki.

This retrospective study examined patients who underwent surgical treatment of meniscal tears between June 2010 and June 2023. Patients were excluded from the study if they had a history of knee infections, osteoarthritis, fractures and surgery on the same knee and had a follow-up period of less than 2 years. **(Figure 1)** The functional assessments of patients with a follow-up time of more than 2 years were evaluated at the final examination in June 2025.

Functional and Radiologic Evaluations

Functional and last radiological evaluations were conducted during the final follow-up visit in June 2025 for all patients with a follow-up duration of at least two years. Two orthopedic and traumatology surgeons (U.S., Ö.C.Ç.), who were not involved in the surgical procedures and were blinded to the patients' clinical data and treatment outcomes, independently performed both the functional and radiologic assessments. At their final follow-up, patients were evaluated for radiologic findings using 1.5-Tesla MRI.

Patient-reported outcomes were assessed using the visual analog scale (VAS), the Lysholm Knee Score, and the The Cincinnati Knee Rating System (CKRS). (13,14) Knee range of motion (ROM) and absence of positive McMurray test was recorded at the final follow-up.

At the final follow-up control the meniscus healing was evaluated according to the Henning classification using knee MRI (15).

Additional clinical parameters, such as the presence of postoperative complications (e.g., joint stiffness, persistent pain, or the need for revision surgery), were also documented.

Surgical Technique and Rehabilitation

All procedures were performed with the patient in the supine position under general or regional anesthesia. A pneumatic tourniquet was applied to the proximal thigh and

the knee was positioned in 90° flexion. After routine antiseptic preparation and draping, a standard anterolateral (AL) portal was created and a diagnostic arthroscopy was performed. All articular surfaces were examined to determine the presence of osteoarthritic changes. A standard anteromedial (AM) portal was then created and the medial and lateral meniscus was examined with a probe.

Once the longitudinal meniscal body and/or anterior horn tear was confirmed, the adequacy of the medial joint space was assessed with a 5 mm hooked arthroscopy probe prior to repair. In cases where the medial compartment was deemed tight, percutaneous needle retraction of the medial collateral ligament was performed under valgus stress with a 19-gauge needle to widen the joint space. This step facilitated the safe insertion and manipulation of instruments such as shavers and suture guides and helped to minimise the risk of iatrogenic cartilage damage.

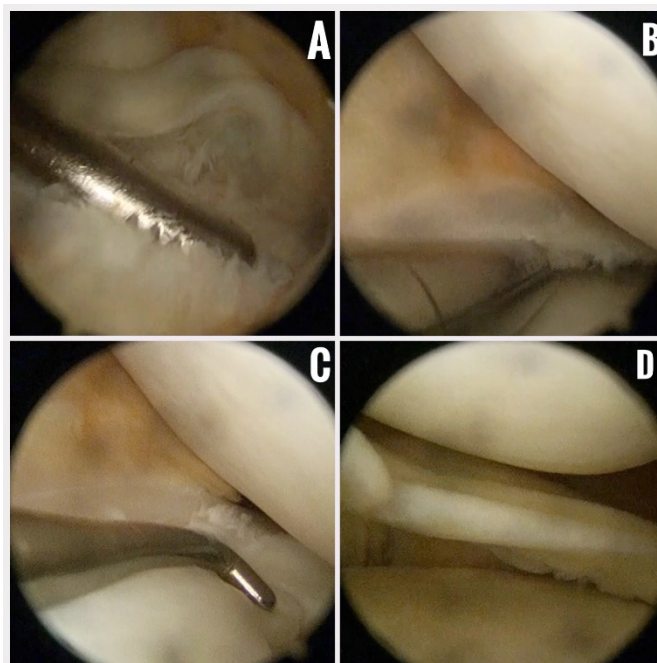


Figure 2 Preparation of torn meniscus and tibial insertion area. A-B) Debridement and revitalization of the torn meniscus edges using a shaver, C) Reduction of the bucket handle meniscus tear with an arthroscopic probe, D) Prepared state of the torn menisci.

The torn meniscus was debrided with a motorized shaver and a meniscus scraper (Figure 2). After revitalization of the torn meniscal ends, a full-thickness suture of No:0 PDS (Ethicon, San Angelo, TX, USA) was passed to the central meniscal piece with a suture passer and both ends were pulled out of the AM portal. Then, as is routine practice, the repair site was inserted into the joint from the skin with a spinal needle and the first suture placed with carrier sutures was pulled out of the skin from the superior and inferior surfaces of the peripheral portion of the meniscus. This process was repeated along the tear and the same technical sutures were placed along the entire tear. **(Figure 3)** Small incisions were then made on the medial skin outside the

Table 1: Demographic characteristics of the patients

	<i>n=90</i>
Age, y	28.2±6.9
Sex, female/male	38/52
Duration of symptoms, w	9.5±6.8
Follow-up period, mo	58.4±38.8
Side affected, right/left	54/36
Meniscus tear location	
Anterior horn	10
Body	62
Bucket handle	18

Data are presented as mean ± SD or No. of patients and median (IQR).

joint, the sutures were tied to the capsule and the repair was completed. After the sutures were tied, the repair site was re-examined with a probe to assess the stability and tension of the sutures.

Following surgery, a standardized rehabilitation protocol was initiated. Postoperative bracing was not required. Patients remained non-weight-bearing for six weeks while performing active range-of-motion exercises and isometric quadriceps and hamstring strengthening. Partial weight bearing was introduced gradually after six weeks, with progression to full weight bearing by the end of the tenth week.

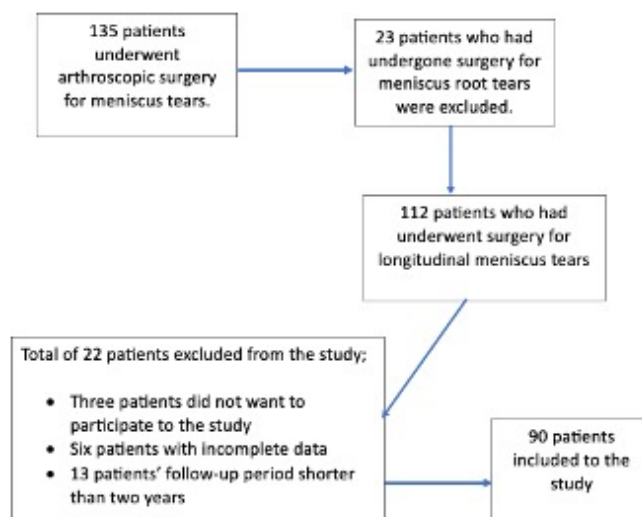
Statistical Analysis

The data were analyzed using SPSS Statistics (Version 23.0; IBM Corp). The distribution of the data was evaluated using the Kolmogorov-Smirnov test. The categorical data

Table 2: The patients' change with Lysholm Knee score, Cincinnati Knee Rating System score and Visual Analogue Scale before and after the operation

	Preoperative	Postoperative	p
Lysholm Knee Score	44.1±1.4	90.4±8.1	< 0.001
CKRS	19.2±3.5	28.1±3.2	< 0.001
VAS	6.4±0.7	2.5±0.9	< 0.001

Boldface P values indicate statistically significant difference between groups regarding pre- to postoperative change ($P < 0.05$). CKRS: Cincinnati Knee Rating System, VAS: Visual Analogue Scale

**Figure 1.** Presentation of the patients participating in our study in the form of a flow chart according to the inclusion and exclusion criteria.

were assessed using the Pearson chi-square, Fisher exact, and Fisher-Freeman-Halton tests. The parametric and nonparametric data were evaluated using a Student's *t* test and a Mann-Whitney U test, respectively. For nonnormally distributed data, the dependent groups were evaluated using the Shapiro-Wilk and Wilcoxon signed rank tests. A value of $p < .05$ was considered significant for all analyses. A prestudy power analysis based on previous data determined that a sample size of 66 patients would be adequate to reach the desired power of greater than 0.8. Postoperative Lysholm score was the primary outcome for 2 means T-test power analysis (16).

RESULTS

During the study period, a total of 135 patients underwent arthroscopic meniscus repair surgery for meniscus tears. Of these, 23 patients were treated due to the meniscus root tears. After excluding 13 patients due to having a follow-up duration of less than two year, six patients with incomplete data, and three who declined participation, the final analysis included a total of 90 patients. (Figure 1).

The mean age of the patients was 28.2±6.9 years (range: 18-41), and the mean follow-up duration was 58.4±38.8 months (range: 24-180). The cohort included 38 females (42.3%) and 52 males (57.7%). Fifty-four patients (60%) underwent right knee surgery, while 36 patients (40%) had surgery on their left knee (Table 1).

According to the pre-operative MRI findings and intraoperative assessment results 62 (68.9%) patients have meniscus body tears, 18 (20%) patients have bucket-handle meniscus tear and rest of 10 (11.1%) patients have anterior horn tears (Table 1). The mean interval from symptom onset

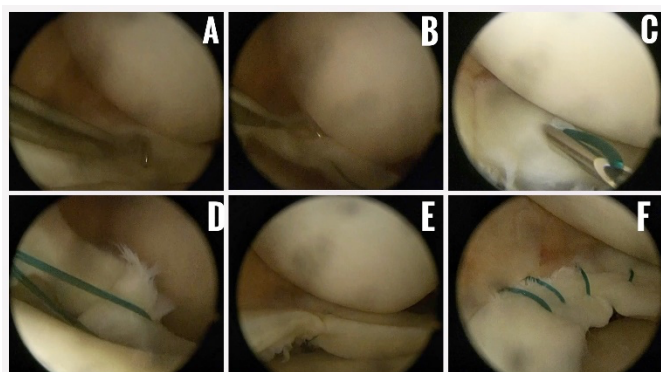


Figure 3. Suturing the torn meniscus. A-B) Full thickness passing of the index suture into the central meniscus piece with a suture passer, C-D) Passing the carrier sutures from outside to inside through the meniscus with the help of a spinal needle, E) Completed

to surgery was 9.5 ± 6.8 weeks (range: 1–17). Twenty-five patients (27.7%) received physical therapy prior to surgery, and none had documented preoperative intra-articular injections.

Statistically significant improvements were observed in the PROs. The Lysholm Knee Score improved from a mean of 44.1 ± 1.4 preoperatively to 90.4 ± 8.1 at final follow-up ($p < 0.001$). The CKRS score increased from 19.2 ± 3.5 to 28.1 ± 3.2 ($p < 0.001$), and the VAS pain score decreased from 6.4 ± 0.7 to 2.5 ± 0.9 ($p < 0.001$) (Table 2). The McMurray test was positive in 62 patients preoperatively, while it was positive in 14 patients at final follow-up. ($p < 0.001$)

The effects of time between trauma and surgery, gender and age on functional outcomes were investigated. It was found that both the Lysholm and CKRS scores of patients over 30 years of age at the time of surgery were statistically significantly higher than those of patients under 30 years of age. ($p < 0.001$, $p < 0.001$, respectively). When the effect of time between trauma and surgery was examined, it was found that there was no statistically significant difference between the Lysholm and CKRS results when 8 weeks was taken as the cut-off point. ($p = 0.254$ and $p = 0.134$ respectively). It was also found that gender did not cause a

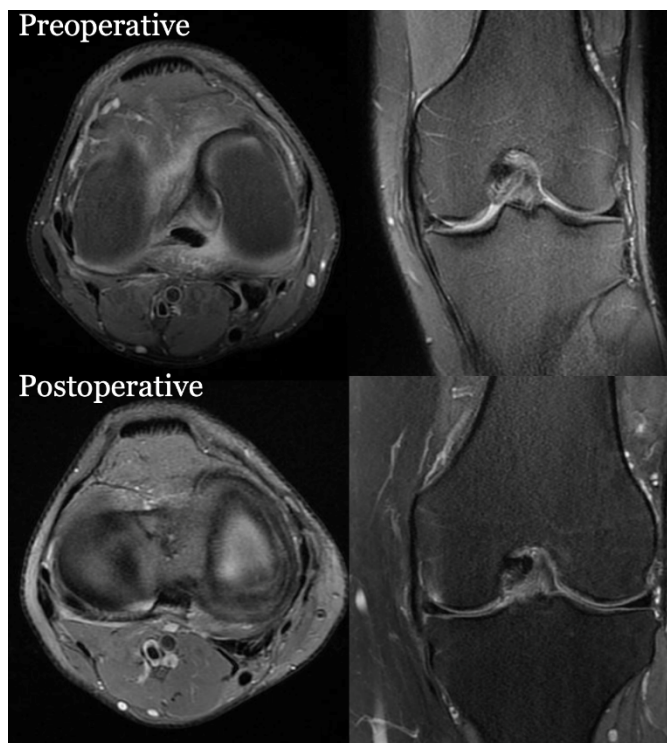


Figure 4. Complete Meniscal healing is seen on the knee coronal MRI section at final follow-up.

statistically significant difference. ($p = 0.142$ and $p = 0.136$ respectively) (Table 3).

All patients underwent a follow-up MRI examination and healing was assessed according to the Henning classification system. Complete healing was observed in 59 (65.5%) (Figure 4) patients, partial healing in 27 (30%) patients and four (4.5%) patients showed $< 50\%$ healing and were considered failures. At the final follow-up examination, all patients showed a full range of motion in the operated knee.

Three patients were treated for early postoperative infection and received oral antibiotic therapy. No cases of repair failure due to infection were observed. One patient who was categorized as unsuccessful complained of knee pain and

Table 3: Outcome analysis based on patient characteristics

Factor	n:90		Lysholm			CKRS		
	1	2	1	2	p	1	2	p
Age (under 30y)	50	40	85.8 ± 9.5	94.0 ± 4.2	< 0.001	26.8 ± 4	29.2 ± 1.9	< 0.001
Gender (F/M)	38	52	89.4 ± 9.1	91.0 ± 7.3	0.142	27.8 ± 3.5	28.3 ± 3.0	0.136
TTS (under 8w)	42	48	90.9 ± 7.3	89.9 ± 8.8	0.254	28.5 ± 3.1	27.8 ± 3.3	0.134

Boldface P values indicate statistically significant difference between groups regarding pre- to postoperative change ($p < 0.05$). The first column contains the examined factor. The second column shows the division of the cohort in 1 and 2 by the examined factor. F: Female, M: Male, y: year, w: week, TTS: time to surgery, CKRS: Cincinnati Knee Ranking System

swelling at six-months postoperatively following re-trauma. The patient underwent a partial meniscectomy.

DISCUSSION

The results of the present study show that meniscal repair using the outside-in technique achieves and maintains a statistically significant improvement in the Lysholm Knee Scoring Scale and the CKRS. Complete or partial healing occurred in the majority of patients, and only four out of 90 patients (4.5%) experienced failure. Only one in 90 patients (1.1%) required reoperation due to significant pain and swelling following hyperflexion trauma.

Keyhani et al. (16) prospectively studied 66 patients who underwent repair using the outside-in technique. At approximately 2-year follow-up, the authors found that 61 patients (92%) achieved clinical success, defined as the absence of clinical symptoms at follow-up. In addition, International Knee Documentation Committee (IKDC) scores increased significantly (54.2–90.8 points; $p < 0.001$), and the Lysholm score was excellent or good in 49 patients (80%) (5). No complications were noted in this cohort (16). Fauré et al. (17) examined the outside-in meniscal repairs in young population and reported that 78% of patients were satisfied with the procedure. Similarly, Sobhy et al (18) investigated the safety of the outside-in technique in 41 consecutive cases and reported a clinical success rate of 88 based on symptom relief and significant improvement in functional scores. Examination of our patients' outcomes showed that the Lysholm score increased from 44.1 ± 1.4 to 90.4 ± 8.1 , while the CKRS increased from 19.2 ± 3.5 to 28.1 ± 3.2 . Both results were statistically significantly improved.

Studies investigating possible risk factors for worsening clinical outcomes are rare. Kubiak et al (19) conducted one of the few studies that investigated possible risk factors for functional outcomes and reported that time between trauma and surgery, age and gender had no effect on functional outcomes. Similarly, the vast majority of studies investigating factors influencing functional outcomes found that age, gender, side and time to surgery had no effect on functional outcomes (20–23). In contrast, a study by Hupperich et al. (24) examining the repair outcomes of bucket-handle tears found that patients operated on at a younger age had worse outcomes, but gender had no effect on functional outcomes. When we compared our results with the literature, we found that, similar to previous studies, gender and time to surgery had no effect on outcomes, and that outcomes were worse in younger patients. We believe that the influence of age on outcomes is closely related to the decreasing healing ability of older patients and that the decrease in their sports activities is closely related to fewer re-tears.

Healing after meniscal repair can be assessed objectively with MRI or second-look arthroscopy and is not always at the same level as functional scores. Henning et al (15)

developed an MRI-based classification method for the assessment of healing after repair. In a recent systematic review by Migliorini et al (25), meniscal healing was assessed using postoperative knee MRIs of 37 patients, with healing achieved in 35 of these patients. Examination of the knee MRIs taken at the last follow-up of our patients showed that, in line with the literature, complete or partial healing was achieved in 86 of our patients.

Limitations

This study has several limitations. Firstly, its retrospective design is inherently limited to the level of evidence and may have led to selection bias. Another limitation was that patients' concomitant anterior cruciate ligament injuries and cartilage injuries were not assessed during surgery and at final follow-up, which could influence functional outcomes. In addition, the fact that the study was performed by a single surgeon using the same technique in all patients and analysed by an independent observer with more than one scoring system represents its strengths.

CONCLUSION

We have observed that repair using the single-loop outside-in technique for longitudinal tears affecting the meniscal body and anterior horn leads to clinically and radiologically significant improvement in the medium and long term. We believe that this technique is associated with good clinical and biomechanical results.

Ethics Committee Approval: The study was approved by the Ethics Committee of Bilecik Şeyh Edebali University Medical Faculty (date: 21.05.2025, decision no: 332000).

Informed Consent: Informed consent was acquired, and only voluntary participants were included in the study.

Authorship Contributions: Concept – M.A.; Design – M.A., M.G.; Supervision – M.A.; Materials – M.A., M.G., M.B.E.; Data collection &/or processing – M.G.; Analysis and/or interpretation – M.G.; Literature search – M.G., M.B.E.; Writing – M.G.; Critical review – M.A..

Conflict of Interest: The authors have no conflicts of interest to declare.

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