Medical Journal of Bakırköy

Med J Bakirkoy 2026;22(Suppl 1):55-63

DOI: 10.4274/BMJ.galenos.2026.2026.2-12

Research

Major, Midi and Multiple Mini Incisions in Inside-Out Meniscal Repair: Neurovascular Safety and Surgical Efficiency

Inside-Out Menisküs Tamirinde Majör, Midi ve Multipl Mini İnsizyonlar: Nörovasküler Güvenlik ve Cerrahi Verimlilik

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ABSTRACT

Objective: This study compared three skin incision strategies used in inside-out meniscal repair with respect to neurovascular complications, surgical parameters, and clinical outcomes.

Methods: Between January 2021 and June 2024, 224 patients who underwent arthroscopic inside-out repair for tears of the medial or lateral meniscal body or posterior horn were retrospectively reviewed. After applying the exclusion criteria, 192 patients were included and divided into three groups: conventional major incision (n=59), single midi incision (2-3 cm; n=65), and multiple mini incisions (n=68). The primary outcome was the overall complication rate, including vascular and neurological complications. Secondary outcomes included operative time and clinical outcomes; the clinical outcomes were assessed using the visual analogue scale (VAS), International Knee Documentation Committee (IKDC) score, and Tegner activity scale.

Results: Overall complication rates were 11.9% in the conventional group, 10.8% in the midi group, and 19.1% in the multiple mini-incision group, with no significant difference among groups (p=0.324). When complications were classified as local (incision-related) or systemic, local complication rates were 8.5%, 6.2%, and 13.2%. Neurological complications occurred more frequently in the multiple mini-incision group. Operative time was significantly longer in this group than in the other two groups (p<0.001). All groups demonstrated significant postoperative improvements in VAS, IKDC, and Tegner scores (all p<0.001), with comparable functional outcomes between the conventional and midi groups.

Conclusion: In this retrospective cohort, the midi-incision technique was not associated with a statistically significant difference in complication rates compared with the conventional major incision, but it demonstrated a shorter operative time than the multiple mini-incision technique. These preliminary findings suggest that the midi-incision approach is a promising alternative that warrants further prospective investigation.

Keywords: Meniscus repair, inside-out technique, skin incision, neurovascular complications, arthroscopy

ÖZ

Amaç: Bu çalışma, *inside-out* menisküs tamirinde kullanılan üç farklı deri insizyonu stratejisini; nörovasküler komplikasyonlar, cerrahi parametreler ve klinik sonuçlar açısından karşılaştırmayı amaçladı.

Gereç ve Yöntem: Ocak 2021 ile Haziran 2024 tarihleri arasında, medial veya lateral menisküs korpus ya da posterior boynuz yırtıkları nedeniyle artroskopik *inside-out* menisküs tamiri uygulanan 224 hasta retrospektif olarak incelendi. Dışlama kriterleri uygulandıktan sonra 192 hasta çalışmaya dahil edildi ve üç gruba ayrıldı: konvansiyonel majör insizyon (n=59), tek midi insizyon (2-3 cm; n=65) ve çoklu mini insizyonlar (n=68). Birincil sonlanım noktası, vasküler ve nörolojik komplikasyonları içeren toplam komplikasyon oranıydı. İkincil sonlanım noktaları ise ameliyat süresi ve görsel analog skala (VAS), I*nternational Knee Documentation Committee* (IKDC) skoru ve Tegner aktivite ölçeği ile değerlendirilen klinik sonuçlardı.

Bulgular: Toplam komplikasyon oranları konvansiyonel grupta %11,9, midi grupta %10,8 ve çoklu mini insizyon grubunda %19,1 olarak saptandı ve gruplar arasında anlamlı fark yoktu (p=0,324). Nörolojik komplikasyonlar çoklu mini insizyon grubunda daha sık görüldü. Ameliyat süresi bu grupta diğer iki gruba kıyasla anlamlı derecede daha uzundu (p<0,001). Tüm gruplarda VAS, IKDC ve Tegner skorlarında ameliyat sonrası anlamlı iyileşme gözlendi (tüm p<0,001) ve konvansiyonel ile midi gruplar arasında fonksiyonel sonuçlar benzerdi.

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Cite as: Altay N, Topsakal FE, Özdemir E, Demirel D. Major, midi and multiple mini incisions in inside-out meniscal repair: neurovascular safety and surgical efficiency. Med J Bakirkoy. 2026;22(Suppl 1):55-63

Received: 07.03.2026
Accepted: 25.06.2026
Publication Date: 25.09.2026

ÖZ

Sonuç: Bu retrospektif kohortta, midi insizyon tekniği konvansiyonel majör insizyona kıyasla komplikasyon oranlarında istatistiksel olarak anlamlı bir fark göstermemiştir. Bu ön bulgular, midi insizyon yaklaşımının ileriye dönük araştırmalarla doğrulanması gereken umut verici bir alternatif olduğunu düşündürmektedir.

Anahtar Kelimeler: Menisküs tamiri, *inside-out* teknik, deri insizyonu, nörovasküler komplikasyonlar, artroskopi

INTRODUCTION

Arthroscopic inside-out meniscal repair has been widely used for decades because of its strong suture configurations and adaptability to various tear patterns, particularly corpus and posterior horn tears of the medial and lateral meniscus (1,2). Despite advances in all-inside devices, it remains a reference technique for many surgeons owing to its biomechanical reliability, its ability to tie knots over the capsule, and its durable clinical outcomes. However, the procedure requires an additional posteromedial or posterolateral incision, placing critical neurovascular structures at potential risk (1,3).

On the medial side, the saphenous nerve and its branches are vulnerable, whereas on the lateral side, the common peroneal nerve and popliteal vascular structures may be endangered depending on incision location and dissection depth (3,4). Traditionally, a 4-6 cm "safety incision" has been recommended prior to suture passage to allow placement of a retractor and protect adjacent structures (1). Although this conventional major incision provides adequate exposure, it may increase operative time, the extent of soft-tissue dissection, postoperative pain, and wound-related complications (5,6).

Recently, efforts to minimize soft-tissue trauma have led to alternative incision strategies. The "midi-incision" technique uses a single 2-3 cm shared incision after suture retrieval, whereas the multiple mini-incision technique creates separate small incisions for each knot (2). Consequently, in recent years, the feasibility of achieving comparable safety with more limited skin incisions during inside-out meniscal repair has gained increasing attention in clinical practice (3,7). While the general complication profile of inside-out repair has been extensively reported, direct comparisons of these incision strategies in terms of neurovascular safety and surgical efficiency remain limited (5,6,8).

The primary aim of this study was to compare three incision strategies for inside-out repair of medial and lateral meniscal body and posterior horn tears with respect to overall complication rates. As a secondary focus, neurovascular complications were analyzed separately to assess incision-related safety. Secondary aims included operative time, wound complications, early postoperative pain, and functional outcomes. We hypothesized that the single midi-incision technique would demonstrate no statistically significant difference in complication rates compared with the conventional major-incision technique, and would be associated with superior outcomes compared with the multiple mini-incision technique.

METHODS

This was a retrospective cohort study. The study protocol was approved by the Erzurum University Faculty of Medicine Scientific Researchs Ethics Committee (approval no: 288, date: 12.11.2025), and the study was conducted in accordance with the principles of the Declaration of Helsinki. Due to the retrospective nature of the study, the ethics committee waived the requirement for study-specific informed consent. Routinely obtained preoperative surgical consent forms were used for all patients. All surgical procedures were performed by two experienced orthopedic surgeons specializing in arthroscopic surgery.

Patients who underwent arthroscopic inside-out meniscal repair for medial and/or lateral meniscal corpus (midbody) or posterior horn tears between January 2021 and June 2024 were identified retrospectively in hospital medical records. During this period, a total of 224 patients were screened. Based on predefined exclusion criteria, 32 patients were excluded, and 192 were included in the final analysis. Patients included in the study were divided into three groups according to the skin incision technique.

All three incision techniques were used concurrently during the study period (January 2021-June 2024). Both surgeons were experienced in all three techniques, and the choice of technique was based on individual surgeon preference rather than patient- or tear-specific factors. No systematic temporal trend or learning-curve effect was identified in the distribution of techniques over time.

Patients aged 14-55 years who underwent arthroscopic inside-out repair of repairable tears of the medial and/or lateral meniscal midbody or posterior horn were included in the study. Eligible tear patterns included longitudinal, horizontal, radial, bucket-handle, and complex types, provided intraoperative assessment confirmed sufficient meniscal tissue quality to allow stable repair. Inclusion

further required the availability of a minimum of 12 months of clinical and functional follow-up data. Patients with previous surgery on the same knee; patients who underwent revision meniscal repair or meniscectomy; patients requiring concomitant anterior cruciate ligament reconstruction or other major ligamentous procedures; patients with advanced cartilage degeneration; patients diagnosed with degenerative meniscal tears; and patients with a history of infectious or inflammatory arthritis, systemic rheumatologic disease, or postoperative follow-up shorter than 12 months were excluded from the study.

Pain and functional status were assessed in all patients preoperatively and at the final clinical follow-up using standardized patient-reported outcome measures. Pain intensity was recorded using the visual analogue scale (VAS), ranging from 0 to 10. Knee function and symptoms were evaluated using the International Knee Documentation Committee (IKDC) subjective knee evaluation form. Activity level was assessed using the Tegner activity scale. Changes in clinical outcomes were analyzed based on differences between preoperative and postoperative scores, and were used for both within- and between-group statistical comparisons.

Surgical Technique

All procedures were performed under general or spinal anesthesia with the patient in the supine position. The operative knee was positioned near the table edge to facilitate posteromedial or posterolateral access, and a lateral thigh post was used when necessary. Diagnostic arthroscopy was carried out through standard anteromedial and anterolateral portals to assess tear location and repairability. Corpus and posterior horn tears were treated using the inside-out technique.

Suture passage was performed with zone-specific cannulas based on tear location. For medial tears, cannulas were introduced through the anterolateral portal; for lateral tears, they were introduced through the anteromedial portal to ensure a safe needle exit trajectory. Sutures were placed in vertical or oblique mattress configurations at 3-5 mm intervals.

Posterior exposure was performed according to the assigned incision strategy. In the conventional major-incision technique, a 4-6 cm posteromedial or posterolateral incision was made before suture passage, and a blunt retractor was placed over the capsule to protect neurovascular structures (Figure 1a). In the single midi-incision technique, sutures were first retrieved through the skin, followed by the creation of a single 2-3 cm shared incision for knot-tying (Figure 1b). In the multiple mini-incision technique, separate small incisions were made for each knot with individual blunt dissection to the capsule (Figure 1c).

Figure 1. a. Conventional major incision technique using a blunt retractor to protect the posteromedial neurovascular structures during inside-out meniscal repair. **b.** Single midi-incision technique (2-3 cm), in which a single shared incision is created after all sutures are retrieved through the skin. **c.** Multiple mini-incision technique, in which separate millimetric skin incisions are made for each suture line and dissected individually down to the capsule. **d.** Arthroscopic view of inside-out repair of a horizontal tear involving the midbody-posterior horn of the medial meniscus

Care was taken to protect the saphenous nerve and vein medially and the common peroneal nerve and popliteal vessels laterally. Transillumination and anatomical landmarks were routinely used to identify safe incision sites. All sutures were tied over the capsule with the knee in near-full extension to reduce the risk of flexion contracture. Final meniscal stability was confirmed arthroscopically.

Deep vein thrombosis screening was performed based on clinical suspicion. Duplex ultrasonography was obtained when patients presented with clinical signs suggestive of deep-vein thrombose (DVT), including calf swelling, calf tenderness, or a positive Homans sign. Standardized universal DVT screening was not routinely performed, which may have resulted in underdetection of asymptomatic events.

Postoperative Rehabilitation

All patients used a knee brace postoperatively, with knee range of motion initially restricted to 0-90°. During the first 2 weeks, partial weight-bearing was allowed as tolerated for isolated repairs, with progression individualized according to tear characteristics and repair stability. Isometric quadriceps exercises, ankle pumps, and patellar mobilization were initiated early, and controlled knee flexion was gradually increased beginning in the second postoperative week.

By the fourth week, supervised closed kinetic chain exercises and light strengthening exercises were introduced, while deep flexion and rotational stress were avoided to protect the repair. After the sixth week, patients progressed to full weight bearing and advanced to active flexion beyond 120°. Running and low-impact activities were generally initiated between weeks 8 and 12. From the third postoperative month, sport-specific training with controlled directional changes was added, and return to contact or high-demand sports was permitted after 6 months, when clinical and functional assessments were satisfactory.

Statistical Analysis

Sample size calculation was based on detecting a clinically meaningful difference in complication rates between groups (α=0.05, power=0.80) and required approximately 60 patients per group. Continuous variables are presented as mean±standard deviation, and categorical variables as frequencies and percentages. Baseline comparisons were performed using one-way analysis of variance (ANOVA) for continuous variables and chi-square or Fisher's exact tests for categorical variables, with Levene's test assessing homogeneity of variances.

Complication rates were compared using the chi-square test, with 95% confidence intervals (CIs) calculated by the Wilson method. Operative time and changes in outcome scores were analyzed using ANOVA with Tukey post-hoc testing. Effect sizes were calculated using eta-squared (η^2) and Cohen's d. Within-group pre-post comparisons were evaluated using paired t-tests.

Multivariable logistic regression was used to identify independent predictors of complications, including surgical technique (with Classic Major Incision as the reference), age, gender, and tear complexity. Anlaysis of covariance (ANCOVA) was used to assess predictors of postoperative functional scores while adjusting for preoperative values and demographic variables. Spearman correlation analysis was used to examine associations between operative time, follow-up duration, and outcome changes. Statistical significance was set at $p<0.05$. Analyses were performed using Python (version 3.10).

RESULTS

Patient Characteristics

A total of 192 patients completed the study protocol (mean age 32.5±11.8 years, 70.8% male). The cohort comprised 59 patients (30.7%) in the Classic Major Incision group, 65 patients (33.9%) in the Midi Incision group, and 68 patients (35.4%) in the Multiple Mini Incisions group. Mean follow-up duration was 29.7±9.5 months, without significant difference between groups (Classic: 31.0±9.0 months, Midi: 30.5±10.0 months, Mini: 27.9±9.2 months). No patients were lost to follow-up.

Baseline demographic and clinical characteristics were generally comparable among groups (Table 1). No significant differences were observed in age (p=0.960), gender distribution (p=0.118), operative side (p=0.324), meniscus side (p=0.405), or tear type distribution (p=0.332). Preoperative VAS pain scores (p=0.159) and Tegner activity levels (p=0.657) were similar across groups. However, preoperative IKDC scores differed significantly among groups (Classic: 46.7±1.5, Midi: 47.3±1.7, Mini: 47.8±1.5; p=0.001), and this baseline imbalance was accounted for in all subsequent between-group functional outcome comparisons using ANCOVA adjustment.

Operative Parameters

The mean operation time differed significantly among groups ($F=135.7$, $p<0.001$, $\eta^2=0.590$), with a large effect size. The Classic Major Incision group had the shortest operative time (25.4±3.2 minutes), followed by the Midi Incision group (27.3±3.2 minutes), with the Multiple Mini Incisions group requiring significantly longer time (33.9±3.0 minutes). Post-hoc analysis revealed all pairwise differences were statistically significant (all $p\leq0.002$). The Multiple Mini Incisions technique required approximately 8.5 minutes longer than the Classic approach (95% CI: 7.2-9.8 minutes) and 6.6 minutes longer than the Midi approach (95% CI: 5.3-7.9 minutes).

Primary Outcome: Complication Rates

Overall complication rates were 11.9% (7/59) in the Classic Major Incision group, 10.8% (7/65) in the Midi Incision group, and 19.1% (13/68) in the Multiple Mini Incisions group, with no statistically significant difference among groups ($\chi^2=2.26$, p=0.324). The overlapping 95% CIs for each group (Classic: 5.9-22.5%, Midi: 5.3-20.6%, Mini: 11.5-30.0%) indicate that the observed differences may be attributable to chance. However, this should not be interpreted as evidence of equivalent

safety because the study was not designed as an equivalence or non-inferiority trial (Figure 2).

When complications were categorized as local (incision-related: neurological and wound complications) or systemic (DVT and thrombophlebitis) categories, the local complication rates were 8.5% (5/59) in the Classic group, 6.2% (4/65) in the Midi group, and 13.2% (9/68) in the Multiple Mini group (p=0.349). Systemic vascular complications occurred in 3.4% (2/59), 4.6% (3/65), and 8.8% (6/68), respectively. This separation provides a clearer assessment of incision-specific safety.

Individual complication types are presented in Table 2. Vascular complications occurred in 11 patients (5.7% overall): 2 (3.4%) in the Classic group, 3 (4.6%) in the Midi group, and 6 (8.8%) in the Mini group. Most were lower-extremity DVTs that were detected through clinical suspicion and managed successfully with anticoagulation. Two cases of superficial thrombophlebitis occurred in the Mini group. Neurological complications occurred in 9 patients (4.7% overall): 1 (1.7%) in the Classic group (saphenous neuropathy), 2 (3.1%) in the Midi group (saphenous neuropathy), and 6 (8.8%) in the Mini group (1 peroneal neuropathy, 5 saphenous neuropathies). Most neurological complications manifested as transient paresthesia

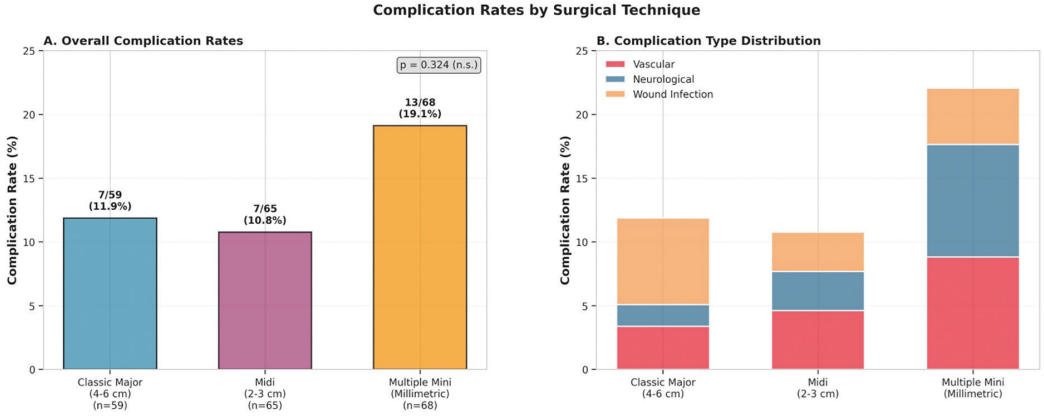

Figure 2. Complication rates by surgical technique. Complication rates comparison among three incision techniques. **A.** Overall complication rates show no statistically significant difference among groups (p=0.324, chi-square test). Multiple Mini Incisions group shows numerically higher rate (19.1%) compared to Classic Major (11.9%) and Midi (10.8%) techniques, but difference did not reach statistical significance. Note: The absence of statistical significance should not be interpreted as evidence of equivalent safety. **B.** Complication type distribution presented as stacked bar chart showing proportion of vascular, neurological, and wound infection complications in each group. Error bars represent 95% confidence intervals

n.s.: Not statistically significant (p>0.05)

Table 1. Patient demographics and baseline clinical characteristics

Characteristic	Classic major (n=59)	Midi incision (n=65)	Multiple mini (n=68)	p-value
Age (years), mean±SD	32.8±11.8	32.2±12.0	32.5±11.6	0.960
Male gender, n (%)	44 (74.6)	50 (76.9)	42 (61.8)	0.118
Right knee, n (%)	40 (67.8)	36 (55.4)	44 (64.7)	0.324
Medial meniscus, n (%)	34 (57.6)	41 (63.1)	47 (69.1)	0.405
Longitudinal, n (%)	15 (25.4)	9 (13.8)	18 (26.5)	0.332[a]
Horizontal, n (%)	20 (33.9)	18 (27.7)	22 (32.4)	—
Complex, n (%)	8 (13.6)	11 (16.9)	11 (16.2)	—
Radial, n (%)	11 (18.6)	14 (21.5)	7 (10.3)	—
Bucket-handle, n (%)	5 (8.5)	13 (20.0)	10 (14.7)	—
Follow-up (months), mean±SD	31.0±9.0	30.5±10.0	27.9±9.2	0.148
VAS pain score, mean±SD	7.3±1.5	7.3±1.7	6.8±1.5	0.159
IKDC score, mean±SD	46.7±1.5	47.3±1.7	47.8±1.5	0.001**
Tegner activity level, mean±SD	3.7±1.4	3.6±1.6	3.5±1.4	0.657

SD: Standard deviation, VAS: Visual analogue scale (0-10), IKDC: International Knee Documentation Committee (0-100), Tegner: Tegner activity scale (0-10). [a]: p-value for overall tear type distribution (chi-square test), **p<0.01

that resolved within 6-12 months; one case of common peroneal neuropathy in the Mini group persisted beyond 12 months with partial recovery. Wound infections occurred in 9 patients (4.7% overall): 4 (6.8%) in the Classic group, 2 (3.1%) in the Midi group, and 3 (4.4%) in the Mini group. All were superficial surgical site infections managed successfully with oral antibiotics; no deep infections or reoperations for infection occurred.

Multivariable logistic regression analysis of the composite complication risk revealed no significant association with surgical technique after adjustment for age, gender, and tear complexity. Compared with the Classic Major Incision group (reference), neither Midi Incision [odds ratio (OR): 0.88, 95% CI: 0.29-2.69, p=0.818] nor Multiple Mini Incisions (OR: 1.82, 95% CI: 0.66-4.98, p=0.247) demonstrated a significantly different risk of complications. Similarly, age, gender, and tear complexity were not independently associated with complication risk (all p>0.32).

Secondary Outcomes: Functional Scores

Within-Group Improvements

All three groups demonstrated statistically significant improvements in pain scores and functional scores from preoperative to postoperative assessments (all p<0.001, Table 3, Figure 3). VAS pain scores improved substantially in all groups: Classic (7.3→2.4, Δ=-4.9±2.0), Midi (7.3→2.2, Δ=-5.1±2.3), and Mini (6.8→3.2, Δ=-3.6±2.1). IKDC scores improved markedly in all groups: Classic (46.7→78.0, Δ=31.3±2.5), Midi (47.3→78.1, Δ=30.8±2.3), and Mini (47.8→68.1, Δ=20.3±2.2). Tegner activity levels also improved across groups: Classic (3.7→6.2, Δ=2.5±2.1), Midi (3.6→6.1, Δ=2.5±2.2), and Mini (3.5→4.8, Δ=1.3±2.2).

Multivariable regression analysis (ANCOVA) confirmed surgical technique as a significant predictor of postoperative IKDC score (R^2=0.915, F=398.0, p<0.001). The high R^2 value was primarily driven by the strong predictive contribution of preoperative IKDC scores. Model diagnostics, including residual analysis and multicollinearity assessment (all variance inflation factors <2.0), were satisfactory. After adjusting for preoperative IKDC, age, and gender, the Multiple Mini Incisions technique was associated with a 9.7-point lower postoperative IKDC score compared with the Classic Major Incision (β=-9.74, 95% CI: -10.3 to -9.2, p<0.001), while the Midi Incision showed no significant difference from the Classic Major Incision (β=0.20, p=0.457). Similar patterns were observed for Tegner activity scores.

Table 2. Complication rates and multivariable risk factor analysis

A. Complication rates by surgical technique

Complication type	Classic major (n=59)	Midi incision (n=65)	Multiple mini (n=68)	p-value
Any complication	7 (11.9%)	7 (10.8%)	13 (19.1%)	0.324
[95% CI]	[5.9-22.5%]	[5.3-20.6%]	[11.5-30.0%]	—
Local complications	5 (8.5%)	4 (6.2%)	9 (13.2%)	0.349
Systemic complications	2 (3.4%)	3 (4.6%)	6 (8.8%)	—
Vascular complication	2 (3.4%)	3 (4.6%)	6 (8.8%)	0.388
*Deep vein thrombosis	2	2	4	—
*Thrombophlebitis	0	1	2	—
Neurological complication	1 (1.7%)	2 (3.1%)	6 (8.8%)	0.117
*Saphenous neuropathy	1	2	5	—
*Peroneal neuropathy	0	0	1	—
Wound infection	4 (6.8%)	2 (3.1%)	3 (4.4%)	0.598

p-values from chi-square test for overall comparison; individual complication types presented descriptively due to low event rates

B. Multivariable logistic regression for any complication risk

Variable	Odds ratio	95% CI	p-value
Classic major incision	Reference	—	—
Midi incision	0.88	0.29-2.69	0.818
Multiple mini incisions	1.82	0.66-4.98	0.247
Age (per year)	1.01	0.98-1.05	0.441
Male gender	1.32	0.51-3.40	0.570
Complex tear	1.68	0.61-4.63	0.320

CI: Confidence interval. Model includes surgical technique (classic major incision as reference category), age, gender, and tear complexity. Pseudo R^2=0.026. No significant independent predictors identified

Given the statistically significant baseline difference in preoperative IKDC scores among groups (p=0.001), all between-group comparisons of postoperative functional outcomes were adjusted for preoperative IKDC values using ANCOVA, ensuring that the observed differences reflected true between-group effects rather than baseline imbalances.

Correlation Analysis

Spearman correlation analysis revealed significant associations between operative parameters and outcomes. Operation time correlated inversely with IKDC improvement (ρ=-0.64, p<0.001), indicating that longer procedures were associated with less functional improvement. Operation time also showed a moderate correlation with VAS change (ρ=0.26, p<0.001) and an inverse correlation with Tegner improvement (ρ=-0.21, p=0.004). Follow-up duration was weakly positively correlated with IKDC improvement (ρ=0.17, p=0.019), suggesting gradual functional gains. IKDC improvement correlated inversely with VAS change (ρ=-0.24, p<0.001), as expected, and correlated positively with Tegner improvement (ρ=0.19, p=0.008).

DISCUSSION

The principal finding is that complication rates did not differ significantly between the 2-3 cm midi incision and the

Table 3. Operative parameters and clinical outcomes

Outcome	Classic major (n=59)	Midi incision (n=65)	Multiple mini (n=68)	p-value[a]	η^2
Operation time (min)	25.4±3.2	27.3±3.2	33.9±3.0	<0.001***	0.590
VAS pain score					
Preoperative	7.3±1.5	7.3±1.7	6.8±1.5	0.159	—
Postoperative	2.4±1.4	2.2±1.5	3.2±1.7	<0.001***	—
Change (Δ)	-4.9±2.0	-5.1±2.3	-3.6±2.1	<0.001***	0.094
IKDC score					
Preoperative	46.7±1.5	47.3±1.7	47.8±1.5	0.001**	—
Postoperative	78.0±1.6	78.1±1.5	68.1±1.4	<0.001***	—
Change (Δ)	31.3±2.5	30.8±2.3	20.3±2.2[c]	<0.001***	0.834
Tegner activity score					
Preoperative	3.7±1.4	3.6±1.6	3.5±1.4	0.657	—
Postoperative	6.2±1.6	6.1±1.5	4.8±1.6	<0.001***	—
Change (Δ)	2.5±2.1	2.5±2.2	1.3±2.2[c]	0.001**	0.068

[a]: One-way ANOVA; [b]: Paired t-test; [c]: Significantly different from both Classic and Midi (Tukey honestly significant difference, p<0.01). **p<0.01; ***p<0.001. η^2 effect sizes: small 0.01-0.06, medium 0.06-0.14, large >0.14

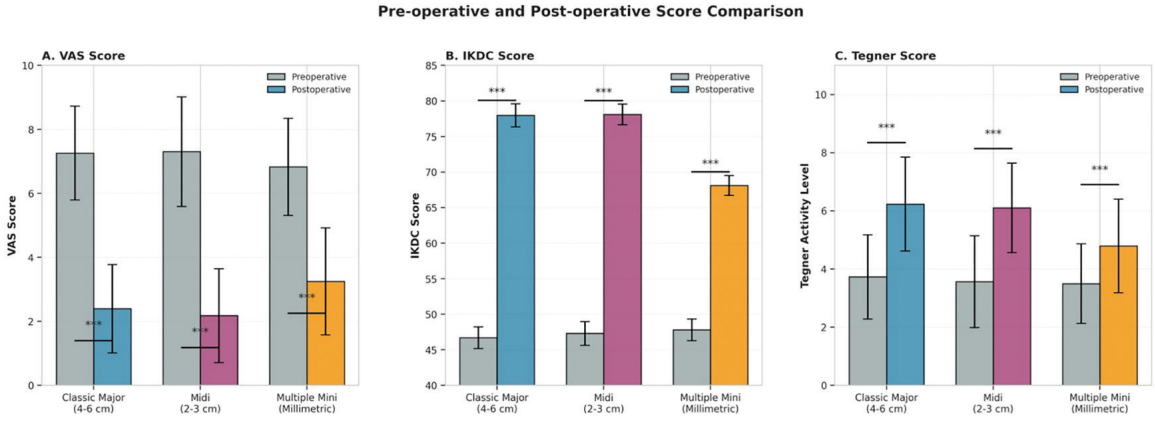

Figure 3. Preoperative and postoperative score comparison. Comparison of preoperative and postoperative functional scores among surgical techniques. **A.** VAS pain scores show significant improvement in all groups (***p<0.001). **B.** IKDC scores demonstrate substantial improvement in all groups (***p<0.001). Classic and Midi groups achieve postoperative scores near 78 points, while Multiple Mini Incisions group shows more modest improvement to 68 points. **C.** Tegner activity levels improve significantly in all groups (***p<0.001)

VAS: Visual analogue scale (0-10), IKDC: International Knee Documentation Committee (0-100): Tegner: Tegner activity scale (0-10)

conventional 4-6-cm major incision in inside-out meniscal repair (p=0.324). Because the study was not designed as an equivalence or non-inferiority trial, this result should not be interpreted as proof of equivalent safety. The multiple mini-incision technique was associated with numerically higher complication rates, significantly longer operative time, and significantly less functional improvement. By contrast, operative time and functional outcomes in the midi group were comparable to those of the conventional approach.

Inside-out meniscal repair is still widely preferred for corpus and posterior horn tears because of its strong suture configurations and durable outcomes (1-3,9). Despite advances in all-inside implants, its biomechanical reliability and capsular knot fixation keep it a reference technique (2,10,11). Its main drawback is the additional posteromedial or posterolateral incision, which exposes neurovascular structures to risk (1,3,12): medially, the variable branching of the saphenous nerve (13,14), and laterally, the proximity of the common peroneal nerve (15).

Traditionally, a 4-6 cm "safety incision" is created before suture passage to allow retractor placement (1). Although reliable, it requires more dissection and is linked to postoperative pain, wound complications, and sensory disturbances (5,6,16-19). The multiple mini-incision technique reduces total incision length but requires repeated dissection, potentially causing cumulative neurovascular manipulation (2,15-18,20,21).

Anatomical studies show that inconsistent saphenous nerve branching prevents a true "safe zone," and repeated small dissections may raise the risk of paresthesia (13,14,20). The numerically higher neurological complication rate and limited functional gains in the multiple mini-incision group align with these concerns, although, with only 9 events, the study was underpowered for a definitive comparison. The midi-incision technique offers a balanced compromise: a single 2-3 cm shared incision after suture retrieval permits controlled capsular dissection while limiting repeated neurovascular contact (2,3).

In our cohort, complication rates in the midi-incision group were not significantly different from those in the conventional group and were numerically lower than those in the multiple mini-incision group. Operative time in the midi group was similar to that in the conventional approach and significantly shorter than in the multiple mini-incision technique.

Prolonged operative time has been linked to greater postoperative pain, slower recovery, and more complications in arthroscopic knee surgery. The inverse correlation observed here between operative time and functional improvement is consistent with this. However, the retrospective design precludes causal inference; operative time may simply reflect technical difficulty. Both the midi and conventional groups achieved clinically meaningful and comparable improvements in VAS, IKDC, and Tegner scores. The smaller gains in the multiple mini-incision group may be related to increased surgical manipulation and neurosensory symptoms, but this is hypothesis-generating and requires prospective confirmation.

Study Limitations

This study has several limitations. The most critical limitation is the complete absence of meniscal healing and repair-failure endpoints: no second-look arthroscopy, magnetic resonance imaging confirmation, recurrent-tear assessment, revision-surgery tracking, or structural integrity evaluation were performed. Because meniscal healing is the definitive measure of repair success, the favorable VAS, IKDC, and Tegner results reported here reflect symptomatic and functional improvement only and must not be interpreted as evidence of successful biological healing or durable structural repair (22-24). Therefore, All comparative conclusions regarding incision techniques apply solely to perioperative safety and short- to mid-term functional outcomes, and not to the durability of the repair. Additional limitations include a retrospective, non-randomized design with surgeon-dependent technique selection, which may have introduced selection bias and unmeasured confounding; the single-center setting and inter-surgeon variability, which limit generalizability; reliance on clinical evaluation and patient-reported outcomes to ascertain neurological complications without routine electrophysiological testing; underpowered for rare events (only 9 neurological complications overall), therefore the numerical trend toward more neurological complications in the multiple mini-incision group (8.8% vs. 1.7% and 3.1%) should be interpreted cautiously; a multivariable model with a limited covariate set that did not adjust for meniscus side, tear zone (posterior horn vs. midbody), number of sutures, or individual surgeon; the unusually high R^2 (0.915) in the ANCOVA, which likely reflects a homogeneous population; and mid-term follow-up that did not allow evaluation of long-term function or healing rates.

CONCLUSION

In this retrospective cohort, the single 2-3 cm midi-incision technique for inside-out meniscal repair was associated with no statistically significant difference in overall complication rates compared with the conventional major-incision technique, while demonstrating shorter operative time

and a numerically lower rate of neurological complications than the multiple mini-incision technique. These findings suggest that the midi-incision approach may be a promising alternative to the conventional major incision; however, the retrospective, non-randomized design of this study precludes definitive conclusions regarding equivalence in safety. Prospective randomized studies with formal equivalence or non-inferiority designs, incorporating meniscal healing endpoints, are warranted to confirm these preliminary observations.

ETHICS

Ethics Committee Approval: The study protocol was approved by the Erzurum University Faculty of Medicine Scientific Researchs Ethics Committee (approval no: 288, date: 12.11.2025).

Informed Consent: Due to the retrospective nature of the study, the ethics committee waived the requirement for study-specific informed consent. Routinely obtained preoperative surgical consent forms were relied upon for all patients.

FOOTNOTES

Authorship Contributions

Surgical and Medical Practices: N.A., F.E.T., Concept: E.Ö., E.D., Design: N.A., F.E.T., Data Collection or Processing: N.A., E.Ö., Analysis or Interpretation: E.Ö., E.D., Literature Search: E.D., F.E.T., Writing: N.A., E.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declare that this study received no financial support.

REFERENCES

1. Nelson CG, Bonner KF. Inside-out meniscus repair. Arthrosc Tech. 2013;2:e453-60.
2. Pareek A, O'Malley MP, Levy BA, Stuart MJ, Krych AJ. Inside-out repair for radial meniscus tears. Arthrosc Tech. 2016;5:e793-7.
3. Kucharik MP, Eberlin CT, Cherian NJ, Summers MA, Martin SD. Using a combined all-inside, inside-out, and outside-in technique to repair bucket-handle medial meniscal tears without a safety incision. Arthrosc Tech. 2023;12:e1065-73.
4. Moran J, LaPrade CM, LaPrade RF. Inside-out repair of medial meniscal ramp lesions in patients undergoing anterior cruciate ligament reconstruction. JBJS Essent Surg Tech. 2024;14:e22.00037.
5. Alhelali HA, Hassan AS 4th, ALZahrani FA, Aljubayri AA, Aljubairy AA, Alalasi A, et al. Comparing surgical techniques for meniscal tears: a systematic review of radiographic and functional outcomes. Cureus. 2023;15:e51239.
6. Screpis D, Qordja F, De Berardinis L, Piovan G, Magnanelli S, Amarossi A, et al. Saving the meniscus: a retrospective observational study of the incidence, treatment, and failure rate of the main meniscal tear types at 24-month follow-up. J Clin Med. 2025;14:3350.
7. Miller AC, Batiste AJ, McQuivey KS, McCarty EC. All-inside versus inside-out suture techniques in athletes undergoing arthroscopic meniscal repair: a systematic review and meta-analysis. Orthop J Sports Med. 2025;13:23259671251361488.
8. Beaufils P, Becker R, Kopf S, Englund M, Verdonk R, Ollivier M, et al. Surgical management of degenerative meniscus lesions: the 2016 ESSKA meniscus consensus. Knee Surg Sports Traumatol Arthrosc. 2017;25:335-46.
9. Abrams GD, Frank RM, Gupta AK, Harris JD, McCormick FM, Cole BJ. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. Am J Sports Med. 2013;41:2333-9.
10. Nepple JJ, Dunn WR, Wright RW. Meniscal repair outcomes at greater than five years: a systematic literature review and meta-analysis. J Bone Joint Surg Am. 2012;94:2222-7.
11. Sarraj M, Coughlin RP, Solow M, Ekhtiari S, Simunovic N, Krych AJ, et al. Anterior cruciate ligament reconstruction with concomitant meniscal surgery: a systematic review and meta-analysis of outcomes. Knee Surg Sports Traumatol Arthrosc. 2019;27:3441-52. Erratum in: Knee Surg Sports Traumatol Arthrosc. 2019;27:3453.
12. Baratz ME, Fu FH, Mengato R. Meniscal tears: the effect of meniscectomy and of repair on intraarticular contact areas and stress in the human knee. A preliminary report. Am J Sports Med. 1986;14:270-5.
13. Dunaway DJ, Steensen RN, Wiand W, Dopirak RM. The sartorial branch of the saphenous nerve: its anatomy at the joint line of the knee. Arthroscopy. 2005;21:547-51.
14. Patterson DC, Cirino CM, Gladstone JN. No safe zone: the anatomy of the saphenous nerve and its posteromedial branches. Knee. 2019;26:660-5.
15. Medvecky MJ, Noyes FR. Surgical approaches to the posteromedial and posterolateral aspects of the knee. J Am Acad Orthop Surg. 2005;13:121-8.
16. Barber FA, Herbert MA, Richards DP. Load to failure testing of new meniscal repair devices. Arthroscopy. 2004;20:45-50.
17. Mahadeva HN, Tantry R, Dasari A, Devendrappa A, Reddy N, Shahid M. Evaluation of functional outcomes after arthroscopic all-inside meniscal repair. Cureus. 2026;18:e104075.
18. Kurzweil PR, Lynch NM, Coleman S, Kearney B. Repair of horizontal meniscus tears: a systematic review. Arthroscopy. 2014;30:1513-9.
19. Vint H, Quartley M, Robinson JR. All-inside versus inside-out meniscal repair: a systematic review and meta-analysis. Knee. 2021;28:326-37.
20. Beaufils P, Pujol N. Management of traumatic meniscal tear and degenerative meniscal lesions. Save the meniscus. Orthop Traumatol Surg Res. 2017;103:S237-44.
21. Miao Y, Yu JK, Ao YF, Zheng ZZ, Gong X, Leung KK. Diagnostic values of 3 methods for evaluating meniscal healing status after meniscal repair: comparison among second-look arthroscopy, clinical assessment, and magnetic resonance imaging. Am J Sports Med. 2011;39:735-42.
22. Choi BS, Won J, Han HS. Augmentation with bone marrow aspirate harvested from the iliac crest for horizontal or radial meniscal tears yields favorable healing rates in magnetic resonance imaging and clinical outcomes. Clin Orthop Surg. 2024;16:897-905.
23. Pujol N, Giordano AO, Wong SE, Beaufils P, Monllau JC, Arhos EK, et al. The formal EU-US Meniscus Rehabilitation 2024 Consensus: an ESSKA-AOSSM-AASPT initiative. Part I-Rehabilitation management after meniscus surgery (meniscectomy, repair and reconstruction). Knee Surg Sports Traumatol Arthrosc. 2025;33:3002-13.
24. Pelletier S, Djebara A, Freychet B, Carnessechi O, Graveleau N, Louis ML, et al.; Francophone Arthroscopy Society (SFA). Medial meniscal repair in stable knees: Survival rate and risk factors for failure at a minimum of 5 years. Orthop Traumatol Surg Res. 2023;109:103681.