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No clinical differences between outside-in and all-inside techniques in medial meniscus repair: emphasizing Minimal Clinically Important Difference (MCID) -based outcomes

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Abstract

Background While the all-inside (AI) technique is widely preferred for its simplicity and efficiency, the outside-in (OI) method is less commonly used. Despite both techniques being effective, direct comparisons of their functional outcomes are limited. This study aims to compare the clinical efficacy of OI and AI repair techniques for zone-3 and zone-4 medial meniscus tears, emphasizing outcomes based on the Minimal Clinically Important Difference (MCID). We hypothesized that there would be no significant difference in outcomes between the two techniques.

Methods A retrospective cohort study was conducted on 93 patients (mean age: 37.6 ± 11.8 years) with isolated zone-3 or zone-4 medial meniscus tears treated between 2020 and 2023. Patients were divided into two groups: OI ($n = 63$) and AI ($n = 30$), with all surgeries performed by two experienced orthopedic surgeons. Clinical outcomes were assessed using the International Knee Documentation Committee (IKDC) score, Knee Injury and Osteoarthritis Outcome Score (KOOS), and Tegner-Lysholm Knee Scoring Scale (TLKS) at a minimum follow-up of 6 months. The MCID was calculated using the 0.5 standard deviation method. Statistical analyses included ANCOVA to adjust for age-related differences, with significance set at $p < 0.05$.

Results Both OI and AI techniques resulted in significant improvements in IKDC, KOOS, and TLKS scores, surpassing MCID thresholds for all measures ($p < 0.001$). No significant differences were observed between the two groups in terms of functional outcomes ($p > 0.05$). The OI group utilized significantly fewer sutures (median: 1 [1–4] vs. 2 [1–7]; $p < 0.001$) and had a higher, though not statistically significant, complication rate (11% vs. 0%; $p = 0.092$). All complications were observed in the OI group, including saphenous nerve palsy and septic arthritis.

Conclusion Both outside-in and all-inside techniques offer comparable clinical improvements in the repair of zone-3 and zone-4 medial meniscus tears, achieving success defined by MCID thresholds. The outside-in group used fewer sutures and exhibited a slightly higher complication rate, although this difference was not statistically significant.

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These findings support similar clinical outcomes for both techniques and may help guide surgical decision-making based on individual cases and surgeon experience.

Keywords Medial meniscus tear, Outside-in repair, All-inside repair, Minimal clinically important difference

Introduction

Meniscal tears are among the most common knee joint pathologies, with an estimated annual incidence of 60–70 per 100,000 people, predominantly affecting males [3]. The meniscus plays a critical role in joint congruity, stabilization, shock absorption, and load transmission within the tibiofemoral joint. Approximately 60% of tibiofemoral load is transmitted through the meniscus [17]. Previous studies have demonstrated that the meniscus tears or absence of meniscus accelerates the progression of knee osteoarthritis (KOA), particularly in medial meniscus tears [2, 23]. Consequently, preserving the integrity of the meniscus through repair techniques is essential to maintaining knee joint function.

The most common medial meniscus repair techniques are all-inside (AI) with arthroscopically used suture devices and inside-out (IO), the sutures are passed through the meniscus and capsule and tied on the outer surface of the capsule. A less frequently employed method is the outside-in (OI), an arthroscopically assisted suture-shuttle method in which the sutures pass through meniscus outside the capsule and are tied to outer surface of the capsule [9, 12, 13]. While the AI technique is time-efficient and technically simple, it requires specialized suturing devices, which increase costs and may not always be available in all settings [16].

Although meniscal repair has shown good clinical outcomes, comparative studies on outside-in versus all-inside repair remain limited [12]. To the best of our knowledge, no previous study has directly compared the clinical outcomes and number of sutures used between OI and AI techniques for medial meniscus repair in zone-3 and zone-4 tears. Therefore, this study aims to compare clinical outcomes between outside-in and all-inside meniscus repair techniques. We hypothesize that there will be no significant differences in clinical outcomes between the outside-in and all-inside meniscus repair techniques for zone-3 and zone-4 medial meniscus tears, in terms of functional recovery, complication rates, and suture efficiency.

Materials and methods

Patient selection and groups

This retrospective study was conducted following approval from the local ethics committee. A total of 93 patients with isolated medial meniscus tears, with tear types recorded, and treated using either the outside-in (OI) or all-inside (AI) technique, were included in the study. Patients were recruited from two different orthopedic clinics.

Inclusion criteria consisted of: Age ≥ 18 years, Isolated medial meniscus tear located in anatomical zone-3 or zone-4 [6, 8, 22], A history of knee pain lasting no longer than three months, Positive meniscus tear signs on physical examination (McMurray test, joint line tenderness, or Apley test), Magnetic resonance imaging (MRI) confirmation of a medial meniscus tear, and surgical repair using either the OI or AI technique.

Exclusion criteria included patients who had previously undergone a surgical procedure on the affected knee, as well as those with a concurrent lateral meniscus tear, medial meniscus posterior root tear, or varus malalignment, which is defined as hip-knee angle < 175. Additionally, patients with grade 3 or 4 cartilage damage, multiple ligament injuries, anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) injuries, and those younger than 18 years or older than 65 years were excluded from the study. All meniscal repairs were performed by two experienced orthopedic surgeons, each exclusively using one technique—outside-in (first author) or all-inside (third author)—both with over five years of experience in arthroscopic knee surgery, between 2020 and 2023, with a minimum follow-up of six months. Patients were divided into two groups (OI and AI) based on the technique used for meniscus repair (Fig. 1).

Surgical techniques

OI meniscal repair was performed in 63 cases, while AI meniscal repair was performed in 30 cases. A 16-gauge intravenous (IV) cannula and 2.0 non-absorbable Prolene sutures were prepared. A standard 16-gauge IV cannula needle was inserted through the skin into the medial compartment of the knee joint using transillumination for guidance. Once the needle penetrated the capsule and passed through the meniscal tear—according to the planned suture configuration (vertical or horizontal mattress)—the Prolene sutures were retrieved to the outer surface of the knee via the anteromedial portal.

The Fiber-Wire knot was secured to the loop of the 2.0 Prolene suture and advanced to the posterior aspect of the knee. Subsequently, a small incision and tunnel were created on the capsule. A 16-gauge needle was then inserted through the pre-formed tunnel and directed appropriately toward the meniscal tear. The 2.0 Prolene suture within the needle was retrieved through the anteromedial portal to the anterior surface of the knee. The Prolene loop was tied to the anterior end of the 2.0

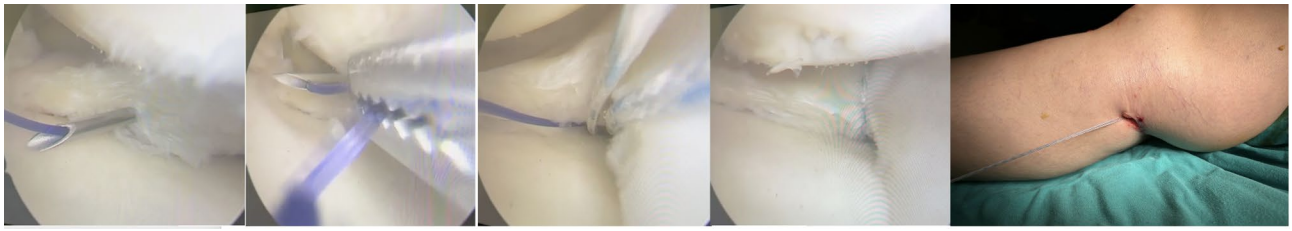


Fig. 1 Illustrates the outside-in suture shuttle repair technique, utilizing a 16-gauge intravenous cannula and a small posteromedial knee incision

Fiber-Wire and transported back to the posteromedial aspect of the knee (Fig. 1).

In the final step, the Fiber-Wire was securely tied and fixed to the outer surface of the capsule [5, 13].The AI meniscus repair technique was performed using a preloaded meniscal repair device (FasT-Fix), which was inserted through the working portal. The first suture anchor was deployed inside the joint to secure the meniscal tissue, followed by the placement of the second anchor at the desired location. Finally, the pre-tied sliding knot was tightened to approximate the tear edges [1].

Data collection

Additionally, demographic characteristics, including age, sex, history of previous knee surgeries, and tear zone location, were recorded. Postoperative complications such as deep vein thrombosis, saphenous nerve palsy, septic arthritis, or medial knee pain requiring second-look surgery were also documented.

At a minimum follow-up of six months postoperatively, patients completed a subjective questionnaire to assess clinical outcomes at the last follow-up. The evaluation included the Knee Injury and Osteoarthritis Outcome Score (KOOS), the Tegner-Lysholm Knee Scoring Scale (TLKS), and the International Knee Documentation Committee (IKDC) score. Clinical outcomes were analyzed using the Minimal Clinically Important Difference (MCID) values for each measure [15].

Rehabilitation

During the first three weeks, knee flexion was restricted to 90°, with full extension being the primary goal. Patient mobilized with knee brace and double crutches. Weight-bearing was not permitted during this period. Early rehabilitation exercises included straight leg raises, hip abduction, and ankle pumps. From week 3 to week 6, partial weight-bearing was gradually introduced, and range of motion (ROM) and stretching exercises were performed to achieve at least 120° of knee flexion. The knee brace lock was removed as stability improved. After week 6, the use of the brace and crutches was discontinued. Stationary cycling was initiated to facilitate the transition to functional activities. Strengthening exercises were progressively advanced to improve muscle endurance and joint stability. Patients were advised to return to unrestricted sports activities between 4 and 6 months postoperatively, depending on individual recovery and adherence to the rehabilitation protocol.

Statistical analysis

Data analysis was performed using ''IBM SPSS Statistics 26''. Categorical independent variables were presented as frequencies and percentages with cross-tabulations. Their distributions were compared using ''Chi-Square Test'' or ''Fisher's Exact Test'' method. The suitability of continuous variables for normal distribution was investigated using graphical examination (Q-Q Plot), normality tests (Shapiro-Wilk) and sample size. Independent group comparisons of variables conforming to normal distribution were made with the ''t test'' and presented with mean and standard deviation. For variables not conforming to normal distribution, the ''Mann Whitney'' test was used and presented with median (min-max). For the difference in measurements taken before and after surgery, ANCOVA analysis was performed for repeated measurements in the comparisons between the groups and correction was made according to age, crude and estimated marginal means were used to assess the patient reported outcomes pre- and post-operatively. Adjusted means are presented. Effect sizes are presented as partial eta squared. In all statistical comparison tests, type-1 error margin was determined as α:0.05 and tested as two-tailed. The MCID was calculated using a distribution-based approach, employing the 0.5 standard deviation (SD) method for each outcome measure (IKDC, KOOS, TLKS). Preoperative SD values were used to determine MCID thresholds for both the outside-in (OI) and all-inside (AI) groups [25].

Results

Demographics and meniscus injury types

Between 2020 and 2023, a total of 93 patients met the eligibility criteria for inclusion in this study. The cohort consisted of 64 males and 29 females, with a mean age of 37.6 ± 11.8 years (range: 18–66 years) and a mean follow-up period of 20.4 ± 11.3 months (range: 7–47.9 months) (Table 1).

Regarding tear location, 49 patients (52.7%) had zone-4 posterior horn medial meniscus tears, 9 patients (9.7%)

Table 1 Patients demographics and characteristics by meniscal anatomic tear zones

	Total (*N*:93)		**OI (*n*:63)**		**AI (*n*:30)**		***p***
Sex. $_{N\%}$							
Male	64	69%	43	68%	21	70%	1.000
Female	29	31%	20	32%	9	30%	
Age. $_{Mean\pm SD}$	37.6 ± 11.8		40.1 ± 11.8		32.4 ± 10.1		0.004
Micro fracture. $_{N\%}$							
Yes	23	25%	21	33%	2	7%	0.011
No	70	75%	42	67%	28	93%	
Meniscus tear zone. $_{N\%}$							
Zone 3	9	10%	4	6%	5	17%	0.287
Zone 4	38	41%	27	43%	11	37%	
Zone 3 & Zone 4	46	49%	32	51%	14	47%	
-Vertical Zone 3	6	6%	3	5%	3	10%	na
-Vertical Zone 4	30	32%	27	43%	3	10%	
-Horizontal Zone 3	1	1%	0	0%	1	3%	
-Horizontal Zone 4	7	8%	0	0%	7	23%	
-Horizontal Zone 3 & Zone 4	13	14%	13	21%	0	0%	
-Radial Zone3	2	2%	1	2%	1	3%	
-Radial Zone 4	1	1%	0	0%	1	3%	
-Bucket handle Zone 3 & Zone 4	24	26%	10	16%	14	47%	
-Parrot beak Zone 3 & Zone 4	4	4%	4	6%	0	0%	
-Complex Zone3 &Zone 4	5	5%	5	8%	0	0%	
Number of sutures. $_{N\%}$							
1	59	63%	56	89%	3	10%	< 0.001
2	18	19%	4	6%	14	47%	
> 2	16	17%	3	5%	13	43%	
Number of sutures. $_{Med.\ (min–max)}$	1 (1–7)		1 (1–4)		2 (1–7)		< 0.001
Follow-up (mos). $_{Med.\ (min–max)}$	17 (7–48)		16 (7–48)		24 (11–44)		0.004
Complications. $_{N\%}$							
Yes	7	8%	7	11%	0	0%	0.092
No	86	92%	56	89%	30	100%	
-Saphenous palsy	4	4%	4	6%	0	0%	na
-Medial knee pain	1	1%	1	2%	0	0%	
-Saphenous palsy. medial knee pain	1	1%	1	2%	0	0%	
-Septic arthritis	1	1%	1	2%	0	0%	
-No	86	92%	56	89%	30	100%	
Return to work (mos). $_{Med.\ (min–max)}$	3 (2–11)		3 (2–11)		4 (3–6)		0.291

had zone-3 medial collateral region tears, and 35 patients (37.6%) had combined zone-3 and zone-4 medial meniscus tears. All 93 patients underwent isolated medial meniscus repair. Additionally, 23 patients (24.7%) with grade 2 chondral injuries underwent combined meniscal repair and microfracture treatment (21 in the OI group and 2 in the AI group; $p = 0.01$) (Table 1).

There were no significant differences between the two study groups in terms of sex ($p = 1.0$). Patient demographics and clinical characteristics are summarized in Table 1.

Analysis by anatomic region and types of meniscal tear

Overall, there was no significant difference in the distribution of meniscal tear types (vertical, horizontal, parrot-beak, and bucket-handle tears) between the two repair groups (Table 1, p = N/A). Specifically, 30 patients (32.3%) had vertical tears, 24 patients (25.8%) had bucket-handle tears, and 20 patients (21.5%) had horizontal tears.

Additionally, there was no statistically significant difference in the distribution of tears across the three anatomical zones ($p = 0.28$, Table 1).

Regarding suture usage, in the OI group, 56 patients (89%) underwent meniscus repair with a single suture, whereas in the AI group, only 3 patients (10%) had a single suture repair. The median number of sutures used was 1 (range: 1–4) in the OI group and 2 (range: 2–7) in the AI group, with a statistically significant difference between groups ($p < 0.001$, Table 1).

In Table 2, with statistical difference in age between OI and AI groups.

Patient-reported outcome scores significantly improved from preoperative to postoperative assessments in all

Table 2 Crude and estimated marginal means

Factor	Operation	Group	*N*	Measured Values		Adjusted Values		
				Mean	S.D.	Mean*	S.E.	95% CI
IKDC	Preop	OI	63	50.7	7.6	50.9	0.9	[49.1–52.6]
		AI	30	48.5	5.0	48.2	1.3	[45.6–50.7]
		Total	93	50.0	6.9	49.5	0.8	[48.0–51.0]
	Postop	OI	63	76.0	8.3	76.6	1.1	[74.4–78.7]
		AI	30	78.2	9.8	77.1	1.6	[73.8–80.3]
		Total	93	76.7	8.9	76.8	1.0	[74.9–78.7]
TLKS	Preop	OI	63	59.7	9.5	60.0	1.2	[57.7–62.4]
		AI	30	57.8	8.7	57.2	1.7	[53.8–60.7]
		Total	93	59.1	9.3	58.6	1.0	[56.6–60.7]
	Postop	OI	63	85.0	8.1	85.6	1.0	[83.6–87.6]
		AI	30	83.7	8.8	82.5	1.5	[79.5–85.5]
		Total	93	84.6	8.3	84.0	0.9	[82.3–85.8]
KOOS	Preop	OI	63	49.3	6.0	49.3	0.8	[47.8–50.8]
		AI	30	52.4	5.5	52.3	1.1	[50.1–54.5]
		Total	93	50.3	6.0	50.8	0.7	[49.5–52.1]
	Postop	OI	63	75.5	10.8	76.1	1.3	[73.5–78.7]
		AI	30	79.5	9.6	78.3	1.9	[74.5–82.1]
		Total	93	76.8	10.5	77.2	1.1	[75.0–79.5]

*Covariates appearing in the model are evaluated at the following values: Age = 37.624

patients, regardless of the surgical technique (Fig. 2) ($p < 0.01$).

As outlined in Table 3, a comprehensive continuous variable analysis was conducted to compare patient-reported outcomes between the two repair techniques. The improvement in subjective outcome scores from preoperative to postoperative assessments met the Minimal Clinically Important Difference (MCID) thresholds for TLKS, IKDC, and KOOS, demonstrating clinically meaningful recovery in both groups (Table 4).

Complications

Postoperative complications were observed in 7 patients (7%), with the following distributions: persistent medial knee pain in 1 patient (1.1%), persistent medial knee pain with saphenous nerve palsy in 1 patient (1.1%), septic arthritis in 1 patient (1.1%), and isolated saphenous nerve palsy in 4 patients (4.3%) (Table 1).

Notably, all complications occurred in Group 1. Among these cases, two patients required secondary surgical intervention: one underwent arthroscopic debridement for septic arthritis, and another underwent high tibial osteotomy for persistent medial knee pain.

The mean preoperative and postoperative TLKS, IKDC, and KOOS scores improved significantly in both groups. The MCID threshold (0.5 SD method) was achieved for all three outcome measures.

- TLKS improved from 59.75 to 85.00, with an MCID of 4.75, surpassing the minimal threshold (64.50) and upper threshold (80.25).
- IKDC increased from 50.73 to 76.04, with an MCID of 3.78, exceeding both the lower (54.51) and upper (72.26) thresholds.
- KOOS showed an improvement from 49.32 to 75.54, with an MCID of 3.01, surpassing the clinically significant range (52.33–72.53).

These findings indicate that both techniques provided meaningful functional improvements, as all patients met or exceeded the MCID criteria for clinical significance.

Discussion

The most significant finding of this study was that both the outside-in (OI) and all-inside (AI) meniscus repair techniques resulted in significant clinical improvement, as evidenced by IKDC, KOOS, and TLKS scores meeting the Minimal Clinically Important Differences (MCID) thresholds. This indicates that both techniques are clinically effective options for treating zone-3 and zone-4 medial meniscus tears.

Previous studies evaluating OI and AI techniques focused on functional scores without incorporating MCID as an objective threshold [10, 11]. Previous MCID reports have demonstrated that a more comprehensible shared decision-making process is facilitated between the surgeon and the patient regarding treatment expectations [4]. To our knowledge, this study is among the first to provide evidence that both techniques lead to not only statistically significant clinical outcomes but also provide clinically meaningful improvements, reinforcing their

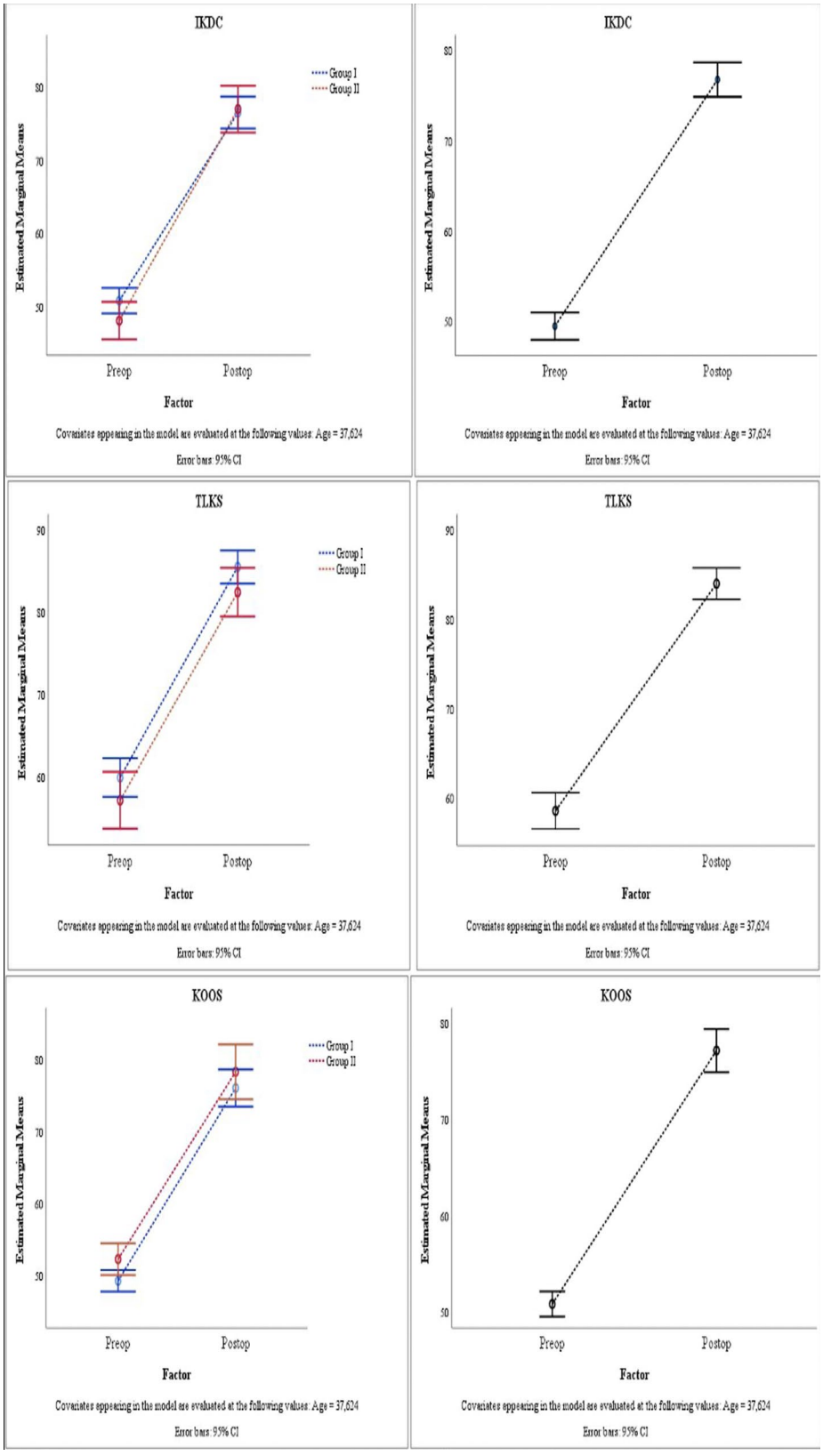


Fig. 2 Group 1 Outside-in repair. Group 2. All-inside repair group Covariates appearing in the model evaluated at the following values age: 37.624, all three scores IKDC (International Knee Documentation Committee), TLKS (Tegner Lysholm Knee Scoring Scale), KOOS (Knee injury and Osteoarthritis Outcome Score). The figures demonstrated pre-operatively scores increased improvingly than post-operatively outcome scores. Also there was no significant differences between groups

Table 3 Tests of Within-Subjects effects, repeated measure ANCOVA

	Source	Type III Sum of Squares	df	Mean Square	F	*P*	Effect Size η2
IKDC	Factor[¥]	4382	1	4382	86.49	**< 0.001**	0.490
	Factor * Age	142	1	142	2.81	0.097	0.030
	Factor * OI&AI	94	1	94	1.86	0.176	0.020
	Error (Factor)	4560	90	51			
TKLS	Factor[¥]	3589	1	3589	68.79	**< 0,001**	0.433
	Factor * Age	88	1	88	1.69	0,197	0.018
	Factor * OI&AI	1	1	1	0.02	0,898	0.000
	Error (Factor)	4696	90	52			
KOOS	Factor[¥]	4741	1	4741	89.96	**< 0.001**	0.500
	Factor * Age	272	1	272	5.16	**0.025**	0.054
	Factor * OI&AI	5	1	5	0.10	0.752	0.001
	Error (Factor)	4743	90	53			

η^2 effect size ranges as small (0.01–0.06), medium (0.06–0.14), and large effects (> 0.14)

[¥] Factor= (Preop-Postop) Difference, statistically significant p<0.05

Table 4 MCID

Score	Preop Mean	Postop Mean	SD	MCID (0.5 SD)	Lower Threshold	Upper Threshold
TLKS	59.75	85.00	9.505	4.75	64.50	80.25
IKDC	50.73	76.04	7.556	3.78	54.51	72.26
KOOS	49.32	75.54	6.018	3.01	52.33	72.53

role as viable treatment options for medial meniscus tears [18, 19, 21].

Additionally, the number of sutures used differed significantly between the two techniques, with OI requiring fewer sutures than AI ($p < 0.001$). Previous reports on bucket-handle meniscus tears have emphasized that stability, rather than the number of sutures, is the key determinant of successful repair outcomes [7, 14, 24]. Although earlier studies have reported favorable results with the outside-in (OI) technique [9, 12]our findings suggest that comparable clinical stability can be achieved with fewer sutures, potentially reflecting surgical preference. While this may offer advantages in terms of procedural simplicity.

The outside-in (OI) technique has not been widely utilized in previous reports and is less commonly employed compared to the all-inside (AI) technique. One of the key considerations in OI repair is the requirement for an additional incision, which may increase surgical complexity [12, 18, 20]. Additionally, although the complication rate in the OI group was slightly higher than in the AI group, this difference did not reach statistical significance.

This study highlights the clinical effectiveness of both outside-in (OI) and all-inside (AI) meniscus repair techniques, with both achieving MCID-defined improvements in functional outcomes. These findings indicate that both techniques can be safely utilized, offering flexibility in technique selection based on surgeon preference and experience. Despite requiring an additional incision, OI showed a higher complication rate ($p = N/A$), particularly saphenous palsy, warrants careful patient selection, reinforcing its viability as a practical and economical alternative for treating zone-3 and zone-4 medial meniscus tears.

As a retrospective study and the unequal sample sizes between groups, this research is inherently subject to some limitations. Although the 6-month follow-up period is sufficient for isolated meniscus healing, it still represents a limitation in evaluating long-term clinical and functional outcomes. Furthermore, all procedures were performed by two experienced surgeons, which, while ensuring surgical consistency, may limit the generalizability of the findings to a broader population and introduce potential bias, as each technique was performed by a different surgeon. Additionally, the lower number of sutures used in the OI group reflects surgeon preference and experience rather than a standardized protocol, which may influence the interpretation of technique-related efficiency. There was a difference in the rate of microfracture procedures between groups, which appears to reflect surgeon preference rather than a standardized indication. This variation should be considered a potential limitation when interpreting the comparative outcomes.

Although our sample size was statistically sufficient, larger multicenter studies are needed to further validate our findings and improve their generalizability across diverse clinical settings. Additionally, long-term prospective, randomized controlled trials are warranted to compare the functional and radiological outcomes of AI and OI techniques beyond six months. Further research

should also explore strategies to minimize the risk of nerve injury associated with OI repair. Expanding the current body of evidence through multi-center collaborations and larger cohorts will provide more robust data to guide surgical decision-making and optimize patient outcomes in meniscus repair.

Conclusion

Both outside-in and all-inside techniques provided comparable improvements in the repair of zone-3 and zone-4 medial meniscus tears, with all outcome measures meeting MCID-defined thresholds for clinical benefit. The outside-in group required fewer sutures and showed a trend toward a higher complication rate, although this was not statistically significant. These findings may assist surgeons in selecting repair techniques based on individual case factors and clinical experience.

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Clinical trial registration
Not applicable.

Authors' contributions
The authors would like to the valuable contributions of their colleagues in the completion of this study. C.A. contributed to the manuscript writing and data organization, while Ç.C. played a key role in the manuscript writing process and the planning of the study methodology. A.S. supported the planning of the methodology and was involved in organizing the data. Ş.K. assisted in data organization and the evaluation of functional scores. D.A. and V.A was responsible for statistical analysis and manuscript formatting. G.C. contributed to data organization, provided statistical input, and prepared the visual materials. Finally, T.A. supported data organization. The authors sincerely appreciate their collective efforts, which significantly enhanced the quality and depth of this research.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee of Eskişehir City Hospital (Approval No: ESH/BAEK 2024/57, Date: 17.10.2024). All procedures were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Consent for publication
Written informed consent for publication was obtained from all participants included in this study.

Competing interests
The authors declare no competing interests.

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