

All-Inside Versus Inside-Out Suture Techniques in Athletes Undergoing Arthroscopic Meniscal Repair

A Systematic Review and Meta-analysis

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Background: Meniscal tears are a common knee injury in athletes, necessitating effective repair techniques. Despite the prevalence of meniscal tears, there is limited literature comparing the efficacy of the 2 primary suture methods—all-inside and inside-out—in the athletic population.

Purpose: To evaluate the postoperative outcomes and failure rates of the all-inside versus inside-out suture techniques in meniscal repairs among athletes.

Study Design: Systematic review; Level of evidence, 4.

Methods: Using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, a comprehensive search was conducted across the PubMed, Cochrane, and Embase databases on July 26, 2023, yielding 245 studies, of which 7 were included in this review. Studies reporting postoperative outcomes and failure rates of both suture techniques were included. Failure was defined as the need for subsequent surgery due to a persistent meniscal tear. Outcome measures included the Tegner, Lysholm, and International Knee Documentation Committee scores. Differences between groups and subgroups were assessed using the Welch *t* test and the odds ratio. Wilcoxon tests were used as a sensitivity analysis to confirm the results of the Welch *t* tests. Heterogeneity was assessed with the I^2 statistic and the Bartlett test. All statistical analyses were done using R.

Results: Seven studies—published between 2009 and 2023—met the inclusion criteria, including 469 operations in 458 patients. A total of 199 operations used the all-inside technique, and 270 operations used the inside-out technique. Of the 469 operations, 377 had documentation on laterality (medial meniscal repair versus lateral meniscal repair), with 167 patients undergoing medial meniscal repair and 210 patients undergoing lateral meniscal repair. Each all-inside repair was done with the Fast-Fix device. The all-inside technique showed a statistically significant increase in failure rate compared with the inside-out technique (23.1% vs 12.2%; $P = .003$). This trend was exaggerated in all-inside repairs for the medial meniscus versus the lateral meniscus (58.1% vs 11.8%; $P = 2.6 \times 10^{-5}$). When excluding all radial tears, the all-inside technique again had an increased rate of failure compared with the inside-out repairs (20.7% vs 8.3%; $P = .01$). No significant difference was found in postoperative Tegner scores between all-inside and inside-out repairs (5.9 vs 6.5; $P = 0.45$).

Conclusion: Our review demonstrated that medial meniscal repairs with the all-inside technique using the Fast-Fix device had a higher failure rate compared with those with the inside-out technique; this trend is not seen for lateral meniscal repairs. Based on the findings of this study, surgeons should consider the inside-out technique first for athletic patients presenting with medial meniscal tears who want to return to their sport. Given the limited scope of existing studies combined with more recent utilization of novel all-inside meniscal repair devices that may not be captured in the present study, additional high-quality, prospective studies in this area are needed to validate these findings.

Keywords: all-inside; athlete; inside-out; meniscal repair; meniscal surgery; meniscus

Knee injuries are among the most predominant injuries in athletes, accounting for about 2.5 million adolescent sports-related emergency department visits annually in the United States.¹⁹ Meniscal injuries are the second most frequent type of knee injury, with a prevalence rate of 61 per 100,000 individuals.^{13,36} A healthy, intact meniscus is essential to an athlete's mobility and performance.¹⁸ As such, effective repair strategies are essential in preserving native joint kinematics and optimizing long-term joint health.

Despite the development of several novel repair techniques, an ongoing debate exists concerning optimal repair, especially in athletes. The 2 most common surgical methods for a meniscal tear are the all-inside and inside-out techniques.^{23,27} The all-inside method is effective and long-lasting; nevertheless, recent studies indicate that the inside-out method could be more effective and durable.¹⁷ Although widely regarded as the gold standard, the inside-out technique is a more invasive procedure that requires an additional posteromedial or posterolateral incision.²⁷ However, it has been shown to be more effective and reproducible in some studies.³⁹

While each technique has been heavily studied, there is a paucity of literature that compares the postoperative outcomes and failure rates of both methods, specifically in an athletic population. This comparison is important in athletes, as this population is exposed to significantly higher loads, stresses, and strain, predisposing them to higher rates of injury when compared with the general population.^{12,16}

This systematic review distinguishes itself from previous research by examining a diverse cohort of athletes, ranging from amateurs to professionals. To the authors' knowledge, no existing studies have explored meniscal repair techniques in such a broad spectrum of athletes, as most research primarily focuses on professionals. By including recreational athletes, this study aimed to provide more generalizable conclusions for the athletic population. In addition, we synthesized return to sports (RTS) data and conducted a subanalysis that excluded studies involving radial meniscal tears because of inconsistencies in their clinical management. This systematic review aimed to compare meniscal repair failures, outcomes (including the Tegner, Lysholm, and International Knee Documentation Committee (IKDC) scores), and RTS metrics of the all-inside versus inside-out suture techniques in meniscal repairs. We hypothesized that, while both the all-inside and inside-out suture techniques would demonstrate similar overall failure rates, the failure rate for repairs of the medial meniscus would be higher, comparable with the lateral meniscus across both techniques.

METHODS

A systematic search was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines⁴⁴ across the PubMed, Cochrane Library, and Embase databases up to January 18, 2024. Two independent reviewers (A.M. and A.B.) were responsible for study selection, and each manually reviewed each article. Inter-reviewer disagreements were brought to the principal investigator (E.M.) for the final decision. We also manually sourced studies and conducted citation analyses to complement our database searches. The following electronic search strategy was used: (all-inside OR inside-out) AND (athletes OR athlete OR sport OR sports) AND (meniscus) AND (arthroscopy OR arthroscopic OR surgery OR surgical). A total of 245 studies were assessed for eligibility based on the inclusion criteria by reviewing their titles and abstracts. Reasons for the exclusion of studies are summarized in Figure 1. The inclusion criteria for this systematic review are as follows: studies involving athletes (professional or amateur) who have undergone arthroscopic meniscal repair; randomized controlled trials; prospective and retrospective cohort studies that investigated the outcomes of arthroscopic meniscal repair using the all-inside or inside-out suture techniques; and studies published in English and available as full-text articles in peer-reviewed journals. The exclusion criteria included nonhuman studies; studies that involved techniques other than the all-inside or inside-out suture technique for meniscal repair; and studies that did not report on failure status for their cohort. Any study with a minimum follow-up of <1 year was excluded. Also, studies involving ramp lesions were excluded because of the inconsistent clinical management of these tears. Patients undergoing revision surgery were also excluded. A standardized form for data extraction was used, allowing the collection of details on study characteristics, outcomes, and potential bias.

For this study, an athlete is defined as any individual (recreational, amateur, or professional) who regularly engages in physical training and participates in organized sports activities. This definition includes individuals of all ages and levels of competition, ranging from high school and college to professional and Olympic-level competitors. In this context, the critical characteristic of athletes is their involvement in physical activities or sports that place significant demands on the knee joint, making them susceptible to meniscal injuries.

Various outcome measures, such as the Tegner, Lysholm, and IKDC scores, are typically used to assess postoperative recovery.^{26,53} The failure rate is another

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Ethical approval was not sought for the present study.

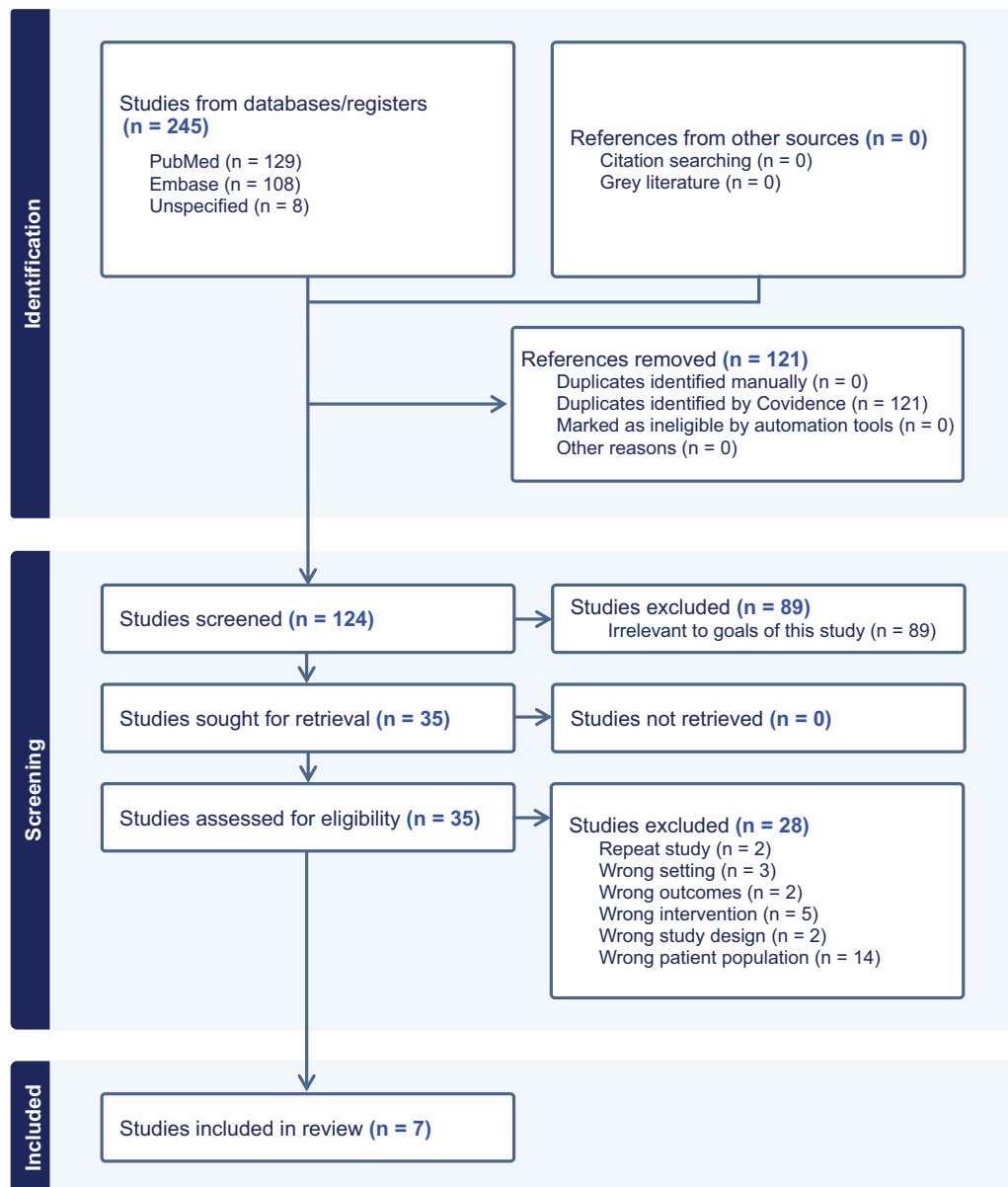


Figure 1. A flowchart of all screened studies included after each round of screening, with reasons for exclusion according to PRISMA guidelines. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

indispensable outcome measure that can be used to gauge the success of either surgical approach. For this study, failure was defined as either a retear of the meniscus at the same site after repair, or any incidence requiring a revision of the original repair due to the patient engaging in their sport. Data on RTS metrics were also gathered. For this study, an athlete successfully returned to sports if they returned to their preoperative level^{3,35,56} or a level that the athlete perceives as satisfactory.⁴²

Bias and Heterogeneity

A qualitative analysis was performed with the methodological index for non-randomized studies (MINORS) scale,

which consists of 12 items.⁵⁰ The first 8 items are designed to evaluate the quality of all studies regardless of study design. Four additional items are added to further examine comparative studies. Each study was assessed by 2 authors independently (A.M. and A.B.).

The included studies did not provide enough comprehensive data to generate a funnel plot to visualize publication bias; thus, the authors of this review relied on a comprehensive search strategy and risk of bias assessment to control for publication bias. A sensitivity analysis was performed using Wilcoxon tests to assess how the conclusions drawn from the data change when using a rank-sum test. The results of the sensitivity analysis can be found at the end of the results section.

TABLE 1
Summary of the Included Studies^a

Study (Year)	Type of Study, Level of Evidence	Surgical Technique	Age, Years	Men, N	Women, N	Failure Rate, %
Alvarez-Diaz et al ³ (2016)	Case series, 4	All-inside	27 (18-37)	29	0	6.7
Borque et al ⁸ (2023a)	Cohort, 3	All-inside	23.15 ± 4.7	100	7	25.2
Borque et al ⁸ (2023b)	Cohort, 3	Inside-out	23.45 ± 5.2	83	2	16.5
Khetan et al ²⁹ (2022)	Case series, 4	Inside-out	23.71 ± 7.8	36	5	4.9
Logan et al ³⁵ (2009)	Case series, 4	Inside-out	23.2 (15-38)	29	13	24.4
Nakayama et al ⁴² (2017)	Case series, 4	Inside-out	22.9 (12-50)	34	12	8.7
Vanderhave et al ⁵⁶ (2011)	Cohort, 3	Inside-out	13.2 ± 2	31	14	3.8
Zimmerer et al ⁶¹ (2018)	Cohort, 4	All-inside	29 (14-49)	40	23	27

^aData are presented as the mean ± SD (range) or mean ± SD, depending on the source paper.

Statistical Analysis. Data were pooled from 7 studies reporting outcomes from meniscal repair surgery. Each meniscal repair was assigned its row, and the repair failure status was set as a binary, with 0 representing no failure and 1 representing a failure. A total of 377 repairs across 5 studies^{8,29,35,42,56} allowed us to pair their meniscal laterality to their surgical technique and failure status. The alpha was set at .05 for all tests. The chi-square test was initially used to establish a significant relationship between the surgical technique and the failure rate. Independent *t* tests were used to determine whether differences in failure rates between groups were significant. The Welch *t* tests were used to assess differences in means across demographic characteristics (mean age), failure rates, and patient-reported outcome (PRO) data because of the heterogeneity of data. Odds ratio (OR) testing was used to determine the relative risk of failure between groups. The Bartlett test was used to determine data heterogeneity. All statistical procedures were executed using the R statistical platform (R Foundation) with various installed packages.^{2,4,34,45,47,52,58,59}

RESULTS

Demographic Characteristics

Seven studies met the inclusion criteria, including 469 operations across 458 patients (382 men, 76 women), with an overall mean age of 23.31 ± 4.6 years (25.56 ± 3 years for the all-inside group and 21.57 ± 4.5 years for the inside-out group (*P* = .11) (Table 1).^{3,8,29,35,42,56,61} A total of 199 (42%) operations used the all-inside technique, and 270 (58%) operations used the inside-out technique (Table 2). Of the 469 operations, 377 had documentation on laterality (medial meniscal repair vs lateral meniscal repair), with 167 (44%) patients undergoing medial meniscal repair and 210 (56%) patients undergoing lateral meniscal repair (Table 3). All included studies utilizing the all-inside technique used the Fast-Fix device (Smith & Nephew). This was not intentionally selected for and is an incidental finding of the included studies; this creates a more homogeneous all-inside treatment group while sacrificing external validity of the findings.

TABLE 2
Summary of the Failure Status by Surgical Technique^a

Technique	No Failure	Failure	Total Number
All-inside	153 (77)	46 (23)	199
Inside-out	237 (88)	33 (12)	270
<i>P</i>	-	.003	-
Total	390 (83)	79 (17)	469

^aData are presented as n (%). Percentages represent the portion of the total in the row.

TABLE 3
Summary of Medial Versus Lateral Repair Events by Surgical Technique^a

Technique	Medial Repair	Lateral Repair	Total Number
All-inside	31 (58)	76 (12)	107 (25)
Inside-out	136 (15)	134 (10)	290 (11)
<i>P</i>	5.4×10^{-5}	.64	-
Total	167 (23)	210 (10)	377 (16)

^aData are presented as n (% of failure).

Risk of Bias Assessment

The range of MINORS scores for the noncomparative studies was 7 to 13 out of 16. The lowest MINORS score was found in the study by Khetan et al.²⁹ The study by Nakayama et al⁴² demonstrated the highest MINORS score. The only comparative study was conducted by Borque et al,⁸ which scored 20 out of a possible 24 points. The MINORS scores are summarized in Table 4.

All-Inside Versus Inside-Out Repair

The overall failure rate across all repairs was 17% (79/469), with a failure rate of 23.1% in the all-inside group and 12.2% in the inside-out repair group (*P* = .003) (Figure 2). Overall, receiving treatment with the all-inside technique resulted in 2.15 times increased odds of failure

TABLE 4
Summary of Risk of Bias for Included Studies According to the MINORS Criteria^a

	Alvarez-Diaz et al ³ (2016)	Borque et al ⁸ (2023)	Khetan et al ²⁹ (2022)	Logan et al ³⁵ (2009)	Nakayama et al ⁴² (2017)	Vanderhave et al ⁵⁶ (2011)	Zimmerer et al ⁶¹ (2018)
1. A clearly stated aim	2	2	2	2	2	2	2
2. Inclusion of consecutive patients	2	2	0	2	2	2	2
3. Prospective collection of data	2	2	0	1	2	2	2
4. Endpoints appropriate to the aim of the study	2	2	2	2	2	2	2
5. Unbiased assessment of the study endpoint	1	1	1	1	1	1	1
6. Follow-up period appropriate to the aim of the study	2	2	2	2	2	2	2
7. Loss to follow-up <5%	1	2	0	2	2	0	1
8. Prospective calculation of the study size	0	0	0	0	0	0	0
9. An adequate control group	N/A	1	N/A	N/A	N/A	N/A	N/A
10. Contemporary groups	N/A	2	N/A	N/A	N/A	N/A	N/A
11. Baseline equivalence of groups	N/A	2	N/A	N/A	N/A	N/A	N/A
12. Adequate statistical analyses	N/A	2	N/A	N/A	N/A	N/A	N/A
Total MINORS score	12	20	7	12	13	11	12
Maximum possible score	16	24	16	16	16	16	16
Legend	Each category was rated on a scale from 0 to 2				2-Reported and adequate	0- Not reported	N/A

^aMINORS, Methodological Index for Non-Randomized Studies; N/A, not applicable.

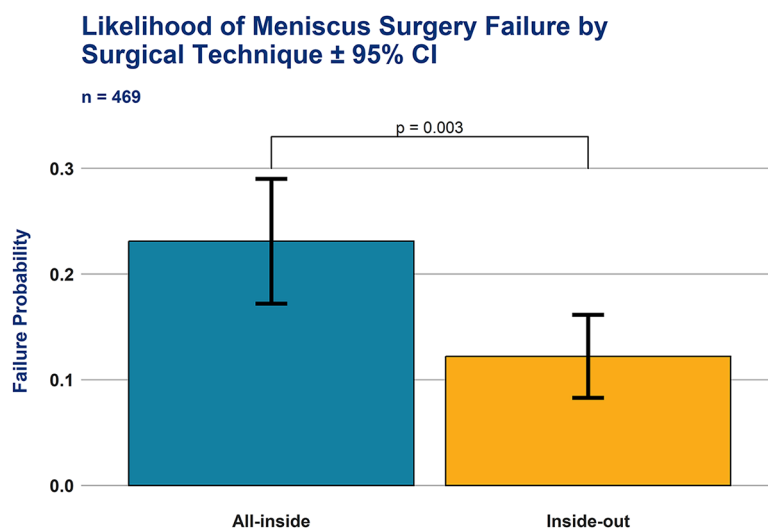


Figure 2. Meniscal repair failure (retear at the site of original repair or any revision of the original repair because of engagement in sports) between all-inside and inside-out techniques.

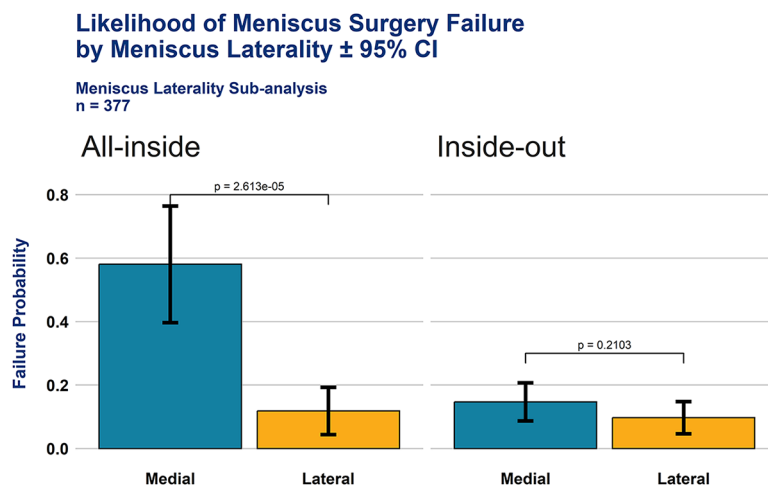


Figure 3. Meniscal repair failure (retear at site of original repair or any revision of the original repair due to engagement in sports) between all-inside and inside-out techniques, with subanalysis of meniscal laterality (medial vs lateral meniscal repair) within these groups.

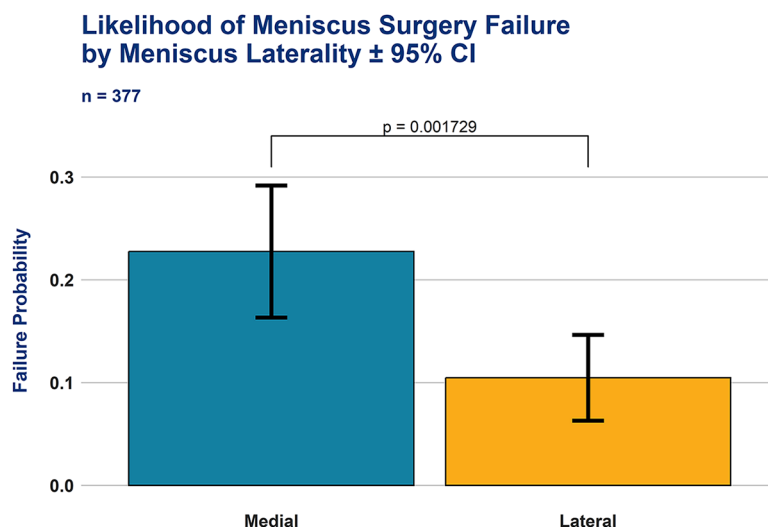


Figure 4. Meniscal repair failure (retear at the site of original repair or any revision of the original repair due to engagement in sports) between medial and lateral repairs.

(OR, 2.15 [95% CI, 1.32-3.55]; $P = .002$; $X^2 = 0.002$) compared with those receiving surgery with the inside-out technique. The effect size for this group was 0.29, with a calculated power of 99%. When each surgical technique was broken down by laterality, there was no significant difference in failure rate between medial and lateral meniscal repairs within the inside-out technique group (14.7% vs 9.7%; $P = .21$) (Figure 3). The effect size for this group was 0.15, with a calculated power of 41%. With the all-inside technique, medial meniscal repairs failed at a significantly higher rate compared with lateral meniscal repairs (58.1% vs 11.8%; $P = 2.6 \times 10^{-5}$). The effect size for this group was 1.20, with a calculated power of 100%. When using the all-inside technique, medial meniscal repairs

are at 7.86 times increased odds of failing compared with lateral meniscal repairs (OR, 7.86 [95% CI, 3.36-19.07]; $P = 2 \times 10^{-6}$; $X^2 = 2 \times 10^{-7}$).

Lateral Meniscal Repairs

Of the 377 patients in whom meniscal laterality was known, 38 medial repairs failed compared with 22 lateral repairs (22.8%, 10.5%; $P = .0017$) (Figure 4). The effect size for this group was 0.36, with a calculated power of 100%. Overall, medial meniscal repairs were at 2.50 times odds of failing (OR, 2.50 [95% CI, 1.42-4.50]; $P = .0014$; $X^2 = 0.0012$). Within the lateral meniscus group, all-inside and

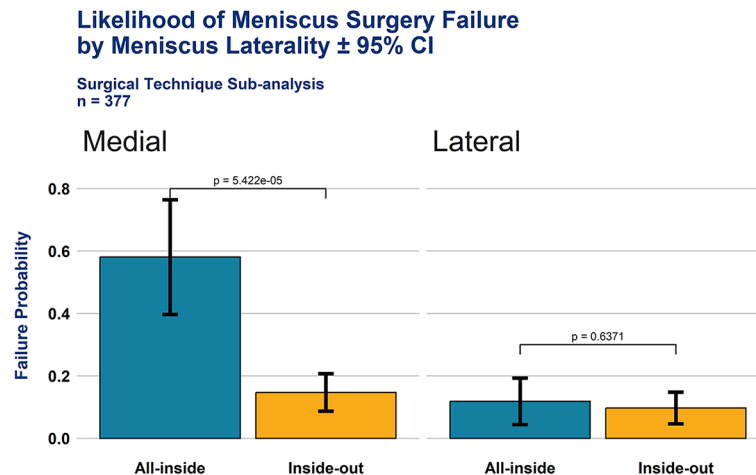


Figure 5. Meniscal repair failure (retear at site of original repair or any revision of the original repair due to engagement in sports) between medial and lateral meniscus groups, with subanalysis of the surgical technique (all-inside vs inside-out) within these groups.

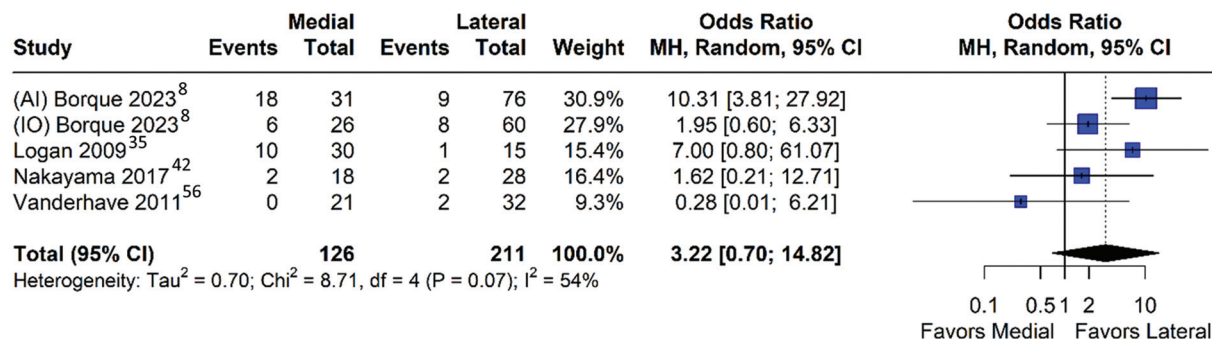


Figure 6. Meta-analysis of studies including both medial and lateral repairs. Borque et al⁸ included both an all-inside group (AI) and an inside-out group (IO). The remaining studies used the inside-out technique. MH, Mantel-Haenszel.

inside-out repairs did not demonstrate different frequency of failures (11.8%, 9.7%; $P = .64$). The effect size for this group was 0.07, with a calculated power of 11%. Within the medial meniscal repair group, the all-inside technique produced significantly more failures than the inside-out technique (58.1%, 14.7%; $P = 5.4 \times 10^{-5}$) (Figure 5). The effect size for this subgroup was 1.12, with a calculated power of 100%. Having a medial meniscus repaired with the all-inside technique puts patients at a 9.9-fold increased risk of failure compared with those repaired with the inside-out technique (OR, 9.91 [95% CI, 3.74-28.4]; $P = 2.2 \times 10^{-6}$; $X^2 = 5.9 \times 10^{-7}$).

Medial Versus Lateral Meta-analysis. Four studies included both medial and lateral repairs and allowed failure frequency within these groups to be determined, and were thus included in this meta-analysis.^{8,35,42,56} Borque et al⁸ used both surgical techniques and split them into 2 entries; all other studies used the inside-out technique. The all-inside variant of the Borque et al study

demonstrated the largest discrepancy favoring lateral meniscal repairs (OR, 10.31 [95% CI, 3.81-27.92]). Vanderhave et al⁵⁶ favored medial meniscal repairs (OR, 0.52 [95% CI, 0.02-13.59]). Overall, lateral meniscal repairs were favored and demonstrated a 3.22-fold reduced odds of failing compared with medial repairs (OR, 3.22 [95% CI, 0.70-14.82]) (Figure 6).

Outcome Measures for All-Inside Versus Inside-Out Repairs

All studies, except for Borque et al,⁸ included information on at least 1 of 3 different PROs: Tegner score, Lysholm score, and IKDC. All scores gathered were taken at the final follow-up time. No significant difference was found in the mean Tegner scores between the all-inside and inside-out techniques (5.9 vs 6.5; $P = .45$). The mean Lysholm score for the inside-out group was 96. The

TABLE 5
Summary of PRO Data^a

Study (Year)	Technique	Total Patients, n	Tegner Score	Lysholm Score	IKDC Score
Alvarez-Diaz et al ³ (2016)	All-inside	29	6.5 (6-9)	-	-
Khetan et al ²⁹ (2022)	Inside-out	85	5.71 ± 1.1	95.89 ± 4.4	92.77 ± 5.31
Logan et al ³⁵ (2009)	Inside-out	6	-	89.6 (87-100)	85.4 (18-100)
Nakayama et al ⁴² (2017)	Inside-out	41	M: 5.7 ± 1.7 L: 6.8 ± 2	M: 98.3 ± 2.2 L: 96.1 ± 5	-
Vanderhave et al ⁵⁶ (2011)	Inside-out	42	8 (6-8)	-	-
Zimmerer et al ⁶¹ (2018)	All-inside	63	5.57 (NR)	-	-
Weighted Mean	All-inside	95	5.9	-	-
	Inside-out	174	6.5	96	92.3
<i>P</i>			.40	N/A	N/A

^aData are presented as mean ± SD^{29,42} or mean (range).^{3,35,56} Zimmerer et al⁶¹ did not report the mean or SD. Nakayama et al⁴² provided data separately for the medial and lateral meniscus. IKDC, International Knee Documentation Committee; L, lateral; M, medial; NR, not reported; PRO, patient-reported outcome.

TABLE 6
Summary of RTS Data^a

Study	Technique	Athletes Returned to Sports	Mean RTS Time, Months
Alvarez-Diaz et al ³ (2016)	All-inside	27 (93.1)	4.3
Khetan et al ²⁹ (2022)	Inside-out	-	12
Logan et al ³⁵ (2009)	Inside-out	34 (81)	10.4
Nakayama et al ⁴² (2017)	Inside-out	37 (80.4)	5.5
Vanderhave et al ⁵⁶ (2011)	Inside-out	40 (88.9)	7.2

^aData are presented as n (%). RTS, return to sports.

inside-out group had a mean IKDC score of 92.3; no all-inside studies reported this outcome measure (Table 5).

Return to Sports

Seven studies^{3,29,35,42,51,55,56} reported on RTS outcomes (Table 6). The highest reported percentage of athletes returning to sports was 93.1% by Alvarez-Diaz et al³ (all-inside). The lowest percentage of returning athletes was 80% given by Nakayama et al⁴² (inside out) (Figure 7). The longest reported time to RTS was 12 months by Khetan et al²⁹ (inside-out), and the fastest return was 4.3 months, given by Alvarez-Diaz et al³ (all-inside). Because of a lack of available data on concomitant anterior cruciate ligament reconstruction (ACLR), no analysis of these data has been done.

Radial Meniscal Tear Exclusion Subanalysis

For this subanalysis, studies were excluded if they mentioned the inclusion of radial tears. For the Borque et al study,⁸ patients or patient groups that had radial tears could be separated from those without radial tears and thus remained in this analysis. A total of 212 operations were performed in 202 patients (161 men, 43 women). A

total of 92 patients underwent surgery with the all-inside technique, and 120 underwent surgery with the inside-out technique. The mean age of the all-inside group was 28.4 years and 19.5 years for the inside-out group ($P = .13$). All-inside meniscal repairs failed more often in this group when compared with inside-out repairs (20.7%, 8.3%; $P = .01$). Meniscal laterality was known for 120 patients—88 operations involved the medial meniscus and 32 operations involved the lateral meniscus. No difference was observed in failure rate between these 2 groups when the surgical technique was not controlled for (9.1%, 6.3%; $P = .60$). However, within this group, 118 of the 120 operations were done with the all-inside technique. Insufficient data exist in this cohort for PRO and RTS analyses.

Sensitivity Analysis

A sensitivity analysis was performed because of the high heterogeneity of the data. Wilcoxon tests were performed on the 6 subgroups, and the obtained P values were compared with the P values obtained from the Welch t tests. Results for this analysis are summarized in Table 7.

The consistency of results between the Welch t test, which accounts for unequal variances and the

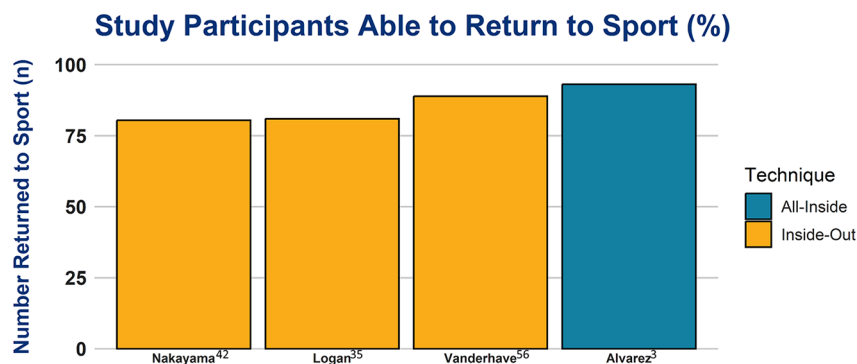


Figure 7. Study participants reported their ability to RTS. Data are expressed as a percentage of total participants within their study. RTS, return to sports.

TABLE 7
Results of the Sensitivity Analysis Performed
for the 6 Main Subgroups in the Study^a

Subgroup	Welch T Test	Wilcoxon Test
Overall all-inside vs inside-out	.0027	.0019
Within all-inside: medial vs lateral repair	2.613e-05	6.851e-07
Within inside-out: medial vs lateral repair	.2103	.2107
Overall medial vs lateral repair	.0017	.0019
Within medial: all-inside vs inside-out	.64	.63
Within lateral: all-inside vs inside-out	5.422e-05	2.244e-07

^aReported results are *P* values gathered from these individual statistical tests.

nonparametric Wilcoxon test, but does not rely on assumptions of normality or variance homogeneity, indicates that the observed differences (or lack thereof) are not artifacts of the statistical methods used. This suggests that the findings are robust and not significantly influenced by potential violations of parametric assumptions such as homogeneity of variances.

DISCUSSION

The major findings of our study were that all-inside medial meniscal repairs done with the Fast-Fix device fail more often than their inside-out counterparts in athletes with a 2.11-fold increased odds of repair failure ($P < .05$) and that lateral meniscal repairs showed no correlation in failure rate based on the surgical procedure ($P > .05$). This trend is also seen when radial tears are excluded from the data. Overall, this study also found that medial meniscal repairs in athletes fail at a higher rate compared with

lateral meniscal repairs. Further, no differences in outcome scores were seen between the 2 surgical techniques. A systematic review by Grant et al²¹ found a 17% failure rate for the inside-out technique compared with 19% for the all-inside technique,²¹ compared with 12.2% and 22.8% found in this review. Similarly, studies done by Kang et al²⁸ and Choi et al¹¹ found no significant difference between the 2 techniques, although the analysis done by Choi et al involved concomitant ACLR.^{11,28} The discrepancy in results between this study and those previously mentioned could be explained by the focus exclusively on athletes in this review. The all-inside technique does still offer some advantages. Modern devices are significantly improved,⁴³ offering reduced operative time⁵⁴ and lower nerve injury risk.⁵⁷ Avila et al⁵ suggest that inside-out repairs carry a higher risk of neurovascular injury. Despite these advantages, intra-articular knots can loosen, and extracapsular anchors are known to potentially cause synovitis and irritation and can even end up in the intra-articular space.

Our study identified a significant ($P < .05$) increase in medial meniscal repair failures compared with lateral repairs, with 2.48 times the odds of a medial repair failing. These findings align with previous studies,^{10,46} including the Ronnblad et al study⁴⁸ that reported an even higher hazard ratio of 3.7 ($P < .001$). Anatomic differences likely explain this discrepancy.³² The lateral meniscus is more mobile than the medial meniscus under load,^{9,20,40} attributed to its lack of capsular attachments at the popliteal hiatus and lateral collateral ligament, whereas the medial meniscus is tightly bound to the medial collateral ligament.³⁰ The lateral meniscus also benefits from menisiofemoral ligaments (Ligament of Humphrey and the Ligament of Wrisberg), of which at least 1 is present in $>90\%$ of knees^{22,60} and plays a role in enhancing knee stability, especially in ACL-deficient knees.³¹ The function of the menisiofemoral ligaments remains a topic of debate; however, recent studies demonstrate a role in increasing overall knee stability and posterior cruciate ligament function.¹⁵ Based on the findings of this meta-analysis, medial

meniscal repairs for athletic patients are recommended to be done with the inside-out technique because of the risk of failure demonstrated in this review. With this in mind, surgeons should still consider an all-inside repair for athletic patients with lateral meniscal tears.

Migliorini et al⁴¹ found that patients treated with the all-inside method were more likely to resume preinjury activity levels compared with those with inside-out repairs, with a significantly higher RTS rate (OR, 2.2 [95% CI, 1.48-3.22]; $P = .0001$). Despite these benefits, and consistent with this review, the same study also reported a higher rate of reinjury associated with the all-inside repair, a finding reflected by several recent studies.^{14,24,25,49} While Migliorini et al⁴¹ advocate for the all-inside technique for athletes needing a rapid RTS, the inside-out method may be preferable for patients prioritizing long-term stability over a quick recovery.

The most commonly reported PRO measures included the Tegner, Lysholm, and IKDC scores. Our review was limited by the quantity of data available; however, we did not detect significant differences in these scores where applicable. Similarly, Grant et al²¹ reported no statistically significant difference in Lysholm scores for all-inside repairs (90.2) compared with inside-out repairs (87.8) or Tegner activity scores at 5.6 for inside-out and 5.5 for all-inside repairs. This again matches the conclusion found by this review, with no significant difference found between groups. Krych et al³³ noted that lateral meniscal repairs were associated with improved IKDC ($P = .02$) and Tegner scores ($P = .05$) compared with medial meniscal repairs, consistent with the conclusions of this review regarding medial and lateral repairs.

Because of the unique and inconsistent clinical management of radial tears,^{6,7,38} this study includes a subanalysis where all studies mentioning an inclusion of radial tears were excluded. Analysis of this new cohort supports the conclusions found in the original group of all patients. The all-inside technique saw a significantly increased frequency of failures compared with the inside-out technique in both cohorts. In the radial exclusion cohort, no difference was seen in medial versus lateral meniscal repairs; however, this is easily explained by the proportion of inside-out repairs in that group (98%). Based on these findings, the conclusions found in this review can be generalized to patients presenting with radial tears.

This paper has several limitations. The primary limitation is due to the quality of data available for review. This paper used level 3 and 4 studies, as these were the only studies available that fit the inclusion criteria; this significantly reduces the strength of conclusions that are drawn. There was also inconsistency in how repair failures were diagnosed; only 2 studies mentioned how this was done—using symptoms consistent with a meniscal tear³⁵ and repeat arthroscopy.⁴² This study was insufficiently powered to detect significant differences between medial and lateral repairs within the inside-out group and all-inside versus inside-out repairs within the lateral meniscal repair group. To confirm the conclusions drawn from this study, prospective research with a large, homogeneous

sample undergoing surgery, ideally with a single surgeon, needs to be done. Studies should also be done on other all-inside devices to improve generalizability to a wider population. Assessment of failure was also likely inconsistent among the different studies, as there is inconclusive data on how studies assessed for failure of repairs. Another important limitation to consider is the heterogeneity of data as a consequence of the nature of meniscal repairs across multiple surgeons. All-inside repairs received 3 implants even within a single study (Borque et al⁸), while inside-out repairs used 8 implants. This study could not account for differences in tear size, tear type, or the presence of concomitant ACLR. Meniscal repairs with concomitant ACL repair are associated with improved outcomes.^{1,48} Therefore, further study is warranted on whether trends identified in this study are present in populations entirely with and without concomitant ACLR. The presence of an ACL repair also affects RTS metrics, which is a principal reason for a lack of analysis on RTS time. RTS is also affected by the subjective nature of how this was assessed by Nakayama et al,⁴² as basing this on an athlete's satisfaction is not typical. Further, conclusions drawn from the medial meniscus group are limited as all 31 all-inside medial meniscal repairs came from Borque et al⁸ while the inside-out medial meniscal repair group included 136 patients across 5 studies.^{8,29,35,42,56} The Bartlett test for heterogeneity demonstrated significant ($P < .001$) variance in failure rates between the studies that formed this medial meniscus group. Although not a requisite inclusion criterion, this study only investigated all-inside meniscal repairs utilizing the Fast-Fix system. Different all-inside devices do exist that may demonstrate different outcomes in the athletic population. Our study also features a high proportion of men to women (4.47:1). Although meniscal injuries are noted³⁷ to have a higher incidence in male populations (2.5-4:1), this study has more men than are representative of meniscal tears. Because of the young and predominantly male cohort, the generalizability of these findings to athletes aged ≥ 30 years and women is limited. Finally, the lack of availability of a funnel plot to determine publication bias in this study further calls for a future high-quality analysis involving randomized controlled trials.

CONCLUSION

Our review demonstrated that medial meniscal repairs done with the all-inside technique using the Fast-Fix device showed a higher failure rate compared with those done with the inside-out technique; this trend is not seen for lateral meniscal repairs. Based on the findings of this study, surgeons should consider the inside-out technique first for athletic patients presenting with medial meniscal tears who want to RTS. Additional high-quality, prospective research in this area is needed to validate these findings, given the limited scope of existing studies combined with more recent utilization of novel all-inside meniscal repair devices that may not be captured in the present study.

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