

Reproducible approach of medial meniscus bucket handle repair with anterior cruciate reconstruction

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Background: Bucket-handle medial meniscal tears (BHMTs) are severe injuries frequently associated with anterior cruciate ligament (ACL) rupture. Meniscal preservation through repair is preferred over meniscectomy to prevent early degenerative changes; however, failure rates remain variable and may depend on repair configuration and biomechanical stability.

Purpose: To evaluate the clinical outcomes, failure rate, and survivorship of a standardized hybrid meniscal repair technique for BHMTs performed concomitantly with ACL reconstruction, and to provide independent evidence regarding the reproducibility of this repair configuration.

Methods: A consecutive cohort of patients with BHMTs associated with ACL rupture treated between 2018 and June 2023 was retrospectively reviewed. All patients underwent arthroscopic meniscal repair using a standardized hybrid configuration combining posteromedial suture-hook stitches, one all-inside device at the posteromedial meniscocapsular junction, and outside-in sutures for the meniscal body, in conjunction with ACL reconstruction and an anterolateral reinforcement procedure. Clinical outcomes were assessed using the Lysholm score and Tegner activity scale. Failure was defined as reoperation on the repaired meniscus. Kaplan–Meier survival analysis was performed.

Results: Forty-three patients (31 men, 12 women; mean age 30.9 ± 8.1 years) were included, with a mean follow-up of 40.7 months (minimum 24 months). The mean Lysholm score at final follow-up was 83 ± 8 , and the mean Tegner activity level was 6.3 ± 0.5 . Three repair failures (7.0%) occurred at 16 to 23 months postoperatively, all following new traumatic events, and were treated with partial meniscectomy. No ACL graft failures were observed. No significant associations were found between failure and sex, graft type, anterolateral procedure, or number of sutures ($p > 0.05$). Minor complications were infrequent and resolved spontaneously.

Conclusion: This standardized hybrid repair technique for BHMTs associated with ACL reconstruction provides satisfactory functional outcomes, low failure rates, and a favorable safety profile at mid-term follow-up. The configuration offers reliable biomechanical stability and supports accelerated rehabilitation without motion restriction.

What this study adds: This study provides independent evidence that a standardized hybrid meniscal repair configuration, combining suture-hook, all-inside, and outside-in techniques, achieves low failure rates and good functional outcomes in bucket-handle medial meniscal tears repaired concomitantly with ACL reconstruction, even when minor technical variations are applied.

How this study might affect research, practice or policy: These findings support the routine use of biomechanically complementary hybrid repair constructs for complex medial meniscal tears, encourage meniscal preservation strategies over meniscectomy, and may inform future comparative studies and surgical guidelines aimed at optimizing repair durability and rehabilitation protocols.

Study Design: Retrospective cohort study

Level of Evidence: Level IV evidence

Keywords: Bucket-handle meniscal tear; Meniscal repair; Anterior cruciate ligament reconstruction; Hybrid repair; Knee arthroscopy.

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Introduction

Bucket-handle medial meniscal tear (BHMT) is a frequent and clinically significant injury pattern, often occurring with an anterior cruciate ligament (ACL) rupture [1][2]. When such lesions are managed by partial meniscectomy, a substantial portion of the meniscus is sacrificed, which accelerates degenerative changes within the knee. For this reason, whenever technically feasible, repair rather than resection should remain the gold standard [3][4][5].

Over the past decade, outcomes of BHMT repair have improved considerably. Several cohort studies and systematic reviews have reported good functional results and acceptable failure rates at mid- to long-term follow-up, particularly when repairs are performed in combination with ACL reconstruction [6]. Even so, reported failures are still relevant, and comparative analyses suggest that both construct design and suture configuration may play a role in long-term durability [2][7][8]. In terms of surgical approach, most published evidence indicates that different repair techniques achieve comparable healing, though all-inside devices may offer certain advantages in operative efficiency and safety for neurovascular structures [9].

There are still relatively few homogeneous case series describing patients with BHMTs associated with ACL rupture who have been repaired using a consistent and reproducible construct [8][10]. A multicenter study by the SANTI group demonstrated that the use of suture hook plus outside-in hybrid construct was associated with the lowest failure rate compared to all-inside techniques, supporting the role of biomechanically complementary repairs in this challenging tear subtype [11].

Based on this study, we retrospectively reviewed a consecutive cohort of patients with BHMTs associated with ACL rupture who were treated using this standardized repair strategy. Our series consisted in a comparable repair philosophy with the aim of reproducing the advantages of hybrid constructs. Specifically, our configuration differs only in that we place one all-inside device at the posteromedial corner of the meniscus, at its transition with the medial collateral ligament, while the remainder of the repair followed the same principles described [11]. Given the encouraging results of the previous reports, it is important to determine whether comparable outcomes can be achieved in independent series using minor technical variations. We hypothesized that this standardized hybrid repair configuration would result in low failure rates and satisfactory functional outcomes at mid-term follow-up in patients with BHMT associated with ACL reconstruction.

Methods

Study Design and Patient Population

The institutional review board approved this retrospective cohort study.

We conducted a single-center retrospective cohort study including patients with simultaneous anterior cruciate ligament (ACL) rupture and bucket-handle medial meniscal tear (BHMT) who underwent meniscal repair and ACL reconstruction between 2018 and June 2023. A total of 43 patients were identified (17 women and 26 men). All procedures were performed by one of the two senior surgeons, always working together, using an identical surgical protocol. Inclusion criteria were (1) acute or subacute BHMT associated with ACL rupture, in which the meniscal tissue could be luxated to the intercondylar notch; (2) meniscal repair performed using the standardized technique described below; and (3) a minimum follow-up of 24 months. Patients with multiligament knee injuries, prior ipsilateral knee surgery, or degenerative meniscal tears were excluded. Patients who underwent second surgeries due to other complications related to the ACL reconstruction procedure, such as septic arthritis, cyclops, or arthrofibrosis, were excluded.

Surgical Technique

All procedures were performed arthroscopically under spinal anesthesia using standard anteromedial and anterolateral portals. Meniscal repair was carried out with the same standardized configuration in every case:

Minimal debridement was performed, between injured margins

Posteromedial ramp region: Two to four stitches were placed using a posteromedial portal and a curved suture hook (with a monofilament absorbable suture.

Posteromedial meniscocapsular junction: One all-inside device was placed at the posterior horn–capsule transition.

Medial meniscus body: Two or more outside-in stitches were applied as needed for stabilization. A spinal needle is first introduced from outside the joint, traversing the capsule and directed toward the site of the lesion. A monofilament absorbable suture (PDS) is advanced into the joint through this needle and positioned above the meniscus. A second spinal needle is then inserted through the capsule, passing beneath the meniscus, and another PDS looped suture is delivered creating a mattress configuration to stabilize the meniscal body. Knot tying was completed through a minimally invasive approach [12]. (Figure 1 and 2).

ACL reconstruction was performed in all patients, and hamstring tendon or bone patellar bone autografts were

used. In addition, all patients underwent an anterolateral procedure, either a modified Lemaire extra-articular plasty or

anterolateral ligament (ALL) reconstruction. Both procedures were performed according to established techniques [13].

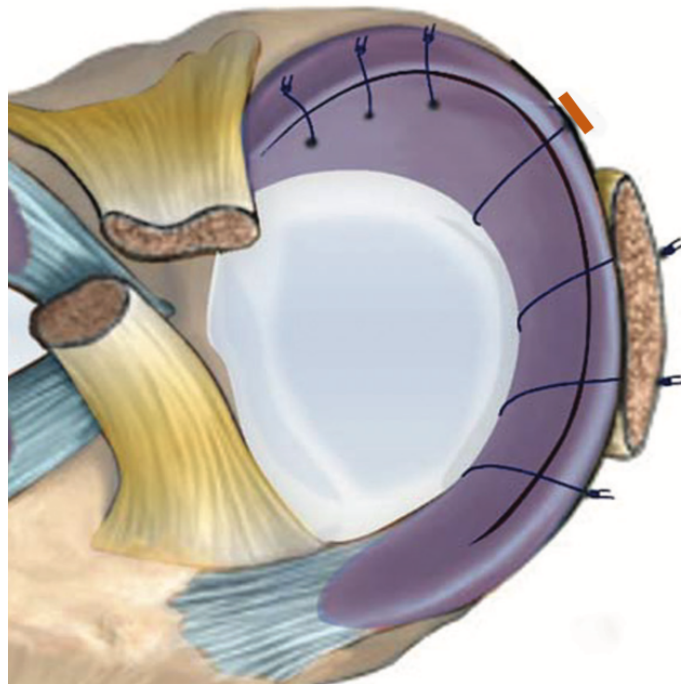


Figure 1. Schematic view of suture placement.



Figure 2. Suture hook (A), Placement of All-inside device (B), Inside-out repair (C).

Postoperative Rehabilitation

Rehabilitation followed the standard institutional protocol for ACL reconstruction, and there was no change despite meniscal repair. Brace-free, immediate full weightbearing, and progressive range-of-motion exercises without restriction of range of motion. Early rehabilitation focused on maintaining full extension and quadriceps activation exercises. Return to sports was allowed at 4 months for non-pivoting sports, 6 months for pivoting non-contact sports, and 8 to 9 months for pivoting contact sports.

Follow-up and Clinical Evaluation

Patients were clinically reviewed at 6 and 12 months postoperatively with standardized examination and functional outcome assessment. After 1 year, follow-up was completed annually via structured telephone interviews conducted by a member of the study team. Medical records of all patients were systematically reviewed.

Failure was defined as repeat surgery with a new procedure on the same meniscus (repeat repair or partial meniscectomy) due to recurrent or persistent pain and dysfunction. To evaluate this endpoint, both clinical records and direct patient interviews were analyzed to ensure the

identification of all cases of failure. Patient notes were reviewed by an independent investigator of the primary surgeons. The minimum follow-up was 2 years and the maximum was 7 years [14].

Statistical Analysis

All analyses were performed using SPSS software (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation (SD) or median with range, depending on data distribution, and categorical variables are reported as counts and percentages. The primary endpoint was repair failure, defined as reoperation on the repaired meniscus. Failure-free survival was estimated using the Kaplan–Meier method, and survival curves were generated for visualization purposes. Subgroup comparisons of failure incidence were performed using exact tests (Fisher’s exact

test or Fisher–Freeman–Halton exact test, as appropriate), given the small number of failure events. Due to the limited sample size and low number of failures, statistical analyses were considered exploratory, and no multivariable analysis was performed. A two-tailed p-value < 0.05 was considered statistically significant.

Results

A total of 43 patients were included in the study, comprising 31 men and 12 women. All patients completed a minimum follow-up of 24 months with a mean follow-up of 40.7 months. The mean age at the time of surgery was 30.9 years (range, 17–49). Average time from injury to surgery was 38 ± 9 days (range, 21–56 days). The right knee was affected in 26 cases (60,5%), while 17 patients (39,5%) presented with left-sided injuries (**Table 1**).

Table 1. Patient Demographics and Clinical Characteristics

		Mean $\pm$ SD
Age(years)		30.9 $\pm$ 8.2 years
Follow-up		40,7 $\pm$ 8,3 months
Time from injury to surgery		38 $\pm$ 9 days (range, 21–56 days)
		N(%)
Sex	Male / Female	31 (72,1%) / 12 (27,9%)
Side	Right/ Left	26 (60,5%) / 17 (39,5%)
Graft	BTB / Hamstrings	9 (20,9%) / 34 (79,1%)
Antero-lateral reinforcement	Lemaire / ALL	34 (79,1%) / 9 (20,9%)

Regarding graft selection, bone–patellar tendon–bone (BTB) autografts were used in 9 patients (21%), and hamstring autografts in 34 (79,1%). All patients underwent an additional anterolateral reinforcement procedure: a modified Lemaire tenodesis in 34 cases (79,1%) and an anterolateral ligament (ALL) reconstruction in 9 cases (20.9%). None of the patients required any additional procedures involving the articular cartilage or the lateral meniscus at the time of surgery.

Functional recovery was satisfactory in the majority of cases. At the last follow-up, the mean Lysholm score was 83 ± 8 , and the mean Tegner activity level was $6.3 (\pm 0.5)$. These values indicate that most patients had regained a high functional level, consistent with light competitive or recreational sports activity. The distribution of these scores was homogeneous across both graft types and anterolateral procedures, with no statistically significant differences observed ($p > 0.05$).

The mean number of sutures used per repair was 5.2 (range, 4–6). Three repair failures (7.0%) were identified during the follow-up period. All failed repairs were subsequently managed with partial meniscectomy. No patient experienced graft rupture or required revision ACL reconstruction.

A descriptive evaluation of the three failure cases was performed. All failures occurred at 16, 22 and 23 months postoperatively and were associated with a new traumatic twisting event during sports activity. All patients had initially demonstrated satisfactory clinical recovery before reinjury. The patients who experienced failure were aged 24, 31, and 34 years at the time of surgery, respectively, and were all physically active individuals. The time from injury to surgery in these cases was 28, 35, and 42 days, respectively, which was comparable to the overall cohort (mean 38 ± 9 days). Two of the failed repairs had been performed using five sutures and one with four sutures, while no failures were observed in cases with six sutures. No consistent pattern

was identified in relation to graft type or anterolateral reinforcement procedure. All failed cases were subsequently treated with partial meniscectomy.

No statistically significant association were identified between failure occurrence and sex, graft type, anterolateral reinforcement technique, or number of sutures (all $p > 0.05$). When analyzed in relation to the number of sutures, two of the failed cases had received five sutures, while one had four.

There were no failures among patients with six sutures (**Table 2**).

Minor postoperative complications were relatively uncommon. The most frequent were medial sensory disturbances in seven patients (17%) and persistent knee effusion lasting up to three months in six cases (15%). Both findings resolved spontaneously without the need for further intervention. No cases of infection, hematoma requiring evacuation, or postoperative stiffness were recorded.

Table 2. Analysis of Repair Failure Cases and Associated Surgical Variables

	Category	Failures (n)	Total	Failure %	No failure %	Test	p-value
Sex	Female	2	12	16.7%	83.3%	Fisher's exact	0.1836
	Male	1	31	3.2%	96.8%		
Graft type	BTB/OTO	1	9	11.1%	88.9%	Fisher's exact	0.5151
	Hamstrings	2	34	5.9%	94.1%		
Anterolateral Plasty	Lemaire	1	34	2.9%	97.1%	Fisher's exact	0.1060
	ALL	2	9	22.2%	77.8%		
Sutures	4	1	10	10.0%	90.0%	Fisher–Freeman–Halton	0.419
	5	2	18	11.1%	88.9%		
	6	0	15	0.0%	100.0%		

Discussion

The main finding of this study was that suture failure occurred in only three of 43 patients (7%), all of which took place during return to sports between 16 and 23 months postoperatively. These results are similar with previously published series, supporting that the configuration described by the Santi group provides excellent biomechanical stability and low failure rates in the treatment of bucket-handle medial meniscus tears (BHMTs) [2][11][15][16]. To the best of our knowledge, this configuration appears to be associated with some of the lowest reported failure rates in the literature [16] [17]. The safety profile in our series was also excellent, with no major complications. The most frequent complaint was medial side tenderness which was present in 7 patients, that fully resolved by six months, further supporting the reproducibility and reliability of this surgical approach [18].

The patient cohort in the present study was relatively young, with a mean age of 30.9 ± 8.2 years, which is consistent with the typical demographic affected by bucket-handle meniscal tears associated with ACL injury. The mean follow-up of 40.7 ± 8.3 months provides a reliable mid-term assessment of clinical outcomes and repair durability, allowing for the

capture of most clinically relevant failure events. The mean time from injury to surgery was 38 ± 9 days (range, 21–56 days), which is relatively short and likely reflects the disabling and mechanically symptomatic nature of BHMTs.

The medial meniscus, especially when repaired concomitantly with anterior cruciate ligament reconstruction (ACLR), has shown acceptable but variable failure rates across the literature, reflecting both biological and mechanical challenges inherent to this structure [19]. While current results for medial meniscal repair associated with ACLR are encouraging, the existing variation across studies emphasizes that there is still room for improvement in both surgical techniques and biological augmentation strategies to further reduce failure rates [20][21]. Helou et al. reported failure rates of 20.2%, 14.8 %, and 5.1% for all-inside repairs, suture hook all-inside repairs, and suture hook plus outside-in configurations, respectively. Other studies using all-inside devices have shown progressive failure rates increasing from 10% at 2 years to nearly 50% at 7 years of follow-up [16][22]. In comparison, our failure rate of 7% stands among the lowest reported, confirming the durability of this combined suture technique (**Figure 3**).

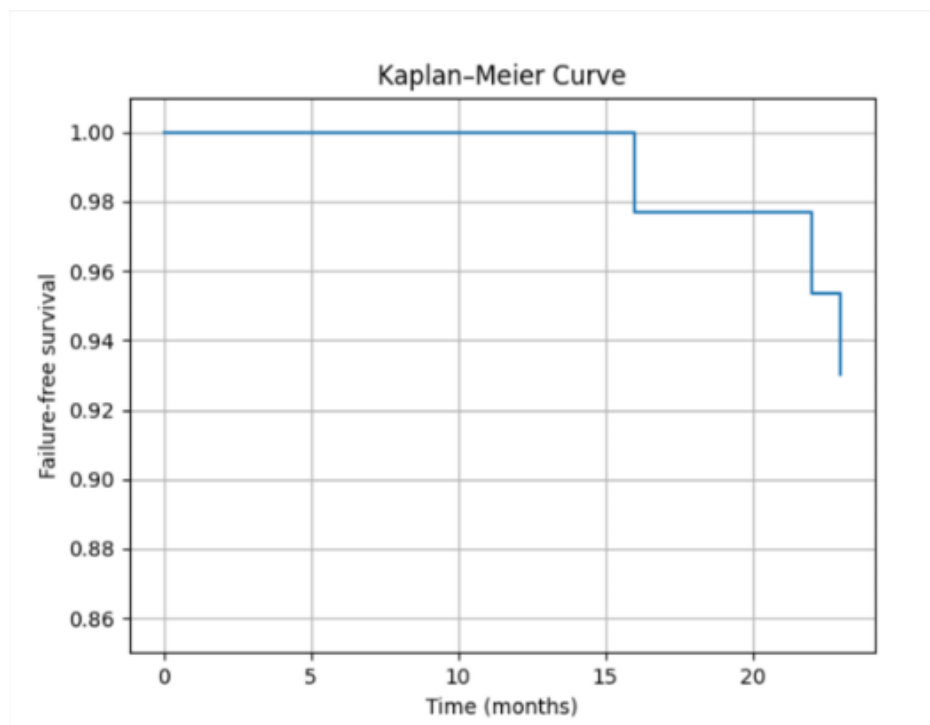


Figure 3. Kaplan–Meier curve demonstrating failure-free survival following meniscal repair.

A detailed analysis of the failure cases suggests that repair failure in this cohort was more likely related to new traumatic events rather than intrinsic insufficiency of the repair construct. All three failures occurred during return to sports and were associated with a new twisting injury, after an initial period of satisfactory clinical recovery. This pattern supports the hypothesis that the repaired meniscus can remain vulnerable to reinjury under high mechanical stress, particularly in young and active patients.

No consistent association was identified between failure and surgical variables such as graft type, anterolateral reinforcement, or number of sutures. Although two of the failures occurred in repairs performed with five sutures, the very small number of events precludes any meaningful interpretation of this finding. Similarly, the time from injury to surgery in the failure cases was comparable to that of the overall cohort, suggesting that surgical timing did not play a decisive role in these cases.

Taken together, these findings highlight that, in this clinical context, failure may be more closely related to external factors such as reinjury and return to sports rather than technical aspects of the repair itself. However, these observations should be interpreted with caution and considered hypothesis-generating only, given the limited number of failure events.

The lack of a statistically significant difference in the number of sutures can be attributed to the fact that patients received

a minimum of four sutures, configured in three different ways. From a technical standpoint, this method offers several advantages; the use of a suture hook through the posteromedial portal enables optimal trajectory and tissue capture while minimizing the risk of suture pullout or meniscal shear, which may explain the lower failure rates observed in our series and others [23]. The addition of outside-in sutures with absorbable monofilament allows precise repositioning of the meniscus into its anatomic footprint without transfixing or damaging the meniscal tissue, potentially facilitating biological healing at the repair site as well as diminishing complications associated with nonabsorbable material [24][25].

There were no differences between grafts as the cause of failure. Furthermore, all patients in our series underwent some form of anterolateral reinforcement, either via a modified Lemaire procedure or an anterolateral ligament (ALL) reconstruction. The literature consistently supports the protective effect of these augmentations on meniscal repairs, likely due to improved rotational stability and reduced shear forces acting on the repair construct [26][27][28].

Finally, the biomechanical security provided by this suture configuration permits an accelerated rehabilitation protocol without the need for postoperative bracing or restriction of motion. This freedom in early mobilization not only enhances patient comfort but also promotes faster functional recovery and an earlier return to sports. These findings suggest that when appropriately indicated, the combined use of suture hook, all-inside implants, and outside-in techniques

represents a safe, effective, and patient-friendly option for the management of BHMTs, yielding excellent stability, low failure rates, and efficient postoperative recovery.

The limitations of this study include its retrospective design, absence of a control group, relatively small sample size, and the occurrence of only three repair failures. These factors substantially limit statistical power, restrict the interpretation of negative findings, and preclude robust identification of predictors of failure. Accordingly, the subgroup comparisons presented in this study should be considered descriptive and hypothesis-generating only.

Conclusion

This standardized hybrid repair technique for bucket-handle medial meniscal tears performed in conjunction with anterior cruciate ligament reconstruction demonstrated favorable functional outcomes, a low mid-term failure rate, and minimal complications. Within the limitations of this retrospective study, the technique appears to provide reliable meniscal stability and represents a reproducible option for meniscal preservation in this challenging injury pattern.

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Conflict of interest

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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