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Arthroscopic medial meniscal repair with or without concurrent anterior cruciate ligament reconstruction: A subgroup analysis

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ABSTRACT

Background: There are few large-scale, long-term studies comparing medial meniscal repairs with or without concurrent anterior cruciate ligament (ACL) reconstruction.
Methods: A total of 140 patients who underwent arthroscopic medial meniscal repair were divided into two groups: Group A, meniscus repair only and Group B, meniscus repair with concurrent ACL reconstruction. Clinical assessments in- cluded physical examination findings, Lysholm score, and the International Knee Documentation Committee (IKDC) form. Barret criteria were used for the clinical assessment of healing status. Magnetic resonance imaging (MRI)was obtained to confirmhealing and failure. Subgroups of participants were compared in terms of suture technique, type of tear, and location of tear. KT-2000 arthrometer testing was used for objective evaluation of anterior–posterior knee movement.
Results: Mean follow-up duration was 61 (34–85) months. Clinical outcomes in both groups were significantly improved compared to baseline ($P = 0.001$ vs. $P = 0.001$); however, there was no significant between-group difference in postoperative Lysholm and IKDC scores ($P = 0.830$). The outcomes of three participants (seven percent) in Group A and 11 (11.3%) in Group B were considered as treatment failures ($P = 0.55$). Red–red zone tears had higher scores. Mean postoperative KT2000 arthrometer values of failed participants in Groups A and B were 4.66 mm (range, four to six) and 5.2 mm (range, two to seven), respectively.
Conclusion: Concurrentmedialmeniscus repair and ACL reconstruction did not have clinical superiority over meniscus repair alone. Repairs in the red–red zone appeared to be associated with better outcomes.

1. Introduction

Menisci have a crucial role in load transmission, shock absorption, and knee joint stability. Preservation of the menisci is therefore imperative. Meniscal tears are the most commonly treated knee injuries [1]. Anterior cruciate ligament (ACL) rupture represents the most frequent pathology that accompanies meniscal tears [2]. When considering meniscal repair, the presence

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of co-existing conditions such as ACL rupture should be carefully assessed to implement a management strategy. Simultaneous repair of meniscus and reconstruction of ACL rupture is thought to positively influence the recovery process. Bone marrow stimulation for meniscal healing is considered to have an impact on the healing process [3–5]. Also, after ACL stabilization, the knee with a meniscal repair will be protected from biomechanical forces accompanying the subluxation; these factors may play a role in the higher meniscal healing rates observed in ACL-deficient knees where ACL reconstruction is performed [6]. Short-term and mid-term studies comparing the outcome of meniscal tears with intact or ruptured ACL have shown high healing rates with ACL reconstruction [7–9]. However, other studies have failed to detect any differences between meniscal tear repairs with or without ACL ruptures [6]. It may also be possible that other factors such as the suture technique, and the location or type of the tear may have an impact on the results [6,10,11]. The current study aimed to investigate meniscal healing in patients who underwent arthroscopic meniscal repair alone, and concurrent meniscal repair and ACL reconstruction; it also conducted subgroup analysis.

2. Materials and methods

2.1. Participants

Between January 2008 and December 2012, 354 patients underwent arthroscopic medial meniscal repairs with or without ACL reconstruction. The inclusion criteria for the current study were: being aged between 18 and 40 years; and having an arthroscopic procedure for: a medial meniscal tear alone or with ACL reconstruction, a medial meniscal tear due to trauma or sports injury, a repair involving a bucket-handle or vertical-longitudinal tear of 15–35 mm in length, and a tear involving red–red (RR) or red–white (RW) zones. Patients were excluded if they had a previous history of knee surgery, <2 years of follow-up, degenerative knee osteoarthritis or septic arthritis sequela, additional pathologic conditions in addition to meniscus and ACL rupture (e.g. cartilage defect, posterior cruciate ligament injury, patellofemoral instability, anterolateral ligament injury and posterolateral corner injury), horizontal or flap-like tears, or patellofemoral joint deformity. The isolated meniscal repair group, and concurrent meniscal repair and ACL reconstruction group were defined as Group A and Group B, respectively. This study was approved by the Institutional Review Board of Erciyes University Medical Faculty Ethics Committee. Informed consent was obtained from all participants.

2.2. Surgical method

Arthroscopic procedures were performed under general or regional anesthesia by two orthopedic surgeons who were experienced in arthroscopic surgery. Routine anteromedial and anterolateral arthroscopic portals were used. Meniscal tears were examined and measured with an arthroscopy probe. Localization of the tears (RR, RW) and the tear types (vertical-longitudinal and bucket-handle) were determined. The subgroups were then defined. Tears within two millimeters of the meniscocapsular region were considered as the RR zone, and two to four millimeters were considered as the RW zone.

A repair was performed using either an all-inside suture or a hybrid method (all-inside and outside-in), depending on the type and location of the tear. A vertical, oblique or horizontal suture configuration was used in all repairs. All-inside sutures were used in the posterior horn and body of the meniscus repairs. Outside-in sutures were used in anterior horn repairs. A hybrid technique was performed in long tears extending to the anterior horn and bucked-handle tears. A Fast-Fix meniscus fixator (Fast-Fix™ 360, Smith & Nephew, Andover MA, US) was used for the all-inside approaches, while #0 Polydioxanone suture (PDS) (Ethicon) sutures were used for the outside-in method (Figure 1A and B). An average of 2.3 (range, one to four) Fast-Fix sutures and two (range, one to three) PDS (Ethicon) sutures were used in repairs. The single-bundle method with semitendinosus and gracilis hamstring tendons was performed in ACL reconstructions.

A femoral tunnel was drilled through the anteromedial portal with the knee in 120° flexion. A guide pin was inserted to achieve a horizontal lateral thigh exit point. The femoral tunnel was then reamed by using an appropriately sized reamer (Smith & Nephew) over the guide pin. Next, debris in the femoral tunnel was removed by an arthroscopic shaver (Smith & Nephew). The tibial tunnel was then drilled through with a guide pin after the guide was set to 55°. The direction and intraarticular entry point of the guide pin were checked before reaming. After tunnel drilling was complete, the leading suture of the graft was pulled into the femoral tunnel through the previously drilled tibial tunnel. An Endobutton (Endobutton™ CL Ultra, Smith & Nephew) was used for femoral fixation. Tibial fixation was achieved using an appropriately sized bioabsorbable screw (Biosure™ HA, Smith & Nephew) and a staple (Smith & Nephew) with the knee in full extension (Figure 2).

2.3. Postoperative rehabilitation

Participants were allowed to mobilize with support. Toe touching was allowed until the sixth postoperative week. Isometric quadriceps exercises were commenced on postoperative day 1. Range of motion exercises were started on postoperative day 1 using a continuous passive motion (CPM) machine; 10° of flexion increase every day was planned. Participants were discharged when they could perform a straight leg raise and had 90° knee flexion. Quadriceps exercises with weights were started three weeks postoperatively in Group B. In Group A these exercises were started one week after surgery. Full weight-bearing was allowed six weeks postoperatively. Resumption of sports activities was allowed at the end of the sixth or eighth months according to healing and rehabilitation status.

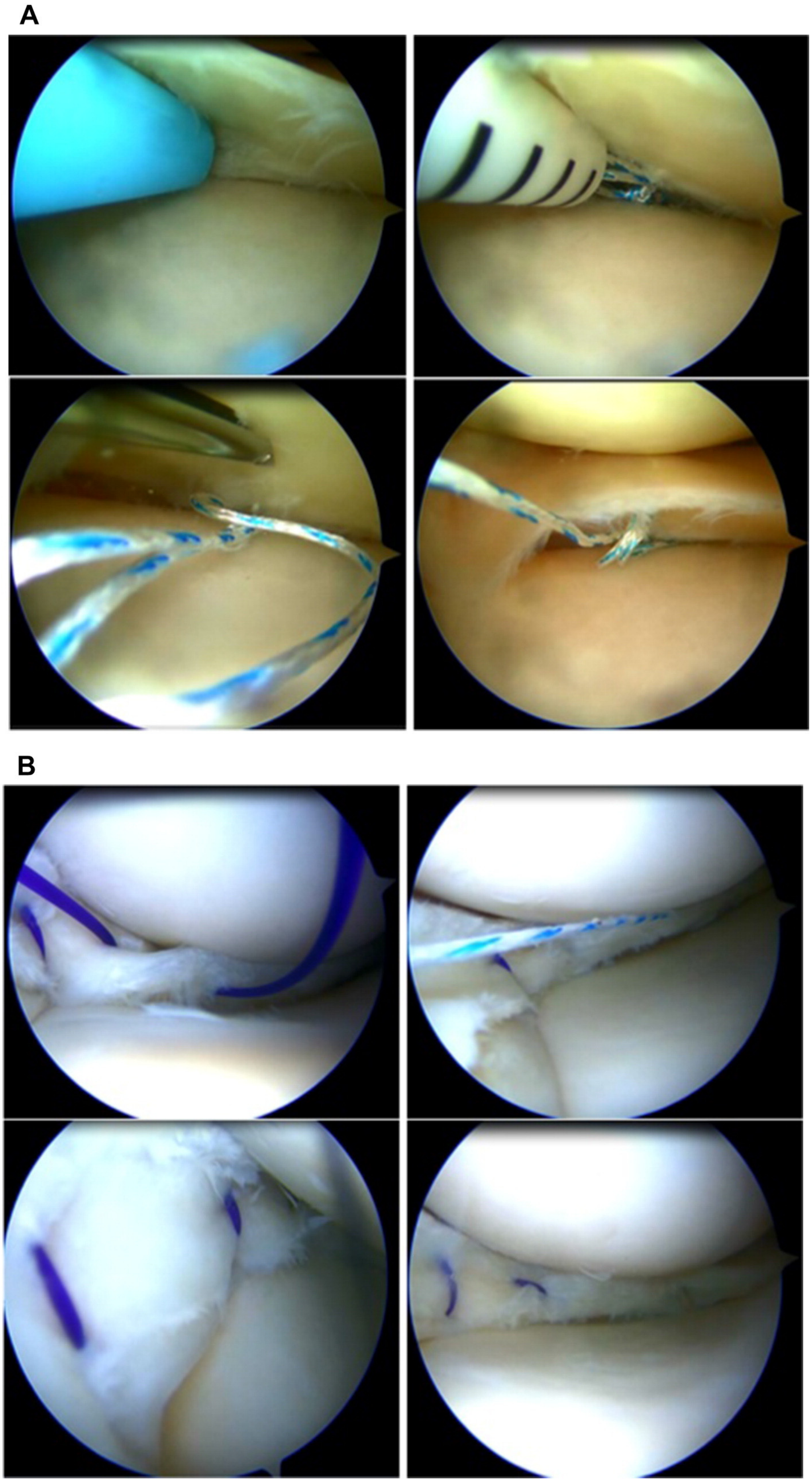

Figure 1. Arthroscopic images of: A. all-inside and B. hybrid (outside-in and all-inside) repair techniques.

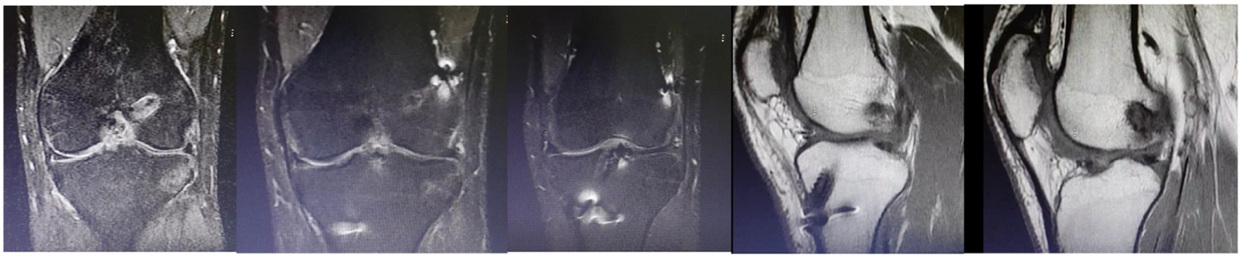

Figure 2. Coronal and sagittal magnetic resonance images of tibial and femoral tunnels from one participant.

2.4. Assessments

Lysholm knee score and the International Knee Documentation Committee (IKDC) subjective knee evaluation form were used for pre-operative and postoperative assessments [12,13]. Barret criteria were used for clinical assessment of the healing status of the repaired menisci [14], where the absence of joint tenderness, effusion and locking, and a positive McMurray test was considered indicative of a healed meniscus. Negative outcomes in any of the scoring or examination measures were considered clinical failures. Healing and failure status was confirmed with magnetic resonance imaging (MRI). On MRI, the meniscus was considered unhealed if Grade 3 signals on T2 sequences were seen. Fluid within the repair site on MRI was considered as a failure (Figure 3A and B). Subgroups of participants were compared regarding suture technique, type of tear, and tear location. Anterior–posterior (AP) laxity of the knee joint was documented with a KT-2000 arthrometer® (MEDmetric, San Diego, CA, USA) in both groups at 30 lb, and values were compared with the contralateral knee.

2.5. Statistical analysis

IBM SPSS Statistics 22.0 (IBM Inc. Chicago, IL, USA) was used for statistical analysis. Descriptive data were presented as median (range) and mean ± standard deviation (SD). Normality was tested by using the Shapiro–Wilk test. Nonparametric tests were used since the data were not normally distributed. The Mann–Whitney U test or Kruskal–Wallis test was used for intergroup comparisons of continuous variables, depending on the number of groups compared, and Wilcoxon test was used for intragroup comparison (last follow-up vs. baseline). The chi-squared test was used for comparison of categorical data. A P-value of <0.05 was considered to be statistically significant.

3. Results

3.1. Clinical characteristics

Participant characteristics are shown in Table 1. After exclusions, a total of 140 patients with medial meniscal tears were recruited to the study. Ninety-seven (69.3%) of 140 participants underwent arthroscopic meniscal repair in conjunction with ACL reconstructions (Group B). The remaining 43 (30.7%) underwent arthroscopic meniscal repair alone with intact ACLs (Group A). Mean trauma to surgery time was three months (range, two to seven). Mean tear length was 20 mm (range, 15–35). Mean duration of surgery was 50 min (range, 20–60), with significantly longer operation time in those who underwent a combined operation (Group B) (50 (45–60) vs. 25 (20–30 min), $P = 0.001$). Mean follow-up period was 61 months (range, 34–85). Mean body mass index (BMI) of Groups A and B was 22.8 kg/m^2 (range, 18.5–24.7) and 23.1 kg/m^2 (range, 21.6–25.4), respectively.

3.2. Meniscus repair vs. meniscus repair with ACL reconstruction

Lysholm knee scores of patients in Group A and Group B were significantly improved compared to baseline (90.0 ± 13.3 vs. 41.6 ± 7.4, $P = 0.001$ and 91.1 ± 10.5 vs. 36.6 ± 9.5, $P = 0.001$, respectively). However, there was no significant between-group difference in postoperative Lysholm scores ($P = 0.830$). In addition, IKDC scores were significantly improved from baseline in both groups (45.6 ± 8.0 vs. 92.6 ± 11.4, $P = 0.001$ and 39.7 ± 11.9 vs. 89.1 ± 11.3, $P = 0.001$). Based on all assessments, the outcomes of three participants (seven percent) in Group A and 11 (11.3%) in Group B were considered as meniscal repair treatment failures ($P = 0.55$) (Table 2).

Mean KT2000 arthrometer values at 30 lb showed a difference of +1.1 mm (range, one to three) between operated and nonoperated sides in Group A and +1.4 mm (range, one to three) in Group B ($P = 0.830$). Three patients with failure in Group A had a mean KT2000 arthrometer value of 4.6 mm (range, four to six). On the other hand, 11 patients with failure in Group B had a mean KT2000 arthrometer value of 5.2 mm (range, four to seven millimeters).

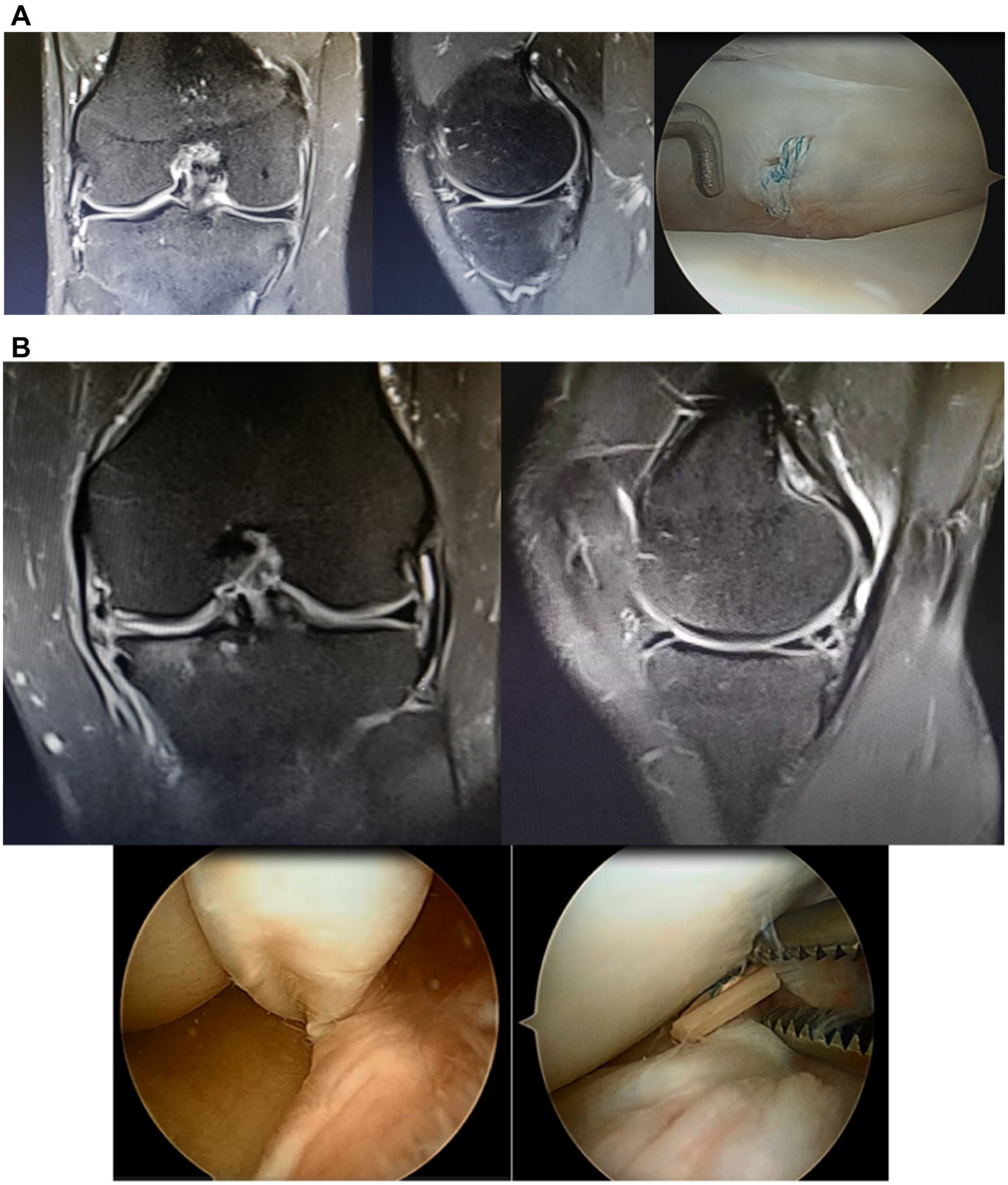

Figure 3. Magnetic resonance and arthroscopy images of two patients: A. A healed medial meniscus repair; B. A failed meniscus repair.

3.3. Subgroup analyses

Both groups of participants were further divided into subgroups based on suture technique, tear type, and tear localization. Tables 3, 4 and 5 show subgroup analysis of Lysholm knee scores and failure rates according to suture type, tear type, and tear localization. All subgroups showed significant improvement of scores when compared to baseline. Postoperative Lysholm knee scores were similar across subgroups of suture type and tear type. However, subgroups of tear localization showed a significant difference for both postoperative Lysholm knee scores ($P = 0.001$) and failure rates ($P = 0.003$). Participants in Group A with an RR zone tear had significantly higher clinical scores compared to those with an RW zone tear ($P = 0.01$). Similarly, participants in Group B with an RR zone tear had significantly higher scores compared to those with an RW zone tear ($P = 0.02$) (Table 5).

Table 1
Participant characteristics.

Characteristic	Meniscus repair group, n (%)	Concurrent meniscus and anterior cruciate ligament repair group, n (%)	Total, n (%)	P*
Number of participants	43 (30.7%)	97 (69.3%)	140 (100.0%)	
Age, mean (range)	28 (18–40)	27 (18–40)	27.5 (18.0–40.0)	0.89
Gender				
Male	38 (27.1%)	91 (65.0%)	129 (92.1%)	0.03
Female	5 (3.6%)	6 (4.3%)	11 (7.9%)	
Suture type				
All-inside	26 (18.5%)	66 (47.2%)	92 (65.7%)	0.67
Hybrid	17 (12.2%)	31 (22.1%)	48 (34.3%)	
Tear localization				
Red–red zone	24 (17.2%)	58 (41.4%)	82 (58.6%)	0.89
Red–white zone	19 (13.5%)	39 (27.9%)	58 (41.4%)	
Tear type				
Vertical-longitudinal	28 (20.0%)	49 (35.0%)	77 (55.0%)	0.83
Bucket-handle	15 (10.7%)	48 (34.3%)	63 (45.0%)	

* P for the intergroup difference.

There was no significant difference in the suture number between successful repairs and failures (2.4 vs. 2.6 in Group A and 2.6 vs. 2.4 in Group B ($P = 0.09$)).

3.4. Complications

Some of the participants who were treated with the outside-in technique had short-term complications: superficial infection in two and transient synovitis in one participant. After 14 days of oral antibiotic therapy, infection regressed in both participants.

4. Discussion

The most important finding of the current study was that meniscus repair in conjunction with ACL reconstruction did not result in clinical superiority over meniscus repair alone in total or in the subgroup analysis. These findings are in contradiction with the findings of previous early to mid-term reports [8,10,15], but consistent with a meta-analysis by Nepple et al. and study by

Table 2
Lysholm scores and failure rates of participants who had meniscus repair and concurrent meniscus and anterior cruciate ligament repair.

Number of repairs (n)	Lysholm	Lysholm	Failure	P[a]
	Pre-operative (mean ± SD)	Postoperative (mean ± SD)	Rates, n (%)	
Meniscus (43)	41.6 ± 7.4	90.0 ± 13.3	3 (7%)	0.001[a]
Meniscus + ACL (97)	36.6 ± 9.5	91.1 ± 10.5	11 (11.3%)	0.001[a]
Total (140)	38.1 ± 9.2	90.7 ± 11.4	14 (10%)	0.001[a]
P	0.002[b]	0.830[b]	0.55[c]	

ACL, anterior cruciate ligament.
[a] Wilcoxon signed-rank test.
[b] Mann–Whitney U test.
[c] Chi-squared test.

Table 3
Analysis of failures and pre-operative/postoperative Lysholm scores according to suture type.

Suture type	(n)	Failure rates, n (%)	Pre-operative Lysholm score mean ±SD	Postoperative Lysholm score mean ±SD	P[a]
Meniscus repair, all-inside	26	1 (3.8%)	42.6 ±7.6	88.0 ±12.1	0.001
Meniscus repair, hybrid	17	2 (11.8%)	39.9 ±7.1	93.1 ±14.9	0.001
Concurrent meniscus and ACL repair, all-inside	66	8 (12.1%)	37.3 ±9.4	92.1 ±10.5	0.001
Concurrent meniscus and ACL repair, hybrid	31	3 (9.7%)	35.1 ±9.7	90.9 ±10.8	0.001
P[b]		0.63		0.09	

ACL, anterior cruciate ligament.
[a] Vs. baseline.
[b] *P* for the intergroup difference.

Table 4
Analysis of failures and pre-operative/postoperative Lysholm scores according to tear type.

Tear type	(n)	Failure rates, n (%)	Pre-operative Lysholm score mean ±SD	Postoperative Lysholm score mean ±SD	P^a
Meniscus repair, V-L tear	28	2 (7.1%)	41.4 ±6.7	88.6 ±13.4	0.001
Meniscus repair, bucket-handle tear	15	1 (6.7%)	41.8 ±8.9	92.5 ±13.3	0.001
Concurrent meniscus and ACL repair, V-L tear	49	4 (8.2%)	37.3 ±9.3	92.0 ±9.9	0.001
Concurrent meniscus and ACL repair, bucket-handle tear	48	7 (14.6%)	35.9 ±9.7	90.2 ±11.2	0.001
P^b		0.69		0.42	

ACL, anterior cruciate ligament; V-L, vertical longitudinal.
[a] Vs. baseline.
[b] *P* for the intergroup difference.

Martin-Fuentes et al. [6,16] As compared to the multiplicity of reports on the short-term outcomes of a variety of techniques used for meniscal repair, publications on the mid-term results are relatively scarce in number. Most studies involve a postoperative follow-up duration of up to three years [17]. Accordingly, Lee and Diduch found increasing rates of failure in the longer term in this group of patients, with failures occurring after an average follow-up of two years accounting for 30% of all failures [18].

The current study investigated the role of concurrent ACL reconstruction in patients undergoing arthroscopic meniscal repair and the impact of the subgroups, including suture technique, tear location, and tear type, on clinical success. The average follow-up period was 61 months, which can be considered adequate for the assessment of meniscal healing.

Efficacy results of the outside-in approach on posterior horns of the menisci are far from satisfactory [19,20]. The inside-out technique is associated with some obvious disadvantages such as the need for an accessory port and increased risk of neurovascular injury. The current study used the all inside-out suture technique with equipment (i.e. Fast-Fix) with proven efficacy and safety for posterior horn tears instead [21]. Kotsovolos et al. reported a 90.2% success rate with the Fast-Fix suture device after 18 months of follow-up [22]. They suggested that a Fast-Fix repair provided a high rate of meniscus healing and appeared to be a safe and effective system. Similar results of meniscal repair with the Fast-Fix suture device, with high satisfaction rates, are reported in the early-to-mid-term [21–25]. Hu et al. reported good clinical outcomes with combined outside-in and Fast-Fix sutures for the treatment of discoid meniscal tears [26]. Poor long-term meniscal repair outcomes with a high failure rate (39 out of 82 patients, 48%) using RapidLoc implants were reported in a recent study [27]. However, few long-term results of meniscus repair with a Fast-Fix fixator have been published [28]. In the current study, the 90% success rate of combined Fast-Fix meniscal repair system and outside-in technique on 140 repaired menisci after a mean follow-up of 61 months was in concordance with the literature.

In the current study, the outside-in approach was used in anterior horn tears due to higher costs and difficulties in performing anterior horn tear repairs with Fast-Fix sutures. The addition of the outside-in method to all-inside approach did not result in a difference in clinical outcomes. In patients with intact or ruptured ACL, the short-term comparison of meniscal repair suggested an association between ACL reconstruction and high healing rates [8,15]. While the reported success rates for meniscus repair in conjunction with ACL reconstruction vary between 62% and 96%, the corresponding figure in patients undergoing meniscus repair is between 17% and 62% [8,29,30]. In a meta-analysis by Nepple et al., where long-term results with meniscus repair were evaluated, no differences were found in success rates regarding presence of ACL rupture [6]. Concurrent ACL reconstruction may play a role in higher success rates, but it is believed that this effect is reduced in the mid-term or long-term.

Recently, Bogunovic et al. reported no difference in failure rates between isolated repairs (12%; 95% Confidence Interval (CI): 20.76–23.76%) and those performed with concurrent ACL reconstruction (18%; 95% CI: 7.47–29.13%) [31]. In the current study, simultaneous reconstruction of ACL and meniscus repairs did not result in any clinical differences, which was consistent with

Table 5
Analysis of failures and pre-operative/postoperative Lysholm scores according to tear location.

Tear location	(n)	Failure rates, n (%)	Pre-operative Lysholm score, mean ±SD	Postoperative Lysholm score, mean ±SD	P^*
Meniscus repair only, red–red zone	24	0 (0%)	43.6 ±8.8	94.5 ±6.5	0.001
Meniscus repair only, red–white zone	19	3 (15.8%)	39.0 ±4.3	84.3 ±17.3	0.001
Concurrent meniscus and ACL repair, red–red zone	58	7 (3.4%)	36.7 ±9.7	94.4 ±7.5	0.001
Concurrent meniscus and ACL repair, red–white zone	39	9 (23.1%)	36.4 ±9.2	86.2 ±12.4	0.001
$P^\dagger$		0.003		0.001	

† for the intergroup difference.
* Vs. baseline.

these studies. In Group A the mean postoperative Lysholm knee score was 90. In Group B it was 91.1, with no significant difference. Similarly, there was no significant difference in failure rates between patients with and without concurrent ACL reconstruction (11 (11.3%) vs. three patients (seven percent)).

Westermann et al. reported meniscal repair failure rates of 14% in their six-year follow-up study with concurrent meniscal repair and ACL reconstruction patients [28]. They reported that no difference was detected in the suture number or type between repair success and failure. In the current study there was no significant difference in the suture number or suture type between success repairs and failures.

Rochcongar et al. denoted that insufficient healing after meniscal suturing contributes to the risk of further meniscal tears [32]. They found new lesions developing in menisci, which were undamaged at the time of ACL reconstruction. They found that the risk of developing new meniscal lesions was increased when the residual anteroposterior laxity was ≥4 mm. In the current study, the mean residual anteroposterior laxity of the three failed patients in Group A was 4.6 mm. The mean residual anteroposterior laxity of 11 patients in Group B was 5.2 mm. These results support that anteroposterior laxity is associated with failure.

The healing rate in tears involving the peripheral vascular zone is much higher than those in the avascular zone. Krych et al. and Ahn et al. found better outcomes in the repairs involving the RR zone as compared with those in the RW zone [33,34]. Also, in their prospective study, Tucciarone et al. reported that best healing occurred in patients affected by meniscal longitudinal vertical tears located in the RR zone of the meniscus with an extension of 10 mm in ACL-deficient knee treated with Fast-Fix sutures and ACL reconstruction [35]. The current study found significantly better healing rates involving the RR zone as compared to those in the RW zone in both Groups A and B. There was no significant difference in healing rates in longitudinal vertical and bucket-handle tears between both groups. However, many investigators have shown no difference in healing rates between RR and RW zone tears [19,36,37]. Current understanding suggests that longitudinal tears of the peripheral vascular zone possess the ideal properties for repair [11]. Favorable healing rates in vertical-longitudinal tears of the peripheral zone have been reported [38]. Unstable vertical-longitudinal tears of traumatic origin are ideal for repair [39]. In the current study, bucket-handle and vertical-longitudinal tears of the RW and RR zones with rich vascularity were treated, considering their higher healing potential. Repair in both sites resulted in significant healing rates. According to the subgroup analyses, the current study was not able to demonstrate any significant difference in failure rates between patients with and without concurrent ACL reconstruction for both bucket-handle and vertical-longitudinal tears.

Strengths of the current study included the relatively large sample size, evaluation of subgroup analysis of both isolated repairs and those performed in conjunction with ACL reconstruction, and full participation in the follow-up limiting attrition bias.

Some authors have questioned MRI examination and clinical assessment for determining meniscal healing, and second-look arthroscopy is the most dependable method [40]. The current study confirmed healing and failures with both clinical examination and MRI in all patients. A second-look arthroscopy was only performed in patients with failures that were confirmed clinically and radiologically. A second-look arthroscopy may give more detailed information about incomplete healing or asymptomatic failures.

A major limitation of the current study was the absence of long-term outcome data, and its retrospective nature. Further studies with longer follow-up periods are needed to evaluate the long-term effect of all-inside and hybrid repair devices, and the factors affecting meniscal healing.

5. Conclusion

This study suggests that all-inside and hybrid meniscal repair techniques provide satisfactory results in both meniscus repair only and concurrent meniscal repair and ACL reconstruction groups. However, red–red zone tear repairs resulted in a significantly higher success rate compared with the red–white zone. Suture or tear type had no impact on outcomes.

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