ORIGINAL RESEARCH

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Clinical Outcomes Following Isolated Anterior Cruciate Ligament (ACL) Reconstruction Versus Combined ACL and Meniscus Surgery: A Comparative Study

Tek Başına Ön Çapraz Bağ (ACL) Rekonstrüksiyonu ile Kombine ACL ve Menisküs Ameliyatı Sonrası Klinik Sonuçlar: Karşılaştırmalı Bir Çalışma

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Abstract

Objective: In this retrospective study, we aimed to compare the clinical results of isolated anterior cruciate ligament (ACL) reconstruction and ACL reconstruction with meniscal repair or meniscal resection.

Method: The isolated ACL reconstruction group included 4 females and 25 males; the ACL reconstruction with meniscal repair group included 6 females and 21 males; and the ACL reconstruction with meniscectomy group included 4 females and 21 males. All patients underwent surgery using a transtibial, quadruple hamstring autograft, single-bundle, and single-tunnel endobutton technique. Meniscal tears were repaired using the all-inside technique. Demographic characteristics, preoperative and postoperative one-year functional scores (Lysholm, Tegner, Cincinnati, and International Knee Documentation Committee), preoperative and postoperative one-year anterior drawer test and Lachman test, injury-to-surgery intervals, meniscus tear type, and posterior tibial slope angles were compared across all groups.

Results: Fifty-six percent of the meniscus resection group underwent surgery after 12 months, and the likelihood of a meniscal tear pattern unsuitable for repair was increased. We found that postoperative functional outcomes were significantly higher in all three groups compared to preoperative outcomes, and early clinical outcomes were satisfactory in all three groups. The Tegner activity level score was significantly higher in the group that underwent meniscal repair

Öz

Amaç: Retrospektif olan bu çalışmamızda izole ön çapraz bağ (ÖÇB) rekonstrüksiyonu ve ÖÇB rekonstrüksiyonu ile birlikte menisküs tamiri veya menisküs rezeksiyonunun klinik sonuçlarını karşılaştırmak amaçlanmıştır.

Yöntem: İzole ÖÇB rekonstrüksiyonu grubunda 4 kadın ve 25 erkek, ÖÇB rekonstrüksiyonu ile birlikte menisküs tamiri yapılan grubunda 6 kadın ve 21 erkek, ÖÇB rekonstrüksiyon ile birlikte menisektomi yapılan grubunda 4'ü kadın 21'i erkek hasta dahil edildi. Tüm hastalarımız transtibial, dörtlü hamstring otogreft ile tek demet ve tek tünel endobutton yöntemiyle opere edildi. Menisküs yırtıkları ise tamamen içerde yöntemle onarıldı. Tüm grupların demografik özellikler, preop ve postop birinci yılda fonksiyonel skorlamaları (Lysholm, Tegner, Cincinnati ve Uluslararası Diz Dokümantasyon Komitesi), preop ve postop 1. yıl ön çekmece testi ve lachman testleri, yaralanma-operasyon arasında geçen süreleri, menisküsün yırtık tipi ve posterior tibial eğim açıları karşılaştırıldı.

Bulgular: Menisküs rezeksiyonu yapılan grubun %56'sı 12. aydan sonra ameliyat olup hastaların menisküs yırtıkların onarıma uygun olmayan bir menisküs yırtığı paternine karşılaşma olasılığı artmış olduğu görüldü. Her üç grubun post-op fonksiyonel sonuçları preop sonuçlarına göre anlamlı düzeyde yüksek ve her üç grubun erken dönemde klinik sonuçları tatmin edici seviyede saptadık. Tegner aktivite düzeyi skoru ÖÇB rekonstrüksiyon ile beraber menisküs

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Abstract

with anterior cruciate ligament reconstruction compared to the group that underwent meniscal resection.

Conclusion: In our study, patients who underwent meniscus repair had higher Tegner activity scores than those who underwent meniscectomy. Weight-bearing and movement restrictions were prescribed for patients with meniscus repair. These results demonstrate that weight-bearing and movement restrictions have no impact on clinical outcomes. Patients should be advised to attempt to return to sports or previous activities as quickly and safely as possible.

Keywords: ACL reconstruction, meniscus repair, meniscectomy

Öz

onarımı olan grupta menisküs rezeksiyonu yapılan grubuna göre anlamlı düzeyde yüksek saptadık.

Sonuç: Çalışmamızda menisküs tamiri yapılan hastalar menisketomi yapılanlara göre daha yüksek tegner aktivite skorlarına sahiptiler. Menisküs tamiri olan hastalarda yük verme ve hareket kısıtlaması verilmişti. Bu sonuçlara göre yük verme ve hareket kısıtlamasının klinik sonuçlarına etkisi olmadığını gösterdi. Hastaların en kısa sürede ve güvenli bir şekilde spora veya eski aktivitelerine dönmeye çabalamalarını tavsiye edilmelidir.

Anahtar kelimeler: Ön çapraz bağ rekonstrüksiyon, menisketomi, menisküs tamiri

Introduction

Anterior cruciate ligament (ACL) tears are commonly observed ligamentous lesions of the knee joint, a complex and dynamic structure composed of the tibiofemoral and patellofemoral articulations, often resulting from athletic activities. Female athletes, especially in games such as soccer and basketball, have higher injury rates than men (1). ACL is necessary for preserving the knee's static and dynamic stability. During sports activities, the knee is frequently injured through non-contact mechanisms including landing, abrupt deceleration, changes in direction and rotation while in valgus and extension (2). Among the other significant causes of ACL injuries are those resulting from high-energy events, such as falls from significant heights and motor vehicle accidents.

In a complete ACL tear, the patient hears a "pop" sound. Common symptoms are pain and swelling caused by intra-articular bleeding. This pain usually limits the mobility of the knee. Another common symptom is a feeling of emptiness in the knee. It can feel like the patient suddenly slips while walking or running fast, increasing the risk of falling. On the other hand, partial ACL ruptures may not lead to knee instability, allowing individuals to return to play after the injury (3). However, in highly active individuals or athletes, overall quality of life can be substantially impacted.

The ACL, which acts as the main stabilizer of the knee, can also lead to other intra-articular injuries when it ruptures. Meniscal lesions have been shown to be associated with 60% of cruciate ligament damage (4). In studies related to ACL reconstruction in the literature, low thigh muscle strength was observed in all graft types (5). Treatment of these two structures together is discussed in the literature with respect to clinical outcomes.

The study sought to compare clinical outcomes between isolated ACL-R and ACL-R combined with meniscal repair or meniscectomy.

Materials and Methods

This study was conducted after the approval received from the Tekirdağ Namık Kemal University Local Ethics Committee meeting dated 28.11.2023 (protocol number 2023.197.11.11.11) and patient consents were obtained.

From 01/01/2019 to 01/11/2022, hospital electronic records were reviewed for 110 patients who underwent ACL reconstruction, and 81 individuals meeting the appropriate criteria were included in this retrospective investigation. All surgeries were performed using the transtibial with a quadruple hamstring autograft and fixed with the single bundle, single-tunnel EndoButton method. The all-inside technique was employed for meniscal repair, and resections were classified as partial or total meniscectomy.

In our study, patients were categorized into three groups: isolated ACL-R, ACL-R combined with meniscal repair, and ACL-R with meniscectomy. Patients aged between 18-48 years who had undergone tendon reconstruction with quadruple hamstring tendon autograft and single-bundle, and single-tunnel EndoButton method at least one year ago; those who had undergone meniscal repair or meniscectomy with ACL-R; those who performed quadriceps strengthening exercises or attendance in physical therapy and rehabilitation in the first 3 months after surgery, those who did not have a sedentary lifestyle before the surgery, and those who were deemed suitable to resume sports in the sixth month of treatment were included.

Patients with a history of revision surgery due to ACL re-rupture; additional knee pathologies other than meniscal injuries, including lateral or medial collateral ligament injuries, MPFL injury, or chondral injury; or re-traumatization after surgery were excluded.

At the time of presentation, 24 patients reported knee pain, a subjective sensation of pressure, and swelling. After history taking, physical examination was performed and Lachman test, anterior drawer, posterior drawer and McMurray tests were noted. Two-way radiographs and magnetic resonance imaging of the knee were examined in detail. Rest, knee brace, cold application and non-steroidal anti-inflammatory drugs were recommended for patients with acute injury history. A preoperative rehabilitation program was applied with the aim of improving range of motion and enhancing the quadriceps strength. Patients were admitted to the clinic one day prior to the operation and preoperative preparations were started.

Lyshlom scoring, International Knee Documentation Committee (IKDC) scoring, Cincinnati scoring and Tegner activity scoring forms were analyzed preoperatively and at 1 year post-op, and post-op lachman test (-), (+), (++), (++), (++++) and anterior drawer tests (-), (+), (++), (++++) were analyzed at 1 year. Age, gender, height, weight, body mass index (BMI), follow-up time, preop lachman test (-), (+), (++), (+++), (++++), anterior drawer test (-), (+), (++), (++++), side of injury, mechanism of injury (sports/non-sports related, contact/non-contact injury) time from injury to operation, type of meniscal tear, and posterior tibial slope angles were investigated.

Using the posterior tibial cortex method introduced by Hewett et al. (6), the anatomical axis of the tibia was established. On a lateral knee radiograph, the posterior tibial slope was computed as the angle -90 formed between lines tangent to the posterior tibial cortex and the tibial plateau. Among the patients, 29 underwent isolated ACL reconstruction (4 females and 25 males), while 27 underwent ACL reconstruction with meniscal repair (6 females and 21 males). In the group that underwent meniscectomy with ACL reconstruction, there were 25 patients, 4 females and 21 males. The mean follow-up period was 17.8 months (mean age 31.8 years) in the isolated ACL R group, 20.5 months (mean age 28 years) in the ACL R+ meniscal repair group, and 22.5 months (mean age 31.4 years) in the ACL R+ meniscectomy group. The IKDC subjective knee form, a reliable and valid knee-specific tool assessing symptoms, function, and sports activity, is suitable for patients who had diverse knee conditions and allows for outcome comparisons between groups.

Statistical Analysis

Data were analyzed using SPSS (IBM SPSS Statistics 27), with results summarized through frequency tables and descriptive statistics. Non-parametric methods were applied for measurement values not following a normal distribution, with comparisons between two dependent groups conducted using the Wilcoxon test (Z-table value), comparisons among three or more independent groups using the Kruskal-Wallis H test (χ^2-table value), and associations between two qualitative variables assessed via Pearson's χ^2 cross tables.

Results

No statistically significant associations existed between the groups and variables including sex, side, type of anesthesia, sports involvement, and injury mechanism ($p>0.05$). These characteristics were consistent and comparable across the groups. However, significant differences in the time from injury to surgery were observed among the three groups ($\chi^2=20,029$; $p<0.001$).

It was determined that 21 (72.4%) in the isolated ACL R group and 17 (63.0%) in the ACL R+ meniscal repair group were 0-6 months, while 14 (56.0%) in the ACL R+ meniscectomy group were >12 months. It was determined that the time of injury was predominantly 0-6 months in those with isolated ACL R and ACL R+ meniscus repair, and predominantly >12 months in those with ACL + meniscectomy (Table 1).

The groups exhibited a statistically significant association with the type of meniscal tear ($\chi^2=11.577$; $p=0.041$). As a result of the post-hoc analysis to identify the source of the significant association, it was found that the association was due to the fact that no flap was performed in the ACL R+ meniscal repair group, whereas in the ACL R+ meniscectomy group, flaps were performed in 7 patients (28.0%) (Table 2).

No statistically significant differences in age (years), follow-up period, or BMI (kg/m²) were observed across the groups ($p>0.05$) (Table 3).

Preoperative and postoperative IKDC scores did not differ significantly across the groups ($p>0.05$) (Table 4, Graphic 1).

Patients in the isolated ACL R group exhibited a statistically significant difference in IKDC scores across the follow-up periods ($Z=-4.706$; $p<0.001$). Postoperative IKDC scores were significantly greater compared to preoperative scores.

IKDC scores differed significantly among patients in the ACL R+ meniscal repair group based on their treatment

processes (Z=-4.543; p<0.001). Postoperative IKDC was significantly greater compared to preoperative values.

When preoperative Tegner scores were examined by group, a statistically significant difference was observed (χ^2=9.749; p=0.008). Pairwise comparisons with Bonferroni correction were used to identify the groups responsible for this difference, revealing a significant difference between the isolated ACL R group and those with ACL R+ meniscal repair.

Table 1. Analysis of the association between study groups and qualitative characteristics

Variable	Isolated ACL R (n=29)		ACL R+ meniscal repair (n=27)		ACL R+ meniscectomy (n=25)		Statistical analysis* probability
	n	%	n	%	n	%	
Gender							
Male	25	86.2	21	77.8	21	8.,0	χ^2=0.737
Woman	4	13.8	6	22.2	4	16.0	p=0.692
Side							
Right	17	58.6	17	63.0	15	60.0	χ^2=0.114
Left	12	41.4	10	37.0	10	40.0	p=0.945
Anesthesia type							
Spinal	26	89.7	23	85.1	22	88.0	χ^2=0.262
General	3	10.3	4	14.8	3	12.0	p=0.877
Sports-related							
Related	18	62.1	16	59.3	16	64.0	χ^2=0.126
Not related	11	37.9	11	40.7	9	36.0	p=0.939
Mechanism							
Non-contact	25	86.2	22	81.5	22	88.0	χ^2=0.474
Contact	4	13.8	5	18.5	3	12.0	p=0.789
Injury (month)							
0-6	21	72.4	17	63.0	9	36.0	χ^2=20.029
7-12	7	24.1	2	7.4	2	8.0	**p<0.001**
>12	1	3.5	8	29.6	14	56.0	

*: Pearson's χ^2 cross-tabulations evaluate the association between two qualitative variables, ACL: Anterior cruciate ligament

Table 2. Examination of the relationship between groups and meniscus type

Variable	ACL R+ meniscus repair (n=27)		ACL R+ meniscectomy (n=25)		Statiscical analysis* probability
	n	%	n	%	
Meniscus type					
Flap	-	-	7	28.0	χ^2=11.577
Horizontal	3	11.1	2	8.0	**p=0.041**
Complex	3	11.1	4	16.0	
Bucket handle	10	37.0	8	32.0	
Longitudinal	5	18.6	3	12.0	
Radial	6	22.2	1	4.0	

*: Pearson's χ^2 cross-tabulations were used to examine the relationship between two categorical variables, ACL: Anterior cruciate ligament

Table 3. Comparison of socio-demographic quantitative findings according to groups

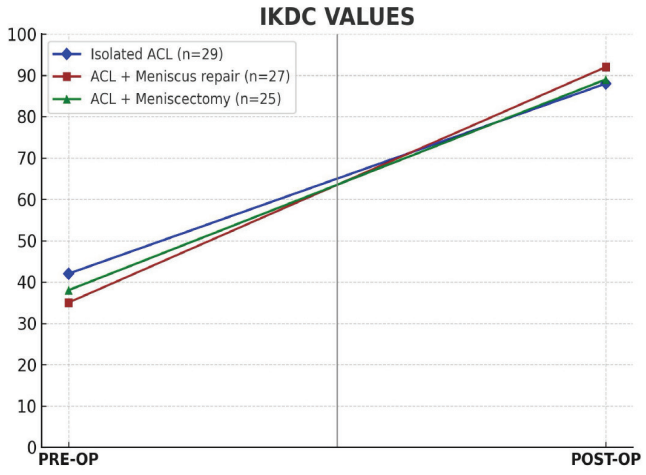
Variable	Isolated ACL R (n=29)		ACL R+ meniscus repair (n=27)		ACL R+ meniscectomy (n=25)		Statiscical analysis * probability
	$\underline{X}$ ± SD	Median [IQR]	$\underline{X}$ ± SD	Median [IQR]	$\underline{X}$ ± SD	Median [IQR]	
Age (years)	31.83±6.79	32.0 [8.0]	28.00±7.49	28.0 [9.0]	31.44±6.58	31.0 [9.5]	χ^2=5.644 p=0.059
Follow-up period	17.83±4.77	18.0 [7.5]	20.59±6.94	18.0 [8.0]	22.56±10.12	18.0 [21.0]	χ^2=2.489 p=0.288
BMI (kg/m^2)	27.16±3.05	27.2 [3.9]	27.21±3.09	26.6 [3.2]	25.89±2.96	25.6 [4.8]	χ^2=3.034 p=0.219

*: The Kruskal-Wallis H test (χ^2 table value) statistics were used to compare the measurement values of three or more independent groups in data that did not show a normal distribution, ACL: Anterior cruciate ligament, BMI: Body mass index, SD: Standard deviation, IQR: Interquartile range

Table 4. Comparison of IKDC values by groups and processes

Variable	Isolated ACL R (n=29)		ACL R+ meniscus repair (n=27)		ACL R+ meniscectomy (n=25)		Statistical analysis* probability
	X ± SD	Median [IQR]	X ± SD	Median [IQR]	X ±SD	Median [IQR]	
IKDC							
Pre-op	41.55±16.17	42.0 [24.5]	34.00±13.61	25.0 [28.0]	39.92±13.92	40.0 [21.5]	χ^2=4.723 p=0.094
Post-op	86.41±10.37	90.0 [13.0]	92.89±6.26	94.0 [10.0]	87.80±10.18	90.0 [12.5]	χ^2=4.840 p=0.089
Analysis probability	Z=-4.706 **p<0.001**		Z=-4.543 **p<0.001**		Z=-4.376 **p<0.001**		

*: To compare measurements between two related groups for non-normally distributed data, the Wilcoxon test (Z-value) was employed, whereas comparisons across three or more independent groups were conducted using the Kruskal-Wallis H test (χ^2 value), SD: Standard deviation, IKDC: International Knee Documentation Committee, ACL: Anterior cruciate ligament, IQR: Interquartile range



Graphic 1. Distribution of IKDC values by groups and processes

IKDC: International Knee Documentation Committee, ACL: Anterior cruciate ligament

Patients with ACL R+ meniscus repair had significantly higher preoperative Tegner scores than those with isolated ACL R.

When postoperative Tegner scores were examined by group, a statistically significant difference was found (χ^2=7.410; p=0.025). To determine the group in which this difference occurred, a significant difference was found between those with ACL R+ meniscus repair and those with ACL R+ meniscectomy. Patients undergoing ACL R+ meniscectomy showed significantly higher postoperative Tegner scores than those with isolated ACL R.

The isolated ACL R group exhibited a statistically significant difference in Tegner activity scores across the treatment process (Z=-2.828; p=0.005). Patients' postoperative Tegner scores decreased significantly compared to their preoperative scores.

The ACL R+ meniscal repair group exhibited a statistically significant difference in Tegner activity scores across the treatment process (Z=-3.419; p<0.001). Postoperative Tegner values were significantly lower compared to preoperative values.

The ACL R+ meniscectomy group exhibited a statistically significant difference in Tegner activity scores across the treatment process (Z=-3.100; p=0.002). Postoperative Tegner values were significantly lower compared to preoperative values (Table 5, Graphic 2).

Preoperative and postoperative Lysholm activity scores did not differ significantly across the groups (p>0.05).

The isolated ACL R group exhibited a statistically significant difference in Lysholm scores across procedures (Z=-4.706; p<0.001). Postoperative Lysholm values were significantly higher compared to preoperative values.

The ACL R+ meniscal repair group exhibited a statistically significant difference in Lysholm scores across procedures (Z=-4.543; p<0.001). Postoperative Lysholm values were significantly higher compared to preoperative values.

The ACL R+ Meniscectomy group exhibited a statistically significant difference in Lysholm scores across procedures (Z=-4.373; p<0.001). Postoperative Lysholm values were significantly higher compared to preoperative values (Table 6, Graphic 3).

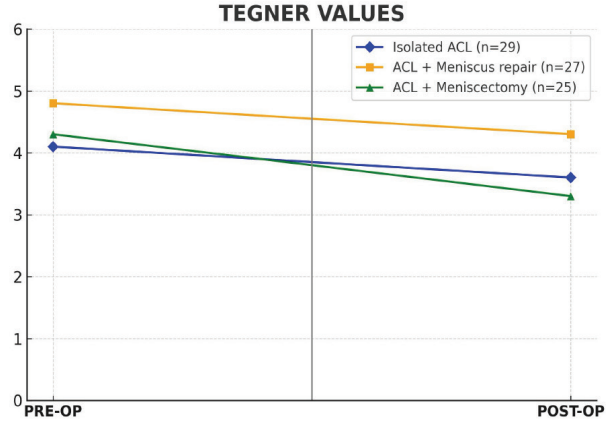
Preoperative and postoperative Cincinnati values did not differ significantly among the groups (p>0.05).

The isolated ACL R group exhibited a statistically significant difference in Cincinnati scores across procedures (Z=-4.706; p<0.001). Postoperative Cincinnati values were significantly higher than preoperative values.

Table 5. Comparison of Tegner values by groups and processes

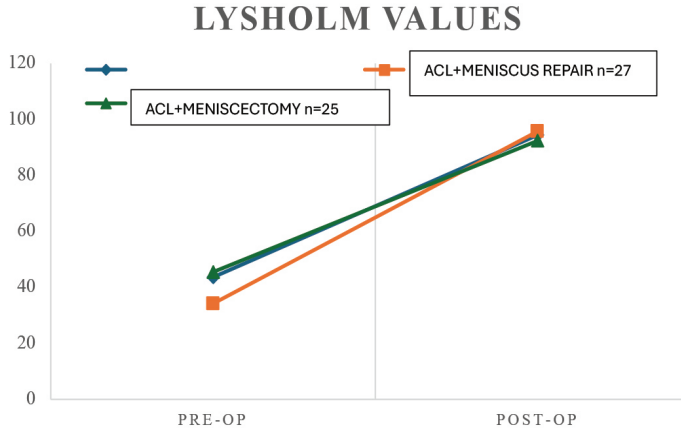
Variable	Isolated ACL R (n=29)		ACL R+ meniscal repair (n=27)		ACL R+ meniscectomy (n=25)		Statistical analysis* probability
	X̲ ± SD	Median [IQR]	X̲ ± SD	Median [IQR]	X̲ ± SD	Median [IQR]	
Tegner							
Pre-op	4.00±0.80	4.0 [0.5]	4.78±1.05	4.0 [1.0]	4.28±1.14	4.0 [1.0]	χ^2=9.749 **p=0.008** **[1-2]**
Post-op	3.72±0.95	4.0 [1.0]	4.22±1.21	4.0 [2.0]	3.40±1.00	3.0 [1.0]	χ^2=7.410 **p=0.025** **[2-3]**
Analysis probability	Z=-2.828 **p=0.005**		Z=-3.419 **p<0.001**		Z=-3.100 **p=0.002**		

*: For data not normally distributed, the Wilcoxon test (Z statistic) was applied to compare two dependent groups, while the Kruskal-Wallis H test (χ^2 statistic) was applied to compare three or more independent groups, SD: Standard deviation, ACL: Anterior cruciate ligament, IQR: Interquartile range



Graphic 2. Distribution of Tegner values according to groups and processes

ACL: Anterior cruciate ligament



Graphic 3. Distribution of Lysholm values according to groups and processes

ACL: Anterior cruciate ligament

Table 6. Comparison of Lysholm values by groups and processes

Variable	Isolated ACL R (n=29)		ACL R+ meniscal repair (n=27)		ACL R+ meniscectomy (n=25)		Statistical analysis* probability
	X̲ ± SD	Median [IQR]	X̲ ± SD	Median [IQR]	X̲ ± SD	Median [IQR]	
Lysholm							
Pre-op	43.62±14.93	45.0 [20.0]	34.18±16.17	40.0 [25.0]	45.48±19.37	48.0 [32.0]	χ^2=4.583 p=0.101
Post-op	94.41±7.06	98.0 [10.0]	95.74±6.57	98.0 [5.0]	92.36±10.11	97.0 [10.0]	χ^2=1.508 p=0.470
Analysis probability	Z=-4.706 **p<0.001**		Z=-4.543 **p<0.001**		Z=-4.373 **p<0.001**		

*: To compare two related groups for non-normally distributed data, the Wilcoxon test (Z value) was employed, whereas comparisons involving three or more independent groups were conducted using the Kruskal-Wallis H test (χ^2 value), SD: Standard deviation, ACL: Anterior cruciate ligament, IQR: Interquartile range

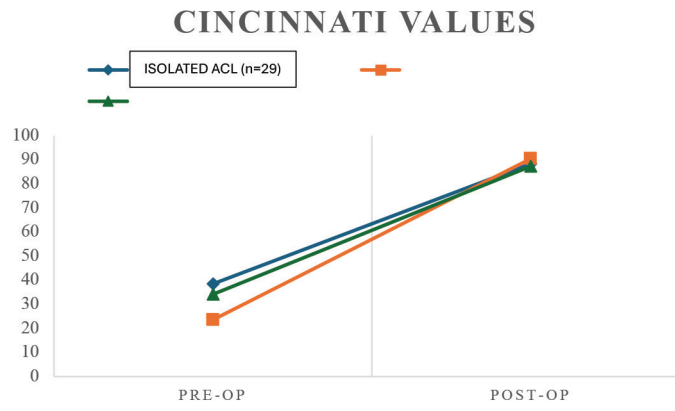
The ACL R+ meniscal repair group exhibited a statistically significant difference in Cincinnati scores across procedures (Z=-4.545; p<0.001). Postoperative Cincinnati values were significantly higher than preoperative values.

The ACL R+ meniscectomy group exhibited a statistically significant difference in Cincinnati scores across procedures (Z=-4.375; p<0.001). Postoperative Cincinnati scores were significantly higher compared with preoperative scores (Table 7, Graphic 4).

Table 7. Comparison of Cincinnati values by group and process

Variable	Isolated ACL R (n=29)		ACL R+ meniscal repair (n=27)		ACL R+ meniscectomy (n=25)		Statistical analysis* probability
	X ± SD	Median [IQR]	X ± SD	Median [IQR]	X ± SD	Median [IQR]	
Cincinnati							
Pre-op	30.48±21.65	20.0 [26.0]	23.56±12.24	23.0 [16.0]	34.16±21.82	30.0 [41.0]	χ^2=2.065 p=0.356
Post-op	88.38±14.89	96.0 [27.0]	90.44±12.36	94.0 [17.0]	87.32±13.42	92.0 [25.5]	χ^2=0.393 p=0.822
Analysis probability	Z=-4.706 **p<0.001**		Z=-4.545 **p<0.001**		Z=-4.375 **p<0.001**		

*: For data not following a normal distribution, comparisons between two related groups were performed via the Wilcoxon test (Z-value), and comparisons across three or more independent groups were conducted via the Kruskal-Wallis H test (χ^2 value), ACL: Anterior cruciate ligament, SD: Standard deviation, IQR: Interquartile range



Graphic 4. Distribution of Cincinnati values according to groups and processes
ACL: Anterior cruciate ligament

Comparison of the groups revealed no statistically significant differences in Lachman test results at either the preoperative or postoperative assessment (p>0.05).

The groups did not differ significantly in Lachman test results at preoperative or postoperative assessment (p>0.05) (Table 8).

The groups did not differ significantly regarding Tegner score differences or posterior tibial slope (p>0.05).

The groups exhibited significant differences in the interval between injury and surgery (in months) (χ^2=12.533; p=0.002). Bonferroni-corrected pairwise comparisons were performed to identify the source of this difference. The isolated ACL R group differed significantly from the ACL R+ meniscus repair and ACL R+ meniscectomy groups. Specifically, patients in the ACL R and ACL R+ meniscectomy groups exhibited a significantly shorter time from injury to

Table 8. Examining the association between groups and the qualitative characteristics of the study

Variable	Pre-op						Statistical analysis* probability	Post-op						Statistical analysis* probability
	Isolated ACL R (n=29)		ACL R+ meniscal repair (n=27)		ACL R+ meniscectomy (n=25)			Isolated ACL R (n=29)		ACL R+ meniscectomy (n=27)		ACL R+ meniscectomy (n=25)		
	n	%	n	%	n	%		n	%	n	%	n	%	
Lachman														
Negative (-)	9	31.0	5	18.5	6	24.0		29	100.0	26	96.3	23	92.0	
(+)	17	58.6	19	70.4	15	60.0	χ^2=3.524	-	-	1	3.7	2	8.0	χ^2=2.409
(++)	3	10.4	3	11.1	3	12.0	p=0.741	-	-	-	-	-	-	p=0.300
(+++)	-	-	-	-	1	4.0		-	-	-	-	-	-	
Anterior drawer														
Negative (-)	6	20.7	2	7.4	3	12.0		22	75.9	22	81.5	19	76.0	
(+)	13	44.8	8	29.6	6	24.0		7	24.1	5	18.5	5	20.0	χ^2=2.539
(++)	9	31.0	16	59.3	16	64.0	χ^2=8.173	-	-	-	-	1	4.0	p=0.638
(+++)	1	3.5	1	3.7	-	-	p=0.226	-	-	-	-	-	-	

*: The association between two qualitative variables was analyzed by Pearson χ^2 cross-tabulation, ACL: Anterior cruciate ligament

surgery (in months) compared to those undergoing ACL R+ meniscectomy (Table 9).

Postoperative anteroposterior and lateral knee radiographs of all study groups are presented to illustrate the surgical reconstruction characteristics. Representative images demonstrate (Figure 1) ACL reconstruction combined with meniscal repair, (Figure 2) isolated ACL reconstruction, and (Figure 3) ACL reconstruction with concomitant meniscectomy.

Discussion

This study aimed to compare one-year postoperative clinical outcomes among patients undergoing isolated ACL-R, ACL-R following ACL rupture, and ACL-R combined with meniscal repair or meniscectomy. The outcomes of 29 patients in the isolated ACL R group, 27 in the ACL R+ meniscus repair group, and 25 in the ACL R+ meniscectomy group were evaluated. The advantages of our study were the homogeneity of the groups regarding age, gender, BMI, follow-up duration, and surgical side, and the fact that it was conducted by the same surgical team. While the follow-up period was sufficient for comparing early-term results, its inadequacy in terms of long-term outcomes is a drawback. Long follow-up is required to evaluate complications such as the development of osteoarthritis, tunnel widening, and re-tear or rupture of the ACL and meniscus. Another drawback was that the majority of the participants were not professional athletes and, therefore, did not return to their prior activities.

Ageberg et al. (5) found that 70% of ACL injuries are non-contact, whereas the remaining 30% are contact injuries. Michalitsis et al. (4) reported non-contact mechanisms in 72% of cases and contact injuries in 28% of cases in a survey of athletes regarding the mechanisms of ACL injuries. There is broad consensus in previous studies that approximately 70% of ACL injuries result from non-contact events (5).

Table 9. Comparison of some quantitative findings by groups

Variable	Isolated ACL R (n=29)		ACL R+ meniscal repair (n=27)		ACL R+ meniscectomy (n=25)		Statistical analysis* probability
	$\underline{X}$ ± SD	Median [IQR]	$\underline{X}$ ± SD	Median [IQR]	$\underline{X}$ ± SD	Median [IQR]	
Tegner score difference	0.28±0.45	0.0 [1.0]	0.56±0.64	0.0 [1.0]	0.88±1.09	0.0 [2.0]	χ^2=4.992 p=0.082
Posterior tibial slope	9.80±2.63	9.9 [4.5]	8.82±2.70	8.8 [3.1]	9.59±2.96	9.2 [4.2]	χ^2=1.641 p=0.440
Time to injury (months)	5.55±5.40	3.0 [8.0]	10.18±10.64	6.0 [15.0]	21.20±17.73	24.0 [32.0]	χ^2=12.533 **p=0.002 [1.2-3]**

*: The Kruskal-Wallis H test (χ^2-table value) was applied to compare measurements among three or more independent groups for data not following a normal distribution, SD: Standard deviation, ACL: Anterior cruciate ligament, IQR: Interquartile range

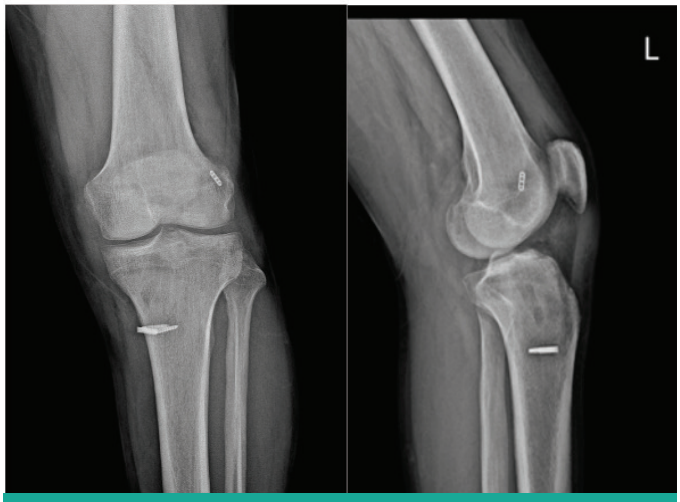


Figure 1. ACL reconstruction combined with meniscal repair

ACL: Anterior cruciate ligament

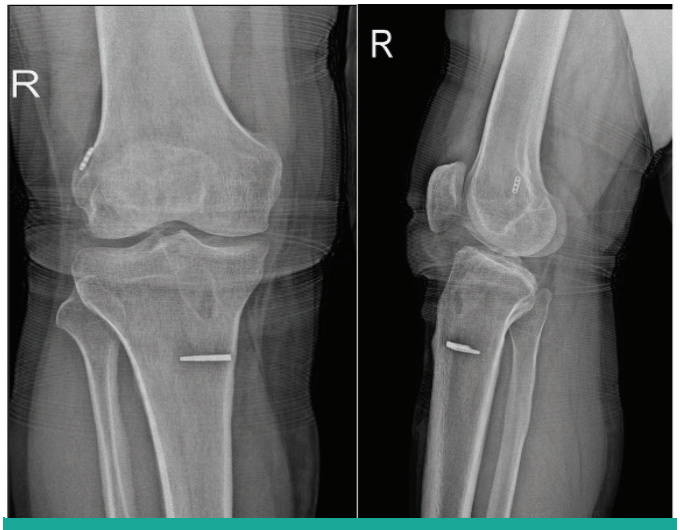


Figure 2. Isolated ACL reconstruction

ACL: Anterior cruciate ligament

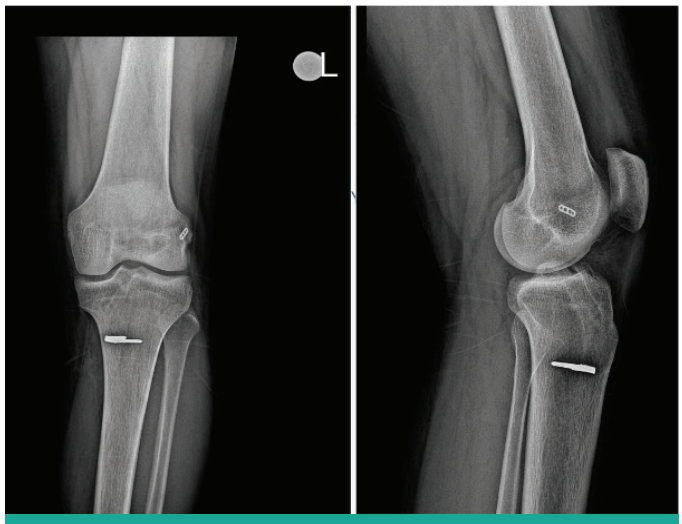


Figure 3. ACL reconstruction with concomitant meniscectomy

ACL: Anterior cruciate ligament

In line with the literature 85% of cases in our study were non-contact, while 15% were contact. An estimated 70% of ACL injuries are sports-related (6). In our patients, the etiology of injuries was found to be sports-related in 61.2% of the isolated ACL R group, 59.3% in the ACL R+meniscus repair group, and 64% in the ACL R+meniscectomy group. The analysis did not reach statistical significance across the groups. Although the risk of injury was higher in women, only one in every five of our patients was female (5). This can be attributed to football being the leading cause of sports-related injuries, with men participating more frequently in such activities. High-energy events, such as construction accidents and traffic collisions, were the most frequent causes of non-sports injuries. This may also be another reason for the low number of female patients presenting.

The mean age of the patient groups treated with isolated ACL R, ACL R+ meniscus repair, and ACL R+ meniscectomy was 31.83, 28.0, and 31.44, respectively, and their BMIs were 27.16, 27.21, and 25.89, respectively. Age, gender, BMI, and injury mechanism did not differ significantly among the groups. The impact of patient age on meniscal repair is debated. Many studies suggest that meniscus tears in the vascular zone, performed with or without ACL reconstruction, have a similar recovery prognosis up to age 58, regardless of age (7,8). Conversely, there are studies showing histologically that menisci in patients over 40 years of age have poorer cellularity and healing potential (9). Another study found that with increasing age, the likelihood of encountering a meniscal tear pattern that is not amenable to repair increases (10).

Meniscal repair rates have been consistently higher in younger patients and those with lower BMI across multiple studies (11-14). Conversely, Abram et al. (12), in a study spanning 1997 to 2017, observed a 2.4-fold increase in meniscal repair incidence among patients aged 30-39 and a 1.3-fold increase among those aged 40-49 during ACL reconstruction. Similar findings have also been reported in other studies (15). Partan et al. (16) observed similar patterns of meniscal preservation among older patients undergoing ACL reconstruction. They also reported a higher proportion of overweight and obese patients receiving concurrent meniscal repair with ACL reconstruction, with only minor differences in mean BMI between those undergoing meniscal repair and those undergoing partial meniscectomy Sommerfeldt et al. (17) investigated the association between BMI and meniscal repair failure, reporting that while higher BMI was linked to an increased likelihood of degenerative meniscal lesions, patients with BMI up to 35 were not at greater risk of repair failure.

In our study, a statistically significant difference was found among the groups with respect to the interval between injury and surgery (χ^2=20.029; p<0.001). It was determined that 21 individuals (72.4%) in the isolated ACL R group and 17 individuals (63.0%) in the ACL R+ meniscus repair group had a mean age of 0-6 months, while 14 individuals (56.0%) with ACL R+ meniscectomy had a mean age of >12 months. The mean interval from injury to surgery was predominantly 0-6 months in patients with isolated ACL R and ACL R+ meniscectomy, it was predominantly >12 months in those with ACL R+ meniscectomy.

The optimal timing for ACL reconstruction following an ACL tear remains a topic of debate (17). Early ACL reconstruction is theoretically advantageous, as it may lower the risk of cartilage or meniscal damage caused by recurrent instability and facilitate a quicker return to sports (18). ACL injury has been linked to a higher risk of osteoarthritis, with cartilage and meniscal lesions in an unstable knee experiencing recurrent sprains potentially playing a contributing role (19-21). ACL injury also affects the patellofemoral joint (22).

Chen et al. (23) reported that medial meniscus tears were more common in ACL reconstructions performed after 12 months compared to those performed before 12 months Allen et al. (11), using a biomechanical force-moment sensor testing system, demonstrated that the medial meniscus experiences significantly higher forces in ACL-deficient knees, highlighting its role in knee stabilization. They

proposed this mechanism to explain the higher prevalence of medial meniscus tears in chronic ACL reconstructions. Most publications indicate that lateral meniscus tears are associated with acute injuries, but the incidence is no different in patients with early and chronic ACL tears. This is thought to result from the greater mobility of the lateral meniscus and the comparatively lower load it experiences during ACL tears (23,24). There is also a relationship between anterior cruciate ligament reconstruction and surgical timing, as well as patients' age, sex, and body mass index (25).

According to Tenuta and Arciero (26), patients receiving acute meniscal repair alongside ACL reconstruction exhibited higher meniscal healing rates than those who underwent delayed meniscal repair. Delayed ACL reconstruction also reduces the likelihood of meniscal repair (26). In our study, 56% of patients who underwent meniscectomy after 12 months were operated on, consistent with literature. Delayed ACL-R is linked to a higher rate of bucket-handle meniscal tears (27). We observed bucket-handle tears as the most common tear type in the group that underwent both meniscal repair and meniscectomy.

Although there is a lack of high-level comparative studies to date, available evidence indicates that meniscal repairs combined with ACL reconstruction are associated with faster healing and lower failure rates compared with isolated repairs. In other words, ACL-R is a protective factor against meniscal repair failure and reoperation. This positive effect is thought to be due to the slower rehabilitation process in meniscal repairs performed simultaneously with ACL-R and the influence of biological factors released by bone tunnels. Another explanation is that meniscal repairs performed alone may cause occult knee instability, which is believed to reduce the success of meniscal repair (27). Therefore, early ACL-R is crucial for reducing the incidence of meniscal tears, preventing joint degeneration, and increasing the likelihood of meniscal repair and healing.

Our results demonstrated satisfactory postoperative IKDC, Lysholm, and Cincinnati scores in all groups, without any statistically significant intergroup differences ($p>0.05$). However, postoperative Tegner scores differed significantly between the groups. ACL R+ meniscus repair patients had significantly higher rates compared to ACL R+ meniscectomy and isolated ACL reconstruction groups.

Eken et al., in a study assessing clinical outcomes of meniscus repair and meniscectomy in chronic bucket-handle tears with ACL reconstruction, found that IKDC scores were significantly higher in the meniscus repair group, although clinical outcomes did not differ. The meniscal repair group exhibited slightly higher Lysholm and Tegner scores; however, these differences did not reach statistical significance (28). Shelbourne and Gray reported that 87% of patients in the isolated ACL reconstruction group, 63% in the medial meniscectomy group, and 60% in the lateral meniscectomy group, who underwent ACL reconstruction with concurrent meniscal intervention, had normal or near-normal IKDC scores (29). In another study, Melton et al. found that after 12.6 years of follow-up, the mean IKDC score in patients with meniscal repair was 14 points higher than in patients with meniscal resection (30,31).

Byrne et al. (32) reported similar results in all three groups at ten months postoperatively in terms of objective measurements, including IKDC scores and return to sports, and that meniscal surgery had no effect on ACL reconstruction. In their meta-analysis, Sarraj et al. (33) found that patients with ACL reconstruction combined with meniscal resection experienced better symptoms at 2-year follow-up than those treated ACL reconstruction with meniscal repair. However, they also reported that ACL-R combined with meniscal repair led to reduced knee joint laxity, better long-term patient-reported outcomes, and higher reoperation rates (32).

In their kinematic analysis, Wang et al. (34) revealed that patients with partial medial meniscectomy had significantly elevated adduction angle during early and mid-stance phases, tibial internal rotation during early stance phases, and anterior tibial translation during the swing phase compared with healthy knees, whereas patients with medial meniscus repair had increased adduction angle and anterior tibial translation only at the beginning of the terminal stance phase (33). According to Seon et al. (35), anterior tibial translation was higher in the partial meniscectomy group than in the isolated ACL reconstruction group, indicating that ACL reconstruction alone may not completely restore normal sagittal kinematics (34).

Our study found that Lachman and anterior drawer test outcomes did not differ significantly between preoperative and postoperative assessments ($p>0.05$). At the one-year postoperative evaluation, the anterior drawer test revealed ++ anterior tibial translation in only one patient (4%) from the meniscectomy group. Downhill running kinematics research has shown that meniscal damage contributes to greater tibial anterior translation at two years following ACL reconstruction (35). In their biomechanical analysis,

Papageorgiou et al. (36) demonstrated that medial meniscus resection led to a 33-50% increase in the forces applied to the ACL graft. Consequently, increased tibial translation, combined with elevated graft tension due to meniscal tissue removal, may predispose the graft to failure.

Most surgeons implement a weight-bearing and knee range of motion restriction protocol following meniscus repair. This significantly limits patient rehabilitation compared to meniscectomy or isolated ACL R (36). Spang et al. (37) assessed biomechanical stresses using a cadaver model in which they created and repaired a meniscal tear and reported no significant changes in the meniscus. The literature does not associate early joint motion resumption with a higher rate of weight-bearing failure after meniscal repair. Our findings suggest that weight-bearing and range of motion restriction do not affect return to sports at 6 months.

Study Limitations

Di Miceli et al. (38) have shown that bracing and delayed weightbearing after ACL repair reduce functional outcomes according to IKDC scores. However, their effect on ACL repair performed in conjunction with meniscal repair has not been investigated. While early motion and early weightbearing may provide functional benefits or, some detrimental effects on limitation in the medium term for isolated ACL repair, our study found this not to be the case for concurrent meniscal repair (37). Di Miceli et al. (38) reported no differences in IKDC and Tegner scores among the three groups in their study. In contrast to these studies, our study found significantly higher Tegner activity scores in the meniscus repair group. We believe that the weightbearing and range of motion restriction protocol positively influences both meniscal and ACL healing.

Conclusion

This study evaluated the one-year postoperative clinical outcomes of patients undergoing meniscal surgery in combination with ACL-R for ACL insufficiency. The key findings and recommendations are summarized below.

Most injuries are sports-related, highlighting the importance of recognizing external and individual risk factors and educating athletes to prevent injury.

An increased interval between injury and surgery raises the likelihood of injury to other knee structures due to instability resulting from an ACL injury. Patients undergoing surgical treatment after 12 months are more likely to exhibit meniscal tear patterns unsuitable for repair. In patients who undergoing surgery in the acute phase, surgery is recommended early, after the exacerbation period (the first 3-4 weeks) has passed, due to the risk of developing arthrofibrosis.

Our study shows that the early clinical outcomes of isolated ACL-R and ligament reconstruction combined with meniscal repair or resection are satisfactory and not poor. However, in the long term, osteoarthritis development is accelerated in patients undergoing meniscectomy. Preserving meniscal integrity whenever possible is recommended to prevent osteoarthritis.

Although the literature indicates that anterior knee stability is lower in patients who undergo meniscal repair compared with those who undergo meniscectomy, the present study found that patients undergoing meniscal repair had higher Tegner activity scores than those undergoing meniscectomy. Weight-bearing and movement restrictions were prescribed for patients with meniscal repair. These results suggest that weight-bearing and movement restrictions have no impact on clinical outcomes. Patients should be supported to safely and promptly return to sports or other pre-injury activities.

Ethics

Ethics Committee Approval: This study was conducted after the approval received from the Tekirdağ Namık Kemal University Local Ethics Committee meeting dated 28.11.2023 (protocol number 2023.197.11.11.11).

Informed Consent: Informed consent was obtained.

Footnotes

This study was presented as an oral presentation at the "6th Bilsel International World Science and Research Congress, 28-29 December 2024, İstanbul/Turkey".

Authorship Contributions

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

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

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