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COMPARISON OF FUNCTIONAL OUTCOMES AND KINESIOPHOBIA LEVELS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH HAMSTRING TENDON AUTOGRAFT VERSUS FRESH-FROZEN ALLOGRAFT: A CROSS-SECTIONAL STUDY

HAMSTRİNG TENDON OTOGREFTİ VEYA TAZE DONDURULMUŞ ALLOGREFT İLE ÖN ÇAPRAZ BAĞ REKONSTRÜKSİYONU YAPILAN BİREYLER İLE SAĞLIKLI BİREYLER ARASINDA FONKSİYONEL SONUÇLARIN VE KİNEZYOFOBİ DÜZEYLERİNİN KARŞILAŞTIRILMASI: KESİTSEL BİR ÇALIŞMA

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ABSTRACT

Objective: Determining the best graft in the selection of various graft types for anterior cruciate ligament reconstruction (ACLR) is still unclear. The study aimed to compare the functional outcomes and kinesiophobia among individuals who underwent ACLR with either hamstring tendon autograft or fresh-frozen allografts and healthy individuals.

Method: A total of 44 individuals undergoing ACLR and 30 healthy individuals were assessed. Individuals who underwent ACLR with hamstring tendon autograft (Group 1) or fresh-frozen allograft (Group 2) and a control group with similar activity levels (Group 3) were included in this study. The surgical groups were evaluated 12-48 months after surgery. Evaluations included detailed history, knee muscle strength, single-leg hop test, and kinesiophobia.

Results: There were 24 individuals (mean age 31.71±9.78 years) in Group 1, 20 individuals (mean age 32.35±5.58 years) in Group 2, and 30 healthy controls (mean age 33.77±7.09 years) in Group 3. There was no difference between the surgical groups in terms of single-leg hop test, kinesiophobia, and muscle strength ($p>0.05$). However, there were significant differences between the ACLR groups with the control group in terms of muscle strength of injured side ($p<0.002$), single-leg hop test ($p<0.029$), and kinesiophobia level ($p=0.005$).

Conclusion: This study showed that no graft type was superior to another in terms of functional outcomes and kinesiophobia after ACLR. In addition, the need for long-term rehabilitation of individuals with ACLR should be taken into consideration to reach their pre-operative functional level.

Key Words: Allografts, Autografts, Anterior Cruciate Ligament Reconstruction, Kinesiophobia, Functional Performance

ÖZ

Amaç: Ön çapraz bağ rekonstrüksiyonu (ÖÇBR) için çeşitli greft tiplerinin seçiminde en iyi greftin belirlenmesi hala belirsizdir. Bu çalışma, hamstring tendon otogrefti veya taze dondurulmuş allogreft ile ÖÇBR uygulanan bireyler ile sağlıklı bireyler arasındaki fonksiyonel sonuçları ve kinezyofobiyi karşılaştırmayı amaçladı.

Yöntem: ÖÇBR uygulanan toplam 44 kişi ve 30 sağlıklı birey değerlendirildi. Bu çalışmaya hamstring tendon otogrefti (Grup 1) veya taze dondurulmuş allogreft (Grup 2) ile ÖÇBR uygulanan bireyler ve benzer aktivite düzeyine sahip kontrol grubu (Grup 3) dahil edildi. Cerrahi gruplar ameliyattan 12-48 ay sonra değerlendirildi. Değerlendirmeler arasında ayrıntılı öykü, diz kas kuvveti, tek bacakta sıçrama testi ve kinezyofobi yer aldı.

Bulgular: Grup 1'de 24 kişi (ortalama yaş 31,71±9,78 yıl), Grup 2'de 20 kişi (ortalama yaş 32,35±5,58 yıl), Grup 3'te ise 30 sağlıklı kontrol (ortalama yaş 33,77±7,09 yıl) vardı. ÖÇBR grupları arasında kas kuvveti, tek bacak sıçrama testi ve kinezyofobi açısından anlamlı fark yoktu ($p>0,05$). Ancak ÖÇBR grupları ile kontrol grubu arasında ameliyatlı taraf kas kuvveti ($p<0,002$), tek bacak sıçrama testi ($p<0,029$) ve kinezyofobi düzeyi ($p=0,005$) açısından anlamlı farklılıklar vardı.

Sonuç: Bu çalışma, ÖÇBR sonrası fonksiyonel sonuçlar ve kinezyofobi açısından herhangi bir greft tipinin diğerine üstün olmadığını gösterdi. Ayrıca ÖÇBR'li bireylerin ameliyat öncesi fonksiyonel seviyeye ulaşabilmeleri için uzun süreli rehabilitasyon ihtiyaçları göz önünde bulundurulmalıdır.

Anahtar Kelimeler: Allogreftler, Otogreftler, Ön Çapraz Bağ Rekonstrüksiyonu, Kinezyofobi, Fonksiyonel Performans

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INTRODUCTION

Anterior cruciate ligament (ACL) injuries are among the most common injuries in the world, and it was reported there are approximately 250,000 injuries in the United States each year [1]. The incidence rate of ACL injuries in females is higher than in males when exposed to the same sport. However, the annual number of ACL injury incidence is higher in males because men play higher-risk sports than females [2]. Anterior cruciate ligament reconstruction (ACLR) has recently been used as the standard treatment for ACL injury [3]. Different types of grafts are used in ACLR, such as autografts and allografts. The commonly used autografts are hamstring, quadriceps tendons, and bone-patellar tendon-bone (BPTB). Similarly, achilles, tibialis anterior and posterior muscles, hamstring and quadriceps tendons, and BPTB are the available allografts [4].

The hamstring tendon autograft has been significantly increased recently [5]. It has been reported to have lower donor site morbidity, anterior knee pain, and immune response, as well as greater satisfaction than other autografts such as BPTB and quadriceps tendon [6-9]. On the other hand, when allografts are used, they can provide shorter surgical time, without donor site morbidity, and a more controllable graft size. However, there are the disadvantages of allografts such as low regeneration capabilities and causing blood-borne diseases such as HIV, Hepatitis B, and C [10]. Although both types of grafts are frequently preferred due to their advantages, autografts using the hamstring tendon have a significant disadvantage. It is stated that since the individual's hamstring tendon is used in hamstring tendon autografts knee flexion strength (ranging from 10% to 20%) is reduced [11,12]. Contrary to previous studies, there are also studies indicating that hamstring tendon autografts and fresh-frozen allografts are similar in terms of knee laxity and subjective clinical results [3,5,9,12-17]. Additionally, higher incidence of graft laxity and weaker knee stability after ACLR have been reported in hamstring tendon autografts [18].

Single-leg hop performance and muscle strength offer important clues to return to functional performance before ACL injury [19]. However, studies comparing both graft types in terms of functional outcomes after ACLR are quite limited [9,12,16,17]. In these studies, functional performance was evaluated only with hop tests (single-leg hop and vertical hop), and the results were found to be similar. Therefore, there is a need for a multifaceted evaluation of functional performance. Knee strength, which is an important determinant of functional performance [20], has not been compared between the two graft types so far.

Approximately 50% of patients with ACLR fail to return to pre-injury activity levels despite improved performance on physical tests [21,22]. It is stated that psychological problems significantly affect the return to sports after injury, but despite this, there is still a need for high-quality observation and intervention studies [23]. Kinesiophobia (eg, fear of movement/reinjury) has been identified as one particularly important psychological factor in post-ACLR [24,25]. Although the kinesiophobia level generally decreases post-ACLR, people suffer from kinesiophobia for many years [25]. Kinesiophobia has been associated with worse physical performance, decreased activity levels, and increased risk of secondary injury after ACLR in individuals with an average activity level of 5.7±1.3 according to the Tegner activity scale [26]. On the other hand, as mentioned above, some disadvantages as well as advantages have been reported in individuals who underwent ACLR with different graft types. Based on this, comparing kinesiophobia in terms of different graft types will be a guide in choosing the appropriate graft type and rehabilitation. However, to date, no study has examined the changes in kinesiophobia levels in different graft types post-ACLR.

In this cross-sectional study, we used hamstring tendon autograft and fresh-frozen allografts for ACLR. The main aim of this study was to compare long-term results of functional outcomes and kinesiophobia in both graft types. The secondary aim was to compare both surgical groups with healthy controls (HC). Our hypothesis was that fresh-frozen allografts would have better functional results and kinesiophobia levels than hamstring tendon autografts. It was also expected that both groups would have worse functional results and kinesiophobia levels than healthy controls.

METHOD

Study Design

This study was a cross-sectional study of people undergoing anatomic single-bundle ACLR using either hamstring tendon autografts or fresh-frozen allografts. We conducted an assessor-blind study. During the assessments, the surgical group the patients were in was hidden, and the assessor evaluated all individuals in a random order without knowing the type of surgery. The information taken from the electronic medical records included their contact information, date of surgery, graft type used, and any associated injuries such as meniscal injuries and other knee injuries. Participants, who met the inclusion criteria, were invited to a university hospital. Assessments were made between December 2023 and January 2024 after ethics approval. After demographic information was collected pain during activity and rest, surgical satisfaction, functional outcomes (using single-leg hop test and knee muscle strength), and kinesiophobia were assessed for the participants who underwent ACLR. Additionally, knee strength, single-hop test, and kinesiophobia were assessed in HC.

Participant

Forty-four male individuals were included in the study, in which ACLR was performed by the same surgeon. The individuals were divided into two groups hamstring tendon autograft (Group 1, n=24) and fresh-frozen allografts (Group 2, n=20). Additionally, the HC group (Group 3, n=30) was included. The participants undergoing ACLR are shown in Figure 1.

Participants were recruited in Gaziantep through direct referral from primary care clinicians, social media and advertisements. Patients meeting the inclusion criteria were divided into 3 groups (n=20 Mat, n=20 Reformer Pilates, n=20 Hammock Yoga) using a closed envelope randomisation method. The same clinician repeated the baseline assessment and the final assessment after 8 sessions (4 weeks). Only pain severity (VAS) was assessed at baseline, and in the 1st, 2nd, 3rd, and 4th weeks (total of 5-time intervals). No one dropped out of any group while studying (Figure 1).

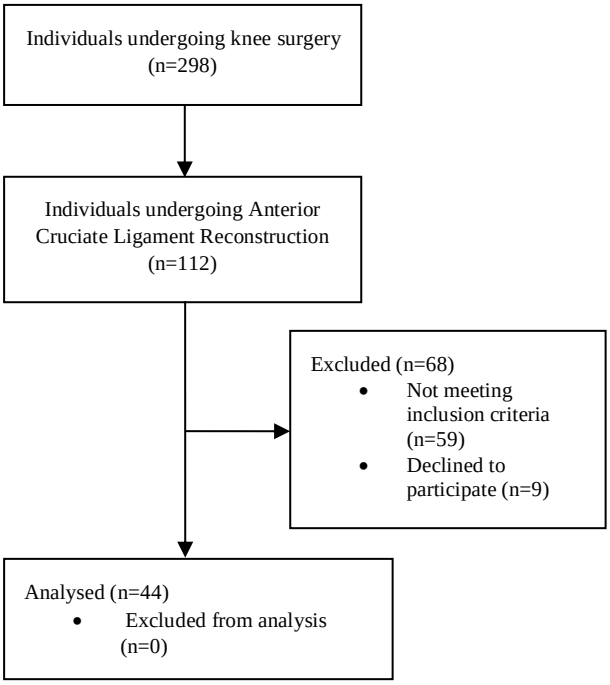

Figure 1. Flow chart of individuals undergoing ACLR

Inclusion Criteria: Inclusion criteria for the surgical groups (Group 1, Group 2) were as follows:

- Unilateral ACLR (Anterior Cruciate Ligament Reconstruction),
- Age between 18 and 65 years,
- Type of surgery involving hamstring tendon autografts or fresh-frozen allografts, with or without concomitant partial meniscectomy or meniscal repair,
- A postoperative period of 12 to 48 months.

Exclusion Criteria:

- Total meniscectomy or revision surgery,
- Multi-ligamentous knee injury or surgery,
- Chondral surgery,
- Combined ligament injury,
- Contralateral knee ligament injury.

Healthy volunteers whose age, gender, and activity levels were compatible with the surgical groups and who did not have any orthopedic surgery or knee injury that could affect the assessments were included in the study as a control group. Activity level was determined by the Tegner activity scale. The Tegner activity scale is a numerical scale with activity levels ranging from 0 (sick leave or disability pension due to knee problems) to 10 (competitive sports on a very high level) [27]. None of the participants were elite athletes.

Rehabilitation

The participants of the ACLR groups underwent a similar rehabilitation for about 3-5 days under the supervision of therapists and were discharged to receive a home exercise program. Partial weight-bearing with crutches was allowed for the first two weeks and knee flexion exceeding 90 was avoided. Then, an increasing amount of knee flexion was allowed. Plyometric exercises were allowed at the end of three months and contact sports were allowed at the end of 12 months [28].

Outcome Measures

Functional outcomes were assessed using the single-leg hop test and knee muscle strength. Kinesiophobia was assessed using The Tampa Scale for Kinesiophobia-17 (TSK-17).

Hop Distance: The Single-Leg Hop Test was used to assess the hop distance. The participants were tested starting with a single-leg stance. The upper limbs were positioned with the hands at the waist. They performed a single leg hop for maximal jump distance on the same leg. Horizontal hop distance was measured from the toe in the starting position to the heel edge at the landing [29]. The mean of three trials for each side was calculated for the data analysis after one trial jump.

Muscle Strength: Isometric knee muscle strength was measured using a Baseline® hand dynamometer (Fabrication Enterprises Inc., NY, USA). Participants were given to warm up with slow walking activities for 5 minutes before the testing. The dynamometer was positioned proximal to the lateral malleolus in the anterior or posterior aspect of the tibia to measure knee muscle strength. Then the strength was measured at 90° flexion position of the knee while the participants were sitting with their arms crossed over their thighs. Those were asked to give a maximal effort against the dynamometer and hold for five seconds after they conducted one practice trial. Meanwhile, the assessor remained stationary by applying counterforce with a hand dynamometer. In this way, the tests were repeated three times for each side, and the averages of the tests were used to measure the outcome [30].

Kinesiophobia: Kinesiophobia was evaluated using the TSK-17 scale. It contains 17 self-report items related to fear of movement, re-injury, and pain. The total score ranges 17-68. Higher scores indicate higher levels of kinesiophobia. In this study, Turkish versions of the TSK-17 were used [3].

Pain: The unidimensional Visual Analog Scale (VAS) was used to evaluate pain intensity during rest and activity and surgical satisfaction in people with ACLR. The scale ranges from “no pain" or "no surgical satisfaction” (score of 0) to “maximum pain” or "maximum surgical satisfaction" (score of 10). The score was determined by measuring the distance on the 10 cm line pointed by the individual [31].

Ethical Approval

This study was approved by the Ethics Committee of the University’s Institutional (approval number: 2023-12/57) and conducted by the Declaration of Helsinki. Additionally, written informed consent was obtained from all study participants and institutional permissions were obtained from the hospital where the assessments were performed.

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 23.0 (SPSS, Chicago, IL). The normality of data was assessed by the Shapiro–Wilk test. Results were reported as mean±SD for normally distributed scale variables, median (interquartile range [IQR]) for non-normally distributed scale variables, and frequency (%) for categorical variables. The Chi-square test was used to compare categorical variables between the groups. The analysis of variance (ANOVA, Tukey test) or Kruskal-Wallis test was used to analyze the differences between the three groups. Independent-samples t-test or Mann-Whitney U test was used to analyze the differences between the two groups. All the significance tests were conducted at the 5% level. Post hoc power analysis was performed using TSK-17 and injured knee extensor strength score of the surgical groups and the power was found to be 0.98 and 0.87, respectively.

Table 1: Demographics and characteristics of participants

	Group 1 (n=24) Mean±SD Median (IQR)	**Group 2 (n=20) Mean±SD Median (IQR)**	**Group 3 (n=30) Mean±SD Median (IQR)**	**p**
Age (years)	31.71±9.78	32.35±5.58	33.77±7.09	0.607
Height (cm)	177.25±6.31	175.70±7.47	176.83±6.91	0.748
Weight (kg)	86.79±13.96	86.6±14.43	81.75±10.40	0.268
BMI (kg/m2)	27.52±3.85	28.03±4.22	26.11±2.60	0.134
Tegner activity scale	4.96±1.57	5.75±1.77	5.86±1.43	0.093
Time since surgery (mo.)	27.08±11.79	33.3±12.21	-	0.094
Surgical satisfaction (10 cm)	6.78 (4.42-8.78)	8.39 (6.11-10.00)	-	0.208
Pain during activity (10 cm)	0.62 (0.00-2.65)	0.26 (0.00-3.85)	-	0.960
	Group 1 (n=24) n (%)	**Group 2 (n=20) n (%)**		**p**
Injured side Right	15 (62.50)	11 (55)	-	0.614
Injured side Left	9 (37.50)	9 (45)		
Only ACLR	14 (58.33)	11 (55)	-	
ACLR+Meniscus repair	9 (37.50)	7 (35)	-	0.747
ACLR+Partial meniscectomy	1 (4.16)	2 (10)	-	

**: p<0.05; BMI: Body mass index; ACLR: Anterior Cruciate Ligament Reconstruction; IQR: Interquartile range. The analysis of variance (ANOVA, Tukey test) test was used to analyze the differences between the three groups and the variables are presented as Mean ± Standard deviation (SD). The independent-samples t-test or the Mann-Whitney U test were used to analyze the differences between the two groups and the variables are presented as Mean ± Standard deviation (SD) or median (interquartile range [IQR]), respectively. The Chi-square test was used to compare categorical variables between the groups.*

RESULTS

A total of 44 ACLR (Group 1; 24, and Group 2; 20) and 30 HC participated in this study. There was no significant difference between the three groups in terms of demographic information and activity score (p>0.05). In addition, there was no significant difference between the ACLR groups in terms of time since surgery, surgical satisfaction, pain during activity, injured side, and additional intervention during surgery (p>0.05), (Table 1). Both surgical groups had no pain during rest.

The knee muscle strength of the injured side and single-leg hop test scores in both surgical groups were significantly lower than HC (p<0.05). Additionally, the TSK-17 scores of both surgical groups were significantly higher than HC (p<0.05). There was no difference between the three groups in terms of knee muscle strength on the non-injured side (p>0.05). There was no difference between both surgical groups in terms of knee muscle strength, single-leg hop test, and kinesiophobia level (p>0.05), (Table 2).

Table 2: Comparison of ACLR groups and healthy controls for outcome variables

		Group 1 (n=24) Mean±SD Median (IQR)	Group 2 (n=20) Mean±SD Median (IQR)	Group 3 (n=30) Mean±SD Median (IQR)	p	p		
						1 vs 2	1 vs 3	2 vs 3
Knee Flexor Strength (N)	Injured	13.99 (11.08-18.60)	12.83 (9.74-16.66)	18.83 (16.24-22.74) (right)	**0.000***	0.305	**0.001***	**0.000***
	Non-injured	16.83 (13.91-21.43)	15.49 (13.41-20.57)	18.16 (14.49-21.41) (left)	0.517	0.402	0.801	0.263
Knee Extensor Strength (N)	Injured	24.52±7.52	24.17±6.47	30.42±6.01 (right)	**0.001***	0.874	**0.002***	**0.001***
	Non-injured	27.60±7.37	26.93±6.02	28.41±6.61 (left)	0.740	0.745	0.671	0.424
Single-Leg Hop test (cm)	Injured	107.33 (88.83-116.12)	111.0 (99.58-131.74)	147.49 (134.91-160.32) (right)	**0.000***	0.253	**0.000***	**0.000***
	Non-injured	126.96±26.55	129.94±28.49	144.25±20.75 (left)	**0.029***	0.722	**0.010***	**0.045***
TSK-17		41.08±4.63	40.45±7.35	36.46±4.50	**0.005***	0.730	**0.001***	**0.039***

N: Newton; TSK-17: Tampa Scale for Kinesiophobia-17.

DISCUSSION

The choice of graft type for ACLR depends on the functional demands of the individual and the advantages and disadvantages associated with each surgical procedure. This study aimed to examine the long-term differences of the commonly preferred hamstring tendon autograft and fresh-frozen allografts in terms of single-leg hop performance, muscle strength, and kinesiophobia level. Our study demonstrated that muscle strength, single-leg hop performance, and kinesiophobia level were similar between both ACLR groups. However, they had significantly lower muscle strength on the injured side, single-leg hop test scores on both sides, and higher kinesiophobia levels than healthy controls.

Single-leg hop performance and muscle strength are key indicators for knee function after ACLR [19]. Therefore, the evaluation of single-leg hop performance and muscle strength offers important clues for the comparison of lower extremity function between different graft types after ACLR. In previous studies, the functional results of people who underwent ACLR using hamstring tendon autograft or fresh-frozen allograft were compared after 2-5.5 years of follow-up, and it was found that the single-leg hop test and vertical hop test results were similar [9,17]. Similarly, Harner et al. [16] compared people with autografts and fresh-frozen allografts at 3–5 years after surgery. They found no statistically significant difference between the groups in terms of single-leg hop and vertical hop performances. This study included people 1-4 years after hamstring tendon autograft or fresh-frozen allografts ACLR. Results showed once again that in parallel with the previous studies, both graft types have similar results in terms of single-leg hop performance. When the literature was examined in terms of knee muscle strength, studies comparing BPTB autograft and BPTB allograft (duration up to 3 years after surgery) reported similar knee muscle strength results [19,32,33]. Similarly, Jung et al. founded similar knee muscle strength results in their study comparing hamstring autograft with tibialis anterior allograft [34]. On the contrary, Landes et al. compared semitendinosus-gracilis autografts with tibialis anterior allografts at 2 years after ACL reconstruction and found that hamstring autograft had lower isometric knee flexor torque [35]. We could not find any study comparing the hamstring tendon autograft and fresh-frozen allograft techniques in terms of muscle strength. In the current study, although the graft types differed compared to those in the previous study [19,32-34], no difference was found between the two surgical groups in terms of both side flexor and extensor strength. The results of the study showed that the use of individuals' hamstring tendons in reconstructions using hamstring tendon autograft did not negatively affect functional performance and kinesiophobia levels as much as expected.

Kinesiophobia level is one of the variables associated with reaching the functional level and returning to sports before the injury [36]. In addition, kinesiophobia has important implications for the individual's perception of function in the long term after ACLR [26]. Although the importance of kinesiophobia post-ACLR has been shown in many studies [26,36], no studies are comparing different graft types in terms of kinesiophobia. Graft types have advantages and disadvantages in various aspects such as their structures and application methods [5,9,37]. For this reason, a comparison of autograft with allograft in terms of kinesiophobia may guide us to better understand the effects on the individual's fear of injury. In this study, kinesiophobia was assessed using the TSK-17. The results of our study showed that both graft types have similar effects in terms of kinesiophobia in the long term. Based on these results, we think that individuals underwent ACLR with hamstring tendon autograft or fresh-frozen allograft have similar kinesiophobia levels, so these two graft types will not make a significant difference in determining rehabilitation goals.

Another outcome of our study was the comparison of ACLR groups and HC. One study showed that individuals with ACLR exhibited lower jumping performance than matched healthy controls [38]. In a systematic review and meta-analysis compiling 21 studies, it was stated that knee muscle strength deficits in individuals with ACLR remained significantly low for many years (up to 4 years after ACLR) despite surgery and rehabilitation [39]. Another study stated that individuals who do not participate in sports regularly have higher kinesiophobia levels after ACLR than healthy controls [40]. In our study, consistent with the literature, both surgical groups had lower muscle strength and single-leg jumping performance and higher kinesiophobia levels compared to HC. This has shown that there is a need for rehabilitation in both surgical groups in the long term.

Limitations

This study had several limitations. Only male participants with ACLR were included in this study. Therefore, the results of the study cannot be generalized to the entire people with ACLR. Another limitation of the study was that the choice of the graft could not be controlled. The choice of the graft may have been decided by the participants themselves or the operating surgeon. Therefore, there may be bias in graft selection. Finally, the individuals included in the study received physiotherapy only in the first week, regardless of the graft type. However, afterward, individuals were followed by a home program. For this reason, it could not be followed exactly how often and how regularly individuals performed the exercises. This may have caused the difference between them and healthy individuals to increase.

CONCLUSION

Based on the results of this cross-sectional study, the use of hamstring tendon autograft and fresh-frozen allograft for ACLR with non-athlete males had similar functional outcomes and kinesiophobia levels. In addition, both graft types had lower functional outcomes and higher kinesiophobia than healthy controls. The results suggest that the requirement for rehabilitation of individuals persists in the long-term following both types of ACLR.

Ethical Approval: *2023-12/57 Non-Interventional Research Ethics Committee of Sivas Cumhuriyet University*

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