Research Article / Araştırma Makalesi

Effects of Femoral Remnant Preservation During Anterior Cruciate Ligament Reconstruction on the Clinical and Functional Outcomes

Ön Çapraz Bağ Rekonstrüksiyonu Sırasında Femoral Kalıntıların Korunmasının Fonksiyonel ve Klinik Sonuçlar Üzerine Etkisi

Baki Volkan ÇETİN [1], Mehmet Akif ALTAY [1], Serkan SİPAHİOĞLU [2], İzzettin YAZAR [3]

[1]Department of Orthopaedics and Traumatology, Harran University Medicine Faculty, Şanlıurfa,TÜRKİYE
[2]Department of Orthopedics and Traumatology, Ordu University Medicine Faculty, Ordu, TÜRKİYE
[3]Department of Orthopaedics and Traumatology, Göksun State Hospital, Kahramanmaraş, TÜRKİYE

Abstract

Background: The aim of this study is to compare the functional and clinical results of the femoral remnant-sparing reconstruction technique with the standard technique in the surgical reconstruction of anterior cruciate ligament (ACL) tears.
Materials and Methods: 150 patients (all men) who underwent surgery for ACL tear were included in the prospective randomized study. The patients were randomly divided into two groups. In Group A (n=75), ACL reconstruction with preservation of tibial and femoral remnants was performed using hamstring tendon autograft. In group B (n=75), standard reconstruction technique was performed with hamstring tendon autograft and femoral remnants were removed while tibial remnants were preserved. The mean age of patients in Group A was 27.23±5.64 years, and 26.72±5.82 years in Group B. The interval between trauma and operation was 4.36±3.21 months in Group A and 3.56±3.08 months in Group B. The mean follow-up period of the patients was 38.05±6.11 months for Group A and 36.86±8.04 months for Group B. There was no difference between the two groups in terms of age of the patients, interval between trauma and operation and follow-up periods (p>0.05). Clinical outcomes of surgery were evaluated using Lysholm score, International Knee Documentation Committee (IKDC) score, Subjective IKDC 2000 knee score, and physical instability tests.
Results: Statistically significant improvement was detected in the preoperative Lysholm, subjective and objective IKDC knee scores, joint range of motion and knee stability tests (Lachman, Pivot Shift, Anterior Drawer) of Group A and Group B patients (p<0.001). When preoperative and postoperative comparisons were made between the groups in early (18 months) controls, a significant increase was found in favor of Group A in Lysholm, subjective and objective IKDC knee scores (p<0.05). There were no significant differences in Lysholm, subjective and objective IKDC knee scores, joint range of motion, and knee stability tests (Lachman, Pivot Shift, Forward drawer) at the last follow-up of the patients (p>0.05).
Conclusions: In the surgical reconstruction of ACL tears, the histologically determined theoretical contribution of ACL femoral remnants in ACL reconstruction performed by preserving the femoral remnants is not clearly observed in clinical and functional results.

Key Words: Anterior cruciate ligament tear, Arthroscopic ACL reconstruction, Femoral remnant.

Öz.

Amaç: Bu çalışmanın amacı, ön çapraz bağ (ÖÇB) yırtıklarının cerrahi tedavisinde, femoral kalıntıların korunduğu rekonstrüksiyon tekniği ile standart tekniğin fonksiyonel ve klinik sonuçlarının karşılaştırılmasıdır.
Materyal ve Metod: İleriye dönük randomize olarak planlanan çalışmaya, ÖÇB yırtığı nedeniyle cerrahi uygulanan 150 hasta (tamamı erkek) dahil edildi. Hastalar randomize olarak iki gruba ayrıldı. Grup A'da (n=75) hastalara hamstring tendon otogrefti kullanılarak tibial ve femoral kalıntıların korunduğu ÖÇB rekonstrüksiyonu uygulandı. Grup B'de (n=75) ise hamstring tendon otogrefti ile standart rekonstrüksiyon tekniği uygulandı ve tibial kalıntılar korunurken femoral kalıntılar temizlendi. Grup A hastaların yaş ortalaması, 27,23±5,64 yıl, Grup B'de ise 26,72±5,82 yıldı. Travma-operasyon arası geçen süre, Grup A'da 4,36±3,21 ay, Grup B'de 3,56±3,08 aydı. Hastaların takip süresi, Grup A için 38,05±6,11 ay, Grup B için ise 36,86±8,04 ay olarak hesaplandı. Her iki grup arasında, hastaların yaşları, travma-operasyon arası geçen süre ve takip süreleri açısından farklılık yoktu (p>0,05). Cerrahinin klinik sonuçları Lysholm skorlaması, Uluslararası Diz Dokümantasyon Komitesi (IKDC) skoru, Subjektif IKDC 2000 diz skorlaması ve fiziksel instabilite testleriyle değerlendirildi.
Bulgular: Grup A ve Grup B hastaların ameliyat öncesi Lysholm, sübjektif ve objektif IKDC diz skorlarında, eklem hareket açıklıklarında ve diz stabilite testlerinde (Lachman, Pivot Şift, Öne Çekmece) ameliyat sonrası istatistiksel olarak anlamlı düzelme tespit edildi (p<0,001). Erken dönem (18 ay) kontrollerde gruplar arasında ameliyat öncesi ve sonrası karşılaştırma yapıldığında Lysholm, sübjektif ve objektif IKDC diz skorlarında Grup A lehine anlamlı yükseklik saptansa da (p<0.05) hastaların son kontrollerinde Lysholm, sübjektif ve objektif IKDC diz skorlarında, eklem hareket açıklıklarında ve diz stabilite testleri (Lachman, Pivot Şift, Öne çekmece) açısından anlamlı farklılık izlenmedi (p>0.05).
Sonuç: ÖÇB yırtıklarının cerrahi tedavisinde, femoral kalıntılar korunarak yapılan ÖÇB rekonstrüksiyonunda, ÖÇB femoral kalıntıların histolojik olarak tespit edilen teorik katkısı, klinik ve fonksiyonel sonuçlarda belirgin olarak izlenmemektedir.

Anahtar kelimeler: Ön çapraz bağ yırtığı, Artroskopik ÖÇB rekonstrüksiyonu, Femoral kalıntı

Corresponding Author/ Sorumlu Yazar

Dr. Baki Volkan ÇETİN
Harran University School of Medicine, Department of Orthopaedics & Traumatology, Osmanbey Campus, Şanlıurfa-Mardin Karayolu Üzeri 18.Km, 63290, Şanlıurfa/TÜRKİYE

E-mail: bvolkanc1@gmail.com

Received / Geliş tarihi: 29.06.2022

Accepted / Kabul tarihi: 05.08.2022

DOI: 10.35440/hutfd.1137590

Introduction

Anterior cruciate ligament (ACL) tears are common sports-related injuries (1). Osteoarthritis may be a possible future outcome in patients with knee instability as a result of ACL tear. The causes of osteoarthritis are chondral lesions and meniscus tears as a result of repeated subluxation (2).

Successful results have been reported in the reconstruction of ACL tears, after the developments in arthroscopic surgical techniques and rehabilitation principles. Purpose of ACL reconstruction is to prevent degeneration by providing knee stabilization and to protect the knee from secondary injuries. Despite advances in ACL reconstruction, graft failure is still a serious problem. Returning to sport activities in the early period and weak graft structure have been shown as the main causes of failure (3). Late-stage osteoarthritis cannot be prevented because of problems related to grafts and proprioception cannot be provided as in the pre-injury period. Accordingly, the biointegration of the graft and optimizing its long-term strength have become important treatment goals.

Some authors reported that preservation of the ACL remnant has positive effects on graft revascularization, ligamentization, tendon-bone integration and proprioceptive functions (4-8) ACL tibial remnants were also examined histologically for their proprioceptive potential in the literature. Dhillon et al. found that 46% of the ruptured anterior cruciate ligaments had proprioceptive fibers and 52.4% had mechanoreceptors (9). Lee et al. compared the sections taken from the intact and torn ACL samples in terms of mechanoreceptor numbers and observed that the mechanoreceptors were distributed similarly in the tibial and femoral attachments (10).

The aim of this study is to evaluate the effect of preservation of femoral side ACL remnant on functional and clinical outcomes in anatomical single band ACL reconstruction method. Our hypothesis is that better results can be obtained with femoral remnant-sparing technique in ACL reconstruction.

Materials and Methods

This a prospective randomized study including 150 patients who were diagnosed with ACL rupture and underwent surgical reconstruction were included in the study between March 2015 and January 2019. Written informed consent was obtained from all parents and the study was approved by the Local Research Ethics Committee (Harran University Ethics Committee (Decision Date: 16.01.2015, No:01-20). ACL injuries were mostly caused by amateur sports-related injuries among the patients (Table 1). There are no professional athletes among the patients. Patients between 18-40 years of age with isolated unilateral ACL tear were included in the study. The diagnosis of the patients was made with physical examination and magnetic resonance image imaging (MRI). First of all, swelling, ecchymosis and deformity were checked and recorded.

Table 1. Injury Types of Patients

Etiology	Group A (n=56)	Group B (n=54)
Sport activity	47	45
Traffic accident	2	1
Jumping	7	8

Then, the knee stability tests were applied (anterior drawer, lachman, and pivot shift). MRI was requested for patients who were thought to have anterior cruciate ligament injury. ACL reconstruction was planned at least three weeks after the trauma. Previous surgery on the same knee, grade 3-4 chondral damage, ACL or meniscus tear in the contralateral knee, concomitant posterior cruciate ligament (PCL) and grade 3-4 medial collateral ligament tear, more than 1 year trauma-operation interval, additional surgery of total and subtotal meniscectomy in more than 50% meniscus was excised and noncompliance with physical therapy and follow-up protocols were exclusion criteria of the study.

Functional evaluations were performed preoperatively and at 3, 6, 12 months and at the last follow-up with Lysholm score, International Knee Documentation Committee Evaluation (IKDC), subjective IKDC 2000 score and physical instability tests (Table 2).

Statistical analyses were conducted with SPSS for Windows version 25.0 software (IBM SPSS Inc, Chicago, IL, USA). The Shapiro Wilk test was employed to assess the normal distribution of data. Numerical variables with normal distribution were presented as mean ± standard deviation, while those without normal distribution were expressed as median (interquartile range) values. Categorical variables were stated as number (n) and percentage (%). Comparison of two-sample numerical variables was conducted using the Unpaired Student's t-test and Mann–Whitney U test. To compare intragroup alterations over time (from preoperative to postoperative), all dependent variables were examined with Friedman's test and Wilcoxon t-test. The Pearson Chi-square test was also used to compare categorical variables. The confidence interval (CI) was accepted as 95% throughout the analyses. A two-tailed p value of <0.05 was considered statistically significant.

Surgical Technique

The patients were followed up for 3 weeks without surgery after trauma. Rehabilitation was performed to relieve the pain and swelling caused by the acute event and to provide the range of motion of the joint. Both groups were repaired with a transtibial hamstring autograft. All operations of group A were performed by the same surgeon, and operations of group B were performed by another surgeon in the same clinic.

The patients were placed in the supine position on the operating table and the knee were hung down from the

table to allow 0-120° range of motion. Pneumatic tourniquet was applied for all patients. Anteromedial (AM) and anterolateral (AL) portals were used for standard knee arthroscopy. First, a systematic arthroscopic knee examination was performed. ACL tear was confirmed (Figure 1). Concomitant meniscus and chondral injury were notted.

In both groups, ACL reconstruction was performed with arthroscopy-assisted double-layer semitendinosus and gracilis hamstring autologous graft. After palpating the tuberositas tibia and pes anserinus fascia, a slightly oblique 2-3 cm incision was made from 1 cm above to 2 cm medial of the tuberositas tibia. Gracilis and semitendinosus tendons were palpated under the fascia and separated from the fascia by blunt dissection. Tendons were fixed to each other in tension with the proximal and distal parts in opposite directions using the Krackow technique. In order to reduce the elongation of the graft in the joint after fixation and to minimize stress relaxation, stretching was applied with a constant force for approximately 10 minutes before the graft was placed.

Table 2. Preoperative Stability Tests and Functional Scores

PREOP	Group A (n=56)	Group B (n=54)	p value
Range of motion	129.26±1.16	130.60±0.60	> 0.05
Stability tests			
Lachman			
negative	0 (0%)	0 (0%)	0.586
+	0 (0%)	0 (0%)	
2+	14 (46.7%)	16 (53.3%)	
3+	42 (52.5%)	38 (47.5%)	
Pivot Shift			
negative	5 (50%)	5 (50%)	0.321
+	17 (54.8%)	14 (45.2%)	
2+	31 (47.0%)	35 (53.0%)	
3+	3 (100%)	0 (0%)	
Anterior drawer			
negative	0 (0%)	0 (0%)	0.172
+	0 (0%)	0 (0%)	
2+	19 (61.3%)	12 (38.7%)	
3+	37 (46.8%)	42 (53.2%)	
Functional scores			
Lysholm	63.00 (7,00)	64.00 (5.00)	0.071
IKDC Subjective 2000	54.50 (6,75)	54.50 (6.00)	0.962
IKDC Objective			
A	0 (0%)	1 (100%)	0.712
B	9 (56.3%)	7 (43.8%)	
C	15 (53.6%)	13 (46.4%)	
D	32 (49.2%)	33 (50.8%)	

First of all, ACL tibial remnant was detected on tibial plato. The tibial tunnel was performed with the transtibial technique in both study groups. In the tibial tunnel preparation, anatomic insertion point of ACL was determined according to the ACL remnant and anatomic landmarks, and drilling was performed in a controlled manner to pass through the remnant. The width of the tibial tunnel was arranged according to graft size.

The intercondylar notch was carefully examined in the patient group (Group A) who underwent ACL reconstruction with preserving the femoral remnants technique. Minimal notch debridement was performed in this group. ACL residues were released if they adhered to the surrounding tissue and PCL. The femoral remnant and footprint were detected by sight and feel with the aid of a probe. Generally, the femoral remnants were plump-looking and firmly attached to the bone. The femoral remnant and footprint remnants were left to preserve proprioception and to be useful in locating tunnels (Figure 2). When the femoral footprint was detected, a femoral tunnel was dirilled to pass through its center as a guide for the tunnel. Drilling was done from the middle of the femoral stump. We did not define the AM and PL bands separately in our cases.

In the patient group who underwent standard ACL reconstruction (Group B), the intercondylar notch was exposed with a radiofrequency device to define the medial wall of the lateral condyle of the femur. The soft tissues and footprints close to the femoral tunnel entry site were removed. Ligament remnants in the tibial tunnel opening into the joint were removed. The tibial stump was preserved as it was in Group A patients (Figure 3).

Graft placement, position during knee movements, tension, presence of impingement were evaluated arthroscopically. A hemovac drain was placed into the knee from the anterolateral portal.

Postoperative Rehabilitation

The same rehabilitation program was used for both groups.

Angle-adjustable knee orthosis is locked in extension. Patient-controlled parenteral analgesia was administered to the patients for 24 hours postoperatively. Quadriceps strengthening exercises were started on the first postoperative day allowing 30° flexion and 0° extension. In the hospital and during the follow-up outpatient clinic controls, flexion was gradually increased by 10° and reached up to 90°. Active exercises were continued during the day in the flexion and extension values of the angle-adjustable knee brace. Knee brace was used with a locked in extension for sleep at night for 6 weeks. Crutches were recommended to the patients for 6-8 weeks postoperatively. Partial weight bearing was allowed from the 3rd week. Walking and light exercise program was applied from the 2nd month. Sport activities were not allowed before 6 months.

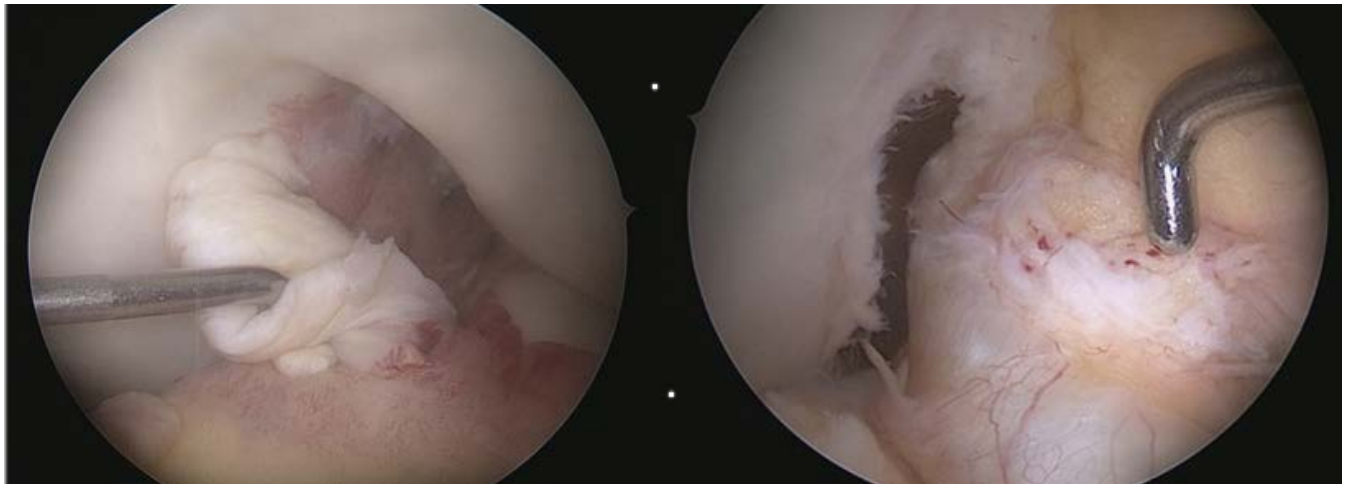

Figure 1. Arthroscopic examination of ACL

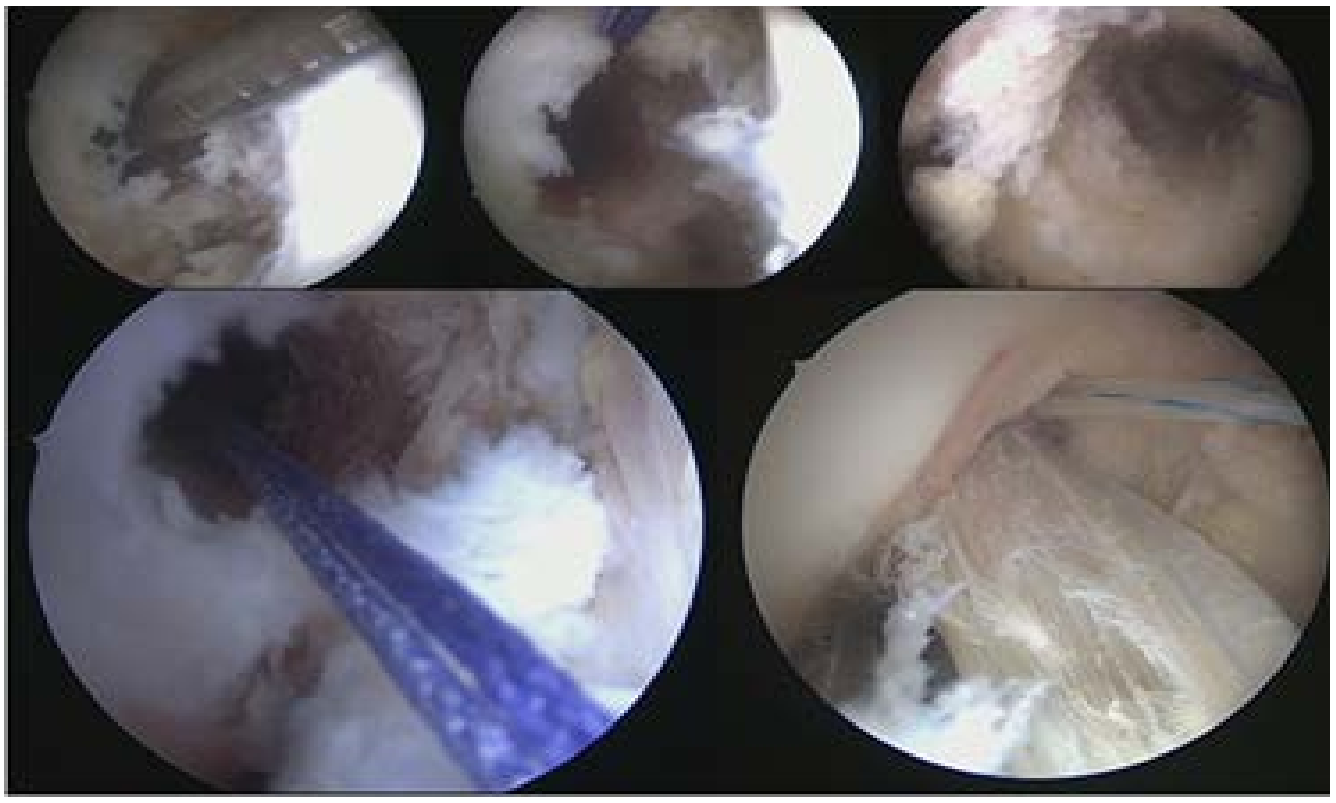

Figure 2. Tunnel Preparation guided by femoral remnants

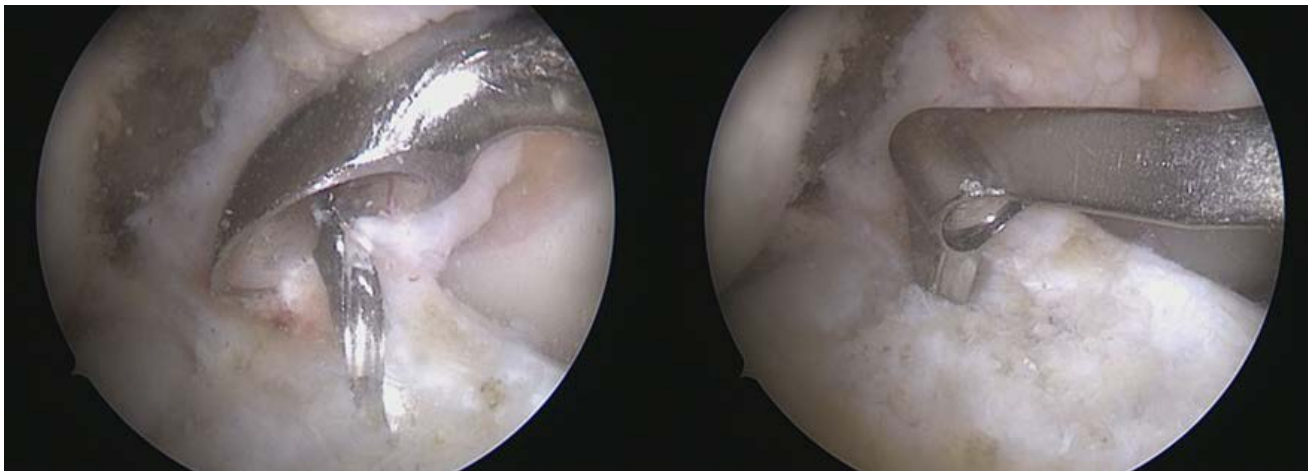

Figure 3. Tibial Tunnel Preparation

Results

The number of 150 patients defined initially for both groups (75 patients for Group A, 75 patients for Group B) was determined as 56 patients for Group A, (ACL remnants were preserved in the femoral attachment area) and 54 patients for Group B, (the remnants were debrided) after examination results and diagnosis of meniscal and chondral injury in the arthroscopic examination in accordance with the exclusion criteria. The mean age of the patients was 27.23±5.64 years in Group A and 26.72±5.82 years in Group B. The interval between trauma and operation day was 4.36±3.21 months in Group A and 3.56±3.08 months in Group B (min 1 month, maximum 12 months). The follow-up period of the patients was 38.05±6.11 months for Group A and 36.86±8.04 months for Group B. There was no difference between the two groups in terms of mean age, interval between trauma and operation and follow-up periods (p>0.05). There was no difference between the groups in terms of meniscus and chondral injuries (Table 3).

Table 3. Demographic and Clinical Factors

	Group A (n=56)	Group B (n=54)	p value
Age	27.23±5.64	26.72±5.82	0.642
Side			
Right	29	33	0.324
Left	27	21	
Time to surgery (months)	4.36±3.21	3.56±3.08	0.083
Follow-up Time (months)	38.05±6.11	36.86±8.04	0.255
Meniscus Injury			
medial	27	28	0.864
lateral	10	8	
medial + lateral	5	3	
No injury	14	15	
Chondral Injury			
Grade 1-2	34	30	0.583
No injury	22	24	

Satisfactory clinical results were obtained compared to preoperative clinical results in both groups. Knee stability and functional scores were significantly higher compared to preoperative results in group A. Similarly, knee stability and functional scores were found to be significantly better in the standard reconstruction group (p<0.001) (Figure 4-5).
The functional scores (Lysholm: p=0.04, IKDC: p=0.05) in the first 18 months were found to be higher in Group A. However, there was no clinically significant difference in joint range of motion, stability tests and functional scores at the final examination (p>0.05) (Table 4).

Superficial wound infection occurred in 7 patients (4 patients group A and 3 patients group B) as an early complication, which was treated with IV antibiotherapy. In 11 patients (6 patients in group A and 5 patients in group B), range of motion was limited due to arthrofibrosis which was observed in the first 3 months. They responded well to physical therapy. Deep vein thrombosis, compartment syndrome were not observed. No re-rupture and implant failure were detected in the last postoperative follow-up of the patients.

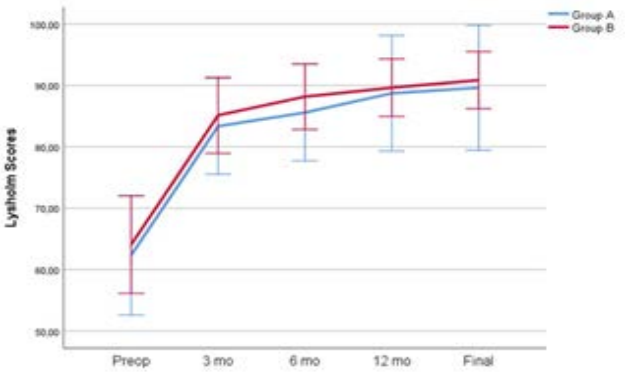

Figure 4. Lysholm Scores

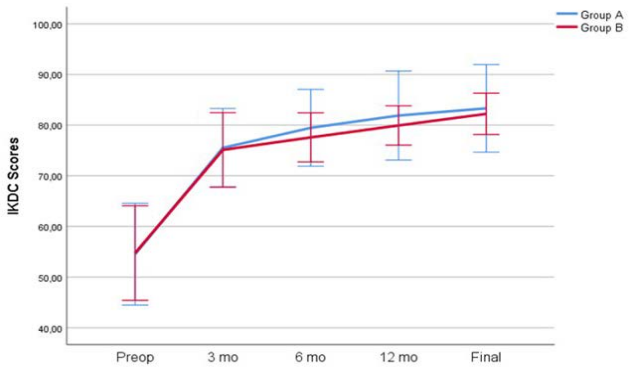

Figure 5. IKDC Scores

Table 4. Stability Tests and Functional Scores (Final)

FINAL	Group A (n=56)	Group B (n=54)	p value
Range of motion	136.60±0.43	136.32±0.44	> 0.05
Stability Tests			
Lachman			
negative	41 (67.2%)	32 (68.1%)	0.150
+	15 (31.9%)	20 (57.1%)	
2+	0 (0%)	2 (100%)	
3+	0 (0%)	0 (100%)	
Pivot Shift			
negative	44 (55.0%)	36 (45.0%)	0.269
+	12 (41.4%)	17 (58.6%)	
2+	0 (0%)	1 (100%)	
3+	0 (0%)	0 (0%)	
Anterior drawer			
negative	46 (55.4%)	37 (44.6%)	0.097
+	10 (37.0%)	17 (63.0%)	
2+	0 (0%)	0 (0%)	
3+	0 (0%)	0 (0%)	
Functional scores			
Lysholm	90.00 (6.75)	91.00 (2.00)	0.195
IKDC Subjective 2000	84.00 (5.75)	82.00 (3.00)	0.071
IKDC Objective			
A	37 (51.4%)	35 (48.6%)	0.907
B	15 (48.4%)	16 (51.6%)	
C	4 (57.1%)	3 (42.9%)	
D	0 (0%)	0 (0%)	

Discussion

According to the main findings of this study, ACL reconstruction performed by preserving the existing femoral footprint and remnant did not have an effect on knee stability. Additionally, no significant difference was found between the two groups in terms of functional scores and range of motion. Furthermore, it was noted that there was no difference in terms of complications in both groups.

Schultz first described the mechanoreceptors and proprioceptive functions in human ACL in detail in 1984 (11). Later, Denti demonstrated mechanoreceptors on the ACL residue that he obtained arthroscopically in 1994 (12). The ACL is highly innervated by mechanoreceptors. Mechanoreceptors contribute to the sense of position of the knee, defined as proprioception. There is a positive correlation between the number of mechanoreceptors and joint position sense, and it has been reported that mechanoreceptors on preserved ACL residues are valuable in gaining joint position sense (10-13). However, the degree of joint laxity due to impaired joint capsule and muscle strength does not affect the proprioceptive function of the knee. It has also been reported that preservation of ACL remnants prevents anterior tibial translation by increasing mechanical resistance (14-16).

Histomorphologically, blood flow, ligamentization, remodeling and type III collagen levels and tendon-bone integration were observed to be better in the tibial remnant preserved patients (8,9,17). It has been reported that the loading capacity of the graft at the 24th week after the reconstruction was significantly higher in the group with preserved tibial

remnant (18). It was reported that the functional results and especially the sense of joint position were better in the group that underwent remnant-conserving surgery (7).

The clinical results of remnant-conserving surgery are still controversial altough the results of histomorphological and animal studies. There are some studies report the positive effect of the preservation of the tibial stump or remnant (19-21) while other studies report that remnant-preserving has no effect (22) or effective only on knee instability (23). The lack of standardization in study designs and short follow-up periods are the limitations of the studies. Therefore, in the present study, we aimed to compare the results of homogeneous patient groups. There was no statistically significant difference between the groups in terms of age, side, gender, follow-up periods, meniscal and chondral injury levels. Morphologically normal mechanoreceptors have been detected in remnants at both tibial and femoral ACL attachments (24,25). The studies on ACL remnant have given different rates for the presence of ACL femoral remnants. Wittsteint et al. evaluated the patients operated for ACL reconstruction (n=111), they reported the presence of femoral remnants was found in 83% of 63 patients retrospectively and 98% of 48 patients followed prospectively (26). A short remnant has been reported in the majority of cases after careful notchplasty. In the present study, we tought it may be beneficial to preserve the ACL remnant at the femoral insertion area, as in the similar technique in which the tibial remnant is preserved (20). In Group A, ACL remnants and/or footprints were not detected at the femoral attachment site in 6 patients (92,86%). Two of 6 patients were already excluded as they have history of trauma 1 year ago.

ACL remnant at the tibial attachment site has been used as a guide for tibial tunnel preparation in the anatomical reconstruction of the ACL (27). This technique can prevent graft compression during knee extension due to tibial tunnel malposition (28). Similarly, the femoral remnant can be used as a guide for femoral tunnel preparation. The femoral remnant will be also a useful marker for correct graft placement. It has been reported that the use of the femoral remnant as a marker in the preparation of the femoral tunnel is more anatomical than the positioning with the over the top position guide (21). Additionally, the valve mechanism provided by the protective remnant tissue prevents synovial fluid entry and and thus graft failure due to tunnel expansion can be prevented (29,30). Despite the theoretical advantage of using the femoral footprint as a guide, the difficulty of the technique and the need for experience appear as a disadvantage.

We thought that the clinical and functional results would be better than the standard procedure as a result of the improvement in the vascularization, ligamentization, integration of the graft, and especially in the proprioceptive functions during the healing process. In the study designed for this purpose, although there was no difference in the results of manual examination in the early postoperative follow-up (18 months), we found a significant difference in functional scores, especially Lysholm scores, in favor of the group with preserved femoral remnant ($p<0.05$). The high functional results in Group A in the first 18 months can be attributed to the contribution of femoral remnants to graft healing. However, in the final controls of the patients, we observed that there was no difference in the effect of preservation of the femoral remnants on the knee stability and functional scores after completing the graft integration and returning to active daily life. Similarly, the lately review of comparative studies of remnant-sparing surgeries (19), revealed that remnant-sparing technique's effect on clinical and functional results could not be demonstrated. These results were consistent with the latest data in the present study.

It is important to evaluate the results of the study that both groups are homogeneous and the accompanying intra-articular lesions are similar. Additionally, the operations of both groups are performed by two different surgeons at the consultant level. We believe that standardization contributes to the value of the study in terms of comparison of clinical and functional efficacy of only femoral remnants. Although femoral remnant-sparing technique contributes to rapid recovery and functional scores in the early period, the difficult and demanding of the technique, the absence of functional and clinical differences between the groups in the final controls can be questioned the necessity of remnant-sparing surgery.

There are several limitations in this study. Firstly, objective parameters are not sufficient, and only male patients are included in the study. Secondly, the structure and quantity of the femoral and tibial remnants and their effect on the results have not been evaluated. Furthermore the condition of the graft and the tunnel could not be evaluated radiologically at the end of the follow-up.

Conclusion

Based on the results we obtained in this study, there is no significant effect of preservation of the femoral remnants during ACL reconstruction surgery on clinical outcomes and functional scores. Therefore, the necessity of very careful preservation of ACL femoral remnants can be questioned considering the difficult and experiential technique.

Ethical Approval: *The study protocol was approved by Harran University Ethics Committee (Decision Date: 16.01.2015, No:01-20).*

Author Contributions:
Concept: B.V.Ç., M.A.A.
Literature Review: B.V.Ç.
Design : B.V.Ç., M.A.A.
Data acquisition: ……..
Analysis and interpretation: B.V.Ç., M.A.A.
Writing manuscript: B.V.Ç., M.A.A.
Critical revision of manuscript: B.V.Ç., M.A.A., S.S., İ.Y.
Conflict of Interest*: The authors declare no conflict of interests.*
Financial Disclosure: *This study was supported by grants from Harran University's scientific committee (Decision 24.04.2015-15064).*

References

1. Erden T, Toker B, Toprak A, Taşer Ö. Comparison of the outcomes of isolated anterior cruciate ligament reconstruction and combined anterolateral ligament suture tape augmentation and anterior cruciate ligament reconstruction. Jt Dis Relat Surg 2021;32(1):129-36
2. McGinty BJ. Operative Arthroscopy. Third Edition: Knee Arthroscopy. Philadelphia, Lippincott 2003;456-567.
3. Shelbourne KD, Gray T, Haro M. Incidence of subsequent injury to either knee within 5 years after anterior cruciate ligament reconstruction with patellar tendon autograft. Am J Sports Med 2009;37:246-51.
4. Borbon CA, Mouzopoulos G, Siebold R. Why perform an ACL augmentation? Knee Surg Sports Traumatol Arthrosc 2012;20 (2): 245–51.
5. Arnoczki SP, Tavin GB, Marshall JL. Anterior cruciate replacement using patellar tendon. An evaluation of graft revascularization in the dog. Am J Bone Joint Surg 1982;64: 217–24.
6. Ochi M, Isawa J, Uchio Y, Adachi N, Sumen Y. The regeneration of sensory neurons in the reconstruction of the anterior cruciate ligament. Br J Bone Joint Surg 1999;81: 902–6.
7. Lee BI, Kwon SW, Kim JB, Choi HS, Min KD. Comparison of clinical results according to amount of preserved remnant in arthroscopic anterior cruciate ligament reconstruction using quadrupled hamstring graft. Arthroscopy 2008;24: 560-8.
8. Papalia R, Franceschi F, Vasta S, Di Martino A, Maffulli N, Denaro V. Sparing the anterior cruciate ligament remnant: Is it worth the hassle? Br Med Bull 2012;104: 91-111.
9. Dhillon MS, Bali K, Vasistha RK. Immunohistological evaluation of proprioceptive potential of the residual stump of injured anterior cruciate ligaments (ACL). Int Orthop 2010;34: 737-41.
10. Lee BI, Min KD, Choi HS, Kwon SW, Chun DI, Yun ES. Immunohistochemical study of mechanoreceptors in the tibial remnant of the ruptured anterior cruciate ligament in human knees. Knee Surg Sports Traumatol Arthrosc 2009;17:1095-101.
11. Schultz R A, Miller D C, Kerr C S, Micheli L. Mechanoreceptors in human cruciate ligaments: a histologic study. J Bone Joint Surg (Am) 1984; 66 (7):1072-76.
12. Denti M, Monteleone M, Berardi A, Panni A S. Anterior cruciate ligament mechanoreceptors. Clin Orthop 1994;308:29-32.
13. Adachi N, Ochi M, Uchio Y, Iwasa J, Ryoke K, Kuriwaka M. Mechanoreceptors in the anterior cruciate ligament contributeto the joint position sense. Acta Orthop Scand 2002;73:330-4.
14. Crain EH, Fithian DC, Paxton EW, Luetzow WF. Variation in anterior cruciate ligament scar pattern: does the scar pattern affect anterior laxity in anterior cruciate ligament-deficient knees? Arthroscopy 2005;21:19-24.
15. Panisset JC, Duraffour H, Vasconcelos W, Colombet P, Javois C, Potel JF. Clinical, radiological and arthroscopic analysis of the ACL tear. A prospective study of 418 cases. Rev Chir Orthop 2008;94(8 Suppl.):362-8.
16. Liu W, Maitland ME, Bell GD. A modeling study of partial ACL injury: simulated KT 2000 tests. J Biomech Eng 2002;124:294-301.
17. Song GY, Zhang H, Zhang J, Liu X, Chen XZ, Li Y, et al. The anterior cruciate ligament remnant: To leave it or not? Arthroscopy 2013;29:1253-62.
18. Wu B, Zhao Z, Li S, Sun L. Preservation of remnant attachment improves graft healing in a rabbit model of anterior cruciate ligament reconstruction. Arthroscopy 2013;29:1362-71.
19. Wang H, Liu Z, Li Y, Peng Y, Xu W, Hu N, et al. Is Remnant Preservation in Anterior Cruciate Ligament Reconstruction Superior to the Standard Technique? A Systematic Review and Meta-Analysis. Biomed Res Int 11;2019:1652901.
20. Nag HL, Gupta H. Anterior Cruciate Ligament Reconstruction With Preservation of Femoral Anterior Cruciate Ligament Stump. Arthroscopy Techniques 2014;3(5):575-7.
21. Kaseta MK, DeFrate LE, Charnock BL, Sullivan RT, Garrett WE. Reconstruction technique affects femoral tunnel placement during ACL reconstruction. Clin Orthop Relat Res 2008;466:1467-74.
22. Naraoka T, Kimura Y, Tsuda E, Yamamoto Y, Ishibashi Y. Is Remnant Preservation Truly Beneficial to Anterior Cruciate Ligament Reconstruction Healing? Am J Sports Med 2017;45(5):1049-58.
23. Andonovski A, Topuzovska S, Samardziski M, Bozinovski Z, Andonovska B, Temelkovski Z. The Influence of Anterior Cruciate Ligament Remnant on Postoperative Clinical Results in Patients with Remnant Preserving Anterior Cruciate Ligament Reconstruction. Maced J Med Sci 2017;5(5):624-9.
24. Löcherbach C, Zayni R, Chambat P, Sonnery-Cottet B. Biologically enhanced ACL reconstruction. Orthop Traumatol Surg Res 2010;96:810-5.
25. Bali K, Dhillon MS, Vasistha RK, Kakkar N, Chana R, Prabhakar S. Efficacy of immunohistological methods in detecting functionally viable mechanoreceptors in the remnant stumps of injured anterior cruciate ligaments and its clinical importance. Knee Surg Sports Traumatol Arthrosc 2012;20:75-80.
26. Wittstein J, Kaseta M, Sullivan R, Garrett WE. Incidence of the Remnant Femoral Attachment of the Ruptured ACL. Clin Orthop Relat Res 2009;467:2691-4.
27. Hantes ME, Dailiana Z, Zachos VC, Varitimidis SE. Anterior cruciate ligament reconstruction using the Bio-TransFix femoral fixation device and anteromedial portal technique. Knee Surg Sports Traumatol Arthrosc 2006;14:497-501.
28. Amis AA, Jakob RP. Principles for placing the tibial tunnel and avoiding roof impingement during reconstruction of a torn anterior cruciate ligament. Knee Surg Sports Traumatol Arthrosc 1994;2:138-46.
29. Demirağ B, Ermutlu C, Aydemir F, Durak K. A comparison of clinical outcome of augmentation and standard reconstruction techniques for partial anterior cruciate ligament tears. Jt Dis Relat Surg 2012;23(3):140-4.
30. Zhang Q, Zhang S, Cao X, Liu L, Liu Y, Li R. The effect of remnant preservation on tibial tunnel enlargement in ACL reconstruction with hamstring autograft: a prospective randomized controlled trial. Knee Surg Sports Traumatol Arthrosc 2014;22(1):166-73.