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Original Research

Effects of Graft Selection in Arthroscopic Anterior Cruciate Ligament Reconstruction: Midterm Functional Results

Ömer Cengiz,[1] Necdet Demir,[2] Ferdi Dırvar[3]

[1]Department of Orthopedics and Traumatology, Mus State Hospital, Mus, Turkey
[2]Department of Orthopedics and Traumatology, Biruni University Medical Faculty Hospital, Istanbul, Turkey
[3]Department of Orthopedics and Traumatology, University of Health Sciences Metin Sabanci Baltalimani Osteopathic Training and Research Hospital, Istanbul, Turkey

Abstract

Objectives: This study is a comparison of the midterm clinical results of patients who underwent anterior cruciate ligament (ACL) reconstruction using an allograft and those who had an autograft procedure.

Methods: The results of 70 patients who underwent ACL reconstruction with an anterior tibial tendon (ATT) allograft (n=18) or a hamstring (HT) autograft (n=52) were evaluated retrospectively. At the last follow-up, International Knee Documentation Committee (IKDC) and Tegner-Lysholm scores were used to assess functional status, as well as results of the Lachman test, the anterior drawer test, and the pivot-shift test.

Results: There was no significant difference between the 2 groups in terms of age, gender, length of time before operation, graft thickness, or femoral tunnel length (p>0.05). The results were satisfactory in both groups in the postoperative period in terms of the length of time until a return to sports, IKDC score, Tegner-Lysholm score, range of motion, quadriceps circumference, and laxity, with no significant difference between the groups (p>0.05).

Conclusion: The results of this study suggested that midterm clinical outcomes of ACL reconstruction with an ATT allograft or an HT autograft are similar when the correct technique is used according to the appropriate indications by an experienced surgeon and a successful rehabilitation program implemented after the operation.

Keywords: Anterior tibial tendon allograft; hamstring tendon autograft; anterior cruciate ligament injury.

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The increase in the rate of participation in sports as amateurs, professionals, or as a hobby, has increased the frequency of sports injuries. The anterior cruciate ligament (ACL), which is frequently affected in sports injuries, plays an important role in the stability of the knee. If there is a loss of function of the ACL, which does not have self-healing potential, it can lead to osteoarthritis, pain, and loss of mobility, and a decrease in quality of life.[1]

Standard surgical treatment after injuries causing loss of function of the ACL is reconstruction. There is no consensus in the literature regarding the ideal surgical procedure for ACL reconstruction. One issue is the choice of graft to be used for reconstruction. The ideal graft should be able to reconstruct the complex anatomy of the ACL, have the biomechanical properties of the ACL, allow for strong and safe placement, adapt quickly to the biological location,

Address for correspondence: Ömer Cengiz, MD. Mus Devlet Hastanesi, Ortopedi ve Travmatoloji Klinigi, Mus, Turkey
Phone: +90 532 386 64 93 **E-mail:** dr.omercengiz@gmail.com

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and produce the least damage possible to the area. Autograft, allograft, and synthetic grafts are used in ACL reconstruction, but regrettably, none yet quite meets the ideal graft definition.[2]

The use of autografts and allografts is more popular than synthetic grafts. Bone-patellar tendon-bone grafts (BPTB), binary or quaternary hamstring tendon (HT) grafts and, less frequently, quadriceps tendon grafts are used as autografts. The Achilles tendon, anterior and posterior tibial tendons, HT, and quadriceps tendon are used as allografts.

The aim of this study was to compare the midterm clinical results of patients who underwent ACL reconstruction with an allograft with those who had an autograft between 2013 and 2016.

Methods

The results of 83 patients who underwent ACL reconstruction as a result of a symptomatic diagnosis of instability due to ACL rupture and were followed up for at least 12 months between 2013 and 2016 were reviewed retrospectively. The patients were informed about both the allograft and the autograft prior to the operation, and an allograft was used in those who did not accept an autograft alternative. After obtaining the necessary permission to access the patients' information, the patient files were reviewed and the patients were contacted for a control visit. Patients who had previous knee surgery, contralateral knee dislocation, or who had voluntarily left the rehabilitation program were not included in the study. Patients with concomitant meniscus injuries and patients with stage 3 or 4 chondral injury were also excluded. Following the examination, 9 patients from the autograft group and 4 patients from the allograft group were excluded from the study. Semitendinosus and gracilis HT tendons were most often used as autografts, and the anterior tibial tendon as an allograft (Fig. 1a, b). In order to reduce immunogenicity, allografts were presoaked in dexamethasone and gentamicin-containing solution for at least 30 minutes. The patients were divided into 2 groups: autograft (n=52) and allograft (n=18). The graft thickness and femoral tunnel length documented in the patients' operation notes were recorded.

All of the patients were operated on by a single surgeon and arthroscopic reconstructive surgery was performed using the anatomical single-tunnel procedure.

Autografts were palpated 2 to 3 cm median of the tuberosity of the tibia, 3 to 4 cm below the medial joint space, and were removed with a tendon stripper with a 3 to 4 cm oblique incision, and in the tensioned position, both tendons were prepared using a 4-strand Krackow suture technique with number 2 Ethibond sutures (Ethicon Inc., Somerville, NJ, USA). After the tibial tunnel and femoral tunnel were prepared with the help of a guide, the graft was tunneled. An EndoButton (Smith & Nephew plc, Watford, UK) was used for femoral fixation and bio-absorbable screws and staples were used for tibial fixation (Fig. 2).

In the postoperative period, a narcotic analgesic (tramadol hydrochloride) was administered for 48 hours and a nonsteroidal anti-inflammatory drug (diclofenac sodium) and paracetamol were used for 2 weeks to provide analgesia. The drain was removed 24 hours postoperatively. Ice was applied on the knee for 2 days and the extremity was elevated. Postoperative rehabilitation was performed at the Physical Therapy and Rehabilitation Clinic of the hospital. Closed-chain exercises and quadriceps empowerment exercises were initiated after draining at the postoperative 24th hour. After surgery, all of the patients were mobilized with the help of an armrest without any load on the operated ex-

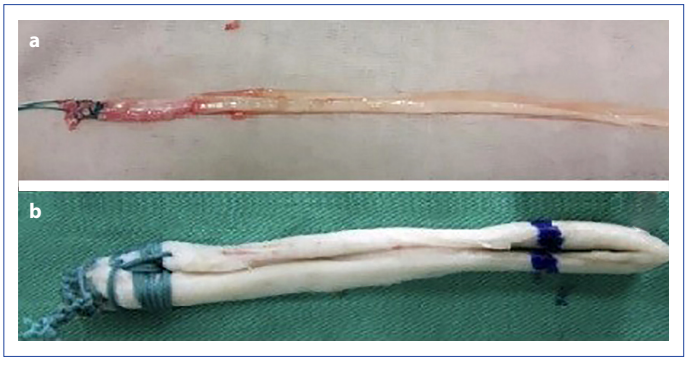

Figure 1 (a, b). Semitendinosus and Grasilis Hamstring Tendon Autograft. **(b)** Tibialis Anterior Tendon Allograft (Maxxeus Sports®, Community Tissue Service, USA).

Figure 2. Post-operative right knee AP-LAT x-ray images.

Figure 3. Quadriceps circumference measurement.

tremity for 6 weeks. Active physiotherapy and rehabilitation were implemented after the sixth week, and all of the patients were permitted to engage in flat running at the postoperative fourth month and active sports at the sixth month.

In the sitting position with the knee at 90° flexion, a point 15 cm above the midpoint of the proximal patella was marked. The quadriceps circumference was measured in the standing position with the feet at shoulder width and the body weight evenly distributed (Fig. 3). At the end of the clinical follow-up, the patients were examined (Fig. 4a, b and Fig. 5a, b) and the findings were documented. The joint range of motion (ROM) of all patients was assessed using a goniometer.

Figure 4. (a) Postoperative 26th month clinical photograph of the patient underwent reconstruction with autograft. **(b)** Postoperative 36th month clinical photograph of the patient underwent reconstruction with allograft.

Gender, femoral tunnel length, graft thickness, age, and time to operation were considered in the comparison of the 2 groups (Table 1). The IKDC (International Knee Documentation Committee) and Tegner-Lysholm scoring systems were used to determine patient satisfaction, and the Lachman, anterior drawer, and pivot-shift tests were performed to evaluate stability. The patients were also asked when they started to participate in sports in the postoperative period.

Figure 5. (a) Postoperative 46th month clinical photograph and x-ray images of the patient underwent reconstruction with autograft. **(b)** Postoperative 39th month clinical photograph and x-ray images of the patient underwent reconstruction with allograft

Table 1. Clinical and demographic information of patients

	Autograft	Allograft
Gender	W:0, M:52	W:0, M:18
Age	27.06 (16-39)	26.40 (20-36)
Follow-up Period (Month)	23.65 (12-49)	35.39 (33-39)
Time to Surgery (Week)	5.10 (3-8)	4.56 (3-6)
Total	52	18

W: Woman; M: Man.

All of the research and procedures performed were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Statistical Analysis

The data were presented as mean±SD or mean (95% confidence interval). According to the power analysis performed, it was estimated that there should be at least 25 patients in the autograft group and 12 patients in the allograft group for a 90% power and 95% confidence level. Statistical analyses were performed using SPSS Statistics for Windows, Version 17.0. (SPSS Inc., Chicago, IL, USA). An independent t-test and the Mann-Whitney test were applied. The level of significance was accepted as $p<0.05$.

Results

The mean age of the 70 patients evaluated was 26.89 years (range: 16-39 years). The mean age of the autograft group was 27.06 years (range: 16-39 years) while the mean of the allograft group was 26.39 years (range: 20-36 years). There was no significant statistical difference between the 2 groups ($p>0.05$) (Table 2).

Table 2. Evaluation of age distribution between groups by T-test

Age	n	Mean	SD
Autograft	52	27.16	4.852
Allograft	18	26.39	3.744
			p=0.597

The mean length of time before the operation was 4.96 weeks (range: 3-8 weeks): specifically, a mean of 5.10 weeks (range: 3-8 weeks) in the autograft group and 4.56 weeks (range: 3-6 weeks) in the allograft group. The comparison of the 2 groups revealed no significant difference in terms of the length of time to operation, femoral tunnel length, or graft thickness (Table 3). The mean follow-up period was 23.65 months (range: 12-49 months) in the autograft group and 35.39 months (range: 33-39 months) in the allograft group, which was statistically significant ($p<0.05$) (Table 3).

At the final control visit of the patients in the autograft group, the results of the anterior drawer test were negative in 43 patients and positive in 9 patients, while the findings in the pivot-shift test were negative in 41 patients and positive in 11 patients, and the Lachman test was negative in 46 patients and positive in 6 patients. In the allograft group, the results of the anterior draw test were negative in 15 patients and positive in 3 patients, the findings in the pivot-shift test were negative in 14 patients and positive in 4 patients, and the Lachman test was negative in 16 patients and positive in 2 patients. There was no statistically significant difference in instability in the laxity tests (p=0.950, p=0.924, p=0.942, respectively) (Table 4).

Table 3. Evaluation of groups according to femoral tunnel length, graft thickness, operation time and follow-up time

	Femoral tunnel length (mm)	Graft thickness (mm)	Time of operation (week)	Follow-up time (month)
Autograft				
n	52	52	52	52
Mean	39.94	7.88	5.10	23.65
SD	3.867	0.471	1.612	9.412
Median	40.00	8.00	5.00	23
Minimum	35	7	3	12
Maximum	46	9	8	49
Allograft				
n	18	18	18	18
Mean	39.00	7.94	4.56	35.39
SD	3.850	0.416	1.042	2.118
Median	40.00	8.00	4.50	36
Minimum	35	7	3	33
Maximum	46	9	6	39
p	0.352	0.618	0.325	0.000

The use of an autograft or an allograft was not statistically significant (p>0.05) in the mean quadriceps measurement, ROM, or length of time to return to sports (p>0.05) (Table 5).

The clinical and satisfaction status of patients at the last follow-up was assessed using the IKDC clinical assessment scale and Tegner-Lysholm score. The graft selection was not statistically significant (p>0.05) according to postoperative IKDC and Tegner-Lysholm evaluations (Table 5).

Discussion

ACL reconstruction is an operation frequently performed by orthopedists, with the aim of correcting knee instability due to the ACL failure. The ACL is an important structure in the functional stability of the knee, protecting against antero-posterior translation and rotational subluxation.[3] There is still no consensus in the literature about the selection of a graft to be used in surgical procedures performed after ACL failure, given all the anatomical, histological, and biomechanical properties to be considered. Furthermore, since the grafts used in surgical procedures do not have the same properties as the ACL, the search for the ideal graft continues.

An autograft or an allograft is usually used in ACL reconstruction. HT grafts and bone-patellar tendon-bone (BPTB) grafts are commonly preferred as autografts, while tibialis anterior, tibialis posterior and Achilles tendon allografts are frequently used as allografts.[4]

Table 4. Inter-groups post-operative laxity evaluation*

	Autograft	Allograft	p
Anterior drawer (-/+)	43/9	15/3	0.950
Pivot-shift (-/+)	41/11	14/4	0.924
Lachman (0/1/2/3)	46/5/1/0	16/2/0/0	0.942
Total	52	18	

*Chi-square test; Anterior drawer: -: Negative; +: Positive; Pivot shift: -: Negative; +: Positive. Lachman: 0: None 1: +; 2: ++; 3: +++.

A BPTB autograft is considered by some to be the gold standard in ACL reconstruction.[5] The autograft consists of a segment of patellar tendon with bone blocks on both sides, and is harvested with a longitudinal or horizontal skin incision from the inferior pole of the patella at the midline to the tibial tuberosity. The bone blocks allow for BPTB autografts to integrate in the tibial and femoral tunnel more quickly. Nonetheless, there are disadvantages to a BPTB graft. Patellar tendon rupture, patella/tibia fracture, quadriceps weakness, loss of knee extension, and anterior knee pain are possible complications.[6, 7] The use of HT autograft and allograft has increased in recent years due to morbidity concerns.[3, 8, 9] The most important feature of HT grafts is that the potential postoperative complications are less likely to affect the daily life of the patient and the graft is less likely to regress over time. Another advantage is that it is mechanically stronger than the original ACL or the BPTB graft.[10] There is a decrease in knee flexion strength and tibial rotation due to donor site morbidity in HT grafts. However, this usually does not cause symptoms in the patients.[11] Sciatic or saphenous nerve damage is also possible, but the likelihood of permanent damage is low.[12] The use of an allograft depends on relative concerns about donor site morbidity and revision surgery. The risk of an immunogenic reaction, the possibility of disease transmission, and greater cost are some of the disadvantages that limit the use of allografts. There are many autograft and allograft options for reconstruction, and the decision of which graft type to use is typically based on surgeon and patient preference, patient age, activity level, and the desired return to sporting activities. It is still unknown which is best overall. The ideal graft should have the capacity for rapid incorporation, a low failure rate, a high degree of safety, low donor site morbidity, wide availability, and low cost.[13, 14] Unfortunately no such graft currently exists. This study will add to the data available about the difference between autograft and allograft reconstruction of ACL tears.

Table 5. Evaluation of groups according to return to sports, range of motion (ROM), quadriceps circumference and post-operative knee function

	Return to Sports (Month)	ROM	Quadriceps Difference (CM)	IKDC	Lysholm
Autograft					
n	52	52	52	52	52
Mean	9.3077	139.9038	1.2500	85.4038	90.2308
SD	2.56323	8.37189	1.34128	7.88498	7.36876
Allograft					
n	18	18	18	18	18
Mean	9.0000	141.3889	1.0556	81.8333	89.1667
SD	2.40098	7.63228	1.21133	6.18585	5.75224
p	0.586	0.557	0.635	0.105	0.442

IKDC: International Knee Documentation Committee; ROM: Range of motion.

Carey et al.[15] and Moses et al.[16] reported that there was no significant difference between patients who underwent autograft and allograft reconstructions in terms of short-term outcomes. There was no statistically significant difference between ACL reconstructions performed using an autograft or an allograft in terms of graft failure, postoperative laxity, or functional patient scores in the review published by Mariscalco et al.[13] and Romanini et al.[3] reported that the clinical outcomes were better in patients who underwent autograft reconstruction than those who underwent allograft reconstruction. A study of 82 patients with a 15-month follow-up period conducted by Aslan et al.[10] found similar clinical results in a comparison of patients who underwent allograft or autograft ACL reconstruction. Jia et al.[14] found no significant differences in the IKDC score, Lysholm score, physical instability tests, patient satisfaction questionnaires, or arthrofibrosis between groups who underwent autograft and allograft reconstruction at the end of the 81-month follow-up period in a study of 106 patients. In the study reported by Bottoni et al.,[17] the postoperative 10-year clinical results of 99 patients (100 knees) who had autograft and allograft procedures were compared using IKDC and Lysholm scoring and there was no statistically significant difference.[17] In a study with 84 patients conducted by Edgar et al.,[18] no statistically significant difference was found between autograft and allograft ACL reconstruction groups in terms of Lysholm, IKDC scores and laxity. Similarly, no significant difference was found between groups who underwent autograft and allograft reconstruction in terms of postoperative Lachman test results, IKDC score, Tegner-Lysholm score, or joint ROM findings in the study of 208 patients with a mean follow-up of 7.8 years conducted by Sun et al.[19] In our study, consistent with the literature, it was found that there was no statistically significant difference between the allograft and autograft patients in terms of the postoperative IKDC score, Tegner-Lysholm score (Table 5), or laxity (Lachman, anterior drawer and pivot-shift tests) (Table 4).

A good rehabilitation program after surgery is necessary for successful ACL surgeries. Howell and Taylor[20] stated that patients could return to sporting activity after 4 to 6 months with the appropriate rehabilitation program. The literature based on surgeon's experiences suggests that the method used or the graft applied is not the main determinant of a successful outcome.[21] Since the remodeling process of allografts and autografts is similar, the same rapid rehabilitation program was used in both of the study ACL reconstruction groups.[22] There were no complaints or pathology records related to rehabilitation at the periodic check-up visits. In the autograft group, the mean time to a return to sports was 9.3 months, whereas in the allograft group, it was 9.0 months: There was no significant difference between the 2 groups (Table 5).

The longer mean follow-up period among the allograft patients compared with the autograft group could be considered a limitation of the study. It was predominantly due to the relatively newer use of autograft ACL reconstruction. In addition, the relatively small number of patients in the allograft group, the lack of long term results due to the short follow-up period, leaving the choice of the graft to the surgeon during surgery, and the absence of patient groups with other graft options (BPTB autograft, quadriceps autograft, BPTB allograft, Achilles tendon allograft, etc.) are limiting factors in our study.

Conclusion

Considering the current literature, none of the grafts currently used for ACL reconstruction complies with the definition of an ideal graft. We believe that the most important factors affecting success in ACL reconstruction are proper graft selection according to the clinical experience of the surgeon and the physical activity level of the patient, correct implementation of the surgical procedure, postoperative patient compliance, and an appropriate rehabilitation program.

Disclosures

Ethics Committee Approval: Our study does not require approval from the ethics committee but instead we recieved approval and confirmation from the hospital management.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declares that there is no conflict of interest.

Human Rights Statement: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Authorship contributions: Concept – Ö.C.; Design – Ö.C.; Supervision – N.D.; Materials – Ö.C.; Data collection &/or processing – Ö.C.; Analysis and/or interpretation – N.D.; Literature search – F.D.; Writing – Ö.C.; Critical review – Ö.C.

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