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Original Research

Effects of Graft Selection in Arthroscopic Anterior Cruciate Ligament Reconstruction on Clinical Results: Mid-Term Functional Results

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Abstract

Objectives: In this study, mid-term clinical results of patients who underwent anterior cruciate ligament (ACL) reconstruction using allograft and autograft were compared.

Methods: Results of 70 patients who underwent anterior cruciate ligament (ACL) reconstruction with anterior tibial tendon (ATT) allograft (n=18) or hamstring (HT) autograft (n=52) were evaluated retrospectively. At the last follow-up, The International Knee Documentation Committee (IKDC) and Tegner-Lysholm score were used to assess the functional status of the patients and the Lachman test, Anterior drawer test and Pivot-shift test for laxity.

Results: There was no difference between the two groups in terms of age, gender, time to operation, graft thickness and femoral tunnel length (p>0.05). Results were satisfactory in both groups in post-operative period in terms of time to returning to sports, International Knee Documentation Committee (IKDC), Tegner-Lysholm, range of motion (ROM), quadriceps circumference and laxity, but there was no significant difference between the groups (p>0.05).

Conclusion: Our study suggests that mid-term clinical outcomes of ACL reconstruction with anterior tibial tendon (ATT) allograft or hamstring tendon (HT) autograft are similar. In conclusion, we believe that the successful rehabilitation program implemented after the operation performed by the experienced surgeon with the correct technique at the appropriate indications has a positive effect on success in ACL reconstruction.

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

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Today, the increase in the rate of doing sports as amateurs, professionals and as a hobby has increased the frequency of sports injuries. Anterior cruciate ligament (ACL), which is frequently affected in sports injuries, is one of the factors that plays an important role in the stability of the knee. If ACL, which does not have self-healing potential, loses its function, it can lead to osteoarthritis, pain and loss of mobility in individuals, and thus, decrease in the quality of life.[1]

Standard surgical treatment after injuries causing the loss of function of the ACL is ACL reconstruction. There is no consensus in the literature regarding the ideal surgical procedure for ACL reconstruction. One of the controversial

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issues is the choice of graft to be used for ACL reconstruction. 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 fast to the biologically placed location, and leave the least damage to the removed area. Autograft, allograft, or synthetic grafts are preferred in ACL reconstruction, but regrettably, they do not exactly meet the ideal graft definition.[2]

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

The aim of this study is to compare the mid-term clinical results of patients who underwent ACL reconstruction using allograft and autograft between 2013 and 2016.

Methods

We retrospectively evaluated the results of 83 patients who underwent ACL reconstruction and followed up for at least 12 months as a result of the symptomatic diagnosis of instability due to ACL rupture between 2013 and 2016. The patients were informed about the allograft and autograft prior to the operation and allograft was used in those who did not accept autograft. After obtaining the necessary permissions to access the patients' information, the patient information was accessed via the file and the patients were called for the controls by phone. Patients who had previous knee surgery, contralateral knee dislocation and who voluntarily left the rehabilitation program were not included in the study. Patients with concomitant meniscus injuries and patients with stage 3-4 chondral injury were also excluded from the study. As a result of the examination, 9 patients from the autograft group and 4 patients from the allograft group were excluded from the study. Semitendinous and grasilis hamstring tendons (HS) were preferred as autografts and anterior tibial tendon as allograft (Fig. 1a-1b). In order to reduce immunogenicity, allografts were presoaked in dexamethasone and gentamicin-containing solution for at least 30 min. Patients were divided into two groups as autograft (n=52) and allograft (n=18) used patients. The graft thicknesses and femoral tunnel lengths used in the patients' operation notes were noted.

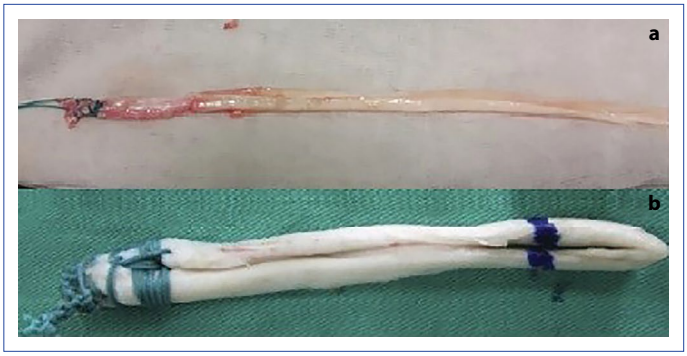

Figure 1 (a-b). Semitendinosus and Grasilis Hamstring Tendon Autograft. **(b)** Tibialis Anterior Tendon Allograft (Maxxeus Sports®, Community Tissue Service, USA).

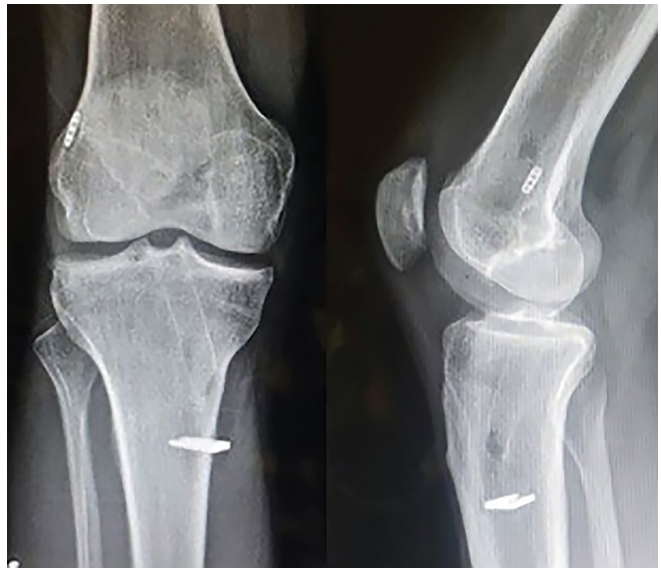

Figure 2. Post-operative right knee AP-LAT x-ray images.

All patients were operated by a single surgeon and arthroscopic reconstruction surgery was performed according to the anatomical single tunnel procedure as the surgical technique.

Autografts were palpated 2-3 cm in median of tuberosity tibia, 3-4 cm below medial joint space, and were removed with tendon scraper with a 3-4 cm oblique incision, and in the tensioned position, both tendons were prepared in four-folds by Krackow stitching method using number 2 Ethibond® suture (Ethicon Inc., USA). After tibial tunnel and femoral tunnel were prepared with the help of a guide in all patients, the graft was tunneled. Endobutton® (Smith & Nephew Inc., USA) was used for femoral fixation and bioabsorbable screws and staples were used for tibial fixation (Fig. 2).

In the postoperative period, narcotic analgesic (Tramadol hydrochloride) was used for 48 hours and nonsteroidal anti-inflammatory drug (Diclofenac sodium) and paracetamol were used for two weeks for analgesia. The drain was removed at 24 hours postoperatively. Ice was applied on the knee for two days and the extremity was elevated. Postoperative rehabilitation was carried out together with the Physical Therapy and Rehabilitation Clinic of the hospital. Closed-chain exercises and quadriceps empowerment ex-

Figure 3. Quadriceps circumference measurement.

Figure 4 (a-b). 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.

ercises were started after draining at post-operative 24th hour. After surgery, all patients were mobilized for six weeks with the help of an armrest without any load on the operated extremity. Active physiotherapy and rehabilitation were started after 6th week for all patients, and all patients were allowed for flat running at post-operative 4th month and active sports at the 6th month.

The joint range of motion (ROM) of all patients was assessed by goniometer. During the examination, at the sitting position and the knee with at 90° flexion, 15 cm above the midpoint of the proximal patella was marked. The quadriceps circumference was measured at the standing position with the feet open at the shoulder width and pointing the body weight evenly distributed to the two legs (Fig. 3). At

Figure 5. Postoperative 46th month clinical photograph and x-ray images of the patient underwent reconstruction with autograft.

Figure 6. Postoperative 39th month clinical photograph and x-ray images of the patient underwent reconstruction with allograft.

the end of the clinical follow-up, the patients were clinically examined (Fig. 4a, b, Fig. 5 and Fig. 6) and the findings were documented.

Gender, femoral tunnel length, graft thickness, age, and time to operation were considered in the comparison of

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.

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

AGE	n	Mean	Std. Deviation
Autograft	52	27.16	4.852
Allograft	18	26.39	3.744
			p=0.597

the groups (Table 1). The IKDC (International Knee Documentation Committee) and Tegner-Lysholm scoring were used to determine patient satisfaction and the Lachman, Anterior drawer and Pivot-Shift tests were performed for stability. In addition, the patients were asked when they started sports in the postoperative period.

Statistical Analysis

Data were presented as mean±standard deviation or mean (95% confidence interval). According to the power analysis performed, it was estimated that there should be at least 25 patients for autograft and 12 patients for allograft for a 90% power and 95% confidence level. Statistical analyses were performed using SPSS for Windows version 17.0 (SPSS Inc, Chicago, IL, USA). Independent T-test and Mann-Whitney test were used for statistical analysis. The level of significance was accepted as $p<0.05$.

Results

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

The average time to operation was 4.96 (3-8) weeks, being 5.10 (3-8) weeks for autograft group and 4.56 (3-6) weeks for allograft group. The two groups were compared according to femoral tunnel length and graft thickness. There was no significant difference between groups in terms of time to operation, femoral tunnel length, and graft thickness (Table 3). The mean follow-up period was 23.65 (12-49) months for autograft group and 35.39 (33-39) months for allograft group and were found statistically significant ($p<0.05$) (Table 3).

In the final control of the patients in the autograft group, the anterior drawer test was found negative in 43 patients and positive in 9 patients; pivot-shift test was found negative in 41 patients and positive in 11 patients; Lachman test was found negative in 46 patients and positive in 6 patients while in the allograft group, the anterior draw test was found negative in 15 patients and positive in 3 patients; pivot shift test was found negative in 14 patients and positive in 4 patients, and Lachman test was found negative in 16 patients and positive in 2 patients. There was no statisti-

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
Std. Deviation	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
Std. Deviation	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

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: +++.

cally significant difference in instability between the laxity tests in both groups (p=0.950, p=0.924, p=0.942, respectively) (Table 4).

The use of autograft and allograft was not statistically significant (p>0.05) on the mean quadriceps measurement, range of motion (ROM) and time to return to sports (p>0.05) (Table 5).

The clinical and satisfaction status of patients at the latest follow-up was assessed using the International Knee Documentation Committee (IKDC) clinical assessment scale and Tegner-Lysholm scores. Graft selection was not statistically significant (p>0.05) according to postoperative IKDC and Tegner-Lysholm evaluations (Table 5).

Discussion

ACL reconstruction is a frequent operation performed by orthopedists, and the aim of the surgery is to remove the knee instability due to the ACL failure. The ACL is an effective structure in the functional stability of the knee, which plays a protective role against antero-posterior translation and rotational subluxation.[3] Considering the anatomical, histological and biomechanical properties of the ACL, there is still no consensus in the literature about the selection of grafts in surgical procedures performed after ACL failure. Since the grafts used in surgical procedures do not have the same properties as the ACL, the search for the ideal graft continues.

Autografts or allografts are usually used in ACL reconstructions. Hamstring tendon grafts and bone-patellar tendon-bone (BPTB) grafts are preferred as autografts while tibialis anterior, tibialis posterior and Achilles tendon allografts are frequently used as allografts.[4]

BPTB autografts are used as gold standard in ACL reconstructions.[5] Autograft consists of a patellar tendon piece containing bone blocks on both sides, extending from the inferior pole of patella at the midline to the tuberosity tibia using a longitudinal or horizontal skin incision. In BPTB autografts, the integration of grafts in the tibial and femoral tunnel occurs faster with bone blocks on both sides of the graft. Besides this advantage, there are disadvantages of BPTB grafts. Patellar tendon rupture, patella/tibia fracture, quadriceps weakness, loss of knee extension and anterior knee pain are possible complications.[6, 7] The incidence of hamstring tendon autograft and allograft use has increased in recent years due to the morbidity of the patients.[3, 8, 9] The most important feature of hamstring tendon grafts is that possible post-operative complications do not affect the daily life of the patient or regress over time. Another advantage is being mechanically stronger than the ACL and the BPTB grafts.[10] Besides, there is a decrease in knee flexion strength and tibial rotation due to donor site morbidity in hamstring tendon grafts. However, this usually does not cause symptoms in patients.[11] Sciatic or saphenous nerve damage is also seen but the likelihood of permanent damage is low.[12] Considering donor site morbidities and revision surgeries, surgeons have been in additional searches for grafts. Depending on these searches, the use of allografts took place in surgical procedures. Compared to au-

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
Std. Deviation	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
Std. Deviation	2.40098	7.63228	1.21133	6.18585	5.75224
p	.586	.557	.635	.105	.442

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

tograft, the risk of an immunogenic reaction, the possibility of disease transmission and being an expensive option are some of the disadvantages that limit the use of allografts. As it is seen, 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 desired return to sport. Yet, it is still unknown which is better. the ideal graft should have rapid incorporation, low failure rates, a high degree of safety, low donor site morbidity, wide availability, and low cost.[13, 14] Unfortunately no such graft exists. By now there is no affirmative data about the difference between autograft and allograft reconstruction for ACL tears. For this reason, we chose to analyze which is better in autograft and allograft choice for ACL reconstruction from 2013 to 2016.

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

A good rehabilitation program is needed after surgery to be successful in ACL surgeries. Howell and Taylor[20] stated that patients could return to the sports after 4-6 months with the appropriate rehabilitation program. Literature in the direction of the surgeon's experiences and habits suggest that method or graft applied is not the main determinant of successful outcomes.[21] Because of the resemblance of remodeling process of allografts to the autografts, we applied the same rapid rehabilitation program in both groups in which we performed ACL reconstruction.[22] We did not find any complaints or pathology due to rehabilitation at periodic controls. In the autograft group, the mean time to return to the sports was 9.3 months, whereas in the allograft group, it was 9.0 months. There was no significant difference in terms of returning to sports between the two groups. (Table 5).

Longer mean follow-up period of allograft patients than that of the autograft group as the limitation of the study is predominantly due to the relatively new autograft reconstruction while ACL reconstruction with allograft has been performed for longer period. Except this, low number of patients in the allograft group, 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 the use of other graft options (BPTB autograft, quadriceps autograft, BPTB allograft, Achilles tendon allograft, etc.) are limiting factors in our study.

Conclusion

As a result, considering the current literature, none of the grafts used for ACL reconstruction complies with the definition of 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, proper and accurate implementation of the surgical procedure, postoperative patient compliance and correct 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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