

Small Size Autograft versus Large Size Allograft in Anterior Cruciate Ligament Reconstruction

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Background: A small autograft diameter negatively affects functional outcomes, knee stability, and the risk of rerupture after anterior cruciate ligament (ACL) reconstruction, whereas the strength of allograft decreases over time. Therefore, it is not clear whether the use of smaller autografts or the use of larger allografts in ACL yields better results. The aim of this study was to compare the outcome of smaller autografts and larger allografts for ACL reconstruction.

Methods: Fifty-one patients who underwent ACL reconstruction with hamstring tendon autografts (size ≤ 8 mm) and 21 patients who underwent ACL reconstruction with allografts (size ≥ 10 mm) were included in our study. All patients underwent the same aggressive early postoperative rehabilitation program. There were no significant differences between the autograft and allograft groups regarding the preoperative patient age, sex, time from injury to surgery, and average follow-up time.

Results: The mean diameter of the 4-stranded hamstring tendon grafts used as autografts was 7.48 ± 0.33 mm and the mean diameter of the allografts was 10.76 ± 0.67 mm. According to specific tests for the ACL (anterior drawer, Lachman, and pivot shift) and clinical evaluation tests (Lysholm knee scoring scale and International Knee Documentation Committee questionnaire), the final follow-up results were significantly better than the preoperative status in both autograft and allograft ACL reconstruction groups. Therefore, there were no significant differences between the autograft and allograft groups preoperatively and at the final follow-up.

Conclusions: The large size of the graft in ACL reconstruction has been reported to affect results positively. However, in our study, we could not find any significant differences between the smaller size autografts and larger size allografts in terms of inadequacy, rerupture, and final follow-up functional results. Although allografts were significantly larger than autografts, we did not have the positive effect of larger size grafts. Smaller size autografts were as effective as the larger size allografts.

Keywords: Anterior cruciate ligament injury, Graft size, Allograft, Autograft

The anterior cruciate ligament (ACL) is important for functional stability of the knee joint.¹⁾ ACL insufficiency accelerates meniscal injury and articular cartilage damage

and evolves into knee joint degeneration.²⁾

There are many autograft and allograft options for ACL reconstruction.³⁾ Although the use of autografts is the gold standard, the use of allografts has recently increased due to the avoidance of donor site morbidity, less postoperative pain, availability of multiple grafts, faster rehabilitation, and faster operating time.³⁾ However, the use of autografts remains the most preferred option because of possible immunogenicity, delayed graft incorporation, and risk of disease transmission associated with the use of allografts.⁴⁾

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Allografts and autografts are divided into 2 groups, bone containing and all soft tissue.⁵⁾ All soft-tissue autografts are as effective as bone-containing autografts in terms of graft strength, stiffness, and functional outcomes. Surgeons often prefer hamstring tendon grafts as all soft-tissue grafts.⁶⁻⁸⁾ With the use of hamstring tendon grafts, complications such as donor site morbidity, anterior knee pain, and postoperative knee motion restriction, which are seen with bone-patellar tendon-bone grafts, are minimized.^{9,10)} The size of the graft influences functional outcomes, knee stability, and the risk of rerupture. The smaller the grafts, the more negative the results.¹¹⁻¹³⁾ Therefore, anthropometric parameters are used to determine the hamstring tendon graft size preoperatively. If the graft size is small, a different graft type is recommended for ACL reconstruction or the small hamstring tendon should be augmented with an allograft or a graft from another part of the body.^{14,15)}

There are many studies in the literature comparing the use of autografts and allografts in ACL reconstruction. However, there is no study comparing a larger size allograft with a smaller size autograft in ACL reconstruction, to the best of our knowledge. Allograft incorporation is slower than autograft incorporation. In the knees reconstructed with allografts, the strength of the grafts decreases in time compared to that of autografts. Therefore, rehabilitation should be implemented in a more controlled setting and slowly for allograft-reconstructed knees.¹⁶⁾

The aim of this study was to compare the outcome of smaller size hamstring tendon autografts and larger size anterior tibial tendon (ATT) allografts for ACL reconstruction. We sought to determine whether larger size allografts should be used instead of smaller size autografts considering the size of the graft used in ACL reconstruction is important in terms of results.

METHODS

This study is a retrospective, non-drug, observational clinical trial. Local Ethics Committee approval was received from the Gaziosmanpaşa Training and Research Hospital (2017), and consent form was obtained from the patients included in the study.

A total of 168 patients who underwent ACL reconstruction with autografts or allografts between 2013 and 2015 were retrospectively reviewed. Exclusion criteria were graft size above 8 mm for autografts and below 10 mm for allografts, the presence of additional fractures around the knee joint, multiligamentous knee injury, chondral lesions, and medial or lateral meniscus injuries. Fifty-one patients

who underwent ACL reconstruction with hamstring tendon autografts (size ≤ 8 mm) and 21 patients who underwent ACL reconstruction with ATT allografts (size ≥ 10 mm) were included in our study. Patient's preoperative age, sex, time from injury to surgery, and average follow-up time were evaluated and there were no significant differences between autograft and allograft groups ($p < 0.05$) (Table 1).

All surgical procedures were performed by the senior author (HB) at the same center. All knees were reconstructed with single-bundle ACL grafts. All grafts were fixed with EndoButton. Patients in both groups followed the same aggressive early postoperative rehabilitation program at the same center.^{17,18)} The patients did not wear a postoperative knee brace or an immobilizer. Passive motion exercises without restrictions on hyperextension were started immediately after surgery. At the same time, range of motion exercise was started with a continuous passive-motion machine from 0° to 50° . Patients began weight bearing as tolerated immediately after surgery and used bilateral axillary crutches. Phase 1 exercises were started to facilitate early motion and muscle activation in the first postoperative week. Mobilization began with full weight-bearing without an assistive device. The phase 1 exercises were continued in the second postoperative week. Phase 2 exercises were started in the fourth postoperative week, phase 3 exercises in the eighth postoperative week, and phase 4 exercises in the twelfth postoperative week.

Preoperative and final follow-up clinical evaluations were performed with the Lysholm knee scoring scale¹⁹⁾ and International Knee Documentation Committee (IKDC) questionnaire.²⁰⁾ In addition, special tests for ACL (anterior drawer, Lachman, and pivot shift tests) were conducted preoperatively and at the final follow-up. The preoperative and final follow-up values were compared between groups and within each group. All patients were assessed by the

Table 1. Demographic Data

Parameter	Autograft group (n = 51)	Allograft group (n = 21)	p-value
Knee side (right : left)	28 : 23	13 : 8	0.61
Sex (male : female)	46 : 5	18 : 3	0.68
Age (yr)	26.3 \pm 4.1	28.9 \pm 5.9	0.11
Mean time from injury to surgery (wk)	23.3 \pm 4.7	26.8 \pm 8.3	0.07
Time to follow-up (mo)	22.3 \pm 4.7	25.0 \pm 5.6	0.07

Values are presented as mean \pm standard deviation.

same evaluator at different centers.

For statistical analysis, patients' mean age, mean time from injury to surgery, and mean follow-up period were compared with a 2-tailed independent sample *t*-test, whereas all other parameters were compared with a chi-square test. Statistical significance was set at $p < 0.05$.

RESULTS

The patients were divided into 2 groups according to the graft type. There were no significant differences between the 2 groups regarding the men-to-women ratio, mean age, mean follow-up period, and mean time from injury to surgery ($p > 0.05$) (Table 1). The mean diameter of the autografts was 7.48 ± 0.33 mm and the mean diameter of the ATT allografts was 10.76 ± 0.67 mm. The diameter of the allografts was significantly larger than that of the autografts ($p < 0.001$). The final follow-up results of the anterior drawer, Lachman, and pivot shift tests were significantly better than the preoperative test results in both autograft and allograft groups. Therefore, there were no significant differences between groups regarding the preoperative and final follow-up ACL test results ($p > 0.05$) (Table 2).

According to the Lysholm knee scoring scale and IKDC questionnaire, the final follow-up results were significantly better than the preoperative values in both autograft and allograft groups. When the groups were compared within them according to their preoperative and final follow-up results, statistically better results were obtained at the final follow-up in both groups ($p < 0.001$). Therefore, there were no significant differences between groups preoperatively and at the final follow-up ($p > 0.05$) (Table 3). Infection developed in a patient in the allograft group at the third postoperative month. Allograft and all implants were extracted and she received antibiotic therapy for 3 weeks. In the autograft group, 2 patients were diagnosed with rerupture and revision surgery was performed.

DISCUSSION

There are many graft options for ACL reconstruction. Although the ideal graft for ACL reconstruction is still controversial, the autograft remains a popular graft choice.²¹⁾ Graft tissue type, bone containing or all soft tissue, is also controversial among surgeons reconstructing the ACL.⁵⁾ Bone-containing autografts (bone-patellar tendon-bone graft) were most preferred previously. However, recent studies have shown that all soft-tissue autografts are as effective as bone-containing autografts in terms of stiff-

ness, strength, and clinical outcomes.^{6,7)} Nowadays, hamstring tendon grafts are the most preferred all soft-tissue autografts.⁶⁻⁸⁾ In addition, the problems of bone-patellar tendon-bone autografts, such as donor site morbidity, postoperative knee motion restriction, and anterior knee pain, are minimized with the use of hamstring tendon autografts.^{9,10)}

The use of allografts has become more common in ACL reconstruction than in the past. Although studies with allografts showed satisfactory results, complications such as longer vascularization time and potential risks including immune rejection and disease transmission are still unavoidable.²²⁾ The incorporation of allografts is slower than that of autografts. In a study by Jackson et al.,¹⁶⁾ at a 6-month follow-up, the cross-sectional area of allografts was smaller than that of autografts and the graft strength

Table 2. Preoperative and Postoperative Physical Evaluation Outcomes

Parameter	Autograft group (n = 51)	Allograft group (n = 21)	p-value
Anterior drawer test under anesthesia			0.77
Grade II	13	6	
Grade III	38	15	
Positive pivot shift under anesthesia			0.79
Grade II	19	7	
Grade III	32	14	
Positive Lachman under anesthesia			0.58
Grade II	16	8	
Grade III	35	13	
Front drawer test at final follow-up			0.89
Grade I	1	1	
Grade II	2	2	
Grade III	2	1	
Positive pivot shift at final follow-up			0.32
Grade I	5	1	
Grade II	3	2	
Grade III	1	2	
Positive Lachman at final follow-up			0.94
Grade I	4	3	
Grade II	2	1	
Grade III	2	1	

Table 3. Preoperative and Postoperative Clinical Evaluation

Variable	Preoperative		p-value	Postoperative		p-value
	Autograft	Allograft		Autograft	Allograft	
Lysholm knee scoring scale			0.90			0.91
Excellent (91–100)	0	0		41	17	
Good (84–90)	2	1		6	2	
Fair (65–83)	10	5		3	1	
Poor (\leq 64)	39	15		1	1	
IKDC questionnaire score			0.92			0.80
A	0	0		37	15	
B	2	1		13	5	
C	22	8		1	1	
D	27	12		0	0	

IKDC: International Knee Documentation Committee.

was weaker for allografts. Therefore, the study suggested that rehabilitation should be implemented slowly in a more controlled setting in allograft reconstruction patients.

In our study, we used all soft-tissue grafts for autografts and allografts. We preferred the smaller size hamstring tendon graft as autografts and the larger size ATT as allografts. The same rehabilitation program was used for all patients who received autografts or allografts. Progressive rehabilitation was started in the early postoperative period in both groups. However, there was no significant difference between autograft and allograft groups in terms of final follow-up results and graft insufficiency.

The size of the graft is important in ACL reconstruction. One study showed that the larger graft diameter was associated with lower meniscal stress, decreased joint laxity, and less articular cartilage contact stress.¹²⁾ In the study, 5-mm-diameter grafts exhibited 30% more anteroposterior translation than 9-mm grafts. The data of the study suggest that an increased graft size confers a biomechanical advantage in the ACL-reconstructed knees. In addition, the smaller the graft size, the higher the rate of revision.^{13,23)} Revision rate decreases 0.82 times per 0.5-mm graft diameter increase between 7-mm and 9-mm graft diameter.¹³⁾ Small graft diameter also adversely affects clinical outcomes.¹¹⁾ Therefore, current studies suggest that increased graft size provides both biomechanical advantages and better functional and clinical outcomes in the ACL reconstructed knees.^{11,24)}

ACL reconstruction with 8-mm and larger diameter

grafts reduces the risk of failure. In a study by Conte et al.,¹¹⁾ the failure rate was higher in reconstructions performed with grafts below 8 mm in diameter, especially in patients under 20 years of age.

Besides the higher revision rate, the smaller graft size was a predictor of poorer functional score at 2 years after primary ACL reconstruction in a study by Magnusson et al.²³⁾ There are not enough studies evaluating the effect of graft size on the results of ACL reconstruction in the literature. Some studies compared autografts with different diameters,^{11-13,24)} but there is no study on the allograft size in the literature. Several studies have reported the average diameter of the 4-strand hamstring tendon grafts to be between 7.7 mm and 8.5 mm.^{14,25,26)} The 4-strand hamstring tendon graft can be small in some patients, which increases the risk of failure and worse results after reconstruction. Thus, surgeons apply various methods to increase the graft size either by using the hamstring tendon of the other healthy extremity or by augmenting with the tendon graft from another part of the body. Some surgeons increase the size of these grafts by augmentation with allografts. However, it has been demonstrated in the literature that augmentation with allografts increases the risk of graft failure and retear rates.¹⁵⁾

In studies on autograft augmentation with allografts, it was found that the purity of the autograft was more important than the size. According to the KT-1000 test scores, autografts were significantly superior to hybrid grafts. It has been reported that increasing the size of autografts with allografts is meaningless.^{27,28)}

The graft diameter can be determined preoperatively in allograft ACL reconstruction. Surgeons prefer large diameter grafts to small diameter grafts in ACL reconstruction. We included patients who underwent ACL reconstruction with 10 mm and 11 mm diameter ATT allografts. In the autograft group, we included patients who underwent ACL reconstruction with a 4-stranded hamstring tendon graft with a diameter of 8 mm or less. However, we could not find any significant difference between the 2 groups in terms of inadequacy, rerupture, and final follow-up functional results. Although allografts were significantly larger than autografts, we did not see the positive effects of larger size grafts as described in the literature.

Studies have shown that allografts and autografts undergo a similar remodeling sequence, which consists of graft necrosis, cellular repopulation, revascularization, and collagen remodeling. Allografts and autografts have simi-

lar phases during their biologic incorporation, but these processes may proceed at a slower rate in allografts than in autografts.^{16,29} We think that this slow biological incorporation in allografts causes negative effects on the results. Therefore, smaller size autografts will give as good results as larger allografts.

We evaluated the early results of ACL reconstruction with a small sample size in this retrospective study; late results were not evaluated. If ACL reconstruction with larger size autografts and smaller size allografts had been included, the importance of this study would have been increased.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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