

## Analyzing the Relationship between Anthropometric Measurements and Hamstring Graft Dimensions in ACL Reconstruction Patients

Amish Rahi MV<sup>1</sup>, Sibin Surendran<sup>2</sup>, Nithin Karun<sup>3</sup>, Nousfier<sup>4</sup>, Raj Vignesh<sup>5</sup>

<sup>1</sup>Senior Resident, Department of Orthopaedics, Government Medical College, Kozhikode, Kerala, India

<sup>2</sup>Additional Professor, Department of Orthopaedics, Government Medical College, Kozhikode, Kerala, India

<sup>3</sup>Assistant Professor, Department of Orthopaedics, Government Medical College, Kozhikode, Kerala, India

<sup>4</sup>Senior Resident, Department of Orthopaedics, Government Medical College, Kozhikode, Kerala, India

<sup>5</sup>Junior Resident, Department of Orthopaedics, Government Medical College, Kozhikode, Kerala, India

---

Received: 05-02-2023 / Revised: 10-03-2023 / Accepted: 08-04-2023

Corresponding author: Dr. Sibin Surendran

Conflict of interest: Nil

---

### Abstract

**Background and Objectives:** Anterior Cruciate Ligament (ACL) damage is a frequent type of knee injury that often requires surgical repair. Hamstring autografts are frequently used in ACL reconstruction (ACLR). The choice of graft is influenced by several factors. There are few studies in the literature that demonstrate a relationship between patients' anthropometric measures and the dimensions of the hamstring tendon graft used in ACLR. The purpose of present study was to compare both the length and diameter of the graft acquired with anthropometric measures.

**Material and Methods:** The study was conducted as a hospital based prospective observational study at the Department of Orthopedics, Government Medical College and hospital of south India. Forty seven patients of more than 18 years age receiving quadrupled hamstring autograft ACL reconstruction were evaluated after receiving institutional ethical committee permission and the informed written consent. The anthropometric measurements were obtained preoperatively and intraoperative measurements of the length of both gracilis and semitendinosus tendon and diameter of the quadrupled graft were obtained. All the data collected were analyzed using SPSS statistical software version 22. Pearson correlation test was used to find out correlation between graft diameter and graft length and anthropometric parameters.

**Results:** Analysis showed a positive relation between height, thigh length and graft diameter ( $p=0.045$  and  $p=0.041$ , respectively). Height showed a positive correlation with both gracilis and semitendinosus length ( $p<0.001$ ) whereas thigh length showed a positive correlation with semitendinosus length only ( $p=0.046$ ). Other factors had statistically insignificant association with the graft diameter and length.

**Conclusion:** For determining graft dimensions for ACLR surgery, anthropometric measures are simple measures. When doing ACLR, affirmative correlation variables (height & thigh length) can be used to predict a high-quality graft.

**Keywords:** Anterior cruciate ligament; Anthropometric measurements; Quadrupled hamstring graft.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

## Introduction

Orthopedic medical professionals frequently perform ACLR because patients acknowledge it as a surgical solution and fixation tools have improved. Patients who have minimally invasive surgery recover more quickly, spend less time in the hospital, and resume their usual activities sooner.

Regarding preoperative determinants of autograft quality, there is not obvious consensus.[1] If left untreated, ACL injuries hasten the ageing process of the joint, causing complex osteoarthritis, meniscus tears, & unsteadiness.[2,3] The most frequently repaired knee ligament is the ACL [2]. The choice of graft is influenced by the patient's age, their extent of activity, and the surgeon's preferences. Hamstring autografts are recommended because they have good graft diameter, the right length, can be harvested quickly, and have lower donor spot morbidity.[3-5]

According to Scott and Insall, the typical length and width of a normal ACL are 38 mm (25–41 mm) and 10 mm (7–12 mm), respectively.[6] It is crucial to get a minimum tendon length that is 28 cm (28-30 cm) and it should have a minimum thickness of 7 mm in order to achieve the ideal 7 cm of quadrupled graft length during ACLR (femoral tunnel 2 cm, intraarticular 3 cm, and 2 cm tibial tunnel).[7,8] Numerous studies advise using grafts with diameters >8 mm to reduce the likelihood of graft failure.[6-8] Hamstring grafts that have doubled semitendinosus & gracilis tendons are known as quadrupled grafts.[6] There is still diversity in the results despite the fact that several research have been conducted to anticipate the optimum graft diameter.

## Aim and Objectives

The goal of this study was to compare the diameter and length of a quadrupled hamstring tendons graft during ACLR surgery to anthropometric data such as weight, height, BMI, thigh circumference, and thigh length.

## Material and Methods

The study was conducted as a hospital based prospective observational study at the Department of Orthopedics, Government Medical College and hospital of south India. Forty seven patients of more than 18 years age receiving quadrupled hamstring autograft ACL reconstruction were evaluated. The research was accepted by the Ethical Committee and complete informed written consent was acquired from the patients.

**Inclusion criteria:** Both males and females above 18 years who were posted for anterior cruciate ligament reconstruction surgery.

### Exclusion criteria:

- Patients who previously had ACL repair and were hospitalized for revision surgery
- Lower limb and hip fractures
- Patients who experienced a prior fracture in the similar limb
- Bilateral ACL injuries
- Patients with neuromuscular disorders
- Patients who refuse to provide consent.

### Sample size calculation:

$N = 4(SD)^2/d^2$  (N=sample size, SD=standard deviation, D=Precision) and the calculated sample size was 47, based on previous study.[4]

### Method of data collection:

The patient's history was used to gather and record demographic data, including the

patient's age, gender, weight, height, thigh length, and circumference, as well as information on the injury's mechanism, affected side, and extent of activity. Using a method developed by the World Health Organization, the body mass index (BMI) was determined. All patients completed a standard pre-anaesthetic checkup (PAC) and underwent elective orthopedic surgery procedures.

The patient's thigh was measured from the medial joint line to the anterior superior iliac spine. 15 cm away from the medial joint line, the thigh's circumference was measured. An orthopedic surgeon skilled in tendon graft retrieval obtained all of the grafts. Both the gracilis and semitendinosus tendon's lengths as well as the quadrupled graft's diameter were measured intraoperatively. Sizing tubing calibrated to 0.5 mm were used to measure the graft's diameter. All measurements were taken following the blunt removal of the associated muscle and fat but prior to any additional post-harvest modification or graft trimming. All calculations in this investigation were done using the diameter of a quadrupled semitendinosus-gracilis graft that was implanted in the femoral tunnel.

### Statistical Analysis

The SPSS statistical software version 22 was used to review and analyze all the data that had been gathered, coded, and entered into a Microsoft Excel sheet. Standard deviation (SD), together with the mean, was used to summarize quantitative data. Frequency and

percentages were used to represent categorical variables. The statistical significance of the disparity in the means of the variables among several independent groups was examined using the independent sample t test. Comparisons between groups of categorical variables were made using the Pearson Chi-square test. To determine the relationship between graft diameter and length along with various other quantitative factors, the Pearson correlation test was performed. Statistical significance was defined as a p value  $\leq 0.05$ .

### Results

The following observations were made from the study. 47 patients underwent the procedure were evaluated. 45 (95.2%) patients were males and 2 (5.7%) females.

Since only 2 females were included in the study, gender based statistical studies were not relevant.

### Graft diameter

Height, thigh length, and graft diameter were found to be positively correlated by analysis ( $p=0.041$  &  $p=0.045$ , respectively). Taller patients often had quadrupled hamstring grafts that were thicker.

The graft thickness was not correlated with age, weight, BMI, or thigh circumference ( $p=0.528$ ,  $0.468$ ,  $0.943$ , and  $0.333$ , respectively). The statistical significance of thigh length as a predictor for graft diameter has been shown to be higher than that of height.[Table 1 & 2]

**Table 1: Factors associated with graft diameter**

Variable	Graft diameter	
	Mean $\pm$ SD	P value
<b>Age</b>		
10-20 years	7.83 $\pm$ 0.81	0.877
21-30 years	7.84 $\pm$ 0.80	
31-40 years	7.57 $\pm$ 1.30	
41-50 years	7.50 $\pm$ 2.12	
<b>Gender</b>		
Male	7.85 $\pm$ 0.87	0.014*
Female	6.25 $\pm$ 0.35	

<b>Obesity</b>		
Underweight	7	0.681
Normal	7.87±0.86	
Overweight	7.59±1.15	
Class 1 obesity	7.75±0.35	

**Table 2: Factors associated with graft diameter**

<b>Variable</b>	<b>Correlation coefficient</b>	<b>P value</b>
Age	-0.094	0.528
Height	0.294	0.045*
Weight	0.109	0.468
BMI	-0.011	0.943
Thigh length	0.299	0.041*
Thigh circumference	-0.144	0.333
Gracilis length	0.182	0.220
Semitendinosus length	0.208	0.160

\*statistically significant

**Graft length:**

Gracilis and semitendinosus lengths correlated positively with height ( $p < 0.001$ ), but thigh length correlated positively with semitendinosus length solely ( $p = 0.046$ ). As a result, the length of the hamstring graft could be predicted statistically by height. [Table 3 & 4]

**Table 3: Correlation of gracilis length with other factors**

<b>Variable</b>	<b>Correlation coefficient</b>	<b>P value</b>
Age	-0.107	0.476
Height	0.521	<0.001*
Weight	0.084	0.576
BMI	-0.225	0.129
Thigh length	0.262	0.075
Thigh circumference	0.259	0.079

\*statistically significant

**Table 4: Correlation of semitendinosus length with other factors**

<b>Variable</b>	<b>Correlation coefficient</b>	<b>P value</b>
Age	-0.024	0.871
Height	0.559	<0.001*
Weight	0.118	0.429
BMI	-0.193	0.194
Thigh length	0.293	0.046*
Thigh circumference	0.251	0.089

\*statistically significant

**Discussion**

The suggested graft diameter and length have been predicted through a number of research, although the outcomes have varied.[3,10] It is now beyond disagreement that arthroscopic

ACL restoration surgery is among the most popular and successful surgical procedures among sports doctors globally.

The purpose of a graft in ACLR is to replace the torn ligament after injury. Common autograft choices include hamstring autograft, bone patellar tendon autograft and quadriceps tendon autograft. Bone patellar tendon graft allows free bone to bone healing within the femoral and tibial tunnels. Main advantage of using this autograft is its faster healing potential. Hamstring autograft (semitendinosus and gracilis) minimize the donor site morbidity when compared with bone patellar tendon autograft. Quadriceps tendon autograft include a bone block from patella.

We discovered a significant positive connection between transplant diameter and patient thigh length. The patient's height significantly positively correlates with the graft's length and diameter.

In western literature, it has been demonstrated that thigh length and patient height are the two most reliable predictors of hamstring graft size [9, 10]. In our study, thigh length likewise proved to be the greatest predictor of graft size (diameter). This suggests that, in accordance with our findings, preoperative measures of thigh length and height may be utilized to determine the transplant size. Previous research also mentioned this useful relationship. [11–13] Similar findings have been made by Moghamis *et al.* on pertinent beneficial characteristics for receiving superior grafts in thigh length & circumference. [3]

The reason for this comparable finding is that tall people with longer thighs have an abundance of collagen, which causes graft length to rise as thigh height and length do. Our study did not demonstrate a favourable correlation between thigh circumference and a high-quality graft in terms of length & diameter, instead other studies did. [3,10]

As a predictor of ultimate graft diameter, earlier research [14,15] have shown a negative connection with age, which is comparable to our study. Younger participants in our study's age range of 18 to 46 likely to have superior

graft diameter. The weight, BMI, gender, or thigh circumference of the patient did not statistically correlated with graft dimension.

Younger age and smaller graft diameter were the biggest risk factors for early revision surgery, according to a research by Magnussen *et al* [6] that looked at 256 patients who had had hamstring autograft ACL restoration. According to the study's findings, individuals under the age of 20 who had graft diameters of 8 mm or smaller underwent revision surgery the most frequently.

According to Tuman *et al.* [4], individuals with heights under 147 cm were at risk for having quadrupled hamstring diameters under 7 mm. Patients with heights less than 140 cm, according to Treme [14] *et al.*, may have insufficient graft diameter. Height was also mentioned by Pinheiro *et al* [10] & Ma *et al* [16] as a factor influencing hamstring graft diameter. However, they did not provide a height cutoff for an insufficient hamstring transplant. Both men and women might benefit from their findings.

Borsvert *et al* [17] suggested that 162.5cm was the height threshold for adequate graft diameter (7mm). But they were unable to apply if for males. Celiktas *et al* [18] proposed the height for minimum thickness of quadrupled hamstring graft diameter as 155.2cm. In this study there was a positive correlation with height and quadrupled hamstring diameter ( $p = 0.045$ ), but the height threshold for adequate graft diameter was not calculated.

### Limitations of the Study

As only 2 female patients were included in present study, these results cannot be used for female patients. Since current sample size was small regression analysis were not applied in this study. Also, that both the anthropometric and intraoperative graft measurements were performed by different surgeons decreases the reliability of present data.

### Conclusion

Preoperative identification of deficient hamstring tendon autograft allows surgeons to choose an alternate surgical strategy, preoperative patient counseling and to adopt other graft options. Anthropometric parameters are easy tools for predicting graft size in anterior cruciate ligament reconstruction surgery. Even though we are accessing graft length and graft diameter, graft diameter of 7mm or more is the single most important factor in determining the postoperative outcomes and failure rates. For preoperative hamstring graft thickness and length predictions for anterior cruciate ligament reconstruction, height and thigh length can be utilized as a reference.

### References

- Pereira RN, Karam FC, Schwanke RL, Millman R, Foletto ZM, Schwanke CH. Correlation between anthropometric data and length and thickness of the tendons of the semitendinosus and gracilis muscles used for grafts in reconstruction of the anterior cruciate ligament. *Rev Bras Ortop.* 2016;51:175-80.
- Kaeding CC, Léger-St-Jean B, Magnussen RA. Epidemiology and diagnosis of anterior cruciate ligament injuries. *Clin Sports Med.* 2016;36(1):1-8.
- Moghamis I, Abuodeh Y, Darwiche A, Ibrahim T, Al Ateeq Al Dosari M, *et al.* Anthropometric correlation with hamstring graft size in anterior cruciate ligament reconstruction among males. *Int Orthop.* 2020;44(3):577-84.3.
- Tuman JM, Diduch DR, Rubino LJ, Baumfeld JA, Nguyen HS, Hart JM. Predictors for Hamstring Graft Diameter in Anterior Cruciate Ligament Reconstruction. *Am J Sports Med.* 2007; 35(11): 1945-9.
- Challa S, Satyaprasad J. Hamstring graft size and anthropometry in south Indian population. *J Clin Orthop Trauma.* 2013; 4(3):135-8.
- Magnussen RA, Lawrence TR, West RL, Toth AP, Taylor DC, Garrett WE. Graft Size and Patient Age Are Predictors of Early Revision Hamstring Autograft. *Arthrosc J Arthrosc Relat Surg.* 2012;28(4):526-31.
- Mariscalco MW, Flanigan DC, Mitchell J, Pedroza AD, Jones MH, Andrish JT, *et al.* Reported Outcomes and Risk of Revision After Anterior. *Arthrosc J Arthrosc Relat Surg.* 2013;29(12):1948-53.
- Conte EJ, Hyatt AE, Gatt CJ, Dhawan A. Hamstring Autograft Size Can Be Predicted and Is a Potential Risk Factor for Anterior Cruciate Ligament Reconstruction Failure. *Arthrosc J Arthrosc Relat Surg.* 2014;30(7):882- 90.
- Pichler W, Tesch NP, Schwantzer G, Fronhöfer G, Boldin C, Hausleitner L, *et al.* Differences in length and cross-section of semitendinosus and gracilis tendons and their effect on anterior cruciate ligament reconstruction: a cadaver study. *J Bone Jt Surgery- British volume.* 2008;90(4):516-9.
- Pinheiro Jr LFB, Anto M, Azevedo L, Gustavo L, Gonzaga A. Intra-operative four-stranded hamstring tendon graft diameter evaluation. *Knee Surg Sports Traumatol Arthrosc.*2011;19(5):811-5.
- Chiang ER, Ma HL, Wang ST, Hung SC, Liu CL, Chen TH. Hamstring graft sizes differ between Chinese and Caucasians. *Knee Surg Sports Traumatol Arthrosc.* 2012; 20(5):916-21.
- Goyal S, Matias N, Pandey V, Acharya K. Are pre-operative anthropometric parameters helpful in predicting length and thickness of quadrupled hamstring graft for ACL reconstruction in adults? A prospective study and literature review. *Int Orthop.* 2016;40(1):173-81.
- Janssen RPA, Velden MJF, Besselaar M, Reijman M. Prediction of length and diameter of hamstring tendon autografts for knee ligament surgery in Caucasians. *Knee Surgery, Sport Traumatol Arthrosc.* 2017;25(4):1199- 204.

14. Treme G, Diduch DR, Billante MJ, Miller MD, Hart JM. A Prospective Clinical Evaluation. *Am J Sports Med.* 2008; 36(11): 2204-9.
15. Asif N, Ranjan R, Ahmed S, Sabir AB, Jilani LZ, Qureshi OA. Prediction of quadruple hamstring graft diameter for anterior cruciate ligament reconstruction by anthropometric measurements. *Indian J Orthop.* 2016;50(1):49-54.
16. Ma CB, Keifa E, Dunn W, Fu FH, Harner CD. Can preoperative measures predict quadruple hamstring graft diameter? *Knee* 2010; 17:81–83.
17. Boisvert CB, Aubin ME, DeAngelis N. Relationship between anthropometric measurements and hamstring autograft diameter in anterior cruciate ligament reconstruction. *Am J Orthop* 2011; 40: 293–295
18. Celiktas. Prediction of the quadruple hamstring autograft thickness in ACL reconstruction using anthropometric measures. *Acta Orthop Traumatol Turc* 2013; 47:14–18.