

Analysis of the Relationship between Hamstring Graft Dimensions and Anthropometric Variables in Patients Undergoing Anterior Cruciate Ligament Reconstruction

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Abstract:

Background & Objectives: Damage to the Anterior Cruciate Ligament (ACL) is a commonly occurring knee injury which frequently necessitates operative intervention for restoration. The utilization of hamstring autografts is a common practice in the surgical procedure known as anterior cruciate ligament reconstruction (ACLR). The selection of graft is determined by numerous factors. There is a limited body of research in the existing literature that presents evidence of a correlation between patients' anthropometric measurements and the size of the hamstring tendon graft utilized in anterior cruciate ligament reconstruction (ACLR). The objective of the current study was to conduct a comparative analysis of the length as well as graft diameter obtained using anthropometric measurements.

Material & Methods: Study participants were hospitalized patients at the Government Medical College and Hospital of Southern India, where a prospective observational study was conducted in the Orthopedics Department. A total of 47 patients, all over the age of 18, who had quadrupled hamstring autograft ACLR reconstruction, were assessed in accordance with the guidelines set by the institutional ethics committee and after obtaining informed written consent from each participant. A patient's anthropometric parameters were taken before surgery, while intraoperative measurements of the quadrupled graft's diameter and the lengths of the gracilis and semitendinosus tendons were taken. All of the collected data was analyzed in SPSS, a statistical tool version 22. The association between graft diameter & graft length, as well as anthropometric parameters, was analyzed using the Pearson correlation test.

Results: The study demonstrated a affirmative association between height with both thigh length as well as graft diameter ($p=0.045$ & $p=0.041$, respectively). Both gracilis and semitendinosus length were positively correlated with height ($p<0.001$). Furthermore, there was a positive association between thigh length and semitendinosus length ($p=0.046$). No correlations between graft diameter, graft length, or any other measured variable were found to exist.

Conclusion: Anthropometric parameters serve as straightforward indicators for evaluating graft size in anterior cruciate ligament reconstruction (ACLR) surgery. In the context of anterior cruciate ligament reconstruction (ACLR), it is possible to utilize positive correlation factors such as height and thigh length to make predictions on the likelihood of achieving a superior-quality of graft.

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

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Introduction

Orthopedic specialists commonly engage in ACLR procedures due to the recognition by patients of its efficacy as a surgical intervention, along with advancements in fixation devices. Patients who undergo minimally invasive surgery get expedited recovery, reduced hospitalization duration, and

earlier resumption of normal activities. The existence of a clear consensus on preoperative factors of autograft quality remains uncertain. [1] If ACL injuries are not addressed, they can accelerate the degeneration of the joint, leading to the development of complicated osteoarthritis,

meniscus tears, and instability. [2,3]. The anterior cruciate ligament (ACL) is the knee ligament that undergoes the highest frequency of repairs [2]. Factors like patient age, amount of physical activity, as well as the surgeon's preferences all play a role in determining the type of graft to be used. Hamstring autografts are commonly advocated due to their favorable characteristics, including optimal graft diameter, appropriate length, expedient harvestability, and reduced morbidity at the donor site. [3,5].

Based on the findings of Scott and Insall, it has been determined that the average dimensions of a healthy anterior cruciate ligament (ACL) are around 38 mm in length, with a range of 25-41 mm, and 10 mm in width, with a range of 7-12 mm. To accomplish the requisite 7 cm length of a quadrupled graft for ACLR, a tendon length of at least 28 cm (28-30 cm) and a thickness of at least 7 mm are required. This length is necessary to accommodate the specific requirements of the procedure, including a 2 cm length for the femoral tunnel, a 3 cm length inside the intraarticular space, and a 2 cm length for the tibial tunnel. [6,7]. Multiple studies recommend the use of grafts with diameters above 8 mm in order to decrease the probability of graft failure. [6-8] Quadrupled grafts refer to hamstring grafts that involve the use of both the semitendinosus and gracilis tendons, resulting in a doubled configuration. [8] Despite the numerous research studies undertaken to predict the ideal graft diameter, there continues to be variation in the outcomes, indicating the presence of diversity.

Aim and Objectives:

The objective of this study was to conduct a comparative analysis between the diameter and length of a quadrupled hamstring tendon graft utilized in anterior cruciate ligament reconstruction (ACLR) surgery and anthropometric measurements including weight, height, body mass index (BMI), thigh circumference, as well as thigh length.

Material and Methods:

Study participants were hospitalized patients at the Government Medical College and Hospital of Southern India, where a prospective observational study was conducted in the Orthopedics Department. A total of 47 patients, all aged over 18 years, who had quadrupled hamstring autograft ACLR, were included in the evaluation. The research study received approval from the Ethical Committee, and all participating patients provided complete informed consent in writing.

Inclusion criteria: Both male and female individuals aged 18 years and older who were

scheduled to have surgery for anterior cruciate ligament repair.

Exclusion criteria:

- Individuals who have undergone anterior cruciate ligament (ACL) repair and were admitted to the hospital for revision surgery
- Fractures occurred in the lower limb & hip region
- Patients who have previously sustained a fracture in the identical limb
- Individuals with bilateral anterior cruciate ligament (ACL) trauma
- Patients diagnosed with neuromuscular disorders
- Individuals who decline to grant consent for medical interventions.

Sample size estimation:

The sample size, computed using the formula $N = 4(SD)^2/d^2$ (N = sample size, SD = standard deviation, D = precision), was 47, based on past research. [4]

Data collection strategy:

Patient age, gender, height, weight, thigh length, and thigh circumference were recorded along with other demographic information retrieved from the patient's medical record. Mechanism of injury, affected side, and extent of activity were all noted for each injury.

A body mass index (BMI) calculation was performed according to WHO guidelines. All patients completed their routine pre-anaesthetic check-up (PAC) and proceeded on to have elective orthopaedic surgeries.

Medial joint line to anterior superior iliac spine was used to determine the patient's thigh measurement. The circumference of the thigh was measured at a distance of 15 cm from the medial joint line. All the grafts were obtained by an orthopaedic surgeon who had expertise in tendon graft retrieval. Intraoperative measurements were taken of the gracilis tendon, the semitendinosus tendon, and the quadrupled graft's diameter.

Tubing with a calibration of 0.5 mm was utilized to measure the diameter of the graft. Prior to any post-harvest adjustments or graft trimming was made, measurements were taken after the appropriate muscle and fat had been bluntly removed. The diameter of the quadrupled semitendinosus-gracilis graft which was surgically placed into the femoral tunnel was used to make the calculations in this investigation.

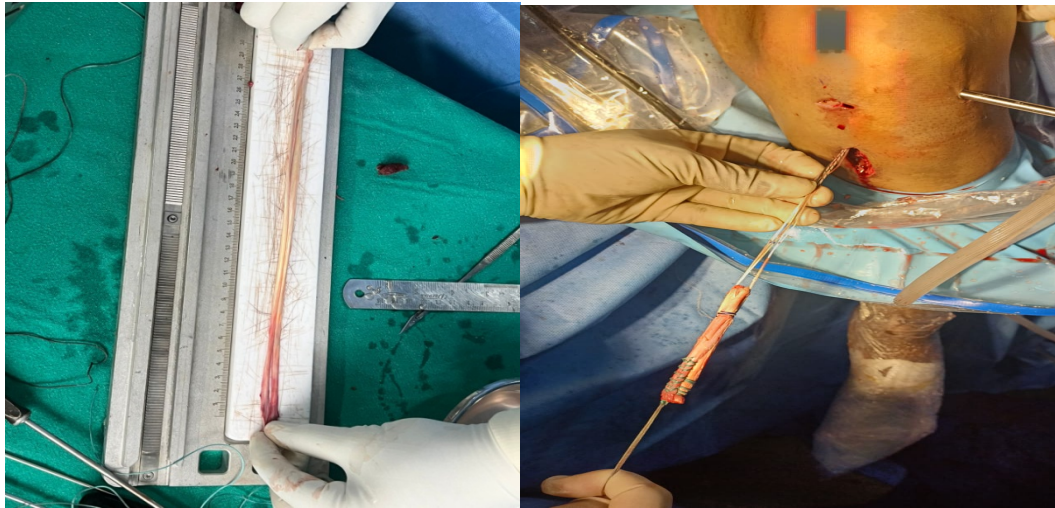


Figure 1 & 2: Quadrupled hamstring graft for ACLR



Figure 3: Arthroscopic view of hamstring graft after fixation

Statistical Analysis: The data analysis was conducted using the SPSS statistical programme, version 22. All collected data was coded and placed into a Microsoft Excel spreadsheet prior to analysis. The utilization of standard deviation (SD), in conjunction with the mean, was employed as a means of summarizing quantitative data. Categorical variables were represented using frequency and percentages. To determine whether or not there was a statistically significant difference between the means of the variables for each of the separate groups, the independent sample t test was implemented. The Pearson Chi-square test was utilized to conduct comparisons among groups of category data. The Pearson correlation test was used to establish the association between graft diameter and length, as well as other quantitative variables. The concept of statistical significance has been codified as a p value of less than or equal to 0.05.

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Results

The research yielded the following observations. A total of 47 individuals who received the treatment were assessed. Out of the total sample size, 45 individuals (95.2%) were identified as males, while 2 individuals (5.7%) were identified as females.

Due to the limited representation of females in the study, the statistical analysis pertaining to gender was deemed inconclusive.

Graft diameter: The research revealed a positive correlation between height and thigh length ($p=0.041$) as well as between height and graft diameter ($p=0.045$). Patients with greater height frequently had quadrupled hamstring grafts with increased thickness. There was no significant correlation seen between graft thickness and age, weight, BMI, or thigh circumference (p -values of 0.528, 0.468, 0.943, and 0.333, respectively). The research findings indicate that thigh length exhibits

a greater level of statistical significance as a predictor for graft diameter compared to height. [Table 1, 2]

Table 1 & 2: Diameter of graft and related factors

| Variables | Diameter of graft | P-value |
|-----------------|-------------------|---------|
| | Mean ± SD | |
| Age | | |
| 10-20 yrs | 7.84±0.82 | 0.878 |
| 21-30 yrs | 7.85±0.81 | |
| 31-40 yrs | 7.58±1.31 | |
| 41-50 yrs | 7.51±2.13 | |
| Gender | | |
| Male | 7.86±0.86 | 0.015* |
| Female | 6.24±0.34 | |
| Obesity | | |
| Underweight | 7.01±0.81 | 0.682 |
| Normal | 7.86±0.87 | |
| Overweight | 7.58±1.14 | |
| Obesity Class 1 | 7.76±0.36 | |

| Variables | Correlation coefficient | P-value |
|--------------------------|-------------------------|-----------|
| Age | -0.095 | 0.529 |
| Height | 0.295 | 0.046 (S) |
| Weight | 0.108 | 0.469 |
| BMI | -0.012 | 0.944 |
| Thigh length | 0.298 | 0.042 (S) |
| Thigh circumference | -0.145 | 0.334 |
| Length of Gracilis | 0.183 | 0.221 |
| Length of Semitendinosus | 0.207 | 0.161 |

(S) - Statistically Significant

Graft length: There was a significant positive correlation between the lengths of the gracilis and semitendinosus muscles and height (p<0.002). There was a significant positive association

between thigh length and semitendinosus length (p=0.046).

Consequently, there exists a statistical relationship between height and the length of the hamstring graft. [Table 3, 4]

Table 3: The relationship between gracilis length and other variables

| Variables | Correlation coefficient | P-value |
|---------------------|-------------------------|------------|
| Age | -0.108 | 0.477 |
| Height | 0.522 | <0.002 (S) |
| Weight | 0.085 | 0.577 |
| BMI | -0.226 | 0.128 |
| Thigh length | 0.263 | 0.076 |
| Thigh circumference | 0.258 | 0.078 |

(S) - Statistically Significant

Table 4: Semitendinosus muscle length and its associations with other variables

| Variables | Correlation coefficient | P-value |
|---------------------|-------------------------|------------|
| Age | -0.025 | 0.872 |
| Height | 0.558 | <0.002 (S) |
| Weight | 0.119 | 0.428 |
| BMI | -0.194 | 0.195 |
| Thigh length | 0.294 | 0.047 (S) |
| Thigh circumference | 0.252 | 0.088 |

(S) - Statistically Significant

Discussion

Diverse researches have estimated the expected graft diameter as well as length with conflicting

outcomes. [3,10] There is a consensus among medical professionals worldwide that arthroscopic ACL reconstruction surgery is widely recognized as one of the most prevalent and efficacious

surgical interventions in the field of sports medicine.

The primary objective of a graft in anterior cruciate ligament reconstruction (ACLR) is to serve as a substitute for the damaged ligament subsequent to injury. Hamstring autografts, bone patellar tendons, and quadriceps tendons are examples of often used autograft choices. The utilization of a bone patellar tendon graft facilitates the occurrence of unhindered osseous union between the femoral and tibial tunnels. The primary benefit associated with the use of this autograft is its enhanced capacity for expedited wound healing. The utilization of hamstring autograft, namely the semitendinosus and gracilis tendons, has been found to reduce the occurrence of complications at the donor site in comparison to the use of bone patellar tendon autograft. The use of a quadriceps tendon autograft involves the incorporation of a bone block sourced from the patella.

A substantial positive correlation was seen between the diameter of the graft and the length of the patient's thigh. There is a strong positive correlation between the height of the patient and the length and diameter of the graft.

Western medical literature suggests that thigh length as well as patient height remain the two most reliable parameters in determining the appropriate size of hamstring transplants. [9, 10]. The thigh length was revealed to be the strongest predictor of graft diameter in our study. Our findings suggest that preoperative evaluation of thigh length as well as height might be used to determine the suitable size for transplantation. The aforementioned link has been discussed in prior scholarly investigations. [11-13] Moghamis et al. have shown similar results about the advantageous attributes associated with obtaining high-quality grafts in terms of thigh length and circumference. According to the source provided. [3]

The observed similarity in findings can be attributed to the fact that individuals with greater height and longer thigh length tend to possess a higher concentration of collagen, leading to an increase in graft length. The length and diameter of a graft were not positively correlated with thigh circumference in our study. However, disparate outcomes have been found by other investigations. [3,10]

Previous studies [14,15] have demonstrated a negative correlation between age and the eventual graft diameter, which aligns with the findings of our investigation. It is probable that individuals within the younger age group, ranging from 18 to 46 years old, have a higher likelihood of possessing better graft diameter, as seen in present study. There was statistically insignificant correlation

seen between the patient's weight, BMI, gender, or thigh circumference and transplant dimension.

According to a study conducted by Magnussen et al [6], early revision surgery in patients who had hamstring autograft ACL repair was shown to be significantly associated with younger age and smaller graft diameter. The research analyzed a cohort of 256 patients. The study found that the rate of revision surgery was greatest for individuals under the age of 20 with graft diameters of 8 mm or smaller. Based on the findings of Tuman et al. [4], it was observed that persons with heights below 147 cm had a heightened susceptibility to quadrupling of hamstring diameters measuring less than 7 mm. According to Treme et al. [14], individuals whose height is below 140 cm may potentially have inadequate graft diameter. The influence of height on hamstring graft diameter was similarly noted by Pinheiro et al. [10] and Ma et al. [16]. Nevertheless, a height threshold was not specified for inadequate hamstring transplantation. The outcomes of this study may have potential benefits for both males and females.

According to Borsvert et al. [17], a height threshold of 162.5cm was proposed as being sufficient for achieving a graft diameter of 7mm. However, the use of this approach was limited to females. In their study, Celiktas et al. [18] put up a measurement of 155.2cm as the recommended height for achieving the lowest thickness of quadrupled hamstring graft diameter. A favorable correlation between height and a quadrupled diameter was found in the present study ($p = 0.045$). However, it is important to note that the study did not determine the specific height threshold required for achieving an appropriate graft diameter.

Limitations of the study: Due to the limited representation of female patients in the present investigation, the findings cannot be generalized or applied to this specific demographic. Due to the limited size of the current sample, regression analysis was not employed in the present investigation. Furthermore, the lack of consistency in the individuals responsible for conducting the anthropometric and intraoperative graft measures undermines the validity of the current data.

Conclusion

The preoperative detection of a hamstring tendon autograft that is insufficient enables surgeons to make informed decisions regarding the selection of an alternative surgical approach, provide preoperative counseling to the patient, and consider other available graft choices.

Anthropometric measures serve as convenient and effective aids in the prediction of graft size during surgical procedures for anterior cruciate ligament reconstruction. Although we are now evaluating

graft length and graft diameter, it is worth noting that a graft diameter of 7mm or above has significant importance as the primary determinant of postoperative outcomes and failure rates.

In order to make predictions regarding the thickness and length of preoperative hamstring grafts for anterior cruciate ligament reconstruction, it is possible to employ height and thigh length as points of 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.
- 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.
- 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.
- 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.
- Treme G, Diduch DR, Billante MJ, Miller MD, Hart JM. A Prospective Clinical Evaluation. *Am J Sports Med.* 2008; 36(11):2204-9.
- 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.
- Ma CB, Keifa E, Dunn W, Fu FH, Harner CD. Can preoperative measures predict quadruple hamstring graft diameter? *Knee* 2010; 17:81–83.
- 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
- Celiktas. Prediction of the quadruple hamstring autograft thickness in ACL reconstruction using anthropometric measures. *Acta Orthop Traumatol Turc* 2013; 47:14–18.