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Anthropometric Measurements of Hamstring Tendon Graft and Its Predictors in Ligament Reconstruction Surgeries of Knee: An Observational Study

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ABSTRACT

Introduction: Hamstring graft use has been in the forefront of ligament reconstruction around the knee. With the increasing number of surgeries, the complications are equally on the rise. One of the detrimental factors for predicting the outcome is the diameter and length of the graft. We did an observational study to find out the relationship of patient factors with the morphometry of the graft.

Materials and Methods: Total 484 patients were included in the study. Preoperatively, the age, sex, height, weight, and activity levels of the patients were noted. They were categorized into two major groups: physically active and inactive. The intraoperative measurements of the grafts were recorded. Analysis of variance for comparing the means of multiple groups was used for statistical analysis.

Results: Among the total 484 patients, 407 were male and 77 were female. The semitendinosus graft diameter did not show any statistical significance to the age and weight of the patient. The mean graft diameter was highest in the 45 to 49-year age group. The average graft diameter in physically active group was 3.704 mm, and 3.503 mm in the inactive group. This and the height of the patient proved to have statistically significant relation with graft diameter.

Conclusion: Physical activity along with the height of the patient must be taken into due consideration before embarking upon ligament reconstruction with hamstring graft in mind, as these two are found to determine the diameter and length of the hamstring graft.

Keywords: Activity, Diameter, Hamstring graft, Height

INTRODUCTION

Injuries of anterior cruciate ligament (ACL), formerly thought to be a career-ending injury, are now typically just a blip on the radar for athletes, with surgical restoration often allowing a successful comeback. Because of the morbidity associated with other grafts (such as the patella-tendon graft), the use of one or all hamstrings for ACL restoration has become increasingly common, as it has no negative impact on hip extension.[1] Although bone-patella-tendon-bone (BPTB) graft results in direct bone-to-bone healing, it is associated with problems such as patellar fracture, extension weakness, and the possibility of patella baja.[2] From single strand of semitendinosus or gracilis to quadruple loop mix of both or a tripled semitendinosus ipsilateral graft, the graft has evolved.

Only one strand of semitendinosus and gracilis tendon has 1,216 N and 838 N power, respectively. The critical tensile load of the quadruple graft is 4,090 N, which is nearly three times that of a regular ACL.[3] The triple hamstrings graft is nearly three times as stiff as a regular ACL and nearly twice as stiff as a 10-mm central-third BPTB graft, with a stiffness of 807 N. The hamstrings' cylindrical shape provides more cross-sectional area than BPTB. The graft of hamstring has a 55-mm cross-sectional area.

We conducted this study for determining the link between diameters of hamstring graft and numerous physiological parameters, as it is obvious that the graft diameter or thickness has a proportionate relationship with its tensile strengths.

MATERIALS AND METHODS

Patients with arthroscopic ACL or posterior cruciate ligament (PCL) reconstruction using three- and fourfold semitendinosus alone with gracilis tendon graft were studied. During the trial period from August 2019 to August 2021, 484 patients were enrolled. The Institutional Ethics Committee approved this research investigation. Patients have given informed and written consent.

The patients' age, sex, height (in cm), weight (in kg), and activity levels were all recorded prior to surgery. They were divided into two categories: physically active and physically inactive. Those who engage in heavy manual labor, participate in frequent sporting activities, and maintain regular exercises such as running and walking were classified as physically active. The remaining patients were classified as physically inactive. The affected knee was prepped and wrapped under regional anesthetic and tourniquet control. The aponeurotic fascia protecting the tendons was revealed by making a 2-cm linear skin incision across the pes anserine. The tendons were identified and stripped by tendon stripper once dissected.

Muscle tissues were removed from the harvested graft. It was measured in length. Using graded metal circular measures, the diameter of the circular tendinous component of the tendon was measured. The measuring device's maximum increments were 0.5 mm. The tendon's maximal circular diameter was measured.

The graft was tripled or quadrupled to get the desired length. After arthroscopic zigs graft preparation, the graft was fixed with an interferential screw.

RESULTS

There were 484 patients in all, including 407 males and 77 females. The group with 20 to 35 years of age had highest total of patients in the study. In this age range, it is natural for the group to be active.

Table 1 shows the diameter of the semitendinosus graft in response to age. There is no statistical importance to it ($p > 0.05$). The 45 to 49-year age group had the largest mean graft diameter.

As shown in [Table 2], the graft diameter exhibited a statistically significant association with the patients' height.

The patients' hamstring graft diameter does not have a statistically meaningful link with his or her weight [Table 3].

In the physically active group, the average semitendinosus tendon graft diameter was 3.704 mm, while in the physically inactive group, it was 3.503 mm. This resulted in statistical significance [Table 4].

Table 1: Relation of graft diameter with age of the patients.

Age group	Mean graft diameter (in mm)	Total number of patients
15–19	3.307	36
20–24	3.8	69
25–29	4.106	85
30–34	3.5	91
35–39	4.1	53
40–44	3	50
45–49	4.205	59
50–54	3.5	41

Table 2: Relation of graft diameter with height of the patients

Height range (in cm)	Mean graft diameter (in mm)
160–164	3.605
165–169	3.980
170–174	4.105
175–180	4.201
180–184	4.306
185–190	4.5

Table 3: Relation of graft diameter with weight of the patients.

Weight range (in kg)	Mean graft diameter (in mm)
50–54	3.307
55–59	0
60–64	3.606
65–69	3.805
70–74	3.708
75–79	3.5
80–84	3.606
85–89	3.307
90–94	0

Table 4: Relation of graft diameter with weight of the patients.

Physical activity status	Mean graft diameter (in mm)
Active	3.704
Inactive	3.042

DISCUSSION

The semitendinosus tendon's diameter and length are deleterious in reconstructive procedures of ligaments around the knee, more so in PCL than in ACL. Preoperative graft morphometric prediction will aid in adequate planning prior to surgery, resulting in effective graft harvesting and, ultimately, a superior surgical and functional outcome. Our research tried to establish a link between patient characteristics and transplant length and thickness.

In 34 patients (15 males and 19 females) with one-sided ACL insufficiency, Yasunari et al investigated the length of the semitendinosus, the relationship between its length and height and femoral length, and the hamstring power of the affected side prior to surgery.[4] He came to the conclusion that the individual's tendon length and height were highly correlated. Tuman et al reviewed investigation for hamstring diameter and discovered that it was best predicted by height, especially in women.[5] In terms of graft diameter prediction, neither weight nor age had statistically significant relationships. Pichler et al conducted a cadaveric investigation and discovered a link among length of the femur with tendon, which has a direct association with the patient's height.[6] We discovered a statistically substantial link among tendon height and length in research ($p < 0.05$).

Tohyama et al investigated the graft morphometry. He measured the span and cross-sectional area of the hamstring tendon in solo as well as multistrand conformations to prepare the graft.[7] Semitendinosus and gracilis had mean lengths of 235 ± 20 mm and 200 ± 17 mm in his study, which are pretty similar to ours of 241 ± 15 mm and 194 ± 16 mm. The cross-sectional extent of twofold semitendinosus was reduced as compared with a 10-mm broad graft from patellar tendon ($p < 0.05$). The triplicated semitendinosus and 10-mm broad graft of patellar tendon had similar dimensions. Area of the tripled configuration graft in our investigation was 10.6 ± 2.7 mm^2, which is similar to Hamada *et al*'s.[8] He used magnetic resonance imaging (MRI) to calculate the cross-sectional extent of the semitendinosus in 79 patients to see if they were suitable for ACL grafts.

Conte et al used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to conduct a thorough evaluation of Level III and IV studies.[9] It includes researches that analyzed usage of imaging or anthropometric patient-specific features to envisage hamstring autograft and studies that evaluated unsuccessful fourfold hamstring graft in ACL restoration with a minimum of 1 year of follow-up. If the graft diameter was less than 8 mm, there was a 6.8 times superior risk of failure ($p = 0.008$). Almost every anthropometric-prediction study that used MRI identified a substantial link between at least one measure and intraoperative graft size. The patient's height had the greatest significant correlation ($p = 0.00001$). With $r = 0.66$ ($p < 0.05$), 83% of imaging-centered investigations found a significant connection amid cross-sectional area and size of graft. This supported the idea that determining the graft size before or during surgery can help achieve the best results and reduce ligament restoration failures. The patient's tallness and physical activity are the best predictors for graft size.

Goyal et al evaluated the role of a mathematical calculation in forecasting graft diameter.[10] Overall, 96% of the grafts had a diameter more than 7 mm. Height and length of the patient's thigh had the strongest relationship with length of the tendons and graft diameter ($p < 0.05$). A height < 147 cm was linked to the highest probability of insufficient graft diameter (<7 mm). Patients with a height of more than 160 cm had a mean graft diameter of 8.9 mm, which reduced the risk of graft failure considerably. Before performing ligament surgery, anthropometric factors, particularly height and thigh length, are used to plan hamstring graft diameter and length. However, it is not always smart to rely on quantitative formulas and computations for graft parameter values, as there is always the potential of overestimation of hamstring length or graft thickness. Before commencing on ligament restoration with hamstring graft in mind, physical activity as well as the patient's height must be taken into account, as these two are the only criteria that impact the diameter and length of the hamstring graft.

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Conflict of interest

None declared.

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