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Semitendinosus Tendon Size as Graft and Anthropometry in West Coast Population of India

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Abstract

Introduction: Need of minimum length and diameter of graft for Anterior Cruciate Ligament (ACL) reconstruction and possible predictability with anthropometric parameters. Semitendinosus as solitary tendon is the preferred choice among all the grafts in recent years. Quadrupled tendon graft requires certain length of the tendon. Pre- operative assessment of graft size helps in planning of procedure. *Materials and Method:* In this prospective study 68 (57 Male and 11 Female) patients undergoing ACL reconstruction using hamstring tendons were included. All the anthropometric parameters like height, weight, age, sex, BMI were recorded preoperatively. Intra operatively tendon length and its quadrupled (by folding the tendon on itself) diameter is measured. *Results:* Average length of tendon was 27 cm and quadrupled diameter 7 mm. Semitendinosus tendon length was adequate in 52% of patients in our study. In female patients only 18% had adequate tendon length. Quadrupled diameter was adequate (7 mm or more) in all the patients. This Indicates that tendon length has no relation to diameter. Height is the only parameter indicative of tendon length in both sexes. Weight/BMI were moderate indicator of thickness or diameter in both the sexes. In our study all those of the height 170 cm or more had adequate tendon length and diameter. *Discussion:* Semitendinosus tendon length is predictable as the study shows strong relation to height of the individual. Similar observations made in other studies on Indian population. Diameter or the thickness is moderately related to BMI. Thickness of tendon in our local population is adequate.

Keywords: Semitendinosus; ACL reconstruction; anthropometry; quadrupled diameter.

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Introduction

Arthroscopic cruciate ligament reconstruction has given promising outcomes in overcoming the functional instability caused by cruciate ligament tears sustained during recreational activities or other traumatic events. Reconstructive procedures for cruciate ligaments of the knee utilize hamstring tendons as autograft or allograft [1]. Bone-patellar-bone and quadriceps tendon are other graft options available, but have their own disadvantages such as donor site morbidity, impairing extensor mechanism and anterior knee pain [1,2]. It has been observed that graft diameter plays a major role in success of reconstructive procedures [3]. Patellar bone-tendon-bone and quadriceps tendon graft of appropriate thickness can be harvested as per surgeons need intra operatively [1]. However, hamstring graft thickness varies considerably in different individuals. Multiple looping of sufficiently long tendon can be done to improve the thickness of the graft [2]. Hence it necessitates preoperative methods of assessing graft size (length and diameter) [1]. Imaging techniques for predicting hamstring graft size preoperatively have not been highly effective [3].

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Advent of latest techniques and modern devices of graft fixation has allowed the use of short graft lengths sufficient enough for reconstruction [4]. Final graft construct length of 7 cm and diameter of 7 mm is considered optimal for Anterior Cruciate Ligament (ACL) reconstruction. Graft length of 7 cm would provide 2 cm of graft length for femoral tunnel, 2 cm of graft length for tibial tunnel and 3 cm of intra articular graft length, which is considered optimal [2]. Semitendinosus graft can be quadrupled (folded over four times), if the harvested tendon measures between 28 – 30 cm in length. Inadequacy of graft size compels augmentation of graft with additional tendon. Since the harvested hamstring graft size is highly protean, preoperative prediction of graft size would provide information regarding the need of alternative graft. So the present study was designed to assess the correlation between anthropometric variables and hamstring graft in the tertiary care hospital which is also a referral centre for neighbouring districts of costal Karnataka and northern part of Kerala.

Anatomy of Anterior cruciate ligament (ACL) and graft properties-

Anterior cruciate ligament (ACL) acts as a static stabilizer of knee preventing anterior translation of tibia throughout range of motion [5]. ACL has its femoral attachment in the medial surface of lateral femoral condyle and is inserted medial to intertubercular ridge between medial and lateral tibial spines [6]. The length of ACL ranges between 25 and 41 mm (average 38 mm) and the width of the ligament ranges between 7 and 12 mm(average 10 mm) [2]. However, ACL width is not uniform throughout the length of the ligament, it is broader at the attachment sites and narrowest at the mid-substance. Functionally ACL is considered to be made of anteromedial and posterolateral bundles referenced according to their relative insertions on tibia [6]. However single bundle ACL reconstruction is considered effective enough to restore native anatomy and kinematics of knee [7]. There was not much difference in the functional outcomes of ACL reconstructed using isolated semitendinosus tendon (ST) and those reconstructed using combined Semitendinosus and gracilis (STG) tendon construct. Since rotational forces are better resisted by isolated multilooped ST graft and sparing of gracilis, it is suggested to use semitendinosus graft alone for ACL reconstruction, especially in sports which require full flexion and maximum rotational strength [8]. Gracilis tendon augmentation might be necessary when graft thickness with semitendinosus alone is not adequate [3]. It is essential to have a sound knowledge regarding the anatomy of these tendon insertion sites to avoid technical difficulties in isolating and harvesting the tendons for reconstructive procedures [9]. Semimembranosus, semitendinosus and the long and short heads of the biceps femoris are posterior compartment group of muscles of the thigh, colloquially termed as "hamstrings". Ischial tuberosity serves as a common site of origin for hamstring group of muscles except for the short head of biceps femoris, which originates from linea aspera of femur [10]. Semitendinosus is a fusiform muscle originating from ischial tuberosity and inserted on the anteromedial surface of tibia. Semitendinosus along with gracilis and sartorius form a confluence of tendinous structure in a radiating pattern to resemble a goose foot, hence named as "pes anserinus" [11]. These group of muscles are known as guy ropes of lower limb. They contribute to the flexion of knee and provide rotatory stability furthermore act as a valgus constraint at knee. Sparing of gracilis is justifiable since it is known to compromise dynamic stability for rotational forces [8]. However the contractile capability of semitendinosus and gracilis muscles is known to restore even after being harvested for grafting [12]. Due to limited morbidity associated with harvesting hamstring tendons, they are preferred grafts for ACL reconstruction [1]. Despite the advantages, obtaining adequate size of the hamstring graft is challenging, hence it is imperative to preoperatively assess the size of the graft. This study aims at finding the correlation between anthropometric factors and semitendinosus graft size.

Material and Methods

Study design and participants: The present study was conducted among 68 patients undergoing reconstruction of cruciate ligaments using semitendinosus tendon or both semitendinosus and gracilis as auto grafts at tertiary care teaching hospital of the region during a span of two years.

Study instrument: A questionnaire was developed after doing an extensive search of literature and by consulting experts in respective field. Alterations were done to the pro forma based on the feedback obtained after pilot study. The questionnaire consisted of three sections. The first section consisted of demographic profile. The second section consisted of clinical details. The final section consisted of various anthropometric measurements which included height, weight, age, sex and BMI.

Ethical consideration: During data collection for the current study the ethical principles were followed. The protocol of the present study was submitted to the Institutional Ethics Committee.

Permissions were also sought from Medical Superintendent of the hospital attached to our medical college.

Intraoperative measurement: Procedure was performed under tourniquet after exsanguinations for complete hemostasis and clear surgical field. Small oblique skin incision inferomedial to tibial tuberosity was used. Infra patellar branch of saphenous nerve which is closely related to insertion of tendons was safeguarded from being severed. Sartorius fascia was incised along the line of inserting tendons to expose Semitendinosus and Gracilis tendons. These tendons are identified separately up to their insertions, any inter tendinous adhesions present along these tendons are released.

Semitendinosus tendon is isolated and detached from its tibial insertion and held with a non-absorbable suture. Before passing the tendon through the graft harvester all the tendinous extensions (vincula) running into the gastrocnemius fascia are released which improves the excursion of the tendon. This would also prevent diversion of the course of tendon stripper and avoid premature division of the tendon. Subsequently the graft is harvested and prepared.

Muscle tissue and fat attached is cleared off from the harvested graft and tendon length is measured over graft preparation stand. Tendon length is measured from the margin of the tendon detached at its tibial insertion site to the ends of flattened (aponeurotic) tendinous strand. If the length of the tendon is adequate (28 cm or more) then tendon is quadrupled and proceeded with graft preparations. If the length of the harvested tendon is not adequate enough then the gracilis tendon is harvested for augmentation. Quadrupled tendon diameter measured using cylindrical sizing tubes calibrated to 0.5 mm increments starting from 6mm to 12 mm.the smallest diameter through which graft could pass through is considered as the graft diameter. The standard tendon harvesting and graft measuring technique as mentioned above was followed for all the patients and was done by the same surgeon. Anthropometric data was also measured by a single researcher. Gracilis morphometry was not included for the study. In cases with short semitendinosus, tendon is quadrupled and diameter was measured for the study purpose. In this study the tendon size as a graft and its relation to patient's anthropometric values are looked into. Type of procedure or the results of reconstruction procedures were not considered. Confidentiality of the patient details was maintained.

Statistical analysis of data collected was entered and analyzed using Minitab ® 17.1.0., © 2013 Minitab Inc. All data distribution analysis was done through Shapiro-Wilk test. After testing normality, an appropriate parametric or non-parametric test was considered. Data were evaluated using conventional statistical tests and multivariable analysis as described. Pearson's correlation test was used to see the correlation between graft size and anthropometric parameters.

Results

The present study includes a total of 68 participants (57 Male and 11 Female). Mean age of the participants was 28.53 yrs (±7.820), mean height was 1.674m (±0.079), mean weight 72.65 kgs (±10.49), mean BMI was 25.98kg/m^2 (±3.813), mean length of semitendinosus (ST) was 27.77cm (±2.008) and mean quadrupled graft diameter was 7.838 mm (±0.444) as shown in Table 1.

As shown in Figure 1. Pearson's correlation test was applied to assess the relation between height of the participant and length of ST tendons and a strong correlation between the two variables was observed r=0.755 (p<0.001).

To evaluate the correlation between height and diameter of the quadrupled tendon Pearson's correlation test was applied and a p value of 0.005 and r= 0.357 was noted (Figure 2). There was a weak correlation between two but statistically significant.

The relationship between length and diameter of ST tendon with remaining parameters is shown in Table 2. Weight and BMI were moderate indicators of diameter of tendon in both the sexes.

Multivariable analysis with linear regression was applied to assess the influence of various independent variables such as age, weight, gender and height on the size of the tendon. In the final model, we included age, height, weight and sex (Table 3). Model fit was adequate with R^2 59.9% (adjusted) and Variance inflation factors within 1 to 3, for all predictors indicating no multi-co linearity between them. The association between the tendon length and the predictors is statistically significant with ≤ α of 0.05 (adjusted *P*, *P*/number of predictors in the model). Height of patient was able to predict the length of tendon in our study. The diameter was not included in final model

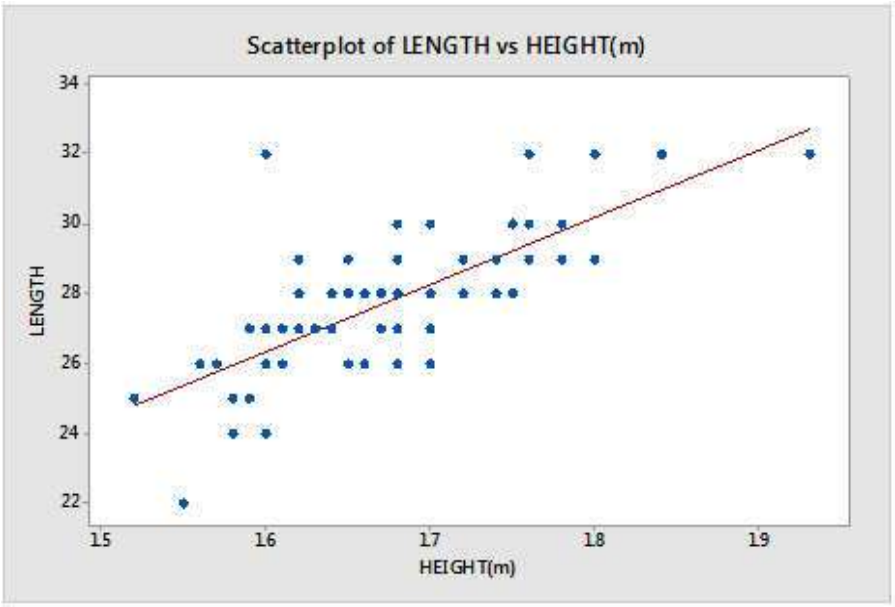

Fig. 1: Scatter plot showing correlation between height and length of semitendinosus tendon.

Pearson's correlation testing demonstrating the relationship between height (m) of the participant and length (cm) of the tendon. The correlation coefficient, r = 0.755, and p-Value < 0.001.

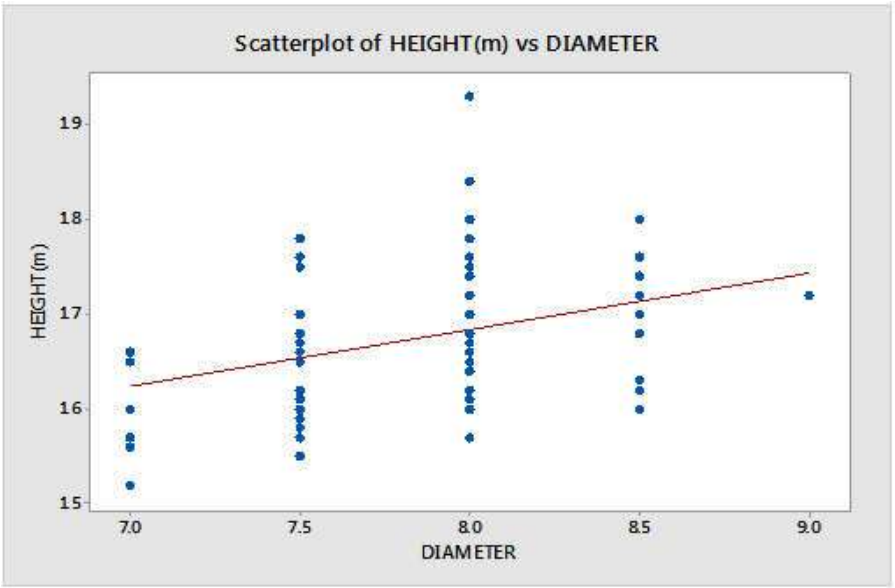

Fig. 2: Scatter plot showing correlation between height and diameter of quadrupled tendon.

Pearson's correlation testing demonstrating the relationship between height (m) and diameter (mm) of quadrupled graft. The correlation coefficient, r = 0.357, and p = 0.005.

Table 1: Discriptive variables with tendon dimensions. (n=68)

Variables	Mean	Standard Deviation	Median	Maximum	Minimum
Age(years)	28.53	7.820	27.50	66	16
Height(m)	1.674	0.079	01.67	1.93	1.52
Weight(kgs)	72.65	10.49	72.00	110	56
BMI(kg/m2)	25.98	3.813	25.46	41.40	19.26
Length of ST(cms)	27.77	2.008	28.00	32	22
Graft Diameter(mm)	07.838	0.444	08.00	9	7

m – Meter, kgs- kilograms, BMI- body mass index, ST- semitendinosus, mm- milimeter

Table 2: Pearson's correlation between graft length and diameter with various anthropometric parameters

Anthropometric measurements	p	r
Length and diameter	0.001	0.400
BMI and diameter	0.908	0.014
BMI and length	0.168	0.169
Height and diameter	0.05	0.337
Height and length	0.00	0.755
Weight and diameter	0.090	0.207
Weight and length	0.007	0.32
Age and length	0.238	0.145
Age and diameter	0.461	0.091

BMI- body mass index

Table 3: Regression analysis for predictors for Semitendinosus tendon length

Predictors	Coef	SE coef	p value	VIF
Constant	-2.71	3.6	0.454	
Age(years)	0.027	0.022	0.228	1.23
Height(m)	15.9	2.33	0.000	1.4
Weight(kgs)	0.027	0.017	0.117	1.26
Gender	1.4	0.495	0.006	1.4

Coef-coefficient; SE- standard error; VIF-variance inflation factor. The linear regression model included age, sex, height and weight as predictors. R^2 and adjusted R^2 were 62.32% and 59.9% respectively for linear regression model. VIF were 1-3.

because of poor fit. This was later translated into following equations which may help in predictions. The equations are as follows for either sex and may be useful in calculating the lengths of tendon necessary in preoperative period.

Regression Equations for length -

length = -1.31 + 0.0268 Age (yrs) + 0.0265 Weight (kgs) + 15.90 Height (m)

Discussion

In our study which included 68 subjects it was observed that there was a significant correlation between height of the individual and the length of semitendinosus graft. Fifty five percent of subjects had adequate length of tendon. In female sex only 18% had adequate length of tendon. Quadrupled diameter of tendon was adequate in all the subjects, indicating that tendon length has no relation to its diameter. Weight and BMI were moderate indicators of diameter or thickness of tendon. All those with adequate tendon length were of the average height of 172 cms which is above the universal average height of young people (170.6 cm) aged between 20-30 yrs [13].

Similar to the observations made in our study, S Challa and J satyaprasad concluded that height of an individual correlates with the length of the hamstring. In contrast to our study, they were able to correlate height of the individual with the graft diameter. But found no correlation of graft size with BMI, age, gender and weight.

Height and weight of the patients correlated with the graft length in a comparable study done by Papastergiou G. Stergios et al. [14]. However, they did not find any statistically significant predictors of graft diameter. In a cadaveric study conducted by Pichler et al, the length of the semitendinosus tendon was found to correlate with femur length [15].

Ravi Gupta in his study on 123 patients had the average length of ST tendon of 312.32±34.61 mm and observed strong correlation with leg length. He proposed a equation to predict the length and thickness [16]. Study conducted by Chiang et al using 100 patients showed that tendon lengths correlated with anthropometric measurements and also concluded that Caucasians had longer tendon lengths when compared to Chinese population [17]. Similarly, study made on forty cadavers in Kenya by brianbundi et al. found to have average semitendinosus tendon length of 29.80±3.59 cm and concluded to have longer semitendinosus tendon when compared to studies from Chinese, Austrian and Indian populations [18].

Anthropometric parameters were correlated to graft diameter in other similar studies.

Pinhiero et al. conducted a study on eighty

patients and observed that there was correlation between weight, height, gender, thigh length and size with graft diameter [19].

The study conducted in north Indian population by Asif et al developed an equation for preoperative prediction of graft diameter in Indian population after finding a strong correlation between thigh circumference and height of individual with graft diameter [2]. Predictors for the length of the graft were not assessed in contrast to our study.

Ma et al noted that height was specific predictor of hamstring diameter in males [20]. In a study conducted by Tuman et al in American population Quadrupled graft diameter was related to height, mass, age, gender but not BMI. Height was considered as a sole variable in an equation predicted by Tuman et al and Treme et al for expected graft diameter [21,22]. Goyal et al utilized preoperative assessment equation formulated by Tuman et al in Indian population and observed the existence of ethnic variation [23]. Similar observations were made in other identical studies [17,24].

Limitations in our study are unequal numbers between sexes, sample size of our study is not sufficient in case of females. Sample population includes only those to whom surgical reconstructive procedures were advised, that includes age restrictions.

Conclusion

Semitendinosus tendon length is predictable as the study shows strong relation to height of the individual. Diameter or the thickness is moderately related to BMI. Thickness of tendon in our local population is adequate. As a solitary graft length of the tendon is the important feature and is not related to thickness according to our study. We believe that these are very useful findings for a surgeon planning for reconstruction of cruciate ligaments.

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