

# Prediction of Adequacy of Quadrupled Hamstring Graft Size for Anterior Cruciate Ligament Reconstruction from Anthropometric Parameters

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## Abstract

Anterior cruciate ligament (ACL) is one of the regularly reconstructed knee ligaments. Various types of grafts are being used for ACL reconstruction. The Quadrupled hamstring tendon graft is now being most commonly used because of its favorable biomechanical profile and positive clinical outcomes. The aim of this study is to establish the correlation of graft length and diameter with anthropometric parameters in Nepalese people. **Methods:** Fifty cases (31 males and 19 females) that underwent ACL reconstruction using quadruple hamstring autograft between December 2014 and November 2015 were prospectively evaluated. Anthropometric measurements including age, height, weight, BMI, tibial length, calf girth, thigh girth and waist circumference were recorded pre-operatively. The graft was harvested and length and thickness were intra-operatively determined using standard sizer. Pearson's correlation coefficient was used to determine the relationship between outcome variable (graft length and thickness) and predictor variables (anthropometric measurements). **Results:** Mean age of the patients was 31.5. There was no statistically significant correlation between any of the anthropometric measurement and graft length and thickness. **Conclusion:** Pre-operative anthropometric measurements like age, height, weight, BMI, tibial length, calf girth, thigh girth and waist circumference cannot accurately determine the length and thickness of quadruple hamstring tendon graft in ACL reconstruction. **Keywords:** Anterior cruciate ligament, ACL, reconstruction, Quadruple hamstring, Anthropometric parameters.

## 1. Introduction

An anterior cruciate ligament (ACL) can result in the significant dysfunctional that is now one of the most commonly reconstructed ligament of the knee<sup>1</sup>. There are various types of grafts which is being used for ACL reconstruction e.g. Bone Patellar tendon Bone (BPTB), hamstring (Semitendinosus and Gracilis), Quadriceps tendon, Achilles tendon, fascia lata etc. These grafts may be allografts or autografts. Allograft facilities are not available in our context because of ethical and storage problems. Synthetic grafts also are known as ligament augmentation and repair system (LARS) are not available in our country and their usefulness is not completely established till date.

Hence, autograft remains the only option that seems feasible and suitable for our context. Amongst all available autografts, BPTB graft and hamstring grafts are popular. The most commonly used autologous graft is Hamstring tendon graft because of its encouraging biomechanical characteristics and good clinical results<sup>2,3</sup>.

The semitendinosus tendon either alone or accompanied by the gracilis tendon is used to make strong hamstring autologous graft. In hamstring graft, primary hamstrings are left intact where as an accessory hamstring is used, and the gracilis is in fact not a hamstring but an adductor.

Now it is widely accepted that four-strand hamstring autograft, the two tendons of semitendinosus and gracilis are commonly combined, doubled up and entwined to form a quadrupled thickness strand for the replacement autologous graft, is a successful option for ACL reconstruction. One of the major disadvantages of quadrupled hamstring autologous graft (QHAG) is the possibility of stuck with a graft smaller in diameter and length. Scott and Insall reported that the length of normal ACL is 38mm (24-41mm) and diameter ranges from 7 to 12 mm (mean 10mm) on an average<sup>4</sup>. It is widely accepted that about 70% of the footprint has to be occupied by the reconstructed graft to ensure optimal graft size. So, the diameter of the quadrupled hamstring tendon graft (QHTG) has to be minimum 7mm and the length has to be at least 100 mm<sup>5-8</sup>.

Biomechanical studies have confirmed that the graft diameter is proportional to the hamstring graft failure to the load applied. Further studies have established that the factors such as gender, height, weight, body mass index, tibial length, thigh girth, calf girth and femoral length correlate with the diameter of the QHAG. This information in turn may be useful to predict the size of the graft<sup>9</sup>. Preoperative prediction of the size of the graft may help in the proper planning of types of graft and adequate counseling to the patient.

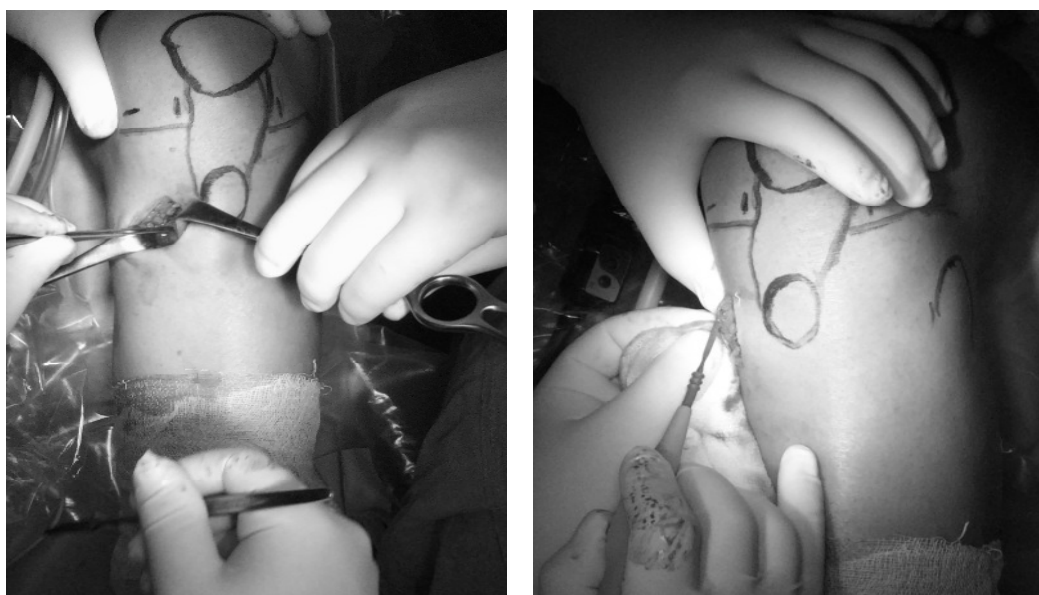
Tuman et al study showed that the increased risk of having inadequate autologous hamstring graft in older, shorter and female patients<sup>10</sup>. WL Loo et al study showed that in Asian male patients height, weight and body mass index could not be used for preoperative prediction of graft size<sup>9</sup>.

There is almost no literature available to correlate the anthropometric parameters and hamstring graft diameter in Nepalese population. We hypothesized that anthropometric parameters such as gender, height, weight, body mass index, tibial length, thigh girth, calf girth and femoral length can be used to predict peri-

operatively graft diameters in quadrupled hamstring autografts in Nepalese population. The purpose of this study is to determine the correlation of graft length and diameter with anthropometric parameters (age, sex, height, tibial length, calf girth, thigh girth) in Nepalese people.

## 2. Methods

A cross-sectional study was conducted at National Academy of Medical Sciences, Bir hospital and National trauma center from December 2014 till November 2015. Before commencement of the study, the proposal was submitted to the institutional review board and ethical clearance was taken. The will of the patient was respected and consent was taken after fully explaining all the relevant details, its importance, and implications. Those who refused to provide consent for any reason were excluded from the study. A convenient sample of 50 patients with the diagnosis of ACL tear was included for the study. The inclusion criterion was isolated ACL tear for reconstruction using autologous quadruple hamstring graft. Only semitendinosus graft, ACL reconstruction using other than hamstring, patient unwilling to give consent and patient with the congenital anomaly. Statistical analysis was done using SPSS 21. Descriptive analysis (mean, median, percentage, standard deviation) was analyzed to describe the demographic and other related variables.



*Figure - Graft harvesting*

Fifty patients were included in this study with the clinically diagnosed case of ACL tear with the confirmation on MRI report of the knee as well as confirmed prior to arthroscopic surgery. The anthropometric parameters like age, height, weight, thigh girth, waist circumference, tibial length, calf girth etc were recorded prior to surgery. Thigh girth, tibial length, calf girth were recorded from uninjured limb. After confirmation of ACL tears arthroscopically, the hamstring graft was harvested with an incision made anteromedially on proximal tibia approximately 4cm distal to the joint and 3 cm medial to tibial tuberosity at the region of pes-anterius. With dissection, tendons were exposed, palpated and semitendinosus, as well as gracilis, were identified. Semitendinosus was harvested first and the length was measured. Likewise, gracilis was also harvested, with both grafts, quadrupled for the reconstruction and monitored whether it is adequate or not to harvest gracilis. The graft was harvested using the same technique in all patients but the surgeons who performed ACL reconstruction were different.

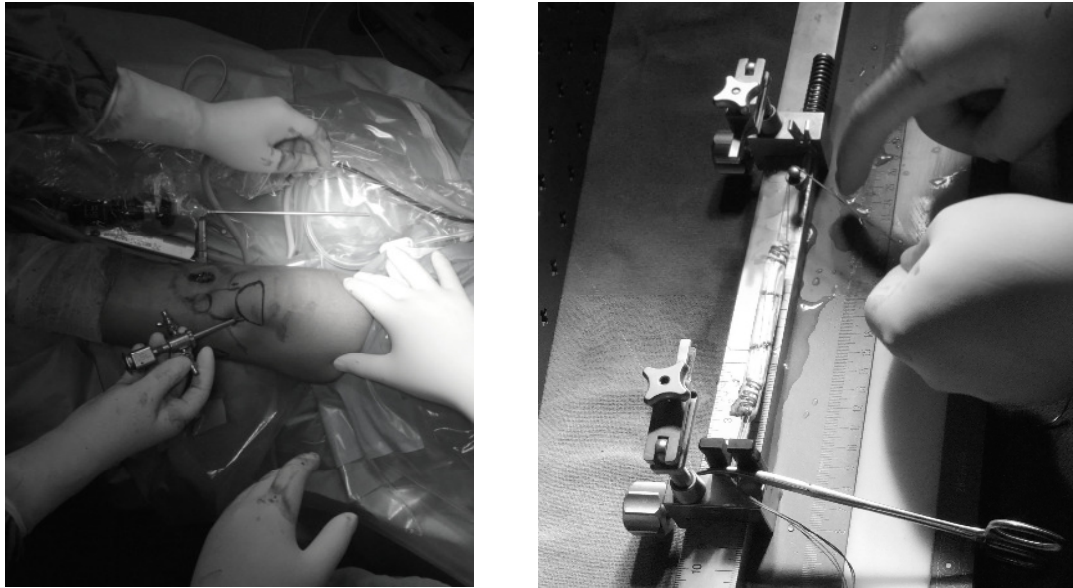


Figure - Arthroscope insertion and graft preparation for reconstruction

In statistical analysis, bivariate correlation coefficients were calculated to evaluate the correlation between clinical data and semitendinosus and gracilis graft lengths. The correlation coefficients if high indicates the strong relation between graft length and anthropometric parameters. A p-value of 0.05 was taken as a level of significance.

### 3. Results

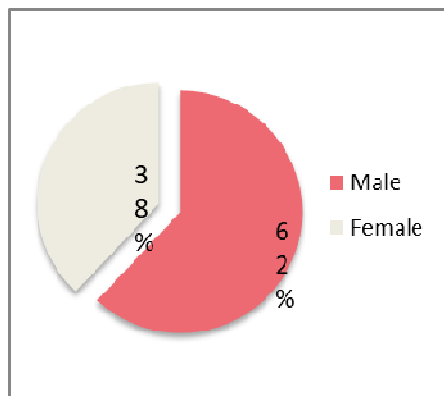


Figure 3 Pie chart showing Age distribution

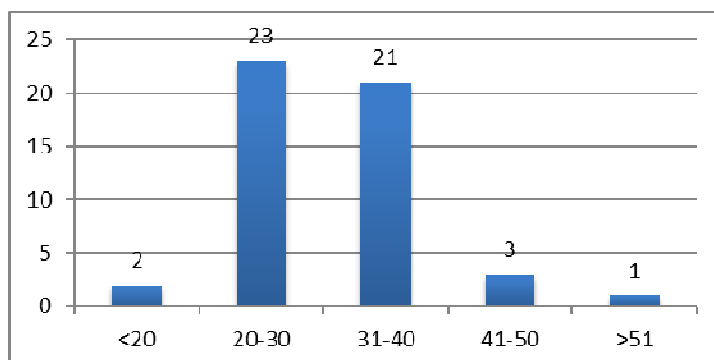


Figure 4 Bar diagram showing age distribution

A total of 50 patient underwent ACL reconstruction surgery using autologus hamstring graft were included for the study. The distribution of sex in this study where there was the prevalence of male. Out of 50 patients, 31

were male with 62% in comparison with female only 19 with 38%. The distribution of age in which the most of the candidates were in the age group 20-30 years old followed by the age group of 31 to 40. The total number of candidates in the age group 21 to 30 years was 23, which is followed by 21 candidates in the age group 31 to 40. We had only one candidate in the age group above 51 years. The number of candidates in age group less than 20 years and 41 to 50 years were 2 and 3 respectively. The mean age in this study was 31.5 years with the standard deviation of 6.001. In this study, the mean length of semitendinosus and gracilis were 28.26 mm and 21.98 mm respectively with the standard deviation of 0.96 and 0.168. In the descriptive analysis of height, the mean height was 1.65 cm with the standard deviation of 0.089 likewise the mean weights was 62.84 kg with the standard deviation of 12.213. The mean BMI is 22.73 kg/square meter with the standard deviation of 3.50. The descriptive analysis of tibial length, calf girth, waist circumference and thigh girth, the mean tibial length, calf girth, waist circumference and thigh girth was 35.76 centimeter with standard deviation of 3.831, 34.10 centimeter with standard deviation of 3.388, 85.12 cm with standard deviation of 10.148 and 260 cm with standard deviation of 0.9649 respectively.

Table 1. Descriptive analysis between graft and anthropometric parameters

	Mean	Std. Deviation	N
Semitendinosus length (cm)	28.260	.9649	50
Gracilis Length (cm)	21.98	1.684	50
Age	31.50	6.001	
Tibial Length (cm)	35.76	3.831	50
Waist circumference (cm)	85.12	10.141	50
Thigh girth (cm)	28.260	.9649	50
Height (m)	1.6588	.08984	50
Weight (kg)	62.84	12.213	50
BMI	22.73	3.506	50
Calf Girth	34.10	3.388	50

Table 2. Correlation Between graft length and anthropometric parameters

	Semitendinosus Length (cm)	Gracilis Length (cm)
Age	.150	.122
Tibial Length (cm)	.078	.089
Waist circumference (cm)	.059	0.071
Thigh girth (cm)	.124	.097
Height (m)	.06	.092
Weight (kg)	.061	.063
BMI	.091	.132
Calf Girth	.220	.118

\* p value <0.05 is significant

In this study, as shown in the table of correlation between the graft and anthropometric parameters, the p-value of the graft was given and was higher than 0.05. The p-value of semitendinosus and gracilis are 0.150 and 0.122 respectively in correlation with age. The correlation between the graft and height with the p-value of semitendinosus and gracilis is 0.06 and 0.092 respectively. The correlation between the graft and weight with the p-value of semitendinosus is 0.061 and 0.063 respectively. The correlation between the graft and BMI with the p-value of semitendinosus is 0.091 and 0.132 respectively. The correlation between the graft and tibial length with the p-value of semitendinosus is 0.078 and 0.089 respectively. The correlation between the graft and calf girth with the p-value of semitendinosus is 0.220 and 0.118 respectively. The correlation between the graft and waist circumference with the p-value of semitendinosus is 0.059 and 0.071 respectively. The correlation between the graft and thigh girth with the p-value of semitendinosus is 0.124 and 0.097 respectively.

#### 4. Discussion

This study is a cross-sectional study performed over 50 patients with isolated ACL tear using transportal anatomical arthroscopic ACL reconstruction using quadrupled autologous hamstring graft. There were total 31 male and 19 female patients with mean age of 31.5 years old with male predominance and a maximum number of patient in the age group 20-30.

In this study, the graft was harvested in the same manner in all patients before the tourniquet was applied for arthroscopic trans-portal anatomical ACL reconstruction. The semitendinosus was harvested initially and length was measured. The adequacy was checked for quadrupled graft size and recorded. Gracilis graft was harvested despite the fact that the semitendinosus graft was adequate or not. With the use of semitendinosus and gracilis, there was enough graft to maintain adequate graft diameter as well as graft length in all patient and with

the use of gracilis and semitendinosus, graft diameter of size 9mm and length was measured.

In this study, the p-value of age in relation with semitendinosus and gracilis is 0.15 and 0.122 respectively. The study concluded that there was no significant between the correlation of age with semitendinosus and gracilis graft length. But the study done by other colleagues, they had similar results. None of the studies had shown that the age can be used as a good predictor for the adequacy of semitendinosus and gracilis graft length and diameter. But with the use of quadrupled hamstring graft using both semitendinosus and gracilis, the study found that there is always enough graft size and diameter no matter what the age of the patient. The minimum requirement of graft size is always fulfilled.

In this study, the correlation between height with semitendinosus and gracilis was shown by p-value as 0.06 and 0.092. Though the p-value is insignificant for the prediction of graft length, height can be used as a moderate predictor for adequacy of graft length. In a study done by Supradeeptha Challa et al (2013) in South Indian population concluded that the height can be taken as a good predictor for the prediction of hamstring graft size. The retrospective study was done by Truman et al (2007) with 106 patients, they concluded that the height can be taken as a weak predictor. The anthropometric parameters between Nepalese and South Indian are comparable and in this study, height is moderate predictor whereas, in the study done by Challa, height is the weak predictor, so height can be taken as a predictor for adequacy of graft size if not, can be used to determine inadequacy with short height. The prospective study was done by Treme et al (2008) with 50 patients, concluded that height cannot be taken as a predictor. The retrospective study was done by Ma et al (2010) and the prospective study was done by Pinheiro (2011) concluded that the height can be taken as a good predictor for the graft length and diameter. In this study, there is no problem regarding graft diameter when both semitendinosus and gracilis were used. The study done by Celiktas et al (2013) concluded that the height can be taken as a strong predictor for the adequacy of quadrupled hamstring graft size for length and diameter. In a study done by Reboonlap N et al (2012) in Thai males concluded height can be used for preoperative identification of patients at risk for insufficient graft tissue and would be useful for patient counseling and alternative graft source planning. In a retrospective study done by Papastergiou G. Stergios et al (2012) with 61 patients (45 male, 16 females) concluded that the length of semitendinosus tendon is usually inadequate to be used alone as a four-strand graft especially in females. The most reliable predictor seems to be patient's height in males. In females, there is no statistically important predictor<sup>12</sup>

In the current study, the correlation of weight with the length of semitendinosus and gracilis is insignificant with the p-value of 0.061 and 0.063 respectively. As p-value is close to 0.05, we can use it as a moderate predictor for the length of the graft and for the adequacy of the graft size using quadrupled hamstring graft size. The study done by Supradeeptha Challa et al (2013) concluded that the weight can not be used as the definitive predictor for the hamstring graft diameter in south Indian population. Our study has the same conclusion, so the study determines the weight cannot be used as a strong predictor but can be used as a measurement to rule out the inadequacy of graft size. In a study done by WL Loo et al (2010) concluded that the weight can not be used for preoperative identification of the graft size in Asian males. In a prospective study was done by Schwartzberg et al (2008) with 119 patients, they concluded that the weight can be used as the moderate predictor for graft adequacy. In the prospective study concluded by Treme et al (2008) concluded weight as the strong predictor for the graft adequacy whereas the retrospective study conducted by Truman et al (2007) concluded the weight as a weak predictor.

In this study, the correlation between BMI and length of semitendinosus and gracilis length using the p-value is 0.091 and 0.132 respectively. The p-value is insignificant so the BMI cannot be used as a definitive predictor. But the p-value of semitendinosus length is 0.091; we can conclude that the BMI can be used as a weak predictor of its length. In a study concluded by Boisvert et al (2011) that BMI did not correlate with graft diameter in the female. BMI greater than 25 kg/square meter correlated with larger graft diameter. In the retrospective study was done by Truman et al (2007) concluded that the BMI as a weak predictor for men where as the prospective study done by Tremen et al (2008) concluded BMI as a strong predictor for men. In a study done by WL Loo et al (2010) concluded that in Asian male BMI cannot be used for preoperative identification of graft size.

In this study, the correlation between tibial length with the length of semitendinosus and gracilis is 0.078 and 0.089 respectively. Though the p-value is insignificant, they are very close to the value 0.05 so tibial length can be taken as a moderate predictor for the graft length and its adequacy. In a prospective study done by Treme et al in 2008 concluded that the leg length is moderate predictor for the graft length and diameter for men, cannot be used for women. Likewise, a prospective study done by Pinheiro et al (2011) concluded that leg length can be taken as a moderate predictor for the adequacy of graft length and diameter.

In the current study, the graft size cannot be predicted using calf girth as the correlation between calf girth and the length of semitendinosus and gracilis with the help of p-value is 0.220 and 0.118 respectively. This study concluded that the calf girth couldnot be used for the prediction of graft length as well as diameter. None of the studies have shown the significance of calf girth in the prediction of graft size.

In the current study, the p-values of semitendinosus and gracilis in correlation with waist circumference are 0.059 and 0.071 respectively. As the p-value is close to the significance level, this study concludes that the waist circumference can be taken as a moderate predictor for the prediction of the graft length as well as the adequacy of the graft size.

In the current study, the correlation between thigh circumference and the length of semitendinosus and gracilis with p-value is 0.124 and 0.097 respectively. With this value, the p-value is insignificant and the graft size cannot be predicted with the use of thigh circumference. But the prospective study was done by Treme et al (2008) concluded that the thigh circumference can be used as a strong predictor for the graft length in men. The prospective studies done by Schwartzberg et al (2008), Pinheiro et al (2011) and Celiktas et al (2013) concluded that the thigh circumference cannot be used as a predictor for graft length, diameter as well as the adequacy of the graft size.

## 5. Conclusion

With the significance level of the p-value less than 0.05, the study concludes that the anthropometric parameters like height, weight, and tibial length can be used as a moderate predictor for the graft length as well as the adequacy of the graft size. The other anthropometric parameters like age, waist circumference, and thigh girth cannot be used to predict the graft size. However, with the use of both semitendinosus and gracilis, there is no problem with the graft diameter in this study. The length if alone used, for quadrupled graft, is inadequate. With the use of both grafts, there was no problem with the adequacy of graft diameter. The study concludes that there is need for further study to be carried out so as to validate the results in the current study. In this study semitendinosus alone was not adequate in order to use as a quadrupled graft for reconstruction. Gracilis has to be harvested for adequate graft length and diameter.

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