Predicting the peroneus longus tendon autograft size in ACL reconstruction by using anthropometric parameters: A study in South Sulawesi population

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Predicting the peroneus longus tendon autograft size in ACL reconstruction by using anthropometric parameters: A study in South Sulawesi population

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ABSTRACT

Introduction: Some literature use peroneus longus tendon (PLT) as the alternative to anterior cruciate ligament (ACL) reconstruction to overcome inadequate autograft size potential risk by using hamstring tendon (HT) autograft. Among the available methods to predict PLT measurements, anthropometric parameters are one of the most accessible and feasible methods. The objective of this prospective study was to predict the PLT autograft sizes in single bundle ACL reconstruction by using preoperative anthropometric measurement.

Method: Anthropometric parameters, including age, gender, height, weight, body mass index (BMI), true leg length (TLL), shank circumference and shank length of 20 patients with primary ACL reconstruction was measured before surgery. Univariate analysis, independent-sample *t*-test, Pearson correlation test, and logistic regression to evaluate the influence of these anthropometric variables on the diameter and length of the PLT autograft obtained.

Result: Pearson correlation test has shown that body weight and height correlates to PLT length and diameter also autograft's length and diameter significantly ($p < 0.05$). The linear regression analysis showed that height, weight, TLL and shank length were signifcantly related to autograft diameter. While height and TLL were significantly related to autograft length.

Conclusion: Height, weight, TLL and shank length can use to predict PLT autograft diameter. While height and TLL can use to predict PLT autograft length.

1. Introduction

Anterior cruciate ligament (ACL) tear is one of the most commonly seen orthopaedic sports trauma with the incidence rate of up to 84/100,000 persons in the United States.[1] A valgus and an internally rotated non-contact mechanism is the most common mode of injury and is often sustained by football players (53% of the total).[1,2] Patients who wish to regain their fitness and the physically active state would undergo ACL reconstruction surgery to restore knee joint stability after an ACL tear. There are 127,000 ACL reconstruction alone in the United States per year.[3]

Many autograft options exist for the reconstruction of ACL tear with injury-specific and patient-specific considerations that need to be made during preoperative planning. Hamstring tendon (HT) graft is the most popular autograft chosen for ACL reconstruction in the United Kingdom, followed by the patellar tendon (PT) graft, with bone blocks at either end.[4]

Although the PT autograft is considered as a gold standard for ACL reconstruction, there are many complications, especially pain at the anterior knee.[5,6] This is found to be very disturbing for most of the Indonesian people, especially during praying, as the majority of the population in Indonesia are Muslims. The use of HT as an autograft of choice has increased over time due to the similar results with reconstruction using PT autograft and the decreased donor site morbidity.[5,7,8] But it is a risk for having inadequate autograft length or diameter, where can be potential for increased autograft laxity over time.[9,10] It is important to identify these at-risk patients to allow proper preoperative equipment planning, therefore the alternative autograft sources and appropriate patient counseling can be performed prior to surgery.[6]

The acceptable amount of strength, the adequate size, and the ease and safety of graft harvesting are the criteria of ideal autograft donor. Some literature suggesting peroneus longus tendon (PLT) as an alternative autograft for ACL reconstruction.[12–14] PLT has enough size and strength to be an autograft in an ACL reconstruction.[12,15] It has no effect on gait and ankle stability when the PLT is removed entirely,

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therefore PLT is considered as an effective autograft option for ACL reconstruction with respect to its strength, safety, and donor site morbidity.[14]

Among some methods that have been performed to explore the most ideal way to predict the graft size, anthropometric parameters are considered an easy and cost-effective method in predicting the size of HT graft.[16] To our knowledge, there has been no study in international literature that correlates anthropometric measurement and PLT autograft diameter and length in arthroscopic-assisted ACL reconstruction on Indonesian population, especially South Sulawesi population.

The objective of this prospective study is to evaluate correlations among preoperative anthropometric parameter measurements such as gender, age, weight, height, body mass index (BMI), true leg length (TLL), shank circumference and shank length and PLT autograft size and can be used to accurately predict the length and diameter of the PLT autograft for ACL reconstruction preoperatively.

2. Materials and methods

2.1. Patients

After Hasanuddin University School of Medicine Ethical Committee approval, we evaluated 20 patients (17 males, 3 females) with ACL tear who will undergo 2-strand PLT autograft for primary ACL reconstruction between January 2016 and December 2018 in Wahidin Sudirohusodo Hospital, Makassar. Written informed consent was obtained from all of those patients. We excluded patient who used other than aforementioned types of autograft in ACL reconstruction, have other injuries around the knee and ankle, multi-ligament knee injuries and cases with incomplete information. All author independently collected anthropometric parameters, including age, gender, height, weight, BMI, TLL, shank circumference, and shank length preoperative directly. While tendon harvesting and graft preparation were done by the first author.

Height was measured with the subject standing in bare feet with his back against anthropometric device, weight was measured with the subject standing over the scale with hands by their side and without shoes and excess clothing, TLL was measured as the distance from the anterior superior iliac spine (ASIS) to the medial malleolus (MM) and shank circumferences were measured 10 cm distal to the medial joint line (MJL) in all patients. For shank length, the distance between the MJL and the most distal point of the MM was measured. BMI was calculated using the patient's weight and height according to the standard formula.

2.2. Operation procedures

All patients received a single bundle reconstruction under spinal anesthesia. All PLT autografts were harvested in the same fashion with a 2-cm longitudinal skin incision at the posterolateral side of the fibula just over the peroneus tendon, 2 cm proximal to the posterior border of the lateral malleolus (Fig. 1). After exposing the distal PLT, a stripper was used to harvest the tendon. The superficial fascia and fat of the PLT were removed, and the rough edge was trimmed appropriately and carefully. The PLT was then folded at the middle to obtain a 2-strand autograft and whip-stitched at its each ends with No. 2 polyester suture (Ethibond). The final diameter of the graft was determined by the smallest diameter allowing smooth passage in 'sizing cylinder' of Smith and Nephew with an increment of 0,5 mm. Graft diameter was obtained from the largest measured portion of the graft and was placed within the femoral tunnel. Any difference in diameter for the trailing was whipstitched at each end and was handled by adjusting the diameter of the drilled tibial tunnel. The functional length of the 2-stranded PLT autograft was defined as the measured end to end length of the prepared autograft.

Finally, the prepared PLT autograft was implanted and fixed. Femoral fixation was achieved with Endobutton while tibial fixation was achieved with Bioscrew.

2.3. Statistical analysis

Statistical analyses were performed using SPSS version 22.0. Independent-sample t tests were used to identify the correlation between the length and diameter of the PLT autograft and dichotomous variables (gender). Correlation coefficients (Pearson r) were used to identify the correlation between the length and diameter of the PLT autograft and continuous variables (age, height, weight, BMI, TLL, shank circumference, and shank length). Higher correlation coefficient shows a stronger correlation between variables. Following the univariate analysis, a simple linear regression analysis was used to evaluate the influence of the anthropometric variables on the length and diameter of the PLT autograft obtained. In order to improve the matching degree of the regression equation and real parameters, we have taken the log of those continuous variables. P values less than 0.05 were considered as significant.

3. Results

This study consisted of 17 males and 3 females with an average age of male (29.4 ± 10.7 years) and the average age of female (31.6 ± 15.1 years). Average values for height (168.1 ± 8.2 cm), weight (71.2 ± 13.1 kg), BMI (25.0 ± 3.1 kg/m2), TLL (84.8 ± 5.9 cm), shank circumference (35.6 ± 2.8 cm), shank length (34.8 ± 2.7 cm), PLT autograft diameter (8.1 ± 0.8 mm) and PLT autograft length (15.5 ± 1.2 cm) (Table 1). When the samples were split by gender, the mean of PLT autograft diameters and length in men were 8.2 ± 0.6 mm and 15.7 ± 1.0 cm and 7.0 ± 0.0 mm and 14.0 ± 1.0 cm in women. Sixty percents of patients had a PLT autograft diameter between 7 and 8 mm, 40% of patients autografts were more than 8 mm, while no patients less than 7 mm in diameter.

From Pearson's correlation test and simple linear regression analysis, we found that weight, height, TLL, and shank length were related significantly to PLT autograft diameter ($p < 0.05$). While height and TLL were related significantly to PLT autograft length ($p < 0.05$) (Table 2).

Through simple linear regression analysis, we constructed the following predictive equation of PLT autograft diameter and PLT autograft length base on the predictor were correlated significantly:

1. PLT autograft diameter
   - PLT autograft diameter = 5.406 + 0.038 (weight (kg))
   - PLT autograft diameter = 0.072 (height (cm)) – 4.003
   - PLT autograft diameter = 1.468 + 0.078 (TLL (cm))
   - PLT autograft diameter = 2.464 + 0.162 (shank length (cm))
2. PLT autograft length
   - PLT autograft length = 2.970 + 0.075 (height (cm))
   - PLT autograft length = 6.896 + 0.102 (TLL (cm))

Correlation analysis indicated that shorter, lighter-weight patients with shorter true leg length and shorter shank length measurements tend to have smaller PLT autograft diameters. While shorter patients with shorter TLL tend to have shorter PLT autograft length. Patients with body weight less than 44 kg, less than 153 cm in height, less than 72 cm TLL, and with shank length less than 28 cm should be considered at high risk for having PLT autograft diameter less than 7 mm.

4. Discussion

Autograft selection is important for ACL reconstruction. Preoperative selection should normally consider autograft volume, strength, donor site morbidity, availability, patient activity level, lifestyle, and personal preferences.[17]

Fig. 1. The procedures for harvesting and preparing PLT grafts: (a) A longitudinal skin incision (solid line) at the posterolateral side of the fibula, 2 cm proximal to the posterior border of the lateral malleolus, (b) Exposing the distal end of the PLT with a mosquito hemostat, (c) Suture and Cutting off PLT at the distal end and putting the striper toward the proximal end and then pulling out the tendon of peroneus longus, (d) Moving the superficial fascia and fat of the PLT and trimming the rough edge carefully, (e) Doubling up the PLT to obtain a 2-strand graft and suturing its ends in a whipstitch style with a No. 2 non absorbable suture (ethibond) and measuring the length, (f) Measuring the diameter of PLT graft using a cylinder in 0.5-mm increments. The final diameter is the smallest possible diameter that allowed smooth passage of the graft.16

This is a prospective study in 20 patients (17 males, 3 females) who undergone ACL reconstruction by using PLT autograft in our institution. We found that weight, height, TLL and shank length have correlation with PLT autograft diameter. While height and TLL have a correlation with PLT autograft length, height has the strongest correlation with PLT autograft diameter and length (R^2 = 0.767 and 0.520, $p < 0.05$). Whereas BMI and shank circumference did not correlate significantly with the length and diameter of the PLT autograft. It is similar to the study by Song et al.[16] who used PLT autograft and other studies using HT autografts.[18–21] TLL is the anthropometric parameter that was first studied as a predictor of PLT autograft size is also the strong predictor of PLT autograft diameter and length. This is the same as was studied by Treme et al.[11] who found that height and TLL were the best predictors of the autograft length.

In this study, the smallest diameter of the PLT autograft was 7 mm. This is one of the advantages of using PLT autografts in ACL reconstruction, where the minimum size to avoid revision surgery is considered as 7 mm. In addition, autograft size is considered as an important factor that influences the outcome of surgery.[22,23] The latest study considered that the autograft diameter of no less than 8 mm is considered as the acceptable length.[20–25] There was a 0.82 times lower likelihood of revision surgery with every 0.5-mm increase of autograft diameter.[26]

The other advantages are that it has more strength than HT autograft and native ACL.[27] It also has nearly the same mean width (8.24 mm) as the native ACL (7–12 mm).[6,28] The other advantage is that it lies superficially in the distal leg makes it easily be harvested.[15] All of these points supported the conclusion of PLT autograft as a safe and effective autograft alternative in ACL reconstruction surgery. However, the use of PLT autograft in our institution has just become popular in the recent two years.

Autograft length is another important component in the ACL reconstruction. An inadequate length may compromise fixation of the autograft, in particular, the tibia fixation component.[29] Autograft length of less than 8 cm is associated with more complications.[30] Thus

Table 2
Correlation coefficients for relationships between intraoperative measurements and clinical data.

	PLT graft diameter	PLT graft length
Age (year)	0.135	0.109
Weight (kg)	0.643*	0.432
Height (cm)	0.767*	0.520*
BMI (kg/m^2)	0.394	0.309
TLL (cm)	0.596*	0.506*
Shank circumference (cm)	0.009	0.108
Shank length (cm)	0.560*	0.279

*P value < 0.01.

it should assure that functional length of the autograft must be 8 cm (2 cm in the femoral tunnel, 4 cm intraarticular, and 2 cm in the tibial tunnel) or more.[30] We found the mean of PLT autograft length is more than 8 cm, this is considered as another advantage of PLT autograft.

Although there are differences between authors regarding the relationship of gender to autograft size, several studies have found that female have a risk of having a smaller PLT autograft. We found a significant difference in the diameter and length of the PLT autograft between male and female in this study. There were also statistically significant differences in age, weight, BMI, TLL, shank circumference and shank length between males and females in this study. So that it can't be identified that gender also affects the diameter and length of the PLT autograft. In future studies, a large number of the female are expected to figure out the influence of gender on the diameter and length of the PLT autograft.

The average height of male and female in this study are 170 cm and 156 mm, which is not equal to the average height of male and female of Indonesian population (172 cm and 159 cm).[31] Therefore, further research is needed to find out whether or not this equation can be applied to the general Indonesian population.

The strength of our study is that all reconstructions were performed by the same operator using the same of the autograft harvesting

Table 1
Subject Data (Mean ± SD) by Gender With Independent *t*-Test Result.

	Total	Men	Women	P value
PLT graft diameter (mm)	8.1 ± 0.8	8.2 ± 0.6	7.0 ± 0.0	0.000
PLT graft length (cm)	15.5 ± 1.2	15.7 ± 1.0	14.0 ± 1.0	0.012
Age (year)	29.8 ± 11.0	29.4 ± 10.7	31.6 ± 15.1	0.760
Weight (kg)	71.2 ± 13.1 kg	73.0 ± 10.8	60.6 ± 22.3	0.135
Height (cm)	168.1 ± 8.2	170.0 ± 6.1	156.6 ± 10.4	0.005
BMI (kg/m^2)	25.0 ± 3.1	25.1 ± 2.5	24.2 ± 6.1	0.816
TLL (cm)	84.8 ± 5.9	86.0 ± 6.24	78.0 ± 10.5	0.318
Shank Circumference (cm)	35.6 ± 2.8	55.1 ± 79.8	34.3 ± 4.0	0.665
Shank Length (cm)	34.8 ± 2.7 cm	35.3 ± 2.0	31.8 ± 4.2	0.031

technique, the same implant, and the same fixation technique. Another strength of our study is that this is the first study to determine the association between anthropometric parameters and PLT autograft diameter and length in Indonesian people, especially in South Sulawesi population.

The small sample size (especially female patient) is this study's limitation which could lead to insufficient statistical power to detect the small correlation between anthropometric parameter and diameter and length of PLT autograft. Secondly, the measurement of the initial diameter and length of the PLT after harvesting and trimming was not performed. Measurement of the functional length of the PLT autograft was performed after trimming. Another limitation is that we did not include the duration of injury and activity level, whereas another study found the correlation between duration of injury and activity level with a diameter of autograft.[11]

Results of this study can be used for preoperative planning of autograft before ACL reconstruction and to counsel patients for autograft choices and available alternatives. In the future, it is recommended that other study to use more anthropometric parameter and sample, especially female, to figure out if there is actually any effect of gender.

5. Conclusion

Height, weight, TLL and shank length can use to predict PLT autograft diameter. While height and TLL can use to predict PLT autograft length. Whereas patients with body weight were less than 44 kg, less than 153 cm in height, with less than 72 cm TLL, and with shank length less than 28 cm should be considered at high risk for having a PLT autograft diameter less than 7 mm. This current data can be a reference for surgeons in preoperative planning and counseling to patients about alternative autograft selection.

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Declaration of competing interest

There are no conflicts of interest.

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