RESEARCH ARTICLE

Predicting the Hamstring Tendon Diameter Using Anthropometric Parameters

Mohsen Mardani-Kivi, MD; Mahmoud Karimi-Mobarakeh, MD; Ahmadreza Mirbolook, MD; Sohrab Keyhani, MD; Khashayar Saheb-Ekhtiari, MD; Keyvan Hashemi-Motlagh, MD; Parham Porteghali, MD

Research performed at Poursina Hospital, Rasht, Iran

Received: 14 October 2015 *Accepted: 28 August 2016*

Abstract

Background: Despite the importance of hamstring tendon autograft, one major disadvantage in applying this technique in the surgical reconstruction of anterior cruciate ligament is individual variability in the tendon diameter. Hence, the purpose of the present study was to use anthropometric parameters such as gender, height and body mass index to predict 4-strand (quadruple) hamstring tendons (gracilis and 2-strand semitendinosus tendons).

Methods: This is a cross-sectional study conducted on all consecutive patients who underwent arthroscopic ACL reconstruction between 2013 and 2015. The anthropometric variables (age, gender, height, and body mass index) were recorded. The quadruple hamstring tendon (gracilis and semitendinosus) autografts were measured using sizing cylinders. The relationship between these parameters was statistically determined using the Pearson Spearman test and linear regression test.

Results: The mean age of the 178 patients eligible for the study was 29.58±9.93 (118 males and 60 females). The mean hamstring tendon diameter was 7.8±0.7 mm, the mean for males was 7.9±0.6 and for females 7.89± mm (*P*=0.0001). There were significant correlations between the mean hamstring tendon diameter with BMI (Pearson correlation=0.375, R^2=0.380, and *P*=0.0001), height (Pearson correlation=0.441, R^2=0.121, and *P*=0.0001), and weight (Pearson correlation=0.528, R^2= -0.104 and *P*=0.0001). However,patient's age and genderwerenot found to be a predictor of the size of the hamstring tendon diameter.

Conclusion: Based on findings from this study weight, height, body mass index,and the length of the tendon may be predictors of the hamstring tendon diameter for anterior cruciate ligamentreconstruction. These findings could be used in preoperative planning of patients undergoing ACL reconstruction surgery to estimate the size of the graft and select of the appropriate type of graft.

Keywords: Anterior cruciate ligament, Anthropometric parameters, Body mass index, Hamstring tendon

Introduction

The prevalence of anterior cruciate ligament (ACL) injuries is increasing as part of the general increase in sport injuries (1). Anterior cruciate ligament injury, the most prevalent among the knee ligament injuries, results in considerable functional disability (2). There is general consensus on surgical reconstruction of the ACL tear as the treatment of choice (3-5); however, the debate is over which surgical technique is more efficient. In the US alone, there are annually over 100,000 ACL reconstruction surgeries (3). Hamstring autografts (semitendinosus and gracilis) are the most common tendons used in the ACL reconstruction (5). One of the most important drawbacks in using hamstring autografts is individual variability in the tendon diameter (5). Little preoperative information is available for the surgeon to prepare the allografts and predict the size and length of the quadrupled semitendinosus and gracilis tendon autografts prior to the operation (6-8). Although several studies have reported the average diameter of the quadrupled semitendinosus to be between 7.7 to 8.5 mm, clinical experience and Magnetic Resonance Imaging (MRI) evaluations indicate that hamstring tendon size is considerably variable between individuals (9-11).

Estimation of the hamstring tendon size could guide surgeons in preoperative planning for the graft of choice.

Corresponding Author: Khashayar Saheb-Ekhtiari, Guilan Road Trauma Research Center, Poursina Hospital, Rasht, Guilan, Iran
Email: Dr.Khashi@gmail.com

AB&JS THE ONLINE VERSION OF THIS ARTICLE ABJS.MUMS.AC.IR

The aim of this study was to finda relationship between the 4-strand hamstring tendon autograft diameters (doubled semitendinosus and gracilis tendons) and anthropometric parameters such as age, gender, height and body mass index (BMI).

Materials and Methods

In this cross-sectional study all the patients had suffered an ACL tear at least 1.5 months prior to the study. The exclusion criteria were: previous history of knee surgery (excluding diagnostic arthroscopy), injury to the contra-lateral lower limb, associated ligament injury, chondral lesions grade III-IV according to the International Cartilage Repair Society criteria, abnormal knee radiographs, and symptomatic hip and/or ankle (12).

From March 2013 to March 2015, 178 patients underwent ACLreconstruction using hamstring tendons. The study was approved by the Institutional Review Board (IRB). All the patients were briefed about the aims of the study and possible complications of arthroscopy and signed the consent forms prior to enrollment.Age, gender, height, and BMI for each patient wererecorded.

An anteromedial 2 cm incision was made on the tibia. The sub-periosteal area over the tendon insertion was dissected to the tendon insertion point on the tibial crest to ensure maximum graft length. The tendon was relegated to its maximum length and then stripped of the muscle and measured. After dissecting muscle and vincula tissue, doubled gracilis and semitendinosus tendons were sutured at the ends using a Krackow suture with No 5 Ethibond string and its smallest possible diameter was measured using a cylindrical sizer with a 1mm measurement error. The surgical technique was the same as described before (13,14). Femoral and tibial sides were fixated using the *Cortico Femoral Ancrage* and *MISBIO*® Bio-absorbable interference screw (both: ORTHOMED, St Jeanet, France) respectively.

The gathered data was analyzed using SPSS software version19 (SPSS Inc., Chicago, IL). Pearson Spearman test was usedto determine the correlation among the variables. Predictive values were reported bythe correlation coefficient(R^2).Thet-test was used to compare the hamstring tendon diameters in both genders. Linear regression test was used to determine the relationship between each anthropometric variable and tendon diameter. A *P*-value of less than 0.05 was considered to be statistically significant.

Results

In this study, 178 patients underwent ACL reconstruction using quadruple hamstring tendon autografts. Of those, there were 118 males (66.3%) and 60 females (33.7%) with the mean age of 29.8±9.9years (range: 17-61 years). The BMI, height and weight means were 24.9±3.5 kg/m^2, 174.8±7.8cm and 76.4±12.7 kg respectively.

The mean hamstring tendon diameter was 7.8±0.7mm; 7.9±0.6 for males and 7.1±0.9for females, and the differences were statistically significant (*P*=0.0001). There were no significant differences between the mean hamstring tendon diameter and patients' age (*P*=0.079). The results of the Pearson correlation test indicated that the patient's age and gender could not be a predictor of the size of the hamstring tendon diameter (*P*=0.442 and *P*=0.116, respectively). However, there were significantcorrelations between the mean hamstring tendon diameter with BMI (Pearson correlation=0.375, R^2=0.380, and *P*=0.0001), height (Pearson correlation=0.441, R^2=0.121, and *P*=0.0001) and weight (Pearson correlation=0.528, R^2= -0.104 and *P*=0.0001).

Below, we have presented a model for predicting the hamstring tendon diameter developed according to the regression analysis that has a predictive value of 36%:

Hamstring tendon diameter = [-17.22+ 0.135 (height in cm) - 0.11 (weight in kg) + 0.4 (BMI)]

Discussion

The principal finding of the study wasthat in addition to gender, anthropometric parameters (height, weight and BMI) can be used as predictors of the hamstring tendon diameter for ACL reconstruction.

The high prevalence of injuries to the ACL has drawn a great deal of attention to ACL reconstruction techniques. However, individual variability in the tendon diameter and inadequacy of the tendon diameter graft may result in weakness and inefficiency of the graft and even graft failure (1, 2, 5). Thus, to prevent such complications, in the present study, during a one-year period we examined the effects of anthropometric parameters such as age, gender, height and BMI in predicting the hamstring tendon diameter in178 patients who underwentsurgical reconstruction of their ACL.

The mean age of the patients in the present study was 29.8±9.9 years. In a study conducted by Tuman (2007) in the US, there were no significant differences between age levels and hamstring tendon diameter (*P*>0.05) (11). The results of the present study provide more support for these studies suggesting no significant differences between the age and hamstring tendon diameter.

In the present study, out of 178 patients, 118 were males and 60 females. In a study conducted on 536 patients (302 females and 234 males) in 2009 in the US, significant difference was found in the hamstring tendon diameter between males and females (*P*<0.0047) (5). In another study in the same year in England, MRI evaluation of the hamstring tendon diameter of 104 patients also showedthe same results, which are in agreement with the results of the present study (15).

The result of this study shows a positive correlation between height and hamstring tendon diameter, which provides more evidence for the studies conducted by Tuman and Wotherspoon(11,15). Our results showed a positive correlation between mean weight and hamstring tendon diameter, which is in agreement with a previous study (11). However, our results provide no evidence for Ma's study in 2009 (5), in that, he found no correlation between the weight and hamstring tendon diameter in 536 patients (*P*>0.05).

Knee instability and graft failure are two major concerns of orthopedic surgeons (6-8). Since graft diameter has a great impact on these unintended consequences, the ability to predict the tendon diameter based on anthropometric characteristics can be very helpful for

orthopedists (16). Measuring height, weight, and BMI are available with no cost in every clinic and we showed that they could affect the graft diameter as much as 36%.

There are many studies that have shown the relationship between the semitendinosus and gracilis tendon diameters in MRI and prediction of hamstring autograft size (16-17). Our findings showed that tendon graft prediction using anthropometrics could favorably help knee surgeons in the selection between an allograft and autograft without imposing additional cost of an MRI on patients or the healthcare system.

It is more likely for the hamstring autograft to provide an appropriate graft size in taller men rather than shorter women. In women, light and/or short persons' other types of autografts (e.g. bone-patellar tendon-bone) or allografts could be alternative options.

To facilitate the selection of the appropriate method of ACL reconstruction, we recommend further studies aimed at determining predictive parameters and developing criteria or a framework for a more precise prediction of the hamstring tendon diameter.

The results of the present study showthat the hamstring tendon diameter tends to be larger in males and has no relation with age. Weight, height, BMI and the tendon length have a positive correlation with the hamstring tendon diameter and may be considered as its significant predictors.

Acknowledgments

Authors would like to thank clinical research development center in Poursina hospital that facilitate the process of the study.

Mohsen Mardani-Kivi MD
Khashayar Saheb-Ekhtiari MD
Keyvan Hashemi-Motlagh MD
Guilan Road Trauma Research Center, Poursina Hospital, Guilan University of Medical Sciences, Rasht, Iran

Mahmoud Karimi-Mobarakeh MD
Orthopedic Department, Bahonar Hospital, Kerman University of Medical Sciences, Kerman, Iran

Ahmadreza Mirbolook MD
Parham Porteghali MD
Orthopedic Research Center, Poursina Hospital, Guilan University of Medical Sciences, Rasht, Iran

Sohrab Keyhani MD
Orthopedics Department, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran

References

1. Beyzadeoglu T, Akgun U, Tasdelen N, Karahan M. Prediction of semitendinosus and gracilis autograft sizes for ACL reconstruction. Knee Surg Sports Traumatol Arthrosc. 2012; 20(7):1293-7.
2. Stergios PG, Georgios KA, Konstantinos N, Efthymia P, Nikolaos K, Alexandros PG. Adequacy of semitendinosus tendon alone for anterior cruciate ligament reconstruction graft and prediction of hamstring graft size by evaluating simple anthropometric parameters. Anat Res Int. 2012; 2012(2012):1-8.
3. Alentorn-Geli E, Samitier G, Alvarez P, Steinbacher G, Cugat R. Anteromedial portal versus transtibial drilling techniques in ACL reconstruction: a blinded cross-sectional study at two- to five-year follow-up. Int Orthop. 2010; 34(5):747-54.
4. Farshad M, Gerber C, Meyer DC, Schwab A, Blank PR, Szucs T. Reconstruction versus conservative treatment after rupture of the anterior cruciate ligament: cost effectiveness analysis. BMC Health Serv Res. 2011; 11(1):317-26.
5. Ma CB, Keifa E, Dunn W, Fu FH, Harner CD. Can pre-operative measures predict quadruple hamstring graft diameter? Knee. 2010; 17(1):81-3.
6. Xie G, Huangfu X, Zhao J. Prediction of the graft size of 4-stranded semitendinosus tendon and 4-stranded gracilis tendon for anterior cruciate ligament reconstruction: a Chinese Han patient study. Am J Sports Med. 2012; 40(5):1161-6.
7. Schwartzberg R, Burkhart B, Lariviere C. Prediction of hamstring tendon autograft diameter and length for anterior cruciate ligament reconstruction. Am J Orthop (Belle Mead NJ). 2008; 37(3):157-9.
8. Wernecke G, Harris IA, Houang MT, Seeto BG, Chen DB, MacDessi SJ. Using magnetic resonance imaging to predict adequate graft diameters for autologous hamstring double-bundle anterior cruciate ligament reconstruction. Arthroscopy. 2011; 27(8):1055-9.
9. Thomas S, Bhattacharya R, Saltikov JB, Kramer DJ. Influence of anthropometric features on graft diameter in ACL reconstruction. Arch Orthop Trauma Surg. 2013; 133(2):215-8.
10. Treme G, Diduch DR, Billante MJ, Miller MD, Hart JM. Hamstring graft size prediction: a prospective clinical evaluation. Am J Sports Med. 2008; 36(11):2204-9.
11. 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.
12. Brittberg M, Aglietti P, Gambardella R. ICRS cartilage injury evaluation package. Switzerland: International Cartilage Repair Society (ICRS); 2000.
13. Mardani-Kivi M, Madadi F, Keyhani S, Karimi-Mobarake M, Hashemi-Motlagh K, Saheb-Ekhtiari K. Antero-medial portal vs. Transtibial techniques for drilling

femoral tunnel in ACL reconstruction using 4-strand hamstring tendon: a cross-sectional study with 1-year follow-up. Med Sci Monit. 2012;18(11):CR674-9.
14. Karimi-Mobarakeh M, Mardani-Kivi M, Mortazavi A, Saheb-Ekhtiari K, Hashemi-Motlagh K. Role of gracilis harvesting in four-strand hamstring tendon anterior cruciate ligament reconstruction: a double-blinded prospective randomized clinical trial. Knee Surg Sports Traumatol Arthrosc. 2015; 23(4):1086-91.
15. Wotherspoon SD, Giffin JR, Fowler PJ, Litchfield RB, Neligan M, Willits KR. Prediction of anterior cruciate ligament hamstring autograft size using preoperative magnetic resonance imaging. Orthp Proc. 2009; 91(Suppl II):241.
16. Conte EJ, Hyatt AE, Gatt CJJr, Dhawan A.Hamstring autograft size can be predicted and is a potential risk factor for anterior cruciate ligament reconstruction failure. Arthroscopy. 2014;30(7):882-90.
17. Bickel BA, Fowler TT, Mowbray JG, Adler B, Klingele K, Phillips G. Preoperative magnetic resonance imaging cross-sectional area for the measurement of hamstring autograft diameter for reconstruction of the adolescent anterior cruciate ligament. Arthroscopy. 2008; 24(12):1336-41.