Correlation between the Length of Gracilis and Semitendinosus Tendon and Physical Parameters in Thai Males

Nitis Reboonlap MD*,
Chut Nakornchai MD*, Korakot Charakorn MD*

** Department of Orthopaedics, Phramongkutklao Hospital, Bangkok, Thailand*

Background: *As anterior cruciate ligament (ACL) injuries became more common, ACL reconstruction using hamstring tendons autograft (i.e. semitendinosus and gracilis) has become increasingly popular. One of the problems encountered during operation is insufficient size of the graft.*
Objective: *In order to determine the size of hamstring graft preoperatively, the authors collect anthropometric data from the patients and compare them with the actual hamstring tendon length harvested from the patient during ACL reconstruction.*
Study Design: *Cross sectional diagnostic study*
Material and Method: *Seventy-five consecutive patients with torn ACL scheduled for reconstruction using hamstring autograft were prospectively evaluated. Preoperatively the authors recorded height, weight, body mass index, age, leg length, thigh length, thigh circumference, length and width of the femur. Intraoperative measurements of both the gracilis and semitendinosus tendons length were made after trimming the useless thin border of the graft and final diameter of the quadrupled graft. Bivariate correlation coefficients (Pearson r) were calculated to identify relationships among clinical data and hamstring graft length and diameter measured intraoperatively.*
Results: *Strongest correlations for graft lengths were height and leg length measurements from both physical examination and x-rays. In contrast, graft diameter was not correlated with any physical parameters.*
Conclusion: *Simple parameter such as 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. Thai male who is taller than 170 cm have a good potential to have semitendinosus tendon longer than 250 mm and maybe candidates to have ACL reconstruction with semitendinosus alone. X-ray of the whole leg did not provide any better prediction of graft length.*

Keywords: *Hamstring, Gracilis, Semitendinosus, Anterior cruciate ligament, Preoperative planning, Hamstring length prediction*

J Med Assoc Thai 2012; 95 (Suppl. 10): S142-S146
Full text. e-Journal: *http://jmat.mat.or.th*

Multiple options for graft choice exist for reconstruction of the anterior cruciate ligament (ACL), including bone-patellar tendon-bone (BPTB) autograft, hamstring tendon autograft quadriceps tendon autograft and multiple allograft sources. All of these choices have inherent advantages and disadvantages that must be considered before clinical use. Clinical studies showing similar results to BPTB reconstructions, decreased donor site morbidity and improved fixation methods have led to the increased use of hamstring as a graft choice. Hamstring tendon autograft has also proved to be effective for other soft tissue reconstructions, including extra-articular procedures around the knee, elbow and ankle. As the use of autograft hamstring tendons increases, the ability to identify those patients at risk for having hamstring tendons of inadequate length or diameter becomes a necessity. Identifying these at-risk patients allows for proper preoperative equipment planning, arrangement of alternative graft sources (such as patellar tendon autograft, quadriceps tendon, or other allograft sources) and appropriate patient counseling regarding graft selection.

From the previous studies by Treme et al[1], and Yasunari et al[2], the length of gracilis and semitendinosus tendon are positively correlated with patient's height and leg length. The quadruple diameter of the graft also correlated with the weight and thigh circumference of each individual. Although Tegner

Correspondence to:
Reboonlap N, Department of Orthopaedics, Phramongkutklao Hospital, Bangkok 10400, Thailand.
Phone: 08-1861-7292
E-mail: nwrbl@yahoo.com

activity rating score doesn't have any correlation with graft length or diameter, the authors found that the length of the tendon grafts reported by Pichler et al[3], whose subjects are in US, were much different from what the authors saw in Phramongkutklao Hospital, which mostly are officers in Royal Thai army.

The previous study of hamstring tendon length in Thai cadavers as reported by Kupniratsaikul et al[4] also found significant short length of semitendinosus tendon in those who were less than 160 cm tall. But the drawback is the method of measuring was not described whether the graft measurement was taken before or after graft preparation (trimming). The thin tendon at musculotendinous junction may be too small to hold any sutures and may not provide any strength for the reconstruction. Thus we think the final length after trimming was more appropriate for preoperative planning.

Objective

To find the relationship between the usable part of gracilis and semitendinosus tendon graft size (length and quadruple diameter) and anthropometric data.

To predict the size of usable part of hamstring tendon during preoperative planning.

Material and Method

The authors prospectively evaluated 76 consecutive patients with torn ACL scheduled for reconstruction using hamstring autograft in Phramongkutklao Hospital between December 2008 and August 2010. Patients were sent for AP radiographs of the hip-knee-ankle to determine the overall alignment. The authors obtained radiographic parameters including distance from ischial tuberosity to medial joint line of the knee, distance from ischial tuberosity to medial malleolus and femoral width. Preoperatively, the authors recorded height, weight, BMI, age, gender, leg length, thigh length, shank length, contralateral thigh circumference. Leg length was measured from the anterior superior iliac spine (ASIS) to the medial malleolus (MM), thigh length from ASIS to tibial tubercle (TT) and shank length from TT to MM. Thigh circumferences were measured 10 cm proximal to the superior pole of patella in all patients. All grafts were obtained by one of the two orthopaedic surgeons proficient in hamstring tendon graft harvest. Part of tendon that was less than 5 mm in width was considered useless and was trimmed out. Intraoperative measurements of both the gracilis (G) and semitendinosus (ST) tendons were made, including absolute length (before trimming) of each, final length (after trimming) of each and diameter of the quadrupled graft using sizing tubes calibrated to 0.5 mm. In the cases which premature

Fig. 1 Measuring the thigh length

Fig. 2 Radiographic measurement

Fig. 3 Graft preparation

rupture of the tendon occurred during graft harvesting process were excluded from the present study.

Statistical analysis

Bivariate correlation coefficients (Pearson r) were calculated to identify relationships among clinical data and intraoperatively measured hamstring graft lengths and diameters. Higher correlation coefficients indicate stronger relationships between variables. The authors used multiple linear regressions to calculate regression coefficients to determine variance explained between clinical predictor variables and outcome variables, that is, graft diameter and length. Finally, the validity of the regression equation for graft diameter from the first study was tested and a new equation to predict graft length was developed.

Statistical results were considered significant at $p < 0.05$.

Results

The present study consists of 74 male subjects. Two were excluded because of premature graft rupture during tendon harvest process. Data was shown in Table 1.

Correlation between physical parameters, radiographic parameters and tendon size were determined by correlation coefficient as in Table 2.

Graft lengths

Simple linear regression for graft lengths indicated that height and leg length explained approximately 28% and 25% of variance in G tendon length, respectively. Similarly, height and leg length explained approximately 36% and 37% of the variance in ST length, respectively. Through regression analysis the authors constructed the following predictive equations for gracilis graft length (GL) and semitendinosus graft length (SL):

For gracilis tendon length prediction:

GL = -26.164+1.570(Height) [$r=0.477$; $R^2=0.288$; $p < 0.001$)

For semitendinosus tendon length prediction:

SL = -53.862 + 1.921 (Height) [$r = 0.603$; $R^2 = 0.364$; $p < 0.001$)

Discussion

The present study results support the hypothesis that anthropomorphic data can predict the length of hamstring grafts. In contrast to previous published studies by Yasunari et al[2] and Kuptaniratsaikul et al[4], the authors found no correlation between graft diameter and any data including weight, height and thigh circumference. For prediction of tendon graft length, the authors found that both physical and radiographic parameters have moderate correlation with the graft length. Since physical parameters are easier to obtain, they should be used for graft length prediction. Among physical parameters, those with strongest correlation with tendon length were height and leg length.

The results can be developed into an easy-to-use table for prediction of tendon graft length in Thai male as in Table 3.

The importance of predicting hamstring dimensions is highlighted by the utility of this tissue as a graft option. The most common use is for ACL reconstruction with quadrupled G and ST constructs. Additionally, some surgeons use a tripled ST graft for ACL reconstruction. Both of these situations require a graft of not only adequate diameter but appropriate length. Secondly, with the increased popularity of double-bundle reconstruction, and the development of new operative techniques, graft choice and size

Table 1. Subject data

	Mean	SD	Median	Min	Max
Age	29.22	9.01	27.50	16.00	53.00
Height (cm)	171.93	6.94	171.50	154.00	188.00
Weight (kg)	71.20	10.40	70.00	49.00	95.00
BMI	24.03	2.83	23.86	17.96	33.66
ASIS-tibial tubercle (cm)	52.68	3.83	52.00	41.00	63.00
ASIS-medial malleolus (cm)	85.69	5.56	85.25	71.00	100.00
Thigh circumference (cm)	47.37	3.85	47.00	40.00	59.00
Ischium tuberosity-medial knee (cm)	39.26	3.25	39.00	31.00	48.00
Ischium tuberosity-medial malleolus (cm)	77.58	4.73	77.25	68.50	90.00
Femoral shaft width (mm)	28.91	2.12	29.25	24.50	33.00
Gracilis tendon-Final length (cm)	243.24	23.43	240.00	180.00	290.00
Semi T tendon-Final length (cm)	275.27	22.66	270.00	210.00	330.00
Quadrupled diameter (mm)	8.04	0.62	8.00	6.50	9.00

Table 2. Correlation coefficients

	Gracilis-Final length (cm)	Semi tendinosus-Final length (cm)	Quadrupled diameter (mm)
Age	- 0.370	- 0.235	- 0.149
Height (cm)	0.477*	0.603*	0.364
Weight (kg)	0.320	0.371	0.179
BMI	0.072	0.049	- 0.015
ASIS-tibial tubercle (cm)	0.467*	0.562*	0.286
ASIS-medial malleolus (cm)	0.502*	0.610*	0.401*
Thigh circumference (cm)	0.309	0.108	0.224
Ischium tuberosity-medial knee (cm)	0.434*	0.557*	0.339
Ischium tuberosity-medial malleolus (cm)	0.254	0.531*	0.285
Femoral shaft outer diameter (mm)	0.359	0.511*	0.340

* denotes moderate correlation

Table 3. Predicted length of usable part of gracilis and semi-tendinosus tendon graft in Thai male

Height (cm)	Gracilis length (mm)	Semi T length (mm)
155	196-240	218-270
160	203-246	227-279
165	210-253	237-289
170	220-263	247-299
175	229-272	256-308
180	235-279	266-318
185	243-286	276-328
190	251-294	285-337

parameters have become more important for preoperative planning. Finally, hamstring tendons have proved to be an effective graft choice for other periarticular reconstructive procedures. Hamstring tendon grafts have long been used in collateral ligament and posterolateral corner reconstruction in the knee. Reconstructive techniques around the elbow and ankle also employ hamstring tendons as the graft of choice. As reconstructive techniques continue to evolve, the ability for the surgeon to predict graft size and identify patients that may have a small or inadequate graft will become more important.

Limitations in the present study include the graft harvest technique, which affected to the graft size. The authors minimized this by using consistent technique of harvesting and set criteria regarding postharvest trimming. To ensure the consistency of judgment for trimming, both operating surgeons have regularly been in the operating room together and they agreed with the trimming performed. In addition, the anthropomorphic data could change with the inclusion

of a greater number of patients and relationships may not hold true at the far ends of the data continuum. The authors do believe, however, that this patient group represents an appropriate sample of our ACL reconstruction population.

Conclusion

The results of the present study indicate that height is the parameter of choice for prediction of hamstring tendon length due to its moderate to strong correlation and being the easy-to-measure and inexpensive data. When considering ACL reconstruction in the shorter patient, discussion regarding graft choice options is appropriate since these patients are at increased risk for having a smaller graft. Diameter of tendon graft cannot be predicted preoperatively. Hamstring grafts less than 7 mm in diameter are rare and identification of these patients remains difficult. Thai male who is taller than 170 cm have a good potential to have semitendinosus tendon longer than 250 mm and maybe candidates to have ACL reconstruction with semitendinosus alone.

Acknowledgents

The authors wish to thank Dr. Nattha Kulkamthorn for the help regarding the intraoperative data collection.

Potential conflicts of interest

None.

References

1. Teme G, Diduch DR, Billante MJ, Miller MD, Hart JM. Hamstring graft size prediction: a prospective clinical evaluation. Am J Sports Med 2008; 36: 2204-9.
2. Yasunari O, Eiichi N, Hiroshi M, Minoru S, Satoshi K, Yoshihiko M, et al. Anatomical study of semitendinosus tendon length in anterior cruciate ligament reconstruction with multistranded medial hamstring tendon. Orthop Traumatol 1999; 48: 329-32.
3. Pichler W, Tesch NP, Schwantzer G, Fronh□fer G, Boldin C, Hausleitner L, et al. Differences in length and cross-section of semitendinosus and gracilis tendons and their effect on anterior cruciate ligament reconstruction: a cadaver study. J Bone Joint Surg Br 2008; 90: 516-9.
4. Kuptniratsaikul S, Kuptniratsaikul V, Udompunturak S, Siripunpiriya M, Tejapongvorachai T, Itiravivong P. Measurement of the semitendinosus muscle tendon length : a cadaveric study in King Chulalongkorn Memorial Hospital. Chula Med J 2002; 46: 123-30.

ความสัมพันธ์ระหว่างความยาวของเอ็นช่วยงอหัวเข่ากับตัวชี้วัดทางกายภาพต่าง ๆในชายไทย

นิธิศ รีบุญลาภ, ชัช นครชัย, กรกฎ ชรากร

จุดประสงค์: *เนื่องจากการผ่าตัดทำเอ็นไขว้หน้าใหม่ได้รับความนิยมมากขึ้น ในผู้ป่วยบางรายอาจพบปัญหาความยาวของเอ็นช่วยงอเข่าที่นำมาใช้ทำเอ็นใหม่นั้นไม่พอ เพื่อให้การประเมินความยาวของเอ็นช่วยงอเข่าก่อนผ่าตัดมีความแม่นยำมากขึ้น ผู้นิพนธ์ได้ทำการรวบรวมข้อมูลทางกายภาพต่างๆมาศึกษาเปรียบเทียบกับความยาวจริงของเอ็นช่วยงอเข่าที่วัดได้ในขณะทำการผ่าตัด*

วัสดุและวิธีการศึกษา: *ผู้นิพนธ์ศึกษาเข่าในผู้ป่วย 75 รายที่มารับการผ่าตัดทำเอ็นไขว้หน้าใหม่โดยใช้เอ็นช่วยงอเข่า ผู้นิพนธ์ทำการเก็บข้อมูลต่างๆทางกายภาพก่อนผ่าตัด และทำการวัดความยาวของเอ็นช่วยงอเข่าในขณะทำการผ่าตัด จากนั้นจึงนำข้อมูลมาศึกษาเปรียบเทียบ*

ผลการศึกษา: *ความยาวของเอ็นที่ทำใหม่มีความสัมพันธ์กับความสูงและความยาวขาของผู้ป่วย แต่เส้นผ่าศูนย์กลางของเอ็นที่ทำใหม่ไม่มีความสัมพันธ์กับตัววัดทางกายภาพใดๆ*

สรุป: *ตัววัดทางกายภาพสามารถใช้ประเมินผู้ป่วยที่อาจมีปัญหาความยาวของเอ็นช่วยงอเข่าไม่พอก่อนทำการผ่าตัดได้ ผู้ชายที่สูงมากกว่า 170 เซนติเมตร มีแนวโน้มว่าจะมีเอ็น semitendinosus ยาวมากกว่า 250 มิลลิเมตร ซึ่งอาจจะใช้ semitendinosus เพียงเส้นเดียวในการทำเอ็นใหม่ได้*