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The measurement of the semitendinosus muscle tendon length : A cadaveric study in King Chulalongkorn Memorial Hospital

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Objective : *To determine the length of semitendinosus graft related to leg and body length of the cadaver, then the minimal leg length and body height in case of semitendinosus graft harvesting can be recommended.*

Methods : *The semitendinosus tendons and cadaveric length including the leg length were recorded bilaterally from 16 fresh cadavers in the Forensic Medicine Department, Faculty of Medicine, Chulalongkorn University and compared the relationship between one another was compared.*

Results : *The average tendon length of semitendinosus muscle was 25.4 cms. The length of semitendinosus graft obtained from cadavers with less than 160 cms. length were shorter than ones which were obtained from cadavers longer than 160 cms. ($p < 0.001$) It is significant to note that to obtain tendons longer than 24 cms. semitendinosus grafts need careful consideration with patients who are shorter than 160 cms. or who have a true leg length of 80 cm.*

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Conclusions : *In patients shorter than 160 cms, the surgeon might use other sites for donor grafts such as bone patella bone grafts or semitendinosus in conjunction with gracilis instead of a single semitendinosus graft for ACL reconstruction. This study is a preliminary report due to the limited in the number of specimens. We expect to extend this study in higher number of specimen to prove the reliability of the outcome soon.*

Key words : *Semitendinosus graft, ACL reconstruction, Cadaveric study.*

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วัตถุประสงค์ : *เพื่อศึกษาหาค่าความยาวของเส้นเอ็นกล้ามเนื้อ semitendinosus เปรียบเทียบกับส่วนสูงและความยาวของขา และหาค่าความสูงที่น้อยที่สุดที่มีความยาวเอ็น Semitendinosus เพียงพอที่จะนำมาใช้ในการผ่าตัด ACL reconstuction*

วิธีการ : *วัดความยาวของเส้นเอ็นของกล้ามเนื้อ semitendinosus ในศพเสียชีวิตใหม่ที่ต้องทำการผ่าพิสูจน์ศพ (autopsy) จำนวน 16 ราย ณ ภาควิชานิติเวชศาสตร์ คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย โดยทำการผ่าตัดวัดความยาวของเส้นเอ็นกล้ามเนื้อ semitendinosus ส่วนสูงและความยาวขา*

ผลการศึกษา : *ความยาวเฉลี่ยของเอ็นกล้ามเนื้อ semitendinosus เท่ากับ 25.4 ซม. ความยาวของเอ็นกล้ามเนื้อนี้ ในกลุ่มผู้ที่มีความสูงน้อยกว่าหรือเท่ากับ 160 ซม. กับกลุ่มที่สูงกว่า 160 ซม. มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($p < 0.001$) และการที่จะได้ความยาวของเส้นเอ็นกล้ามเนื้อ semitendinosus อย่างน้อย 24 ซม. นั้น ผู้ป่วยควรจะมีส่วนสูงมากกว่า 160 ซม. หรือความยาวขาอย่างน้อย 80 ซม.*

สรุป : *ศัลยแพทย์ควรระวังในการนำเอ็น semitendinosus มาใช้เพื่อการผ่าตัดซ่อมเอ็น ACL ในข้อเข่าของผู้ป่วยที่มีความสูงน้อยกว่า 160 ซม. หรือความยาวขาน้อยกว่า 80 ซม. ข้อแนะนำ คือควรพิจารณาเลือกเอ็นทดแทนจากตำแหน่งอื่น*

Currently the number of sports injuries has been increasing according to the member sports participation especially within adults. Anterior cruciate ligament (ACL) injury is a very common condition and important among many other sports injuries due to its prevalence and function.[1] This ligament can restrain the knee from rotational deformation and antero-posterior translation.[2] The patients whose ligament was absent due to any cause will loose their knee stability and cannot use their knee in normal daily activity so they need to be replaced as non functional ACL in the reconstruction procedure.[3] Some widely accepted grafts are bone-patella tendon-bone, semitendinosus, gracilis and quadricep bone graft. Each of which has its own advantage and disadvantage.

As we know from the animal model study after graft maturation, the strength will lessen to 80 % of its original strength[4] (the starting point) and the normal ACL has the ultimate tensile strength (UTS) of 2,160$\pm$ 157 N/m^2 with the stiffness of 242 $\pm$ 28 N/m, so the proper donor graft should have a higher UTS and stiffness higher than mentioned.

A semitendinosus graft is one of the most common grafts used in ACL reconstruction, because its insertion is within the operative field, and causes less incidence of anterior knee pain, patellar tendinitis and quadricep weakness.[5] However some unfavorable properties of this graft are well documented such as high creeping property, less secure fixation to bone and prolonged healing to the bone tunnel recipient.[6]

Noyes et al [7] have studied an ultimate tensile strength of single strand semitendinosus graft which was only 70 % of the normal ACL. However double strand semitendinosus can increase only 60 - 70 %[3] of a single strand semitendinosus and is not a linear variable. The ultimate tensile strength of quadruple semitendinosus graft was 4,400 N,[8] so to harvest a long enough semitendinosus graft it is necessary to take a graft that can be looped to be a quadruple strand.

This length should be 4 times the minimum length of graft required for replacement of the intraarticular portion plus the bony embedded portion of ACL graft.

Miller et al [9] measured the intraarticular portion of ACL length in the cadaver of which the average length is 3 cms. The distance between the femoral and tibial tunnel is also 3 cms[10] which means, then the minimum length of semitendinosus graft should be 24 cms. (4 X (3+3) = 24 cms).

This study is designed to measure the length of semitendinosus in fresh cadaver and correlate that to the total length and leg length of the cadaver.

Materials and Methods

We measured the length of semitendinosus in fresh cadavers without knee injuries from the Forensic Department, King Chulalongkorn Memorial Hospital. The total number were 16 cadavers 14 males and 2 females. True leg length which is the length from anterior superior iliac spine to ipsilateral medial malleolus and the length of semitendinosus tendon from pes ancerinus insertion to myotendinus junction and the cadaver body length from head to sole were measured.

An unpaired t-test was used to compare means between groups. A significant difference was defined as a p-value of less than 0.05. And the

correlation analysis was used to predict the relationship of tendon length to body and true leg lengths.

Results

The total number were 16 cadavers which included 14 males and 2 females. The average age was 30.3 years old. All the cases had died from accident related causes. The average total length of cadavers was 164 cms. (156 -170 cms). The average true leg length was 82.06 cms. (78 - 84 cms) and the average semitendinosus tendon length was 25.41 cms. (Table 1). Table 2 reveals the correlation between the length of the semitendinosus tendon to total body length.

We found that at the cadaveric length of 160, 162, 164 and 165 cms, the semitendinosus grafts of each had a different length with the value of 0.001, 0.032, 0.012 and 0.002 respectively (Table 2). However at the cadaveric body length of 160 cms, the semitendinosus graft had a very significant difference of tendon length ($p < 0.001$), so we set a cut off value at the cadaveric body length of 160 cms.

Table 1. General data mean and standard deviation of the samples.

No.	SEX	AGE (Yrs.)	BL (cms)	LL (cms)	TL (cms)
1	M	34	156	78	22.5
2	M	28	160	81	22
3	M	26	160	82	26
4	M	28	160	81	22
5	F	20	162	80	26
6	M	34	162	82	25.5
7	F	30	162	80	26
8	M	34	162	82	25.5
9	M	24	164	82	24.5
10	M	30	165	83	25
11	M	40	166	84	28
12	M	31	167	83	26
13	M	35	168	83	26
14	M	37	170	84	27.5
15	M	26	170	84	27
16	M	28	170	84	27
MEAN		30.31	164.00	82.06	25.41
STANDARD DEVIATION		5.17	4.21	1.73	1.84

Note: BL, Body length; LL, Leg length; TL, Tendon length.

Table 2. Stratified data to reveal the significance of semitendinosus length.

Body length (cms)	Number	Tendon length	P value
≤ 160	4	23.13 ± 1.93	0.001*
> 160	12	26.17 ± 1.03	
≤ 162	8	24.44 ± 1.90	0.032*
> 162	8	26.38 ± 1.22	
≤ 164	9	24.44 ± 1.78	0.012*
> 164	7	26.64 ± 1.03	
≤ 165	10	24.5 ± 1.68	0.002*
>165	6	26.92 ± 0.80	
≤ 166	11	24.82 ± 1.91	0.054
> 166	5	26.70 ± 0.67	
≤ 167	12	24.92 ± 1.86	0.062
> 167	4	26.88 ± 0.63	

*significant difference

The cadavers were divided into two groups; one shorter than 160 cms. and one longer than 160 cms. The mean and standard deviation of cadaveric body length, leg length and semitendinosus tendon length of each group were analyzed. All variables of both groups were significantly different. (Table 3).

Furthermore, using the correlatoin analysis, there was correlation between the semitendinosus length to body and true leg lengths (r = 0.741, 0.683 respectively) as shown in figure1 and 2.

Table 3. Data reveal the mean and standard deviation of body, leg and tendon length of sample between two groups (body length 160 cms. cut off level) .

Variables	Group1 (≤ 160 cms.)	Group2 (>160 cms.)	P value
Age (yr)	29.0 ± 3.46	30.75 ± 5.69	0.576
Body length (cms)	159.0 ± 2.0	165.67 ± 3.31	0.002*
Leg length (cms)	80.5 ± 1.73	82.58 ± 1.44	0.031*
Tendon length (cms)	23.13 ± 1.93	26.17 ± 1.03	0.001*

*significant difference

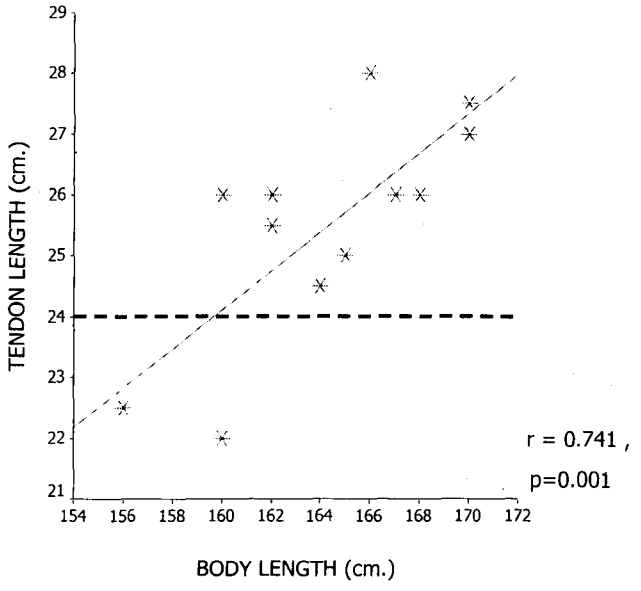

Figure 1. The relationship between tendon length and body length.

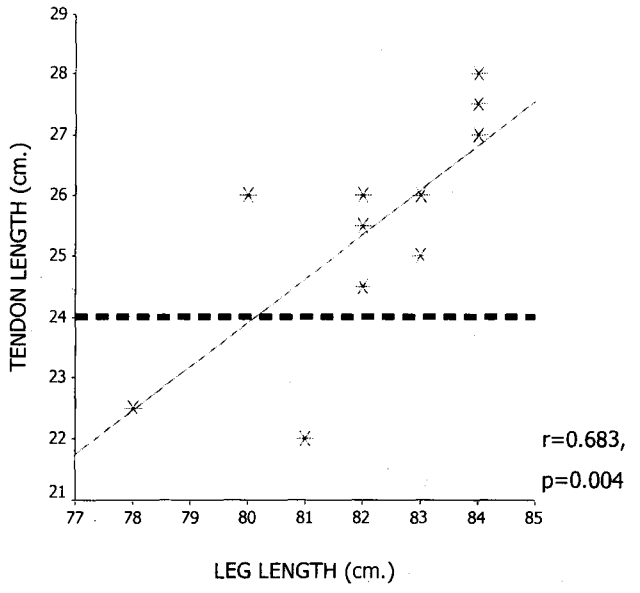

Figure 2. The relationship between tendon length and true leg length.

Discussion

It is widely accepted that the common autogenous donor site of graft for ACL reconstruction are bone patella tendon bone and semitendinosus graft. Each type of graft has individualized advantages such as the healing process or ligamentization, donor site morbidity, appropriate fixation technique to the graft and graft strength.[11] Semitendinosus graft is an alternative for donors in ACL reconstruction due to less donor site pain, less quadriceps atrophy common to bone patella tendon bone graft.[5] However some draw backs of semitendinosus graft for ACL reconstruction exist such as the reliability of graft recipient tunnel ligamentization. Other than that the amount of available donor is not only limited by the diameter of the tendon but also by the length of the tendon itself.

The results from this study revealed that the average of semitendinosus in Thai cadavers samples was 25.4 cms. with the average height of 164 cms. (Table I) which is much less than the study of Noyes et al.[7] He concluded that the average length of the tendon was 36.3 cms. whereas the average height of his specimens was 173 cms. The reason for the different amounts might be due to the demographic distributive difference of the location for specimen taking and the difference is body length of the specimens.

After we divided the specimens into two groups at the 160 cms. cut off height and compared the mean of semitendinosus length between both groups, we found that the semitendinosus length in specimens shorter than 160 cms, would be less than the ones whose length was significantly higher than 160 cms. ($p < 0.001$) (23.13 ± 1.93, 26.17 ± 1.03 cms. respectively). We determine that the minimum requirement of semitendinosus graft is 24 cms. (four strands,double loop), which is the minimum length to

replace the original ACL. From figure 1 and 2, If the length of graft is at least 24 cms., the minimum height for the patient should be 160 cms, and the true leg length of the patient should be 80 cms.

The suggestion from this study is that the surgeon should be aware that there are minimum length requirements for semitendinosus graft harvesting for ACL reconstruction in patients shorter than 160 cms. or leg lengths less than 80 cms. He might use other sites for donor grafts such as bone patella bone graft or semitendinosus in conjunction with gracilis instead of a single semitendinosus graft for ACL reconstruction.[12] Due to the limited in the number of specimens from our study, this is a preliminary report which will be extended for further study soon.

Anyway to achieve the best result from ACL reconstruction many other factors should be considered such as surgical technique, correct fixation site, correct adjustment of graft tension, post operative protection allowing time for remodelling, and a careful rehabilitation program.[1,7]

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