

# Morphometric Study of the Semitendinosus Muscle; A Cadaver Study

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**Abstract:** ***Objective:** The purpose of this anatomical study was to explore the morphological, parameters, topography and diameter of neurovascular pedicles of the semitendinosus muscle. **Materials and Methods:** The study was conducted on 46 formalin fixed adult human cadaveric lower limbs (20 right and 26 left), at the Department of Human Anatomy, Faculty of Medicine, Umm al Qura University, Makkah- Saudi Arabia. The semitendinosus muscle was dissected and studied regarding its origin, insertion, parameters and the number and points of entry of the supplying nerves and diameters of arteries just before entry to the semitendinosus muscle. **Results:** The mean width of ST fleshy part near origin, at middle and before overlap part were  $2.07 \pm 0.41$ ,  $3.01 \pm 0.48$ ,  $2.46 \pm 0.44$  cm respectively. ST muscle thickness mean of fleshy and tendentious parts were  $1.45 \pm 0.28$ ,  $0.39 \pm 0.53$  cm respectively. 1-3 neurovascular pedicles entering into the ST muscle. The distance of the entry of neurovascular pedicle to the ST muscle from ischial tuberosity was ranging between 7.2 to 27.8 cm. It was observed that the neurovascular pedicles were highest (41.3%) at the range of 15.1–20.0 cm away from the ischial tuberosity. The diameter of the neurovascular pedicle at their entrance into the ST muscle was ranging between 0.05 and 0.2 cm and the main pedicles diameter were 0.2 cm. ST muscle innervate by the sciatic nerve, in 82.4% received one branch, 17.4 % supplied by two branches. The present study revealed insignificant statistically difference between FP length, Overlap length, Tendon length, FP thickness, Tendon thickness, FP width near origin, FP width at middle, FP width before tendon and the side of ST muscle or gender. There were moderate correlation between tendon length, FP width near origin, FP width at middle, FP width before tendon and the total length of the lower limb in ST muscle. **Conclusion:** The semitendinosus tendon remains a popular graft for many reconstructive procedures, including anterior cruciate ligament reconstruction. The muscle is suggested to fulfill the criteria of muscle transposition for anal neosphincter formation.*

**Keywords:** Semitendinosus, Morphometric, Blood supply, Surgical uses, Gender

## 1. Introduction

The semitendinosus is one of the hamstrings muscles, a long superficial muscle lies posterior and medial in the thigh, superficial to the semimembranosus. It's origin from the lower and medial impression on the upper part of the ischial tuberosity, by a short tendon with the long head of the biceps femoris muscle. It also arises from an aponeurosis which connects the adjacent surfaces of the two muscles to the extent of about 7.5 cm. from their origin (1).

It's fleshy part is spindle-shaped and ends a little below the middle of the thigh in a long round tendon which path through the medial aspect of the popliteal fossa, it then bend over the medial condyle of the tibia and is inserted into the upper part of the medial surface of the tibia. At its insertion it gives off a prolongation to the deep fascia of the leg and lies behind the tendon of the Sartorius, and below that of the gracilis, to which it is united to form pesanserinus[1,2].

Semitendinosus muscle receive arterial blood by several arteries, the main two are branches from medial circumflex femoral artery and the first perforating arteries. It's innervation by the tibial division of the sciatic nerve [1].

Several surgical strategies exist for the treatment of an anterior cruciate ligament lesion, one of which by using the Semitendinosus and Gracilis muscles tendons for intra-articular reconstruction [3,4]. It's tendon was used for acromioclavicular reconstruction[5], tears of tendo-calcaneus[6] and reconstruction of lateral ligaments of the

ankle joint[7]. Preoperative estimation of the length and diameter of the semitendinosus tendons can assist surgeons and allow them to have the opportunity to choose alternative grafts[4]. There are limited high-level studies, data reported in the literature concerning the semitendinosus muscle morphometric which can be useful for decision-making criteria for the management of the graft surgery.

## 2. Materials and Methods

The study was conducted on 46 formalin fixed adult human cadaveric lower limbs (20 right and 26 left), at the Department of Human Anatomy, Faculty of Medicine, Umm al Qura University, Makkah- Saudi Arabia.

The lower extremities were already disarticulated, dissected and were stored in a formalin tanks. Muscle fasciae were removed and specimens will be checked that they had no surgery or congenital deformities involving the area under study.

The length of the lower limb (from antero- superior iliac spine to lateral malleolus) was measured. The length of the hall ST muscle, fleshy, overlapping parts and its tendon were measured as separate. The length of the muscle fleshy part was measured at the midpoint from its origin on the ischial tuberosity. The overlap part as well the tendon were measured (Fig. 1). This measurement was performed by using a measuring tape. The length of the tendon of the ST muscle was measured from the end of the overlapping part until its insertion into the supero-medial surface of the tibia

at the pesanserinus formation (Fig. 1). Linear measurements of ST fleshy width near origin, at middle and before overlap part, ST fleshy thickness, ST tendon thickness, ST+ Biceps femoris aponeurosis length together at origin, ST+BIC width together, Distance of tendon insertion from anterior tibial border, were done by using Vernier caliper (General Tools Mfg. Co. LLC New York, NK 10013).

The number of neurovascular pedicles entering into the ST muscle (Fig. 2) were counted in each lower limb, distance of them from the origin of the ST muscle (by tape) and their diameters were measured by using Vernier caliper (General Tools Mfg. Co. LLC New York, NK 10013).

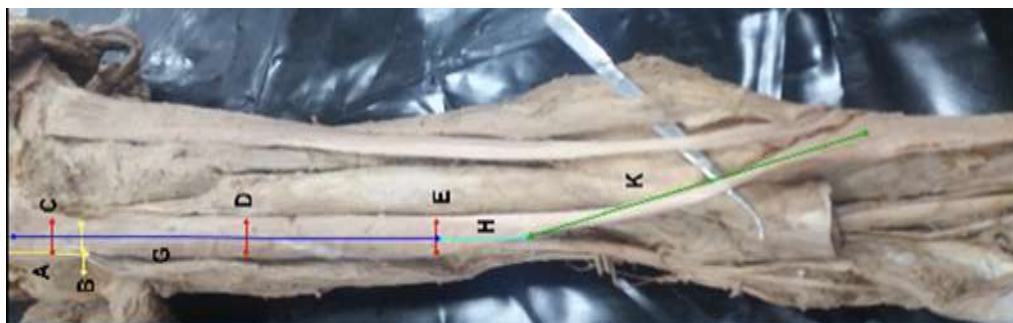
All the measurements were recorded in centimeters. Each of the measurements were performed by three authors. The average of the three measurements were obtained and tabulated for the data analysis.

**Ethical consent:** The study was approved by the biomedical ethics committee, faculty of medicine, umm Al-Qura University, Makkah, Saudi Arabia.

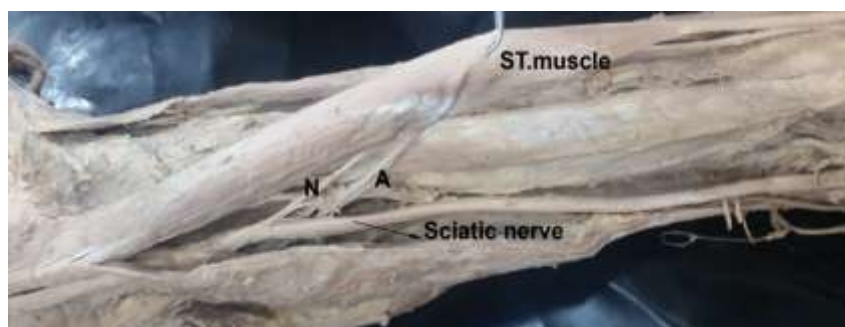
**Statistical analysis:** For all statistical analyses the SPSS statistical software version 15 was used. The ANOVA and person chi square tests were used and P. values of 0.05 or less were regarded as statistically significant.

**Table 1:** Morphometric data obtained in the present study for semitendinosus muscle (ST)

Measurements	Mean	STD	Minimum	Maximum
Lower limbs length	89.748	5.9621	79.9	99.1
ST muscles length	48.50	3.70773	41.80	56.30
ST fleshy length	21.4739	2.10804	17.70	25.40
ST overlap length	11.4391	2.32041	6.80	15.40
ST tendon length	15.5739	2.70676	10.50	22.30
ST fleshy width near origin	2.0674	0.41275	1.20	3.00
ST fleshy width at middle	3.0065	0.48390	2.10	3.90
ST fleshy width before overlap part	2.4565	0.44192	1.90	3.30
ST fleshy thickness	1.4543	0.28680	1.10	2.00
ST tendon thickness	0.3870	0.5269	0.30	0.50
Distance of main pedicle from ST origin	17.9217	2.5879	13.50	23.50
ST+ Biceps femoris (BIC) width together	2.7304	0.40360	1.70	3.40
ST+ BICaponeurosis length together at origin	7.5804	0.65483	7.00	9.40
Distance of tendon insertion from anterior tibial border	1.9217	0.28716	1.60	2.60



**Figure 1:** Measurements performed in the present study: ST+ BICaponeurosis length together at origin (A- yellow), ST+ BIC width together (B- yellow), ST fleshy width near origin (C- red), ST fleshy width at middle (D- red), ST fleshy width before overlap part (E- red), ST fleshy length (G- blue), ST overlap length (H- light blue), ST tendon length (K- green).



**Figure 2:** Neurovascular pedicles entering into the semitendinosus (ST) muscle. Its nerve (N) is branch from the sciatic nerve. The main artery (A) accompanying with two veins.

### 3. Results

This study revealed that, the mean of lower limbs length was  $89.75 \pm 5.96$  cm. ST muscle mean of total length, fleshy part length, overlap length, tendon length measured  $48.50 \pm 3.71$ ,

$21.47 \pm 2.11$ ,  $11.44 \pm 2.32$  and  $15.57 \pm 2.71$  cm respectively (Table 1). The data are given in their frequency of range in Table 1.

The mean width of ST fleshy part linear measurement: near origin, at middle and before overlap part were  $2.07 \pm 0.41$ ,  $3.01 \pm 0.48$ ,  $2.46 \pm 0.44$  cm respectively (Table 1). ST muscle thickness mean of fleshy and tendentious parts were  $1.45 \pm 0.28$ ,  $0.39 \pm 0.53$  cm respectively (Table 1).

ST+BIC width together at their origin was  $2.73 \pm 0.53$  cm, while their length was  $7.58 \pm 0.65$  cm (Table 1). Insertion of ST muscle by the tendon, into the upper part of the medial surface of the tibia. The mean distance of tendon insertion from anterior tibial border was  $1.92 \pm 0.29$  cm (Table 1). The ST muscle tendon expanded to deep fascia of the leg and gracilis muscle.

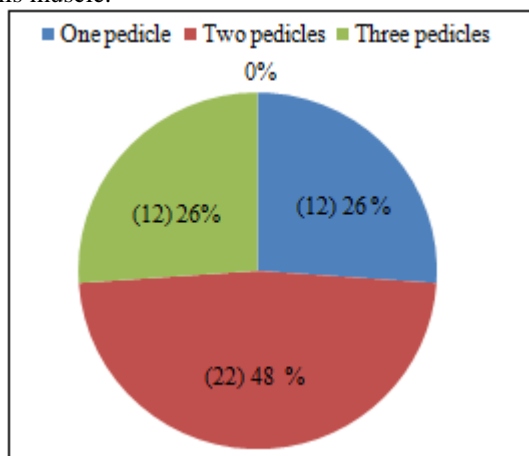


Figure 3: Frequency of the neurovascular pedicles number entering the semitendinosus muscle (n=46).

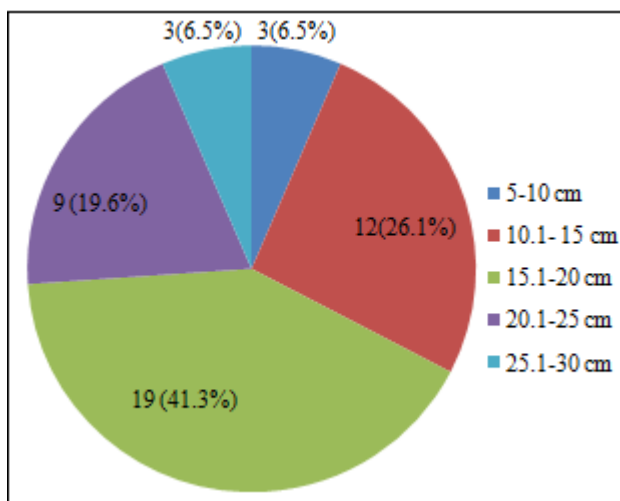


Figure 4: Frequency of distance of neurovascular pedicles entering into the semitendinosus muscle from the ischial tuberosity

The neurovascular pedicles number entering into the ST muscle were ranging between 1 and 3 and represented in Fig. 3. The distance of the entry of neurovascular pedicle to the ST muscle from ischial tuberosity was ranging between 7.2 to 27.8 cm. The frequency of range of distance of neurovascular pedicles from the origin of ST muscle (from the ischial tuberosity) is being represented in Fig. 4. It was observed that the neurovascular pedicles were highest (41.3%) at the range of 15.1–20.0 cm away from the ischial tuberosity. The diameter of the neurovascular pedicle at their entrance into the ST muscle was ranging between 0.05 and 0.2 cm and the main pedicles diameter were 0.2 cm, it is

accompanying by two veins. ST muscle innervation by the sciatic nerve in all studied specimens [Fig.2]. Regarding the nerve supply of the muscle, in 82.4% of the cases, the muscle received one branch that entered the muscle  $15.42 \pm 0.71$  cm from the origin of ST muscle (ischial tuberosity). In 17.4% of the cases, the muscle was supplied by two branches arising from the sciatic nerve and they entered the muscle  $15.5 \pm 0.65$  cm and  $24.4 \pm 0.43$  cm respectively, from the origin of ST muscle (ischial tuberosity).

The present study revealed insignificant statistically difference between FP length, Overlap length, Tendon length, FP thickness, Tendon thickness, FP width near origin, FP width at middle, FP width before tendon and the side of ST muscle or gender ( $P > 0.05$ ). These are being represented in Tables 2,3,4,5.

Table 6 showing that, There were moderate correlation between tendon length, FP width near origin, FP width at middle, FP width before tendon and the total length of the lower limb in ST muscle.

Table 2: The parameters of the fleshy, overlapping and tendentious parts of ST muscle in left side, both genders and their significance

	Female	Male	Significance
FP length	$20.82 \pm 1.69$	$21.73 \pm 2.45$	0.46
Overlap length	$12.32 \pm 2.75$	$12.26 \pm 2.62$	0.97
Tendon length	$14.13 \pm 1.67$	$16.74 \pm 2.82$	0.07
FP thickness	$1.39 \pm 0.27$	$1.55 \pm 0.37$	0.40
Tendon thickness	$0.37 \pm 0.04$	$0.41 \pm 0.06$	0.11
FP width near origin	$1.94 \pm 0.45$	$2.09 \pm 0.28$	0.49
FP width at middle	$2.68 \pm 0.56$	$3.19 \pm 0.40$	0.09
FP width before tendon	$2.33 \pm 0.49$	$2.64 \pm 0.33$	0.21

Table 3: The parameters of the fleshy, overlapping and tendentious parts of ST muscle in right side, both genders and their significance

	Female	Male	Significance
FP length	$22.90 \pm 2.24$	$20.44 \pm 1.47$	0.08
Overlap length	$9.32 \pm 5.38$	$11.32 \pm 2.03$	0.46
Tendon length	$14.88 \pm 3.00$	$16.56 \pm 2.96$	0.40
FP thickness	$1.48 \pm 0.29$	$1.49 \pm 0.23$	0.95
Tendon thickness	$0.38 \pm 0.06$	$0.50 \pm 0.20$	0.24
FP width near origin	$2.04 \pm 0.65$	$2.22 \pm 0.30$	0.59
FP width at middle	$2.91 \pm 0.58$	$2.94 \pm 0.28$	0.92
FP width before tendon	$2.46 \pm 0.54$	$2.47 \pm 0.72$	0.98

Table 4: The parameters of the fleshy, overlapping and tendentious parts of ST muscle in female, right and left sides and their significance

	Right	Left	Significance
FP length	$22.90 \pm 2.24$	$20.82 \pm 1.69$	0.32
Overlap length	$9.32 \pm 5.38$	$12.32 \pm 2.75$	0.52
Tendon length	$14.88 \pm 3.00$	$14.13 \pm 1.67$	0.92
FP thickness	$1.48 \pm 0.29$	$1.39 \pm 0.27$	0.76
Tendon thickness	$0.38 \pm 0.06$	$0.37 \pm 0.04$	0.31
FP width near origin	$2.04 \pm 0.65$	$1.94 \pm 0.45$	0.45
FP width at middle	$2.91 \pm 0.58$	$2.68 \pm 0.56$	0.27
FP width before tendon	$2.46 \pm 0.54$	$2.33 \pm 0.49$	0.60

**Table 5:** The parameters of the fleshy, overlapping and tendentious parts of ST muscle in male, right and left sides and their significance

	Right	Left	Significance
FP length	20.44±1.47	21.73±2.45	0.32
Overlap length	11.32±2.03	12.26±2.62	0.52
Tendon length	16.56±2.96	16.74±2.82	0.92
FP thickness	1.49±0.23	1.55±0.37	0.76
Tendon thickness	0.50±0.20	0.41±0.06	0.31
FP width near origin	2.22±0.30	2.09±0.28	0.45
FP width at middle	2.94±0.28	3.19±0.40	0.27
FP width before tendon	2.47±0.72	2.64±0.33	0.60

**Table 6:** The significance difference between the total length of the lower limb and different parameters of the semitendinosus muscle

	FP length	Overlap length	Tendon length	FP thickness	Tendon thickness	FP width near origin	FP width at middle	FP width before tendon
Lower limbs length	0.22	0.07	0.03	0.46	0.43	0.02	0.013	0.05

#### 4. Discussion

The incidence of ACLR increased in USA, mainly in younger than 20 years and older than 40 years, especially in females [8]. Conservative treatment for ACL-deficient knees shows satisfactory outcome, despite a re-injury rate [9]. Several surgical strategies used for intra-articular reconstruction of an ACL lesion. Most used are the tendons of the hamstring muscles as a source for auto graft [10]. The tendon of ST muscle give powerful strength [6]. It has been reported that the remaining portion of the ST muscle tendon regenerates after few years of harvesting [11,12]. The ST muscle graft for the anterior cruciate ligament reconstruction is usually tripled or quadrupled. This needs a graft of acceptable width and suitable length [13]. The morphometric of ST muscle, the topographic and diameter of its neurovascular knowledge illuminate to the orthopedic and plastic surgeons [14].

Major previous studies for ST muscle measurements concentrate on the length of the tendinous part during ACL operation and few of them mentioned belly parts parameter. They ignore the part where the two parts overlapping. Vadgaonkar R et.al [14], during their study on cadavers, observed that the border between the belly and its tendon in ST muscle was oblique and serrated. They call this zone as transitional zone, where in our study we mentioned it as the overlapping part of the ST muscle and we measured it as a separate part. The present study shows that, ST muscle mean of total length, fleshy part length, overlap length, tendon length measured 48.50±3.71, 21.47±2.11, 11.44±2.32 and 15.57±2.71 cm respectively. These findings are similar to the data mentioned by Vadgaonkar R et.al [14], in which ST muscle mean of total length, belly part length, tendon length measured 48.71, 33.23 and 15.48 cm respectively. We believe that they considered the fleshy part length and overlap length as belly part length. The length of the ST muscle tendon in this study is lesser in comparison to what mentioned from Brazilian [4], Japanese [16] populations and Elbarrany WG et. al

study [17]; 28.75, 23.5, 25cm respectively. We believe that it is due to the variation in the measurement performance and they considered the tendinous part length and overlap length as tendon length.

The present study revealed that: ST muscle thickness mean of tendentious parts was 0.39±0.53 cm (range 0.3-0.5) after removal of its covering fascia, while Elbarrany WG et. al. [17] preserved its covering sheath and the diameter was 7±0.12mm (range 5-9.4).

The fleshy part of ST muscle was used by Guelinckx PJ et.al. [18], Doust R and Sullivan M [19] for anal sphincter repair in dog. Zailani MHM et.al. [20] describe a modified technique of dynamic graciloplasty as neoanal sphincter for the treatment of severe faecal incontinence. Rab M et.al. [21] reached to conclusion that, semitendinosus seems suitable to serve as an alternative to gracilis. In our knowledge by literature review no previous studies concerning the width and the thickness of the fleshy part of the ST muscle. The mean width of ST fleshy part near origin, at middle and before overlap part were 2.07±0.41, 3.01±0.48, 2.46±0.44 cm respectively. ST muscle thickness mean of fleshy part was 1.45±0.28 cm. These finding may be helpful in future if we use ST muscle in grafts or anal sphincter repair in human.

The origin of the long head of the biceps femoris adjoined that of the semitendinosus from the lower and medial impression on the upper part of the ischial tuberosity. In the proximal regions of these muscles, the long head of the biceps femoris consisted of the tendinous part; however, the semitendinosus mainly consisted of the muscular part. There was aponeurosis which connects the adjacent surfaces of the two muscles to the extent of about 7.5 cm. from their origin [1,22]. In this study ST+BIC width together at their origin was 2.73±0.53 cm, while the aponeurosis length which connects the adjacent surfaces of the two muscles together was 7.58±0.65 cm.

The ST muscle tendon expanded before its final insertion to deep fascia of the leg and gracilis muscle. This finding is similar to previous studies [1,2,17]. The mean distance of tendon insertion from anterior tibial border was 1.92±0.29 cm.

In plastic and reconstructive surgery the neurovascular pedicles of the muscle are of major importance. Regarding anal neosphincter formation, semitendinosus offered distinct advantages in comparison with the long head of biceps femoris. Due to its vascular and nerve topography, semitendinosus seems suitable to serve as an alternative to gracilis [21]. This study revealed that the neurovascular pedicles number entering into the ST muscle were ranging between 1- 3, 48% had one pedicle, 26% had double and same percentage for three neurovascular pedicles. The distance of the entry of neurovascular pedicle to the ST muscle from ischial tuberosity was ranging between 7.2 to 27.8 cm. It was observed that the neurovascular pedicles were highest (41.3%) at the range of 15.1–20.0 cm away from the ischial tuberosity. These findings were approximately the same as what observed by Vadgaonkar R et.al. [14]. The diameter of the neurovascular pedicle at their

entrance into the ST muscle was ranging between 0.05 and 0.2 cm and the main pedicles diameter were 0.2 cm, it is accompanying by two veins. Vadgaonkar R et.al.[14] mentioned that, the mean diameter of the vascular pedicle was  $11.4 \pm 9.1$  mm, just before its entrance into the semitendinosus muscle. ST muscle innervation by the sciatic nerve, as it is mentioned in all literature.

Limitlaohaphan C et al. and Chiang et al. [15, 23], judgment that the leg length can be used to predict the graft length. Since the graft length is proportional to the height of the person, it is advisable to prepare the graft with respect to the height of the person. The radiological investigations like computed tomography and nuclear magnetic resonance can be performed to predict the length and diameter of the grafts, before the surgical procedure [4]. The present study showed that: there were moderate correlation between tendon length, FP width near origin, FP width at middle, FP width before tendon and the total length of the lower limb.

The present study revealed insignificant statistically difference between FP length, Overlap length, Tendon length, FP thickness, Tendon thickness, FP width near origin, FP width at middle, FP width before tendon and the side of ST muscle or Gender

One study carried on relatively old age of the specimens (49 to 92 years). Tuman et al [24], find that the tendons in males had a larger cross-section than those in females. There was a significant correlation between height and the cross-section of both the tendons in all the specimens, suggesting that height may be used as a predictive factor for the cross section of the tendons. They concluded that height was the best predictor of hamstring tendon diameter, particularly in women. Also Tuman et al [24] find that significant correlations between the length of the femur and the length of both tendons were only found in females, and thus height can be used as a predictive factor for the length of tendons in women only, but the reasons for these gender differences remain unclear.

Vadgaonkar R et.al [14] reported that: the statistical comparison of the length of ST muscle belly and its tendon over the right and left sides was not significant.

The current data may provide surgeons with important preoperative information about the measurements of ST grafts and would be useful for patient counseling and alternative graft source planning. However there are several anatomical issues which must be taken into account when performing semitendinosus muscle graft harvesting in order to minimize intraoperative as well as post-operative complications.

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