

## Morphometric Study and Variations in Plantaris Muscle

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### Abstract

**Introduction:** Tendon of Plantaris muscle is one of the most desirable tendon used for reconstructive surgery. Other tendons are Palmaris longus, flexors as well as extensors of fingers and long extensors of the toes. The surgeon must base his selection of the donor tendon for grafting on the basis of tendon length or width. The Plantaris muscle is considered to be the one of the easiest tendon to harvest and therefore it remains one of the ideal choices for flaps or tendon grafts. **Aims and Objectives:** 1. To study the presence or absence of Plantaris muscle. 2. To study the variations of Plantaris muscle and its tendon. 3. To compare the prevalence of absence of plantaris muscle unilaterally or bilaterally. **Materials and Methods:** The study was done on 30 cadavers in the department of anatomy at Dr SCGMC Nanded and SRTR GMC Ambajogai. Plantaris muscle is subject to variations in the form of its presence or absence and attachments. Parameters like length of muscle, length of tendon and length of belly were measured using measuring tape and belly width and tendon width were measured using digital vernier caliper and recorded bilaterally and statistically analyzed. **Observations:** It was observed that length of tendon of plantaris muscle is more than the length of belly. There is statistically significant difference in the mean value of the total length of plantaris on the right and left side. There was unilateral absence of plantaris muscle on right side in 1 male cadaver and a bilateral absence in one female cadaver. Variations in insertion of plantaris were observed, like distal part of the tendon is fused with medial margin of soleus in a female cadaver on left side. Bilateral multiple slips from the tendon, few slips inserted to deep fascia, few slips to medial margin of soleus muscle and a long slip to calcaneum in a male cadaver. **Conclusion:** Based on the morphology and prevalence of the Plantaris muscle, it is ideal for use as the tendon graft or flap in reconstructive surgery.

**Keywords:** Plantaris Muscle; Prevalence; Variations; Reconstructive Surgery.

### Introduction

The desire to replace missing tissue in the human body had existed since the beginning of the medicine [1]. The first efficient procedure of replacing mutilated nose with a tissue flap was accredited to susruta who lived in the 6<sup>th</sup> or 7<sup>th</sup> century [2].

In the 16<sup>th</sup> century the term flap originated from the Dutch word fleppe which means something that is loose and only attached by one side [3].

At the end of 19<sup>th</sup> century, physicians realized that

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by transferring tendons, functions of an extremity could be restored. The polio epidemic in Europe, in the 20<sup>th</sup> century, helped with the advancement of tendon transfers. Later tendon transfer surgery expanded not just to the patients with polio and cerebral palsy, but also to those who required reconstructive surgery for injuries during the First World War.

Tendons are frequently used for reconstructive surgery [4,5]. This includes Palmaris longus, plantaris, the long extensors of the toes and fingers [4,5,6]. The surgeon must base his selection of the donor tendon for grafting on the basis of tendon length or width. A tendon of more than 190 mm cannot be harvested from upper limb, while the lower limb can yield lengths upto 400 mm. The upper extremity can provide tendons as wide as 6 mm compared to lower limb that provides a maximum width of 4 mm. An important factor to consider is that difference in strength between 2 mm and 3 mm

tendon could be significant. Thus according to Wehbe & Mawr(1992), tendons from upper limb should be considered when strength is important and lower limb tendons when length is a factor [4].

The most desirable tendons in reconstructive surgery are of Palmaris Longus and plantaris, while the long extensors of the toes and fingers as well as the flexor digitorum superficialis are regarded as suitable.

It is said that the existence and importance of the Plantaris muscle cannot be underestimated [7]. The Plantaris tendon is a great graft than the fascia lata, because it is easy to handle, harvesting, saves time and there is less mutilation of the body [8].

#### *Aims and Objectives*

1. To study the presence or absence of Plantaris muscle.
2. To study the variations of Plantaris muscle and its tendon.
3. To compare the prevalence of absence of plantaris muscle unilaterally or bilaterally.

#### **Material and Method**

##### *Source of Data*

The present study was carried out on 30 adult cadavers of both sexes in the anatomy department at Dr. Shankarrao Chavan Government Medical College Nanded and Swami Ramanand Treeth Rural Government Medical College Ambajogai, Dist. Beed, Maharashtra.

For this, approval of Institutional Ethical Committee was taken. The study was carried out over a period of two years.

##### *Instruments Required*

Dissection set, Digital Vernier Caliper and measuring tape, digital camera.

##### *Inclusion Criteria*

Adult cadaver of both sexes without any limb deformity.

##### *Exclusion Criteria*

Cadaver having any limb deformity was excluded from the study.

#### **Method**

The study was done on 30 cadavers in the department of anatomy of Dr SCGMC NANDED and SRTR GMC Ambjogai Dist Beed Maharashtra. Cadavers were dissected by routine dissection method. The study included 25 male and 5 female cadavers.

Origin of plantaris muscle is from the inferior part of the lateral supracondylar line of the femur and oblique popliteal ligament. Insertion is on the middle one third of posterior surface of calcaneum, medial to tendocalcaneus. Measurements included the length and the width of both belly and tendon of Plantaris. The origin, insertion and possible variations were observed and documented. Total length of muscle from its origin to insertion was measured using measuring tape. Length of belly was measured by its origin to the junction of fleshy and tendinous part of the muscle. Length of tendon was measured from the junction of fleshy and tendinous part of the muscle to the point of insertion on calcaneum. Width of both belly and tendon was taken at their widest parts.

The measurements of the length was done by using the measuring tape in centimeters and width of tendon in millimeters by digital vernier caliper. Each data was recorded bilaterally. The specimens with variations were photographed. The collected data was statistically analyzed.

#### **Statistical Methods**

Results on continuous measurements are presented on Mean±SD (Min-Max) and results on categorical measurements are presented in numbers.

Unpaired t test has been used to find out the significance of study parameters on continuous scale between two groups (inter group analysis) on metric parameters.

##### *Observations*

Dissection of 30 cadavers (25 male, 5 female cadavers) revealed the following details:

There is unilateral absence of plantaris muscle in one male cadaver on right side and bilateral absence in one female cadaver.

Table 2 shows that right plantaris was present in 28 specimens, absent in 2 specimens. Mean of right total length is 41.94643 cm and SD is 4.611458 and range is 32-51. The left plantaris was present in 29 specimen, absent in 1 specimen. Mean of left total



Fig. 1: Showing Instruments used for the study

length is 41.51724cm and S.D is 3.776059 and range is 33-49.

Table 3 shows that right plantaris was present in

Table 1: Showing presence or absence of Plantaris

	Presence of Plantaris		Absence of Plantaris	
	Male(n=25)	Female(n=5)	Male(n=25)	Female(n=5)
Unilateral	24	5	1	0
Bilateral	25	4	0	1

Table 2: Comparison of total length of plantaris of both sides

	No. of specimens	Mean (cm)	Std. deviation	Minimum	Maximum
Rt total length	28	41.94643	4.611458	32	51
Lt total length	29	41.51724	3.776059	33	49

Table 3: Comparison of belly length of plantaris of both sides

	No. of specimens	Mean(cm)	Std. deviation	Minimum	Maximum
Rt belly length	28	7.453571	0.7366	6.5	9
Lt belly length	29	7.472414	0.742533	6	8.7

Table 4: Comparison of tendon length of plantaris of both sides

	No. of Specimens	Mean (cm)	Std. Deviation	Minimum	Maximum
Rt tendon length	28	34.49286	4.57877	24	43.5
Lt tendon length	29	34.04483	4.004692	24.6	42.1

Table 5: Comparison of belly width of plantaris of both sides

	No. of Specimens	Mean(mm)	Std. deviation	Minimum	Maximum
Rt belly width	28	2.064286	0.527197	1.5	3.1
Lt belly width	29	is 2.096552	0.652185	1.5	4

28 specimens, absent in 2 specimens. Mean of right belly length is 7.453571cm and SD is 0.7366 and range is 6.5-9. The left plantaris was present in 29 specimens, absent in 1 specimen. Mean of left belly length is 7.472414cm and SD is 0.742533 and range is 6-8.7.

Table 4 shows that right plantaris was present in 28 specimens, absent in 2 specimens. Mean of right tendon length is 34.49286 cm and SD is 4.57877. The left plantaris was present in 29 specimens, absent in 1 specimen. Mean of left tendon length is 34.04483cm and SD is 4.004692.

Table 5 shows that right plantaris was present in 28 specimens, absent in 2 specimens. Mean of right belly width is 2.064286cm and SD is 0.527197 and range is 1.5-3.1. The left plantaris was present in 29 specimens, absent in 1 specimen. Mean of left belly width is 2.096552 cm and SD is 0.652185 and range is 1.5-4.

Table 6 shows that right plantaris was present in 28 specimens, absent in 2 specimens. Mean of right tendon width is 3.067857 mm and SD 0.88194 and range is 1.5-4. The left plantaris was present in 29 specimens, absent in 1 specimen. Mean of left tendon width is 2.87931mm and SD is 0.907658 and range is 1.5-4.

**Table 6:** Comparison of tendon width of plantaris of both sides

	No. of Specimens	Mean(mm)	Std. deviation	Minimum	Maximum
Rt tendon width	28	3.067857	0.88194	1.5	4
Lt tendon width	29	2.87931	0.907658	1.5	4

Tendon length and belly length is normally distributed.

In the total length, there is significant difference between right and left.

Right and Left total length P value is 0.7017

Right and Left belly length P value is 0.9237

Right and Left tendon length P value is 0.6954

Right and Left belly width P value is 0.8383

Right and Left tendon width P value is 0.43

Unpaired T test was used to compare the total length, tendon length, belly length, tendon width and belly width between right and left sides and it was found that, the P value was statistically not significant for all the parameters.

By dissection method it is observed that there is unilateral (right sided) absence of plantaris in one male cadaver and bilateral absence in one female cadaver.

In plantaris when mean of all the parameters of both sides were compared, the total length, tendon length and tendon width of right side was greater than left side. Belly length and belly width were greater on left side.

The mean and range of measurements from minimum to maximum in centimeters for total plantaris muscle n=57 specimens (1 unilateral and 1 bilateral absence of plantaris) are

1. Mean Total length is 41.731835 cm (32-51 cm)
2. Mean Tendon length is 34.171785 cm (24-43.5cm)
3. Mean Belly length is 7.46299 cm (6-9cm)
4. Mean Belly width is 2.077414 cm (1.4-4 cm)
5. Mean Tendon width is 0.2982415 cm (0.15-0.5 cm)

By dissection method it is observed that there was unilateral absence of plantaris muscle in 1 male cadaver on right side and bilateral absence in one female cadaver.

Variations in insertion of plantaris were present, like small muscle belly, with thick short tendon. Distal part of the tendon is fused with medial margin of soleus in a female cadaver on left side. Bilateral multiple slips from the tendon, few slips

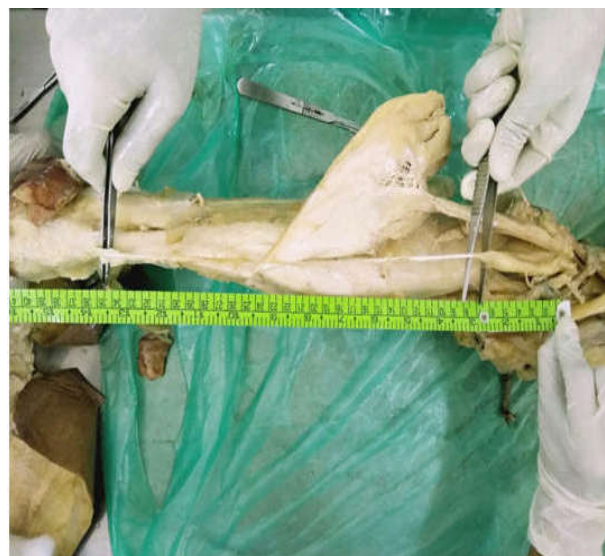
inserted to deep fascia, few slips to medial margin of soleus muscle and a long slip to calcaneum in a male cadaver.

## Discussion

Aim of this study was to study the morphology and to determine the incidence of plantaris muscle.



**Fig. 2:** Showing Belly of Plantaris



**Fig. 3:** Showing measurement of total length of plantaris



Fig. 4: Showing measurement of tendon length of plantaris

The results of above mentioned study were then compared with what has been reported in the literature in previous similar studies. From information gained from this study, we hope to help orthopaedic and plastic surgeons, using these muscles as grafts or flaps in reconstructive surgery and to make knowledgeable decision based on the morphology of these muscles as well as on the analysis of the presence and or absence of these muscles.

The plantaris muscle is vestigial and may show variation in its structure, as well as in its point of origin and insertion [5]. This is important to realize when to plan to use the plantaris tendon in reconstructive surgery. Morphology of plantaris muscle was described. However the variation described up to date, and the location of this muscle in the lower leg, could be seen as a disadvantage when using this tendon in reconstructive surgery [9,8].

Slight differences were found between the current study and that reported in the literature. The prevalence of this muscle yielded the same result when compared to past studies.

Anatomy of the plantaris muscle examined on the cadaver specimens, correlated to the studies of previous workers. In Table 7 the measurements taken for the plantaris muscle is shown and compared to the measurements found in the previous studies.

White (1960) described the tendon length (300-400) and belly length (100 mm) of the plantaris muscle[6]. Carlson and co-workers (1993) noted the length of the plantaris tendon, which averaged 334 mm [5]. Daseler, Anson (1943) and Williams(1995) described the length of plantaris belly, which ranged between 70-100 mm [11,14].

The length of the plantaris tendon measured in the present study is longer than described in the literature (334 mm). Average width of the plantaris muscle tendon was found to be 5.53mm, and based on a search of similar studies conducted in the past, to the author's knowledge this is the first study to measure the width of the plantaris tendon on a cadaver sample. The length of the belly is within the range described in the previous studies. The total length of the plantaris muscle was, on an average, 420.3mm. The length of the plantaris tendon, in the current study, meets the requirements necessary to be used as a graft in reconstructive surgery. White (1960) [6] reported the length of the muscular belly of the plantaris muscle does seldom exceed 100mm and that the length of the tendon is about three to four times longer, meaning 300-400 mm . Daseler and Anson (1943) [11] and Williams (1995)[14] and reported a belly length of between 70 mm and 100 mm.

Variations were noted in the insertion of the plantaris muscle, like short tendon, inserted either on the gastrocnemius or soleus muscle. A female cadaver had a plantaris tendon that inserted on the soleus muscle in left lower limb and a male had a similar short plantaris tendon which inserted on the medial margin of soleus and to deep fascia with splitting of the tendon.

**Table 7:** Comparison of the measurements of the plantaris muscle to that described in the previous studies. The measurements are in millimeters (mm)

	Tendon length	Tendon width	Belly length	Belly width	Total length
White (1960)6	300-400	-	100	-	-
Carlson and co-workers(1993)5	334	-	-	-	-
Williams (1995)14	-	-	70-100	-	-
Daseler and Anson(1943)11	-	-	75-100	-	-
Present study(min-max)	240-435	1.5-4	60-90	15-40	320-510

Some of the characteristics of the plantaris muscle make it a fitting donor tendon for grafting procedures [11]. The plantaris tendon can be used for a variety of reconstructions, because of its length [11,12].

#### *Prevalence of the Plantaris Muscle*

Harvey (1983) contended that the dispensability of the plantaris makes it a fitting donor tendon for reconstructive surgery [12].

However, the prevalence of this muscle must first be determined before its suitability for grafting can be established. It is reported that the prevalence of the plantaris muscle may differ between different races [9].

The prevalence of the plantaris muscle was similar to what has been reported in previous studies (Table 8).

Daseler and Anson (1943) studied 750 leg specimens (375 individuals) and reported a bilateral absence of 3.5% [11]. When looking at all the studies done on the prevalence of the plantaris muscle, it is clear that the muscle is present on both sides in 83.45% of the population (1142/1369) and absent in 8.47% (116/1369). Globally the muscle is absent only on the left side in 4.31% (59/1369) and on the right side in 3.80% (52/1369). In present study plantaris is absent unilaterally on right side in 6.66% and unilaterally on left side in 3.33%. Other studies included more information regarding the morphology of the plantaris muscle, as seen in Table 7.

**Table 8:** Prevalence of the plantaris muscle, a comparison between different studies

Author	Total sample	Present bilaterally		Absent bilaterally		Unilateral absence (left)		Unilateral absence (right)	
		N	%	N	%	N	%	N	%
Daseler & Anson (1943)11	375	338	90.13	13	3.46	18	4.8	6	1.6
Harvey et al.,(1983)12	658	502	76.29	84	12.77	32	4.86	40	6.08
Vanderhooft (1996)10	186	174	93.55	6	3.23	4	2.15	2	1.08
Present study	30	29	96.6	1	3.33	1	3.33	2	6.66

## Conclusion

Plantaris muscle is a muscle of superficial flexor compartment of the leg. It is one of the most variable muscle in human body, not only in terms of absence but also in terms of its muscle variation. It is phylogenetically classified as retrogressive muscle as it has short belly and long tendon.

It has been the subject of several cadaveric as well as in vivo studies because of its clinical importance as donor tendon. Although it is well known that there is wide variation in the reported prevalence of absence or plantaris absence in different ethnic groups, it is clear that a standard prevalence of absence of plantaris muscle cannot be applied to all population.

Variation in form and attachment of the plantaris was found in one male cadaver and one female cadaver. Absence of plantaris unilaterally on right side in a male cadavers 3.3%. Knowledge of these variations are important before harvesting the tendon for graft. Plantaris tendon length and total length is normally distributed. And in total length, there is significant difference between right and left.

## Summary

Plantaris muscle is a muscle of the posterior (flexor) compartment of leg. In the plantaris muscle, muscular belly ends in a long, slender tendon which descends between the gastrocnemius and soleus muscles, towards the medial border of the calcaneal tendon. The plantaris muscle is vestigial and subject to variation that may be brought about by "functional evolutionary influences".

The study was done in the department of anatomy at Dr. Shankarrao Chavan Govt. Medical College, Nanded and SRTR Govt. Medical College Ambajogai. Cadavers were dissected by routine dissection method. The sample included 25 male and 5 female cadavers. Variations were noted and photographed. Measurements of tendon length, tendon width, belly length, belly width and total length were obtained for plantaris muscle and results were statistically analyzed by unpaired t test and excel sheet.

There was unilateral absence of plantaris muscle on right side in a male cadaver. Percentage of unilateral absence is 3.3% and a bilateral absence of plantaris muscle in a female cadaver. Percentage of

bilateral absence is 3.33%. Upon investigation of the prevalence of plantaris muscle, it was found that the percentage values, obtained in this study, correlated well with what has been reported in the literature.

Variations in insertion of plantaris were present, like small muscle belly, with thick short tendon. Distal part of the tendon is fused with medial margin of soleus in a female cadaver on left side. Bilateral multiple slips from the tendon, few slips inserted to deep fascia, few slips to medial margin of soleus muscle and a long slip to calcaneum in a male cadaver.

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