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**Original research article**

# Study of Morphometric and Anatomical Variations of Palmaris Longus and Plantaris Tendons

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**Abstract**

**Background:** Tendons are frequently used for reconstructive surgery. This includes tendons ofpalmaris longus, plantaris, the long extensors of the toes and fingers as well as the flexors of the fingers. The surgeon must base his or her selection of the donor tendon forgrafting on what is needed, for example tendon size, length, and width. The most desirable tendons in reconstructive surgery are the palmaris longus and plantaris tendons. These two muscles are also considered to be the easiest tendons to harvest, and therefore they remain the ideal choices for flaps or tendon grafts**.**

**Objectives**: To determine and compare whether there is any significant difference in the prevalence of absence of these tendons among different ethnic groups .To compare the prevalence of absence in right and left sides.

**Methods:** The study was done on 30 cadavers . The palmaris longus and plantaris muscles are indeed subject to variation, whether in the general anatomy, form, attachment, actions and/or prevalence. Parameters like muscle length , tendon length, total length, of both the muscle were measured using measuring tape and the muscle width and tendon width were measured using digital vernier caliper and recorded bilaterally and statistically analysed. **Conclusion:** based on the morphology and prevalence of the palmaris longus and plantaris muscles in Bihar, they are ideal for the use of flaps and/or tendon graft in reconstructive surgery. But it is of utmost importance that the reconstructive surgeon, remember that both these muscles are subject to variation and not only will it be beneficial to employ proper detection methods to determine the viability of either muscle before considering its suitability in reconstructive surgery but also a sound knowledge of the anatomy of these muscles must be known.

**Keywords**: Palmaris Longus, Plantaris Prevalence, Variation Reconstructive Surgery.

## Introduction

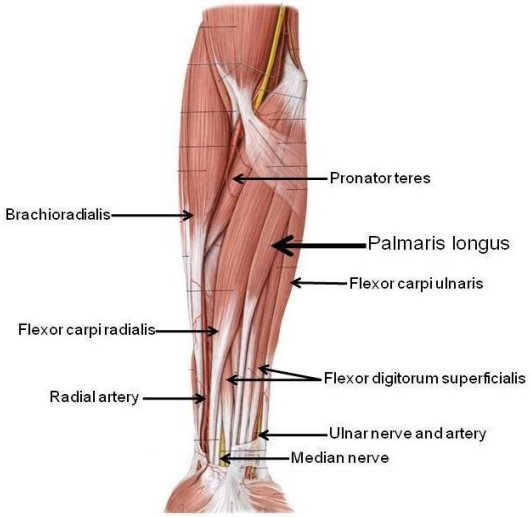
The desire to replace missing tissue in the human body had existed since the beginning of medicine[1]. The first efficient procedure of replacing a mutilated nose with a tissue flap was accredited to susruta who lived in the 6th or 7th century[2]. In the 16th century, the term flap originated from the dutch word flappe which means something that is loose and only attached by one side[3]. About 4 centuries ago, an Italian surgeon called Gaspere Taglliacozzi took a delayed flap from an arm and used it for reconstruction of the nose[2]. 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[4]. Thus all the concepts, technical abilities and the anatomical knowledge were adequetly established in the 1920s to make reconstructive surgery using flaps or tendon possible[2,4] . flaps are defined as units of tissues that can be transferred from one site to another, keeping its own blood supply. Flaps may include skin, fascia, fat, bone, muscle and viscera[3,5] and differ from grafts due to the fact that the latter is harvested without its own blood supply and, consequently depend only on the blood supply of the recipient site[3]. Five principles of the flap surgery are described in the literature to consider before performing surgery. The fourth principle stands out clearly above the rest and states that one should " steal from peter to pay paul". But this is only true if "peter" can afford it[3]. That is why a donor flap is selected for transfer because it is thought to be nonessential in its original location[6,4] , meaning that the donor site can survive without the presence of this structureand functionally is not compromised. This is the case with the plantaris and Palmaris longus muscles, which are found to be frequently absent without any adverse effects. Zeineh (2008) states one basic concept of surgery using tendon transfer, which is that a balance should be achieved in the extremity, meaning that one should strive to accomplish an equal distribution of the replacement of the tendons[4]. Other concepts of tendon transfer include the following: the function of the recipient unit is more important than the donor unit[6], the donor tendon should have adequate strength and work capacity for its new function[6,7] and the muscle or tendon should pass in a direct line from its origin to insertion[7]. Tendons are frequently used for reconstructive surgery[6,8]. This includes Palmaris longus , plantaris, the long extensors of the toes and fingers[9,6,8]. The surgeon must base his or her selection of the donor tendon for grafting on what is needed, for example tendon size, length, and width. A tendon of more than 190mm cannot be harvested from the 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 of width of 4 mm. An important factor to consider is that a difference in strength between a 2 mm and a 3 mm tendon could be significant. When one take a closer look at the Palmaris longus tendon its superficial location makes the process of harvesting easier and these makes the procedure less complicated and safer[10]. It is also said to be a dispensable tendon, whichwill not affect the function of the wrist significantely[10]. Kapoor and co-workers (2008) is of the opinion that the Palmaris longus tendon has little functional use to the upper limb in humans, but has great significance when used as a donor tendon in reconstructive surgery[11].

## Objectives

To study the presence, variations and relationship between palmaris longusandplantaris tendons .To obtain data of dimensions of these tendons to evaluate the adequacy for grafting which will be helpful for surgeons. To determine and compare whether there is any significant difference in theprevalence of absence of these tendons among different ethnic groups .

## Review of Literature

The Palmaris longus muscle is described as a slender, fusiform musclethat is found medial to the flexor carpi radialis muscle in the anterior compartment of the forearm- meaning that the Palmaris longus muscle has a relatively short muscular belly in comparision to the length of the tendon. The Palmaris longus possesses a long tendon that has a uniform oval cross- sectional shape with an even taper along its longitudinal axis and flattens and broadens as it passess anterior to the flexor retinaculum[12]. Only a few of the tendon fibers interweave with the retinaculum. The tendon of the Palmaris longus muscle splits in the palm to form fibers that are longitudinally directed and part of the palmar aponeurosis.




**Relations of the Palmaris longus muscle in the forearm. Illustration from: Atlas of Anatomy**

The Palmaris longus muscle is subject to some anatomical variations which usually do not effect function in the patient, but are of interest for the academic researcher and reconstructive surgeon. Variations of the Palmaris longus tendon may even confuse an experienced surgeon, and one should consider this if an abnormal swelling is located in the distal aspect of the forearm . Cases were reported in the literature where the muscular belly of the Palmaris longus were found distally in the forearm, and the upper third of this muscle was tendinous [13,] This type of variation was originally described as "musculus Palmaris longus inversus" and only later was the term " reversed Palmaris longus" recognised[14]. Oommen (2002) reported such a case where the muscular belly covered the median nerve. This made it easy to mistake the Palmaris longus belly for flexor digitorum superficialis [15]. It was added that a distally placed belly of the palmaris longus muscle may present symptoms of median nerve entrapment, when the belly increases in size during exercise [16,]. Nayak *et al.,* (2008) reported a case where the long thin tendon, 15.2cm, of the Palmaris longus originated from the medial epicondyle[17]. The literature mentions muscular bellies of the Palmaris longus muscle that are located centrally in the forearm i.e., in the centre, between two tendons, Stecco *et al.,* (2009) reported a central belly of the Palmaris longus that was 120mm in length and located between a proximal tendon of 50mm and a distal tendon of 90mm another variation is the 'digastric type' of belly, with two bellies, proximal and distal, and a central tendon Carlson and co-workers (1993) even mentioned a Palmaris longus with more than one tendon. As time goes by, researchers realize that there is always a need for replacement

tissue, for example tendons, has been and will always be present. The literature indicated that there is a difference in the morphology as well as the prevalence of these muscles between different population groups or races.

**Material and methods**

The present study was carried out on 30 adult cadavers of both sexes of Anatomy department of, Indira Gandhi institute of medical sciences, Patna, and help of other medical college, patna, Bihar. Study duration of Two years. The palmaris longus and plantaris muscles are indeed subject to variation, whether in the general anatomy, form, attachment, actions and/or prevalence. Parameters like muscle length , tendon length, total length, of both the muscle were measured using measuring tape and the muscle width and tendon width were measured using digital vernier caliper and recorded bilaterally and statistically analysed.

**Inclusion criteria:** Adult cadavers of both sexes without any limb deformity were studied.

Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5% level of significance. The following assumptions on data are made, Assumptions: 1.Dependent variables should be normally distributed, 2. Samples drawn from the population should be random, Cases of the samples should be independent. Student t test (two tailed, independent) has been used to find the significance ofstudy parameters on continuous scale between two groups (Inter group analysis) on metric parameters. Leven1s test for homogeneity of variance has been performed to assess the homogeneity of variance. Chi-square/Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups.

**Chi-Square Test:** The chi-square test for independence is used to determine the relationship between two variables of a sample. In this context independence means that the two factors are not related. In the chi-square test for independence the degree of freedom is equal to the number of columns in the table minus one multiplied by the number of rows in the table minus one. Fisher Exact Test:

The Fisher Exact Test looks at a contingency table which displays how different treatments have produced different outcomes. Its null hypothesis is that treatments do not affect outcomes-- that the two are independent. Reject the null hypothesis (i.e., conclude treatment affects outcome) if *p* is "small".

| | **Class1** | **Class2** | **Total** |
|---|---|---|---|
| **Sample1** | a | b | **a+b** |
| **Sample2** | c | d | **c+d** |
| **Total** | **a+c** | **b+d** | **n** |

**Comparison of Tendon length of Palmaris longus of both sides**

| | **No. Of specimens** | **Mean (cms)** | **Std. Deviation** | **Minimum (cms)** | **Maximum (cms)** |
|---|---|---|---|---|---|
| **Rt_TENDON_LENGTH** | 28 | 13.0143 | 2.06393 | 9.00 | **18.00** |
| **Lt_TENDON_LENGTH** | **29** | **12.9207** | **1.85460** | **9.00** | **16.00** |

**Table 1: Distribution of the Study population by Gender and Age Groups**

| Age Group | Sex | | Total |
|---|---|---|---|
| | Male | Female | |
| 18 – 29 years | 12 (16.2%) | 5 (19.2%) | 17 (17.0%) |
| 30 – 44 years | 24 (32.4%) | 7 (26.9%) | 31 (31.0%) |
| 45 – 59 years | 18 (24.3%) | 8 (30.8%) | 26 (26.0%) |
| ≥60 years | 20 (27.0%) | 6 (23.1%) | 26 (26.0%) |
| Total | 74 (74.0%) | 26 (26.0%) | 100 (100%) |

Majority of patients were from urban areas (55%). Out of the total patients who were residents of rural areas majority were above 60 years of age. Among the residents of urban areas majority belonged to the age group of 45-59 years.

**Table 2: Distribution of the Study population by Place of Residence and AgeGroups**

| | Place of Residence | | Total |
|---|---|---|---|
| | Rural | Urban | |
| 18 – 29 years | 3 (6.7%) | 14 (25.5%) | 17 (17.0%) |
| 30 – 44 years | 16 (35.6%) | 15 (27.3%) | 31 (31.0%) |
| 45 – 59 years | 9 (20.0%) | 17 (30.9%) | 26 (26.0%) |
| ≥60 years | 17 (37.8%) | 9 (16.4%) | 26 (26.0%) |
| Total | 45 (45.0%) | 55 (55.0%) | 100 (100%) |

In the present study 51.0% patients had heartburn, Reduced appetite was the next major symptom seen in 40.0% patients, followed by nausea (33.0%), Pain abdomen (30.0%) and regurgitation (21.0%).

**Table 3: Distribution of the Study population by Gender and Smoking History**

| Gender | Smoking | | Total |
|---|---|---|---|
| | No | Yes | |
| Male | 43(58.1%) | 31(41.9%) | 74(74.0%) |
| Female | 26(100%) | 0(0%) | 26(26.0%) |
| Total | 69(69.0%) | 31(31.0%) | 100(100%) |

## Results

Illustrates that the right palmaris longus tendon was present in 28 specimens, absent in 2specimens. Mean is 13.0143 cm and S.D is 2.06393, interquartile range is 12 to 14 (Interquartile range is 25% to 75% percentile). The left palmaris longus tendon was present in 29 specimens, absent in specimen. Mean is 12.9207 cm and S.D is 1.85460, interquartile range is 9 to 16. Illustrates that the the right palmaris longus tendon was present in 28 specimens, absent in 2 specimens. Belly length mean is 11.4036 cm and S.D is 2.75647,interquartile range is 9-21.50. The left palmaris longus tendon was present in 29 specimens, absent in 1specimen. Belly length Mean is 11.1828 cm and S.D is 2.26969, interquartile range is 8 to 18.40. Illustrates that the the right palmaris longus was present in 28 specimens, absent in 2 specimens. Mean of right side total length is 23.2224 cm and S.D is 5.13086, interquartile range is 0.53-29. The left palmaris longus tendon was present in 29 specimens, absent in 1specimen. Mean of left side total length is 24.0517 cm and S.D is 2.30862, interquartile range is 19-29. Illustrates that the the right palmaris longus was present in 28 specimens, absent in 2 specimens. Mean of right tendon width is 0.5722 cm and S.D is 0.21967, interquartile range is 0.20-1.28. The left palmaris longus was present in 29 specimens, absent in 1 specimen. Mean of left tendon 0.6177 is cm and S.D is 0.18295, interquartile range is 1.28-1.31. Illustrates that the the right palmaris longus was present in 28 specimens, absent in 2 specimens. Mean of right belly width is 1.3984 cm and S.D is, 0.35026, interquartile range is 1.00-2.52. The left

palmaris longus tendon was present in29 specimens, absent in 1 specimen. Mean of left belly width is1.3677 cm and S.D is, 0.36614, interquartile range is 0.49-1.89. illustrates that 2-tailed test was used to compare the difference in the mean values of Palmaris longus Right and left belly length P value is 0.821, right and left total length P value is 0.278, right and left belly width P value is 0.839, right and left tendon width P value is 0.074. Paired sample T test was used to compare the difference in the mean values of Rt and Lt tendon lengths and P value is 0.915. Illustrates that the right plantaris was present in 29 specimens, absent in 1 specimen. Mean of right tendon length is 35.4897 cm and S.D is 5.67383 interquartile ranges are 8-40. The left plantaris was present in 30 specimens. Mean of left tendon length is 34.5167 cm and S.D is 6.86320, interquartile range is 8-41. Illustrates that the right plantaris was present in 29 specimens, absent in 1 specimen. Mean of right belly length is 7.0833 cm and S.D is 2.07798 interquartile range is 0.20-12.00. The left plantaris was present in 30 specimens. Mean of left belly length is 7.2433 cm and S.D is 1.59950, interquartile range is 4.00-11.50. Illustrates that the right plantaris was present in 29 specimens, absent in 1 specimen. Mean of right total length is 42.6448 cm and S.D is 6.86870, interquartile range is 13-49. The left plantaris was present in 30 specimens . Mean of left total length is 41.4167 cm and S.D is 8.07564, interquartile range is 12-49 illustrates that the right plantaris was present in 29 specimens, absent in 1 specimen. Mean of right belly width is 1.7014 cm and S.D is, 0.57534 interquartile range is 0.52-2.51. The left plantaris was present in 30 specimens. Meanof left belly width is 1.7303 cm and S.D is 0.58901, interquartile range is 0.52-2.80. Illustrates that the right plantaris was present in 29 specimens, absent in 1 specimen. Mean of right tendon width is 0.5297 cm and S.D is 0.11747 interquartile range is 0.3-0.82. The left plantaris was present in 30 specimens. Mean of left muscle width is 0.5009 cm and S.D is 0.13151, interquartile range is 0.30-0.79. There is a statistically significant difference in the mean value of the total length of the right and left length of plantaris muscle and the P value is 0.058. By comparing the mean of all the parameters of both the palmaris longus, the tendon length, belly length, and belly width is greater on the right side when comparedwith left side.

The total length and tendon width is greater in left side when compared with right side. 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. B/L multiple slips form the tendon, few slips inserted to deep fascia, few slips to medial margin of soleus muscle & a long slip to calcaneum in amale cadaver.

**Discussion**

The focal point of this study was to study the morphology and determine the incidence of the palmaris longus and plantaris muscles of a Bihar region. The results of the above-mentioned were then compared with what has been reported in the literature in studies done on other population groups. From the information gained from this study we hope to aid surgeons, using these muscles as grafts or flaps in reconstructive surgery, to make knowledgeable decisions based on the morphology of these muscles as well as on the analysis of the presence and/or absence of these muscles, The morphology of the palmaris longus and plantaris muscles were described and slight differences were found between the current study and that reported in the literature. The length and width of the palmaris longus tendon was also measured in paediatric patients undergoing ptosis correction[10]. The tendon lengths ranged from 90- 120 mm and the width ranged from 2-3 mm, depending on the age of the patient. Masaaki and co-workers (2001) reported that the average tendon length for adult Japanese males is 124.6 mm, 108.3 mm in females and 116.6 mm in the total sample. They further stated that the average tendon width is 4.5 mm in males, 4mm in females and 4.2 mm for the study[18]. Mobarakeh (2008) measured the tendon length and width in an Iranian population. The length of the tendon in this

study was 136.2 mm and the width was 4 mm[19]. Stecco *et al.* (2009) measured the palmaris longus muscle and found that the muscle in total was 225-315 mm long. The muscular belly measured 95-230 mm long and the tendon between 80-155 mm. It was further stated that the length of the tendon represents about half of the total length of the palmaris longus muscle[20]. Georgiev *et al*., (2009) reported a case of a male with Palmaris longus with a muscular belly, proximal and two tendons, distally on his left arm. The medial tendon inserted on the proximal aspect of the flexor retinaculum, while the lateral tendon passed superficial to the flexor retinaculum and inserted on the Palmaris aponeurosis. Although palmaris longus is completely present on both or at least one arm in 95 % of the bihar population, the presence of the palmaris longus muscle does not guarantee its usefulness in reconstructive surgery[21]; instead its usefulness is determined by the morphology of this specific muscle. Thus the palmaris longus muscle needs to be present in the patient, in order for it to be used in a reconstructive procedure. However, even if present it might still not be viable for use in reconstructive surgery, as variation in the morphology of the palmaris longus muscle was found during this study and described in the literature. The literature mentions various characteristics of the palmaris longus muscle that are disappearing with time[22,]. This includes: it was a metacarpo-phalangeal joint flexor the substitution of the distal tendon by the palmar aponeurosis and different frequencies of the muscle among different races[23]. A bilateral absence of the palmaris longus muscle was found in 5% , except for the study conducted by Kapoor *et al.* (2008) on an Indian population (bilateral absence in 17.2%) and Oluyemi *et al*., 2008 on an Nigerian population (bilateral absence in 18.75%)[24] is slightly higher when compared toprevious studies which

## Conclusion

Palmaris longus muscle is one of the common flexor muscles of the forearm and it is homologous with plantaris muscle of the leg. Both the muscles are most variable in humans. Phylogenitically classified as retrogressive muscles as both muscles have short belly and long tendon. The palmaris longus muscle is one of the most variable muscle in the human body, not only in terms of absence but also in terms of its muscle variation and anomalies. . Although these muscles may look alike, when it comes to the surgical aspect it is suggested that the palmaris longus is used when a wider tendon is preferred and the plantaris muscle when a longer tendon is needed.

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