Original Article

A Cadaveric Study for Preoperative Estimation of Length of Palmaris Longus Tendon in Reconstructive Surgeries

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Abstract

Introduction: The palmaris longus (PL) muscle is described as one of the muscles with most anatomical variations and classified as a muscle in phylogenetic regression. The aim of this study is to demonstrate that the tendon of the PL muscle can be estimated in relation to its length and width before using it as a graft in any surgical procedure. **Material and Methods:** The material for the present study consisted of 40 limbs (20 – right and 20 – left) of different age groups and sex (28 males and 12 females). The limbs were made available in the Anatomy Department for dissection purpose at Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab. The forearm length (FAL) and PL tendons length (TL) and width (TW) were measured. Degree of association between measurements was calculated by Pearson's correlation coefficient. **Results:** The mean TL and TW in male cadavers (15.918 ± 1.462 cm and 0.463 ± 0.100 cm) was more than in female cadavers (15.050 ± 1.046 cm and 0.355 ± 0.060 cm) and PL-TW was found to be statistically significant ($P < 0.001$). The mean FAL in male cadavers (23.025 ± 2.050 cm) was more than in female cadavers (20.483 ± 1.109 cm) and was found to be highly significant ($P < 0.001$). A statistically significant correlation was observed between TL and FAL in males ($P = 0.010$) and in females ($P = 0.021$). However, TW presented a statistical significance in males only ($P = 0.025$). The mean TL of the left side (15.690 ± 1.336 cm) was slightly more than the right side (15.625 ± 1.489 cm), whereas the mean TW of the right side (0.435 ± 0.099 cm) was slightly more than the left side (0.426 ± 0.108 cm). The mean FAL on the right side (22.295 ± 2.272 cm) was slightly more than the left side (22.230 ± 2.091 cm). **Discussion and Conclusion:** The statistically significant correlation observed between the PL-TL and the FAL indicates that the PL-TL can be predicted for reconstructive surgeries preoperatively.

Keywords: *Palmaris longus, reconstructive surgeries, retrogressive, tendon*

Introduction

The palmaris longus muscle (PLM), the thinnest of the superficial flexor muscles of the forearm, occupies the region between flexor carpi radialis laterally and flexor carpi ulnaris medially and lies superficial to the flexor digitorum superficialis muscle.[1] Its short, fleshy belly originates from the medial epicondyle of the humerus along with other superficial flexors, extends downward, and prolongs into a long slender tendon and the largest portion of the tendon passes distally.[2] As the tendon crosses the flexor retinaculum, it broadens out and turns into a flat sheath which then becomes incorporated into the palmar aponeurosis. A few fibers separate from the tendon and interweave with the transverse fibers of the retinaculum.[3] It is irrigated by the ulnar recurrent arteries and innervated by a single branch of the median nerve.[2]

Studies by dissection and clinical testing show the bilateral absence of PL in 8%–16% of the individuals and unilateral absence in 4%–14%.[4] The absence of PL in humans appears to be hereditary, but its genetic transmission is not clear.[5] Among vertebrates, the PL is restricted to the mammals and is well developed in those where the forelimbs are used for ambulation.[6,7] Degeneration has proceeded much further in the group of animals generally considered as phylogenetic forebears. Some remnant of it is usually present in the gibbon and orangutan but less often in the chimpanzee and ape, and it is only present in about 25% of gorillas. In this respect, the PL belongs to a group of muscles which are more degenerate in the apes and monkeys than in man.[7-9]

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In human beings, many authors consider it to be a tensor[10] of the palmar aponeurosis and that it possibly contributes to wrist flexion.[11] PLM could also contribute to thumb abduction when a slip extending from it attaches to the superficial surface of the abductor pollicis brevis muscle.[12] Morphogenetically, its tendon and muscle are developed and regulated by a HOX gene.[13,14]

PLM is considered an accessory muscle, not essential for normal function, and its absence has not been associated with loss of grip and pinch strengths,[15] and due to its topographical importance, it is used as a reference in wrist surgery.[2] Thus, this tendon is used as a graft in a large number of surgical procedures such as chronic injuries of the flexor tendons,[5,16] ligament reconstructions,[17] pulley reconstruction, ocular defects, reconstructions of ligaments of the thumb and elbow, blepharoptosis, and other surgical reconstructions.[17,18] The PLM can develop in proportion to the forearm length (FAL) genetically determined before birth.[10] The PL is also the first option in tendon graft procedures, for it fulfills the necessary criteria of length, breadth, and easy surgical accessibility as well. The purpose of this study is to measure and compare the PL-tendon length (PL-TL) and PL-tendon width (PL-TW) with FAL and to predict the sizes of these tendons preoperatively as this could ease the preoperative planning at reconstructive areas of surgery.

Material and Methods

The material for the present study consisted of 40 limbs (20 – right and 20 – left) of North Indian origin of different age groups and sex (28 males and 12 females). The limbs were made available in the Department of Anatomy for dissection purpose for the 1st-year medical students at Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab. Only those limbs which were showing complete anatomy of PLM were included in the study. Limbs with absent PLM or any other variation were excluded from the study.

The FAL, which was defined from the ulnar styloid apophysis (the styloid process of the ulna that projects from posteromedial aspect at its distal end) to the top of the olecranon, was measured. The flexor compartment of the forearm of the upper limb was dissected using standard procedure.[19] The PLM was identified and traced from its origin to its insertion with blunt dissection. The TL of the PLM was defined, in its distal part, as a point at which it crosses the distal wrist fold and in its proximal part as the most distal point between the muscle and the tendon. The measurements of the TL and TW were taken with the help of a sliding Vernier caliper, accurate to 1 mm during the course of the anatomical dissection. The FAL was measured with the help of a measuring tape and measuring scale.

Palmaris longus-tendon length

The point of measurement taken for the tendon is in proximal-distal plane from the musculotendinous junction to its distal attachment. It was marked as "AB" [Figure 1].

Palmaris longus-tendon width

It is the dimension taken in mediolateral plane at the maximum TW and marked as "CG" [Figure 2].

Forearm length

It is the dimension taken in proximal-distal plane from the top of the olecranon process to the ulnar styloid apophysis and marked as "EF" [Figure 3].

All the measurements were taken, and then, the data were stored on the computer sheet. Degree of association between measurements was calculated by Pearson's correlation coefficient. The ratio between TW and TL and FAL was evaluated using the Student's *t* statistical method.

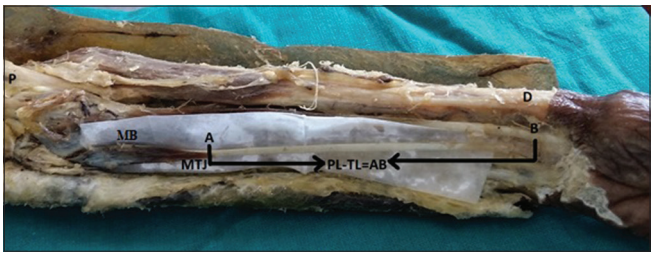

Figure 1: Length of palmaris longus tendon (PL-TL = AB) in the left upper limb. MTJ: Musculotendinous junction, MB: Muscle belly, P: Proximal, D: Distal

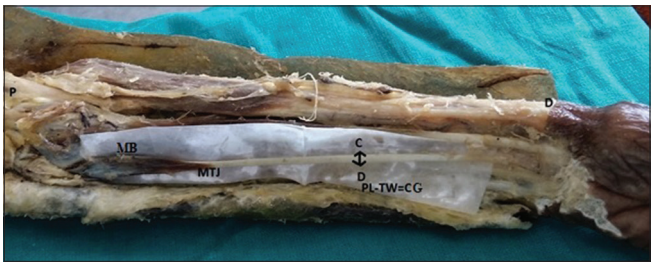

Figure 2: Width of palmaris longus tendon (PL-TW = CG) in the left upper limb. MTJ: Musculotendinous junction, MB: Muscle belly, P: Proximal, D: Distal

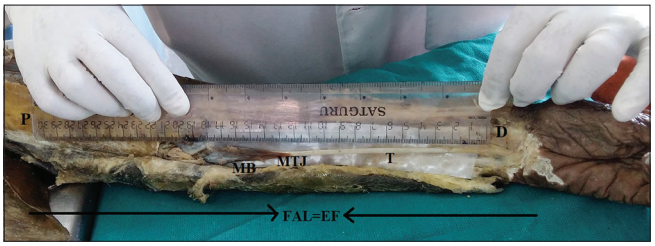

Figure 3: Measurement of forearm length (FAL = EF) in the left upper limb. MTJ: Musculotendinous junction, MB: Muscle belly, T: Tendon, P: Proximal, D: Distal

Observations and Results

The mean PL-TL and PL-TW in male cadavers were 15.918 ± 1.462 cm and 0.463 ± 0.100 cm and in female cadavers were 15.050 ± 1.046 cm and 0.355 ± 0.060 cm, respectively. These dimensions were found to be more in male cadavers than in female cadavers [Table 1].

The mean FAL in male cadavers was 23.025 ± 2.050 cm and in female cadavers was 20.483 ± 1.109 cm and was found to be more in male cadavers than in female cadavers [Table 1].

The mean PL-TL on the left side (15.690 ± 1.336 cm) was slightly more than on the right side (15.625 ± 1.489 cm)

The mean PL-TW on the right side (0.435 ± 0.099 cm) was slightly more than the left side (0.426 ± 0.108 cm) [Table 2].

The mean FAL on the right side (22.295 ± 2.272 cm) was slightly more than the mean FAL on the left side (22.230 ± 2.091 cm) [Table 2].

According to the test for equality of means of the measurements, a correlation was observed between tendon length (PL-TL), tendon width (PL-TW), and FAL between both sexes [Table 3].

Discussion

The large variations in the prevalence of the PL among humans may be indicative that this muscle is degenerating[20] and its small belly may suggest that it is a vestigial muscle.[21] Although there are several studies investigating the frequency of PL in humans, only a few studies have been done so far to measure and compare the TL and TW with FAL and to predict the sizes of these tendons preoperatively. To the best of our knowledge, this is the first study in North India. The correlation between the length or width of the extremity and the tendon to be harvested could be designated as the ratios presented, and this could ease the preoperative planning at the site of reconstructive surgery. As depicted in Table 1 that in the present study, the mean TL and TW in male cadavers (15.918 ± 1.462 cm and 0.463 ± 0.100 cm) was found to be more than in female

Table 1: Mean length and width of palmaris longus tendon and forearm length in males (28) and females (12)

Present study, 2019									
Variable	**Sex**	**Mean±SD**	**SEM**	**95% CI**		**Range**		***t***	***P***
				Lower	**Upper**	**Minimum**	**Maximum**		
TL	Male	15.918±1.462	0.276	15.35	16.48	13.20	18.80	1.856	0.071
	Female	15.050±1.046	0.302	14.39	15.71	13.30	16.40		
TW	Male	0.463±0.100	0.019	0.42	0.50	0.29	0.63	3.441	0.001*
	Female	0.355±0.060	0.017	0.32	0.39	0.29	0.47		
MBL + TL	Male	22.454±2.051	0.388	21.66	23.25	19.00	26.90	3.934	<0.001**
	Female	19.950±1.194	0.345	19.19	20.71	18.40	21.80		
FAL	Male	23.025±2.050	0.387	22.23	23.82	19.50	27.60	4.030	<0.001**
	Female	20.483±1.109	0.320	19.78	21.19	19.00	22.00		

*P<0.05; significant, **P<0.001; highly significant. Unpaired t-test: P>0.05; not significant. SD: Standard deviation, SEM: Standard error of mean, 95% CI: Confidence interval, MBL: Muscle belly length, TL: Tendon length, TW: Tendon width, FAL: Forearm length

Table 2: Mean length and width of palmaris longus tendon and forearm length on the right (20) and left (20) sides of the cadavers

Variable	**Side**	**Mean±SD**	**SEM**	**95% CI**		**Range**		***t***	***P***
				Lower	**Upper**	**Minimum**	**Maximum**		
TL	Right	15.625±1.489	0.333	14.93	16.32	13.20	18.80	0.145	0.885
	Left	15.690±1.336	0.299	15.06	16.32	13.70	18.50		
	Total	15.658±1.397	0.221	15.21	16.10	13.20	18.80		
TW	Right	0.435±0.099	0.022	0.39	0.48	0.29	0.61	0.259	0.797
	Left	0.426±0.108	0.024	0.38	0.48	0.29	0.63		
	Total	0.430±0.102	0.016	0.40	0.46	0.29	0.63		
MBL + TL	Right	21.820±2.354	0.526	20.72	22.92	18.50	26.80	0.340	0.736
	Left	21.585±2.001	0.447	20.65	22.52	18.40	26.90		
	Total	21.703±2.160	0.341	21.01	22.39	18.40	26.90		
FAL	Right	22.295±2.272	0.508	21.23	23.36	19.00	27.50	0.094	0.925
	Left	22.230±2.091	0.468	21.25	23.21	19.30	27.60		
	Total	22.263±2.156	0.341	21.57	22.95	19.00	27.60		

Unpaired t-test: P>0.05; not significant. SD: Standard deviation, SEM: Standard error of mean, 95% CI: Confidence interval, MBL: Muscle belly length, TL: Tendon length, TW: Tendon width, FAL: Forearm length

Table 3: Correlation between tendon length, tendon width, and forearm length in males (28) and females (12)

Sex	Variables	TL	TW	FAL
Males (28)	TL (*r*, *P*)	-	0.870, <0.001**	0.477, 0.010*
	TW (*r*, *P*)	-	-	0.423, 0.025*
Females (12)	TL (*r*, *P*)	-	0.294, 0.353	0.654, 0.021*
	TW (*r*, *P*)	-	-	−0.351, 0.263

**P*<0.05; significant, ***P*<0.001; highly significant. *r*: Pearson correlation coefficient, TL: Tendon length, TW: Tendon width, FAL: Forearm length

cadavers (15.050 ± 1.046 cm and 0.355 ± 0.060 cm). The differences observed in the morphometric dimensions of PL-TW in the context of gender of cadavers were found to be statistically significant. Table 1 also reveals the mean FAL in male and female cadavers. It has been observed that the mean FAL in male cadavers (23.025 ± 2.050) was found to be more than in female cadavers (20.483 ± 1.109 cm), and it was found to be highly significant (<0.001). In a study done in 2008, it was observed that the mean TL in male and female cadavers was 123.6 mm and 111.4 mm, respectively. In relation to the FAL, the mean value for the male sex was 277.5 mm, whereas for the female sex, it was 270.8mm.[22]

As can be depicted from Table 2 that in the present study, the dimensions of FAL on the right side (22.295 ± 2.272 cm) were slightly more than on the left side (22.230 ± 2.091 cm), but these differences were statistically not significant. Table 2 also reveals that the mean TL on the left side (15.690 ± 1.336 cm) was slightly more than on the right side (15.625 ± 1.489 cm), whereas the mean TW on the right side (0.435 ± 0.099 cm) was slightly more than on the left side (0.426 ± 0.108 cm), but these differences were statistically not significant. However, there was no mention of the dimensions of right- and left-side morphometry of PL in the accessible available literature.

As depicted from Table 3, according to the test for equality of means of the measurements, we found a statistically significant correlation between the length of the extremities and the length of the muscle tendons (between TL and FAL) (r = 0.477, P = 0.010* and r = 0.654, P = 0.021*) in males and females, respectively. The TW presented statistical significance in males (r = 0.423, P = 0.025) but not in females (P = 0.351, r = 0.263). Degree of association between measurements was calculated by Pearson's correlation coefficient. The present study supports the correlations formulated by Angelini Júnior (2008) who also observed that between the two sexes, there is a significant correlation between TL and FAL.[22]

Machado and DiDio,[23] Alves *et al*.,[24] and Thompson *et al*.[25] studied the frequency of the musculus PL by observing its tendon *in vivo* in 379 Amazon Indians, 200 Chilean individuals, and 300 Caucasians, respectively, where the only agenesis of PL was reported.

Clinical studies can check the presence of the PL for preoperative evaluation for harvesting grafts, yet these studies can be poorly interpreted.[15,26] Milford[27] also mentioned in his study that the PL offers a length of approximately 15 cm for grafts, but there was no mention of TW. Other authors carried out the same study on black or Japanese cadavers[10,26-29] where their main focus was on the absence or presence of PLM. The measurement of the tendon of the PLM has the advantage of allowing the estimation of its length and width before removing it for surgical graft procedures, besides favoring the possibility of making only two excisions to remove it.[22] With the present study, one can suggest the TL to be retrieved for its use in grafts.

Although PL tendons are ideal for use of flaps and tendon grafts in reconstructive surgeries, it is of utmost importance that has to be remembered that the PL muscles or tendons are subject to its variations or absence (15% cases). In cases of its absence, it can be harvested from the compatible donor as, being a vestigial tendon, it is not going to lead to any functional defect in the donor. Its superficial location makes the process of harvesting of the tendon easier and also makes the process less complicated and safer.[30] From the five principles of flap surgery described in the literature, the fourth principle stands out clearly that "one should steal from Peter to pay Paul." However, this is true if Peter can afford it,[31] that is, why a donor flap is usually selected for transfer because it is thought to be nonessential in its original location.[5] Kapoor *et al*.[32] are of opinion that the PL tendon has little functional use to the upper limb in humans but has great significance when used as a donor in reconstructive surgery. However, one basic concept of surgery using tendon transfer, a surgeon must make that the selection for donor tendon for grafting is based on tendon size, length, and width. The donor tendon should also have adequate strength and work capacity for its new function and the muscle or tendon should also pass in a direction from its origin to insertion.[5]

Conclusion

To our knowledge, this is the first study in North India to predict the size of PL tendon preoperatively. There was a statistically significant correlation observed between the TL-PL and FAL. The results indicate that one can estimate the PL-TL tendon before surgical intervention when it is necessary to use it for grafts. Even in cases of PL agenesis, a compatible donor will be the one from whom a desired TL can be harvested for reconstruction. It is also important to mention that in such cases, the donor site can survive without the presence of this structure, and functionally, it will not be compromised. Thus, being the most desirable tendon or ideal choice for tendon grafts in reconstructive surgery, a sound knowledge of anatomy of PLM and its tendon must be known.

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Conflicts of interest

There are no conflicts of interest.

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