Ultrasonograpic Assessment of Relationship Between the Palmaris Longus Tendon and the Flexor Retinacular Ligament and the Palmar Aponeurosis of the Hand

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ABSTRACT

***Aim**: This study aimed to evaluate the presence of the Palmaris Longus Tendon (PLT) and the relationship between the Flexor Retinacular Ligament (FRL) and the Palmar Aponeurosis (PA) of the hand.*

***Method**: 62 voluntary subjects (31 female, 31 male students and personnel from the Inonu University, at the average age 28.38 ± 6.86 years ranging from 19 to 48 years) took part in this study using ultrasound.*

***Result**: Significant differences were found in the PA p-m-d diameters of subjects between with and without PLT bilaterally, on the right and the left hand ($p<0.05$), whereas there was no meaningful difference considering FRL diameters ($p>0.05$). Furthermore, this ultrasonographic assessment revealed the continuity of collagen bunches of the PL tendon up to FRL, but not PA.*

***Conclusion**: Although not demonstrated by ultrasonography here, the increased thickness of the PA in subjects with a PLT supports the findings in the literature in which the structural continuity between the PLT and PA have been stressed.*

***Key words**: Palmar aponeurosis, palmaris longus tendon, flexor retinacular ligament, ultrasonography*

Palmaris longus tendon varlığı ile eldeki flexor retinacüler ligaman ve palmar aponöroz arasındaki ilişkinin USG ile değerlendirilmesi

Amaç: *Elde palmaris longus tendonunun (PLT) varlığı ile palmar aponöroz ve fleksör retinaküler ligaman (FRL) arasındaki ilişki tartışmalıdır. Bu çalışmada Palmaris longus tendonun varlığı ile eldeki flexor carpal ligaman (FCL), Palmar aponöroz (PA) arasındaki ilişkinin değerlendirilmesi amaçlanmıştır.*
Metod: *Bu çalışmaya yaşları 19- 48 arasında (ortalama yaşları 28.38 ± 6.86 yıl) olan, 31'i erkek ve bayan, toplam 62 sağlıklı gönüllü hastane ve üniversitede çalışan personel alınmıştır. Yazı yazmada kullandıkları el dominant el olarak kabul edildi.*
Bulgular:*Sağ elde, sol elde ve bilateral elde PLT olanlarla olmayanlarda karşılaştırıldığında PA p-o-d çapları bakımından anlamlı derecede fark bulunurken (p<0.05), FRL çapları bakımından anlamlı fark bulunmamıştır (p>0.05).*
Ayrıca PLT mevcut olanların tümünde, PL kollajen demetlerinin FRL ve PA'da devamlılık gösterdiği bulunmuştur.
Sonuç: *USG incelemesi ile yapılan bu çalışmada, deneklerde PLT mevcut olanlarda, olmayanlara göre PA kalınlığının anlamlı derecede daha kalın bulunması; USG ile bu tendonun FRL ile devamı gösterilmesi, fakat PA'daki devamı gösterilemese de PA'nın PLT'nun anatomik yapı olarak devamı diyen çalışmaları desteklemektedir*
Anahtar kelimeler: *Palmar aponöroz, palmaris longus tendonu, fleksör retinaküler ligaman, ultrasonografi*

INTRODUCTION

The palmaris longus tendon (PLT) and its relationship with the palmar aponeurosis (PA) remains a prominent area of research for anatomists and surgeons. Once the development of the musculus (m.) palmaris longus is understood, the foundation is laid for solving the ontogenesis of the PA and of certain other fibrous structures of the hand. Dylevsky emphasized that without knowing the ontogenesis of the long palmar muscle, the question of the phylogenesis of the PA and of the whole volar group of antebrachial muscles has not been successfully resolved. The position of this muscle allows the formation of a connecting link between the superficial structures of the palm and the superficial layer of the antebrachial muscles (1). Dylevsky studied transverse and longitudinal histological sections of hands and forearms of 32 foetuses and reported that 1) as stated before by Straus (2), the m. flexor digitorum superficialis and m. palmaris longus represent a new layer that can be found typically only in the mammalian limb; 2) the retinaculum flexorum differentiates from the ulnar side in the form of a cell band dividing into two crura at the radial margin of the canalis carpi. The superficial crus connect the anlage of the tendon of the m. palmaris longus and its distal margin with the central part of the PA. Kaplan et al. reported that the palmaris longus originates, together with the pronator teres the flexor carpi radialis, and the flexor carpi ulnaris, from the medial epicondyle of the humerus. Arising from the common tendon, the intermuscular septum, and the overlying fascia, the PLT projects distally towards the wrist, parallel with the medial side of the flexor carpi, and in or near the midpalmar fascia. The muscle belly is slender and flat; however, approximately in the middle of the forearm, it starts to form a tendon on the volar surface. The tendon, flat throughout its course, spreads out upon reaching the midpalmar fascia and continues directly into this fascia (3). As one of the most variable muscles, most anatomists agree that it is absent, either unilaterally or bilaterally, in 11-12% of the population. Since it is used in hand surgery as a source of tendon material for free tendon grafts, these variations are of the great importance (4).

The PA has a triangular shape and lies in the central area of the palm. Its apex is attached to the distal border of the flexor retinaculum and it receives the insertion of the palmaris longus tendon. At the bases of the fingers, the base of the aponeurosis divides into four slips. Each slip also divides into two bands; one going superficially to the skin and the other proceeding deeper to the roof of the finger; here, each deep band first divides into two bands, then diverges around the flexor tendons and finally fuses with the fibrous flexor sheath and the deep transverse ligaments. The palmar aponeurosis firmly attaches to the overlying skin, improving the grip and protecting the underlying tendons (5). The PA is strengthened by the insertion of the tendon of palmaris longus. Fahrer and Stranding indicated the longitudinal tensor role of the PLT on the PA and stated that, in the case of its absence, the flexor carpi ulnaris takes over this role (6,7).

The flexor retinaculum, actually a thickening of deep fascia, stretches across the front of the wrist and converts the concave anterior surface of the carpus into an osteofascial tunnel, called the Carpal Tunnel, enabling the passage of the median nerve as well as the flexor tendons of the thumb and fingers. Medially, it is attached to the pi-

Table 1. The present/absent ratios of palmaris longus in voluntary subjects

Palmaris Longus Tendon												
Right Hand				Left Hand				Bilateral Hands				
Present		Absent		Present		Absent		Present		Absent		
n	%	n	%	n	%	n	%	n	%	n	%	
34	55	28	45	33	53	29	47	29	47	24	39	

siform bone and the hook of the hamate, and laterally to the tubercle of the scaphoid and the trapezium bones (5).

This study aimed to evaluate the presence of the PLT and the relationship between the flexor retinacular ligament and the PA of the hand in 62 voluntary subjects using ultrasound.

MATERIALS AND METHODS

Sixty-two healthy voluntary subjects (31 female and 31 male students and personnel at the Inonu University, between 19 and 48 years of age (mean age 28.38 ± 6.86 years), took part in the study. Criteria for inclusion were no restriction of movement in the upper limbs and no history of any disease or injury to the upper limbs. Our institutional Ethics Committee approved the study protocol and informed consent was obtained from each patient. The dominant hand was defined as the one used for writing. Fifty-four participants were RDH, five were LDH, and three were ambidextrous.

The anatomic location of the PLT can be observed in ulnar to the flexor carpi radialis tendon. If the tendon was not readily observable, the patient was asked to oppose the thumb to the little finger while flexing the wrist to ease assessment of the PLT. The presence of the PLT was not verified by ultrasonographic examination. It was accepted as absent if the tendon was not observed or was not palpable and the presence of the PLT was assessed on both sides (8).

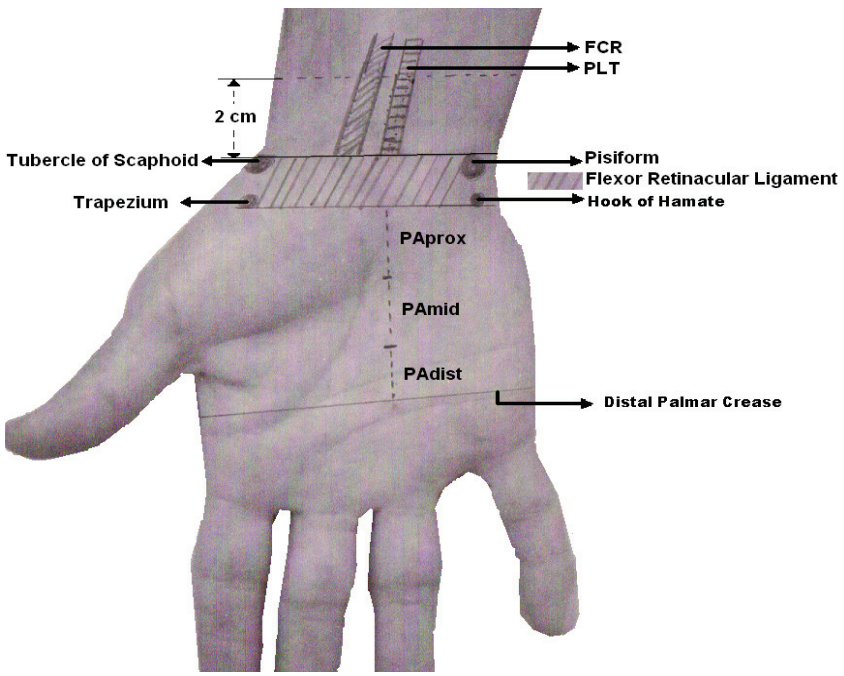

***Figure 1**. Illustrations of the landmarks used for USG measurements on the hand.*

***Table 2**. The results of the assessment the relationship among the presence of PLT, FCL and palmar aponeurosis.*

	Palmaris Longus						
	Present			Absent			
	x	s	n	x	s	n	p
PLDR	1.10	0.24	34	-	-	0	-
PLAR	0.07	0.03	34	-	-	0	-
FCRDR	1.43	0.17	34	1.42	0.23	28	0.850
FCRAR	0.11	0.03	34	0.10	0.04	28	0.154
FRLDR	0.06	0.02	34	0.07	0.02	28	0.819
PADRp	0.31	0.06	43	0.26	0.05	28	0.002
PADRm	0.54	0.14	34	0.42	0.10	28	0.001
PADRd	0.71	0.13	34	0.62	0.15	28	0.009
PLDL	1.05	0.26	33	-	-	0	-
PLAL	0.07	0.03	33	-	-	0	-
FCRDL	1.41	0.19	33	1.42	0.20	29	0.740
FCRAL	0.11	0.03	33	0.10	0.02	29	0.337
FRLDL	0.06	0.01	33	0.06	0.02	29	0.883
PADLp	0.33	0.06	33	0.26	0.06	29	0.0001
PADLm	0.57	0.15	33	0.42	0.11	29	0.0001
PADLd	0.70	0.11	33	0.61	0.15	29	0.009
PLDRb	1,13	0.26	29	-	-	0	-
PLARb	0.07	0.03	29	-	-	0	-
FCRDRb	1.44	0.16	29	1.42	0.23	24	0.776
FCRARb	0.11	0.03	29	0.10	0.04	24	0.132
FRLDRb	0.06	0.02	29	0.07	0.02	24	0.583
PADRpb	0.32	0.05	29	0.26	0.06	24	0.003
PADRmb	0.54	0.15	29	0.41	0.09	24	0.0001
PADRdb	0.70	0.12	29	0.60	0.14	24	0.012
PLDLb	1.06	0.27	29	-	-	0	-
PLALb	0.06	0.03	29	-	-	0	-
FCRDLb	1.43	0.19	29	1.39	0.18	24	0.388
FCRALb	0.12	0.03	29	0.14	0.02	24	0.075
FRLDLb	0.06	0.01	29	0.06	0.02	24	0.788
PADLpb	0.33	0.06	29	0.25	0.05	24	0.0001
PADLmb	0.58	0.15	29	0.39	0.10	24	0.0001
PADLdb	0.69	0.11	29	0.59	0.15	24	0.007

PLDR : Palmaris Longus Diameter of Right Hand
PLAR : Palmaris Longus Area of Right Hand
FCRDR : Flexor Carpi Radialis Diameter of Right Hand
FCRAR : Flexor Carpi Radialis Area of Right Hand
FRLDR : Flexor Retinacular Ligament Diameter of Right Hand
PADRp : Palmar Aponeurosis Diameter of Right Hand- proximal
PADRm : Palmar Aponeurosis Diameter of Right Hand- middle
PADRd : Palmar Aponeurosis Diameter of Right Hand- distal
PLDL : Palmaris Longus Diameter of Left Hand
PLAL : Palmaris Longus Area of Left Hand
FCRDL : Flexor Carpi Radialis Diameter of Left Hand
FCRAL : Flexor Carpi Radialis Area of Left Hand
FRLDL : Flexor Retinacular Ligament Diameter of Left Hand
PADLp : Palmar Aponeurosis Diameter of Left Hand- proximal
PADLm : Palmar Aponeurosis Diameter of Left Hand- middle
PADLd : Palmar Aponeurosis Diameter of Left Hand- distal

PLDRb : Palmaris Longus Diameter of Right Hand-bilateral
PLARb : Palmaris Longus Area of Right Hand- bilateral
FCRDRb: Flexor Carpi Radialis Diameter of Right Hand-bilateral
FCRARb: Flexor Carpi Radialis Area of Right Hand-bilateral
FRLDRb: Flexor Retinacular Ligament Diameter of Right Hand-bilateral
PADRpb: Palmar Aponeurosis Diameter of Right Hand- proximal- bilateral
PADRmb: Palmar Aponeurosis Diameter of Right Hand- middle- bilateral
PADRdb: Palmar Aponeurosis Diameter of Right Hand- distal- bilateral
PLDLb : Palmaris Longus Diameter of Left Hand-bilateral
PLALb : Palmaris Longus Area of Left Hand-bilateral
FCRDLb: Flexor Carpi Radialis Diameter of Left Hand-bilateral
FCRALb: Flexor Carpi Radialis Area of Left Hand-bilateral
FRLDLb: Flexor Retinacular Ligament Diameter of Left Hand-bilateral
PADLpb: Palmar Aponeurosis Diameter of Left Hand- proximal- bilateral
PADLmb: Palmar Aponeurosis Diameter of Left Hand- middle- bilateral
PADLdb: Palmar Aponeurosis Diameter of Left Hand- distal- bilateral

PLT diameters and spheres were measured 2 cm proximal to the wrist distal flexor crease; the FRL diameter was measured from between the scaphoid tubercule-trapezium and the pisiform-hook of the hamate; and PA diameters were measured between the lower edge of the FRL and the distal palmar crease by dividing PA into proximal (p), middle (m), and distal (d) (at the three equal distances; PAp=PAm=PAd) using the 5-10 MHz linear muscle-skeletal probe of the ultrasonograph (HDI 3500, Philips Medical Systems) device (Figure 1). With the longitudinal manipulation of 5-10 MHz ultrasonic probe on the tendon, the tendon's bunches were followed up to the FRL. However, its relation with the PLT was not evaluated owing to impossibilities of the follow-up from the end of the FRL.

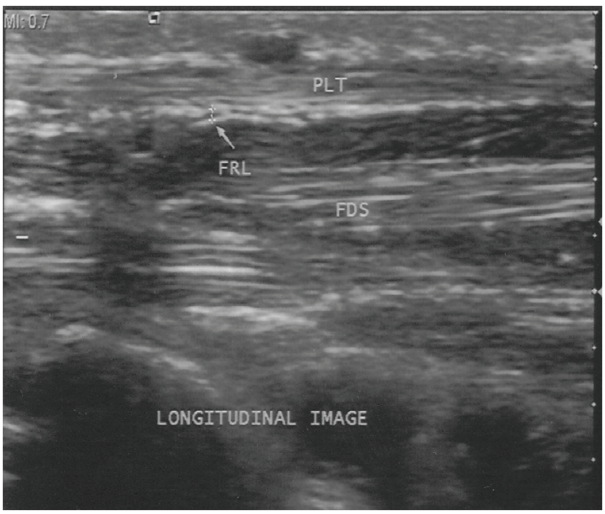

***Figure 2**. Demonstration of the PLT, FRL and PA by USG*

Statistical Analysis

SPPS for Windows 13.0 version was used to analyze the data. The Shapiro Wilks test was used to analyze normality. According to the normal distribution of variables, an unpaired t-test was performed to compare variables between the groups, and $p<0.05$ was regarded to be statistically significant.

RESULTS

Considering the dominant hands of the subjects, FRL, PA p-m-d diameters were compared between PLT diameters of the dominant and the non-dominant hands, and no meaningful difference was found between them ($p>0.05$). The PLT was absent bilaterally in 24 subjects (39%). Unilateral absence was found to be 55% and 53% for the right and left hands, respectively (Table 1). Significant differences were found in the PA p-m-d diameters of subjects with and without PLT on the right hand ($p<0.05$), whereas there was no significant difference in FRL diameters ($p>0.05$, Table 2). Similarly, significant differences were found in the PA p-m-d diameters of subjects with and without PLT on the left hand ($p<0.05$), with no significant difference in FRL diameters ($p>0.05$, Table 2). Significant differences were found in the PA p-m-d diameters of subjects with bilateral PLT compared to subjects without bilateral PLT ($p<0.05$), whereas there was no significant difference in FRL diameters ($p>0.05$, Table 2). Furthermore, this ultrasonographic assessment revealed the continuity of collagen bunches of the PL tendon up to FRL, but not PA (Figure 2).

DISCUSSION

Palmaris longus is a slender, fusiform muscle medial to the flexor carpi radialis. It proceeds from the medial epicondyle via the common tendon, adjacent intermuscular septa, and deep fascia. It converges onto a long tendon, which passes anterior to the flexor retinaculum. Despite a few fibres leaving the tendon and interweaving with the transverse fibres of the retinaculum, the majority of the tendon passes distally. As the tendon crosses the retinaculum, it expands to become a flat sheet, which incorporates into the palmar aponeurosis (7). Kaplan et al. and Snell published similar articles that indicate the PL continues as the PA (9,5). Our study revealed similar findings supporting these studies: 1.) collagen bunches of the PLT continue inside FRL, but not the PA in all subjects with a PLT; 2.) the PA thickness of subjects with a PLT is significantly greater than subjects without PLT ($p<0.05$). Consequently, we consider that the protecting effect of the PA is stronger on directly subjacent structures in people with PLT. In this event, it can be concluded that in the subjects without PLT, the thickness of the FRL increases at the beginning of life or compensation for the palmar loading forces develop later in life.

Although the PA can also be considered as a part of the palmar fascia, a distinction between them may be necessary. The palmar fascia (known as the deep fascia in other areas of the body) is a compact connective tissue covering the muscles and tendons on the palmar aspect as an extensive layer. Usually, the PA is a continuation of the PLT beyond the wrist. However, some fibres from the flexor carpi ulnaris tendon reach the proximal aspect of the PA. These fibres merge with the palmar fascia and forms a thickened sheet in the midpalm (10). However, Tubiana et al. emphasized that even if the PL is a continuity of the PA, they are totally separate structures (11). In this sense, Caughell et al. examined the PA and the PLT in 33 hands of foetuses from a gestational age of 5 weeks to term. At the 5th week of gestation, both the longitudinal and transverse layers of the PA and the PLT were present and in continuity. In five subjects, the PLT was absent and the longitudinal fibers of the PA blended into the antebrachial fascia. However, there was no difference in the structure of the PA in the presence or ab-

sence of the PLT. The PLT displayed staining characteristics of a tendon whereas the PA stained like fascia. Thus, the PA and the PLT are considered as separate anatomic structures, which develop independently and are associated only by anatomic proximity. Similarly, based on the evidence of their study on bioptic samples from normal subjects of different ages by means of optical and electron microscopic analyses and by immunocytochemistry (12). Also, Contri et al. indicated that normal aponeurotic cells cannot be regarded as typical tenocytes (13).

In our study, since ultrasonographic evidence of PA thickness of subjects with PLT is significantly higher than that of subjects without PLT, and this tendon continues up to the FRL, but not the PA, our results support previous studies suggesting that the PA is a continuity of the PLT as an anatomic structure.

Furthermore, we also suggest that the PL enhances the protecting effect of the PA primarily on the median nerve, but also on other palmar arteria and tendons as well by increasing its thickness by merging and through the pulling forces that develop the muscle. Additionally, in the subjects without PLT, the increases in FRL diameter may take on the roles of the PLT on the FRL and the PA (Figure 2).

Although not demonstrated by ultrasonography here, the increased thickness of the PA in subjects with a PLT supports the findings in the literature in which the structural continuity between the PLT and PA have been stressed.

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