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MORPHOLOGY OF THE PALMARIS LONGUS AND PLANTARIS MUSCLES EMPLOYED AS FLAPS IN RECONSTRUCTIVE SURGERY

By

Gerda Venter

Thesis submitted in fulfilment of the requirement for the degree of

MASTER OF SCIENCE

in the

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Declaration of Original Work

I, Gerda Venter, hereby declare that this thesis entitled,

MORPHOLOGY OF THE PALMARIS LONGUS AND PLANTARIS MUSCLES EMPLOYED AS FLAPS IN RECONSTRUCTIVE SURGERY

Which I herewith submit to the University of Pretoria for the Degree of Master of Science in Anatomy, is my own original work and has never been submitted for any academic award to any other tertiary institution for any degree.

_____ _____

G Venter **Date**

FOREWORD AND ACKNOWLEDGEMENTS

Firstly I would like to thank our Heavenly Father, whom without anything in life would be possible. For designing this remarkable body of ours so we as anatomists can study it.

I would also like to thank the University of Pretoria for allowing me the opportunity to do postgraduate research. I extend my appreciation furthermore to the Anatomy department for support and motivation as well as exposure to the research community, especially the following people: The technical staff, especially Mr Lewis, who was always willing to lend a helping hand during the measurements taken in this study. The second-year medical students, of 2008 and 2009, for their patience during their Block 4 dissection of the upper and lower limbs.

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On a personal note, I would like to thank my husband, Herkie for all his support and patience with me, while working on his own Master's degree. My parents and parents-in-law, for all their support throughout all my studies.

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ABSTRACT

Tendons are frequently used for reconstructive surgery. This includes palmaris 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 for grafting 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. Apart from what is mentioned in the literature, questions remain such as: which characteristics do the palmaris longus and plantaris muscles possess that make them suitable for use as flaps or grafts in reconstructive surgery and; how can knowledge of the characteristics of these muscles improve reconstructive surgery in South Africa? The palmaris longus and plantaris muscles are indeed subject to variation, whether in the general anatomy, form, attachment, actions and/or prevalence. A statistical significant difference was found between the male and female sample when considering the length of the palmaris longus muscle. When comparing the palmaris longus muscle to the plantaris muscles, it was found that there is a statistical significant difference between them as well. Therefore, 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. The prevalence of the palmaris longus and

plantaris muscles compared well with studies done on other population groups. No correlation was found between the sex of the cadaver and the prevalence of the palmaris longus and plantaris muscles. In addition it was established that there is no relationship between the prevalence of the palmaris longus and plantaris muscles in the same individual. A possible phylogenetic degenerative trend for the palmaris longus muscle was also examined. After studying various age groups, it was determined that such a trend could not be established for this sample. In conclusion, based on the morphology and prevalence of the palmaris longus and plantaris muscles in a South African population, 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, working on South African patients, 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.

OPSOMMING

Tendons word dikwels gebruik vir rekonstruktiewe chirurgie. Dit sluit die M. palmaris longus en M. plantaris, die lang ekstensors van die tone en vingers, sowel as die fleksors van die vingers in. Die chirurg moet sy of haar keuse van die skenkertendon baseer op dit wat benodig word, byvoorbeeld tendongrootte, ~lengte en ~breedte. Die mees gesogte tendons in rekonstruktiewe chirurgie is dié van M. palmaris longus en M. plantaris. Hierdie twee spiere word ook geag as die maklikste spiere om te oes / bekom, en daarom bly hulle die ideale keuse vir weefselsnitte of tendon-oorplantings. Afgesien van wat in die literatuur beskryf word, bly die volgende vrae onbeantwoord: Watter eienskappe maak M. palmaris longus en M. plantaris geskik vir die gebruik as weefselsnitte of tendon-oorplantings in rekonstruktiewe chirurgie en, hoe kan kennis van hierdie eienskappe van dié spiere, rekonstruktiewe chirurgie in Suid-Afrika verbeter? M. palmaris longus en M. plantaris is inderdaad onderworpe aan variasie van die algemene anatomie, vorm, aanhegtings, aksies en / of aanwesigheid en/of afwesigheid. 'n Statistiese beduidende verskil is gevind tussen die manlike en vroulike steekproef ten opsigte van die lengte van M. palmaris longus. M. palmaris longus is met M. plantaris ook vergelyk en daar was gevind dat

daar 'n statisties beduidende verskil tussen hierdie spiere is. Alhoewel hierdie spiere dieselfde lyk, is dit belangrik om in ag te neem dat as dit by die chirurgiese aspekte kom, word daar voorgestel dat M. palmaris longus eerder gebruik moet word wanneer 'n wyer tendon verkies word en M. plantaris gekies moet word wanneer ‘n langer tendon benodig word. Daar is goeie ooreenkoms tussen die aanwesigheid en/of afwesigheid van M. palmaris longus en M. plantaris wanneer hul met studies, wat op die ander bevolkingsgroepe gedoen was, vergelyk word. Geen ooreenkomste was tussen die geslag van die kadawer en die aanwesigheid en/of afwesigheid van M. palmaris longus en M. plantaris gevind nie. Daarbenewens was dit vasgestel dat daar geen verhouding tussen die aanwesigheid en/of afwesigheid van M. palmaris longus en M. plantaris in dieselfde individu is nie. 'n Moontlike filogenetiese degeneratiewe tendens vir M. palmaris longus is ook ondersoek. Na die bestudering van verskillende ouderdomsgroepe, is daar bepaal dat so 'n tendens nie bevestig kon word vir hierdie steekproef nie. Ter afsluiting, die morfologie en die aanwesigheid en/of afwesigheid van M. palmaris longus en M. plantaris, in 'n Suid-Afrikaanse bevolking, is ideaal vir die gebruik van weefselsnitte of tendon-oorplantings in rekonstruktiewe chirurgie. Maar dit is van uiterste belang dat die rekonstruktiewe chirurg, wie met Suid-Afrikaanse pasiënte werk, onthou dat beide hierdie spiere onderworpe is aan variasie. Dit sal dus voordelig wees om behoorlike opsporingsmetodes te gebruik om die vatbaarheid van hierdie spiere in rekonstruktiewe chirurgie vas te stel, maar hy of sy het ook kennis van die anatomie van hierdie spiere, nodig.

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1. INTRODUCTION AND AIMS

The desire to replace missing tissue in the human body has existed since the beginning of medicine (Riediger & Ehrenfeld, 1989). The first efficient procedure of repairing a mutilated nose with a tissue flap was accredited to Suśruta who lived in the 6th or 7th century (Masquelet & Gilbert, 1995).

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 (Chrysopoulo, 2008). About four centuries ago, an Italian surgeon called Gaspare Tagliacozzi took a delayed flap from an arm and used it for reconstruction of the nose (Masquelet & Gilbert, 1995).

In 1863, the first true axial pattern cutaneous flap was done by John Wood in London, whose main interest was in reconstructive surgery. He reported a case of an 8 year-old girl with severe burns to her hand. He attempted an operation to transplant a flap what he called a 'groin flap' (Masquelet & Gilbert, 1995).

At the end of the 19th century physicians realized that by transferring tendons, function of an extremity could be restored. The polio epidemic in Europe, in the 20th 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 (Zeineh & Wilhelmi, 2008). Thus all the concepts, technical abilities and the anatomical knowledge were adequately established in the 1920s to make reconstructive surgery using flaps or tendons possible (Masquelet & Gilbert, 1995; Zeineh & Wilhelmi, 2008).

Recent advances in reconstructive surgery would never have been possible without the ability to suture vessels and perform microsurgical anastomoses under the microscope (Masquelet & Gilbert, 1995). Today, flaps are defined as units of tissue that can be transferred from one site to another,

keeping its own blood supply. Flaps may include skin, fascia, fat, bone, muscle and viscera (Chrysopoulo, 2008; Stedman's medical dictionary, 2000) 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 (Chrysopoulo, 2008).

Five principles of 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 (Chrysopoulo, 2008). That is why a donor flap is usually selected for transfer because it is thought to be nonessential in its original location (Wehbé & Mawr, 1992; Zeineh & Wilhelmi, 2008), meaning that the donor site can survive without the presence of this structure and functionality 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 tendons. Other concepts of tendon transfer include the following: the function of the recipient unit is more important than the donor unit (Wehbé & Mawr, 1992), the donor tendon should have adequate strength and work capacity for its new function (Wehbé & Mawr, 1992; Sanghavi & Ali, 2008) and the muscle or tendon should pass in a direct line from its origin to insertion (Sanghavi & Ali, 2008). Sanghavi and Ali (2008) further stated that a transfer unit should not be used if it has been re-innervated or paralyzed.

Tendons are frequently used for reconstructive surgery (Wehbé & Mawr, 1992; Carlson *et al.,* 1993).This includes palmaris longus, plantaris, the long extensors of the toes and fingers as well as the flexors of the fingers (White, 1960; Wehbé & Mawr, 1992; Carlson *et al.,* 1993) 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 190 mm

cannot be harvested from the upper limb, while the lower limb can yield lengths up to 400 mm. The upper extremity can provide tendons as wide as 6mm compared to the lower limb that provides a maximum width of 4 mm. An important factor to consider is that a difference in strength between a 2mm and 3mm tendon could be significant. Thus, according to Wehbé and Mawr (1992), tendons from the upper limb should be considered when strength or width is important and the lower limb tendons when length is a factor.

The most desirable tendons in reconstructive surgery are the palmaris longus and plantaris tendons, while the long extensors of the toes and hands as well as the flexor digitorum superficialis are regarded as suitable (White, 1960).These two muscles are also considered to be the easiest tendons to harvest, and therefore they remain the ideal choices for tendon grafts (Wehbé & Mawr, 1992).

When one takes 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 (Lam *et al.,* 1998). It is also said to be a dispensable tendon, which will not affect the function of the wrist significantly (Lam *et al.,* 1998). 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.

It is said that the existence and importance of the plantaris muscle cannot be underestimated (Rana *et al.*, 2006). The plantaris tendon is a better graft than the fasciae lata, because it is easier to handle, harvesting saves time and there is less mutilation of the body (Glissan, 1932).

Apart from what is mentioned in the literature, questions remain such as: which characteristics do the palmaris longus and plantaris muscles possess that make them suitable for use as flaps or grafts in reconstructive surgery and; how can one's knowledge of these characteristics of these muscles in our population improve reconstructive surgery in South Africa?

Therefore the aims of this study were to:

1. Describe the macroscopic structure of the palmaris longus and plantaris muscles and to compare to previous studies found within the literature.
2. Determine the prevalence of the palmaris longus and plantaris muscles in both a living and cadaver population, and to compare to previous studies found within the literature.
3. Determine whether an absence of the palmaris longus muscle correlates with an absence of the plantaris muscle in a cadaver population.
4. Determine whether a trend exists whereby the occurrence of the palmaris longus muscle decreases in subsequent generations.

2. LITERATURE REVIEW

2.1 Morphology of the palmaris longus and plantaris muscles

2.1.1 Palmaris longus

2.1.1.1 General overview of the anatomy

The palmaris longus muscle is described as a slender, fusiform muscle that is found medial to the flexor carpi radialis muscle in the anterior compartment of the forearm - meaning that the palmaris longus muscle has a relative short muscular belly in comparison 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 (Carlson *et al.,* 1993) and flattens and broadens as it passes anterior to the flexor retinaculum (Williams, 1995; Sinnatamby, 1999) (see figure 1). Only a few of the tendon fibres interweave with the retinaculum (Williams, 1995; Sinnatamby, 1999). The tendon of the palmaris longus muscle splits in the palm to form fibres that are longitudinally directed and part of the palmar aponeurosis (Sinnatamby, 1999).

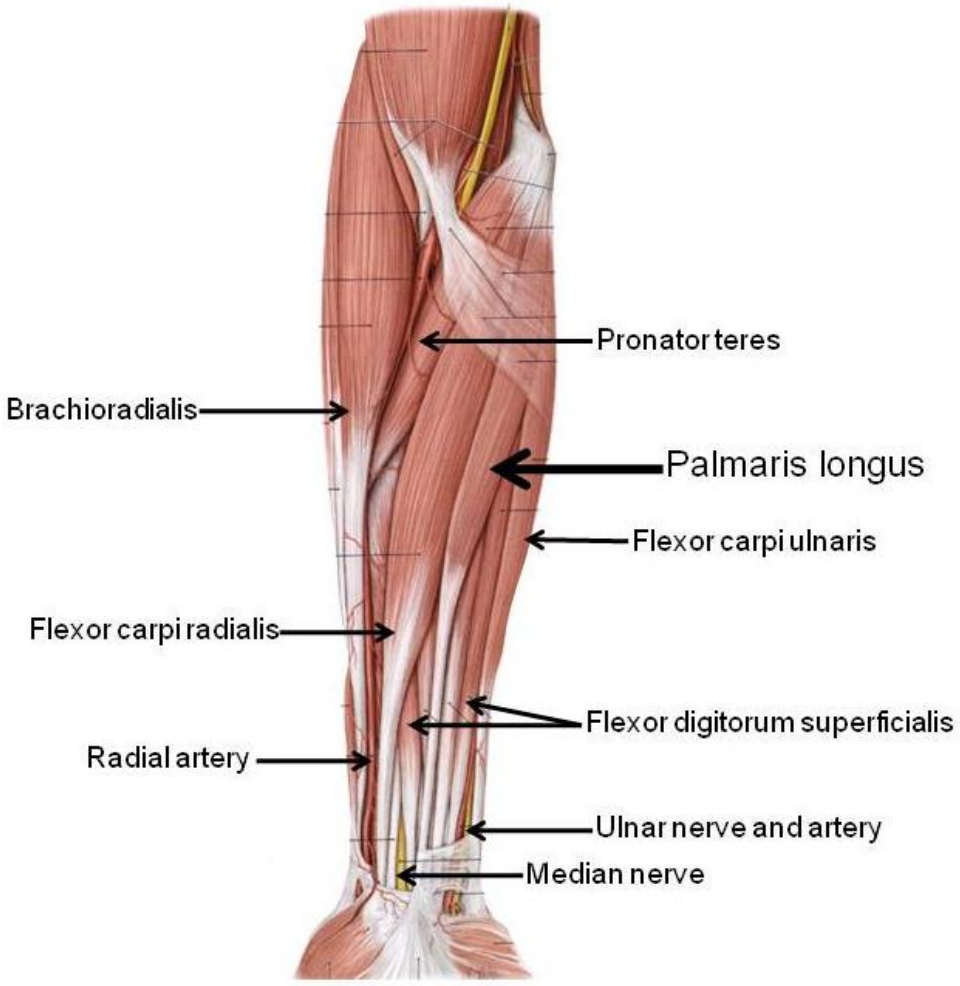


Figure 1: *Relations of the palmaris longus muscle in the forearm. Illustration from: Atlas of Anatomy (Gilroy et al., 2008)*

The palmaris longus muscle receives its nerve supply from the median nerve with a root value of C7 and C8 (Williams, 1995; Sinnatamby, 1999).

2.1.1.2 Variation in form

The palmaris longus muscle is subject to some anatomical variations (Incavo *et al*., 1987; Vanderhooft, 1996; De Smet, 2002; Mobarakeh *et al.,* 2008), which usually do not effect function in the patient, but are of interest for the academic researcher and reconstructive surgeon (Nayak *et al*.,2008). 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 (Nayak *et al*., 2008; Thejodjar, 2008).

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 (Reimann *et al.,* 1944; Carlson *et al*., 1998; Depuydt, *et al.,* 1998; Timins 1999; De Smet, 2002; Oommen, 2002; Rawat & John, 2003; Tiengo *et al.,* 2006; Natsis *et al.,* 2007; Mobarakeh *et al.,* 2008; Nayak *et al.,* 2008) (see figures 2 to 4). This type of variation was originally described as "musculus palmaris longus inversus" and only later was the term "reversed palmaris longus" recognized (Natsis *et al.,* 2007)

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. 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 (Depuydt *et al.,* 1998; Tiengo *et al.,* 2006). Nayak *et al.* (2008) reported a case where the long thin tendon, 15.2cm, of the palmaris longus originated from the medial epicondyle of the humerus. The muscular belly, 8.9cm, was found in the distal region of the fore-arm. The fibres of this belly ended as a tendon which continued into the palmar aponeurosis.

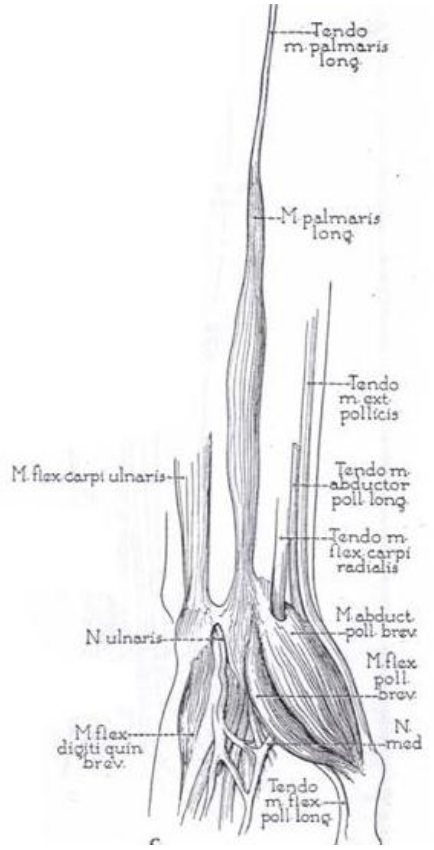


Figure 2: *The palmaris longus muscle with a distally placed belly of broad insertion (Reimann* et al., *1944).*

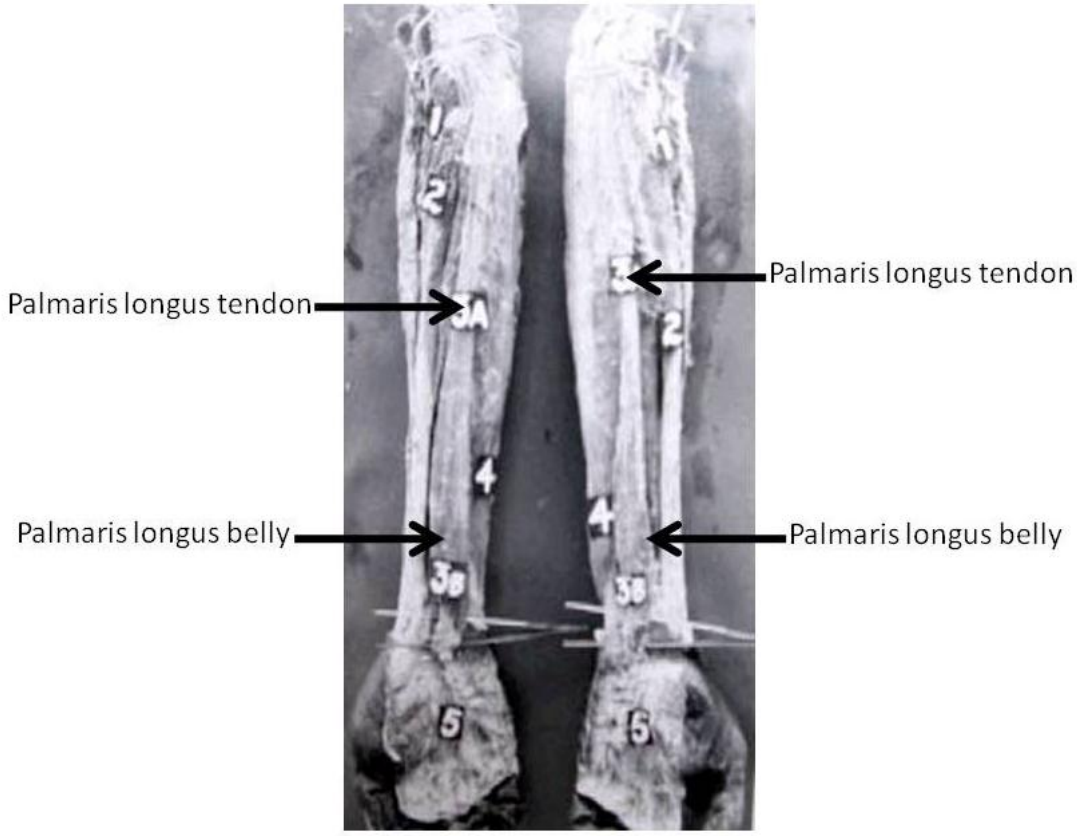


Figure 3: *Abnormal palmaris longus on both the left and right arms (Oommen, 2002)*

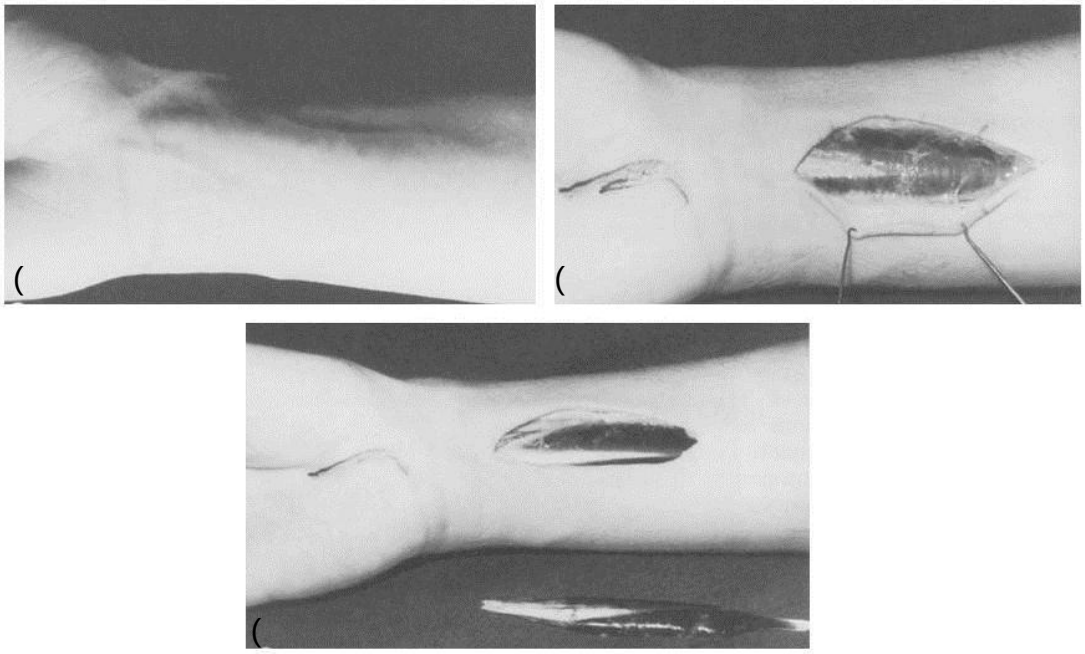


Figure 4: *"Reversed palmaris longus". (a) Obvious swelling on the flexor surface of the distal forearm. (b) The antebrachial fascia covering the reversed palmaris longus. (c) The resected palmaris longus muscle (Depuydt* et al., *1998)*

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) (Reimann *et al.,* 1944; Carlson *et al*., 1993; Timins, 1999; De Smet, 2002; Stecco *et al.,* 2009). 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 (Reimann *et al.,* 1994; Mobarakeh *et al*., 2008) (see figure 5). Carlson and co-workers (1993) even mentioned a palmaris longus muscle with more than one tendon.

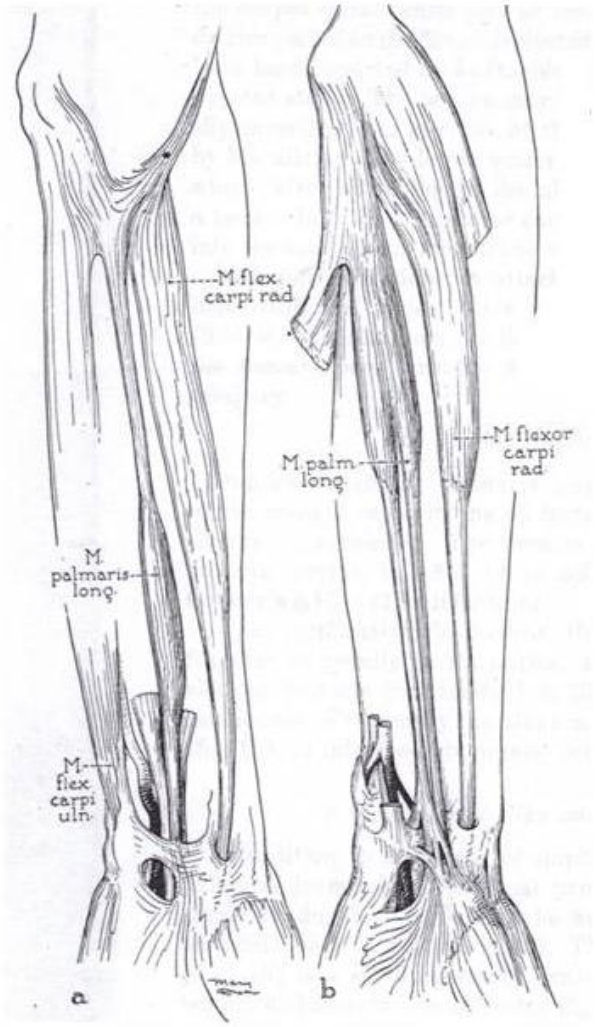


Figure 5: *Digastric type of palmaris longus. (a) A centrally placed belly. (b) A bifid palmaris longus muscle (Reimann* et al., *1994)*

Natsis (2007) reported a case where a female cadaver had a three-headed reversed palmaris longus in the left arm, while the right arm had a normal muscle. The muscular belly consisted of three bundles or heads: radial, central and ulnar (see figure 6). The radial bundle originated from the radial aspect of the tendon. The tendon continued onto the central bundle. The ulnar bundle originated more distally than the central bundle and ran more deeply than the others, following the ulnar artery and nerve, and later inserted onto the pisiform bone and flexor retinaculum.

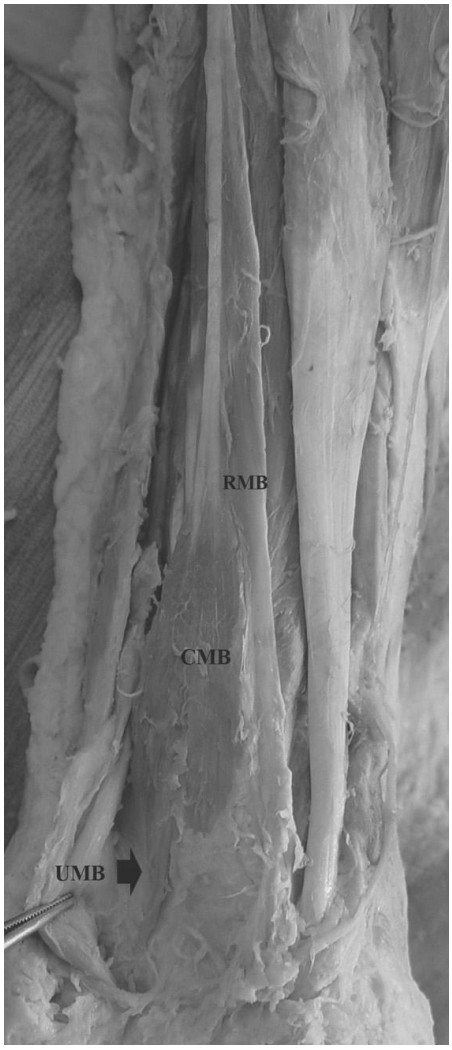


Figure 6: *The three-headed reversed palmaris longus muscle. RMB: radial muscular bundle, CMB: central muscular bundle, UMB: ulnar muscular bundle (Natsis* et al., *2007)*

Georgiev *et al.* (2009) reported a case of a male with a 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 palmar aponeurosis (see figure 7).The person also showed variation with the flexor carpi ulnaris muscle, which also presented with an extra belly (Georgiev *et al*., 2009).

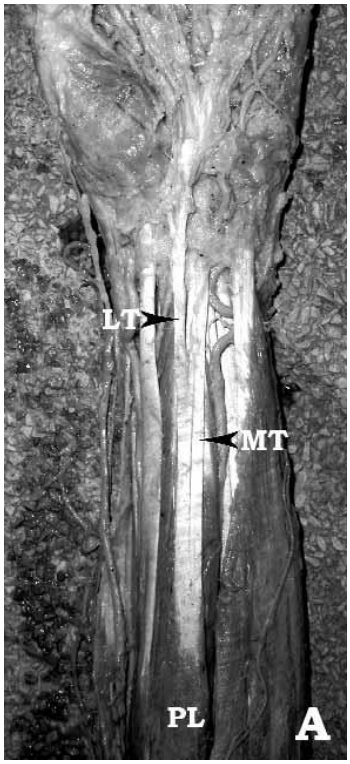


Figure 7: *The palmaris longus (PL) with its medial tendon (MT) and lateral tendon (LT) (Georgiev* et al., *2009)*

Another variation described in the literature is the 'palmaris profundus' (Server *et al.,* 1995; De Smet, 2002).In this specific condition the tendon of the palmaris longus tendon is found to course deep to the transverse ligament or flexor retinaculum.

2.1.1.3 Variation in attachment

Variation of this muscle's attachment has been reported to have a combined incidence of in 6.5% (Reimann *et al.,* 1944). The most common origin for the palmaris longus muscle mentioned, is the common flexor tendon (Reimann *et al.,* 1944; Williams, 1995; Sinnatamby, 1999; Natsis *et al.,* 2007; Thejodjar *et al.,* 2008; Stecco *et al.,* 2009) (see figure 8), while others add the following to the list: the antebrachial fascia and related intermuscular fascia (Reimann *et al.,* 1944; Williams, 1995; Stecco *et al.,* 2009), and to muscles such as flexor carpi radialis, flexor carpi ulnaris, flexor digitorum superficialis and the bicipital aponeurosis (Reimann *et al.,* 1944).

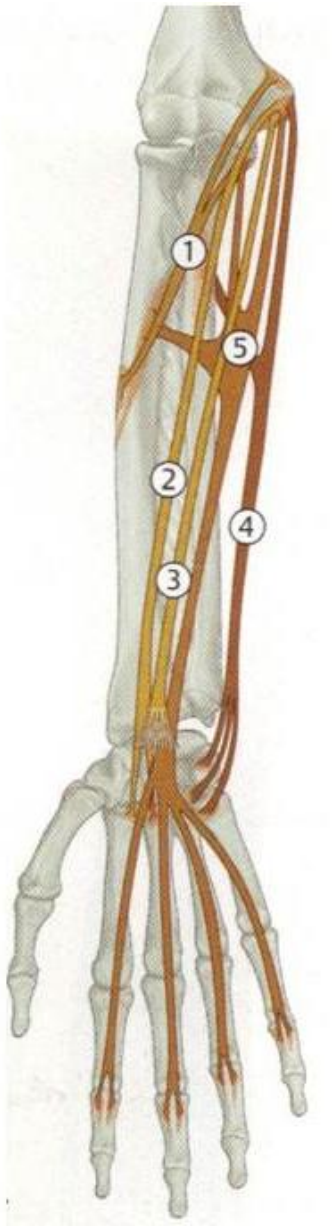


Figure 8: *The origin, course and insertion of the palmaris longus muscle (3), according to textbooks. Illustration from: Atlas of Anatomy (Gilroy* et al., *2008)*

The palmar aponeurosis is the most common insertion of the palmaris longus muscle (Reimann *et al.,* 1944; Williams, 1995; Vanderhooft, 1996) (see figure 8). Other insertions mentioned in the literature includes the: antebrachial fascia (see figures 9 and 10) and fascia of the thenar eminence (Reimann *et al.,* 1944; Carlson *et al.,* 1993; Mobarakeh *et al.,* 2008; Stecco *et al.,* 2009) muscles such as flexor digitorum superficialis, flexor digitorum profundus, flexor carpi radialis and the expansion of the flexor carpi ulnaris

muscle (Reimann *et al.,* 1944; Carlson *et al.,* 1993) (See figure 10), and the carpal bones (Reimann *et al.,* 1944).

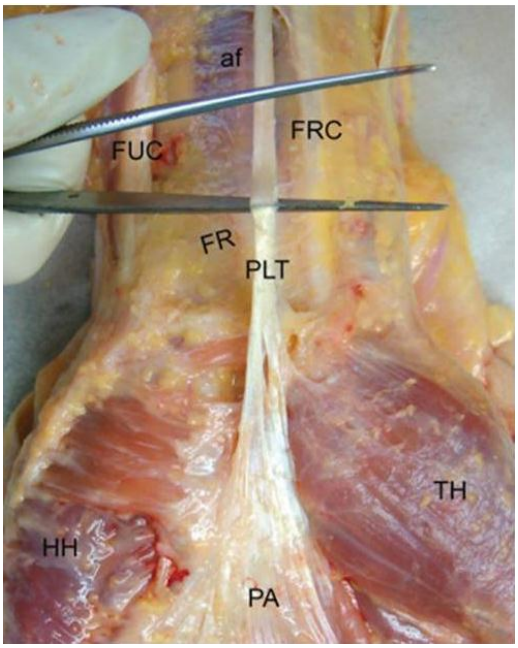


Figure 9: *Insertion of the palmaris longus tendon (PLT) on the palmar aponeurosis (PA) (Stecco* et al., *2009)*

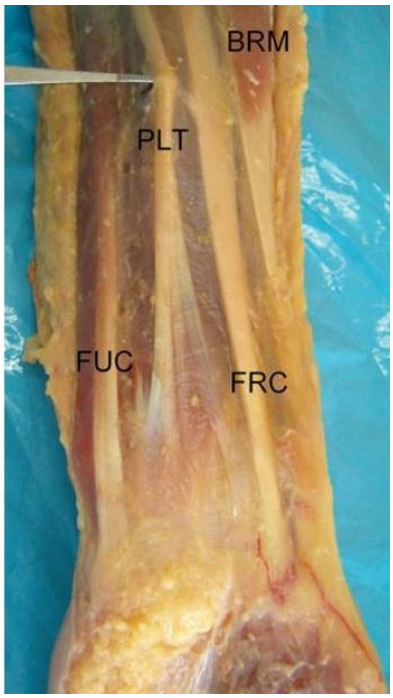


Figure 10: *Distal termination of the palmaris longus tendon (PLT) with a fan-like expansion in the antebrachial fascia (Stecco* et al., *2009)*

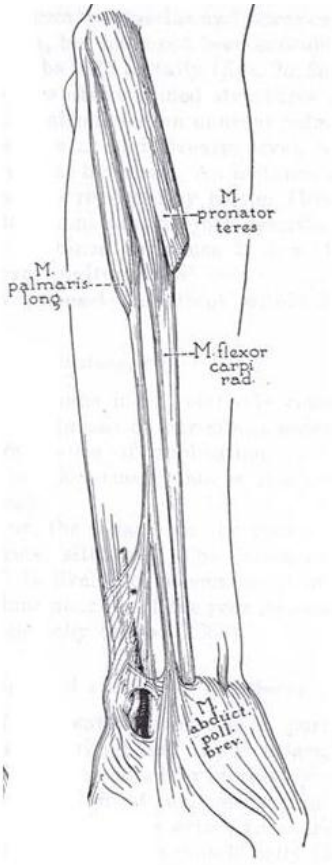


Figure 11: *Palmaris longus where part of the tendon forms an ulnar slip, inserting into antebrachial fascia (Reimann* et al., *1944)*

2.1.1.4 Duplication, accessory slips and substitute structures

Duplication of a muscle means that there is more than one of the same muscle in a specified arm. Reimann and co-workers (1944) predicted that should duplication of the palmaris longus muscle occur, the muscle on the radial side of the forearm will be normal and the one on the ulnar side will be smaller, with a distally or intermediate placed belly (see figure 12).

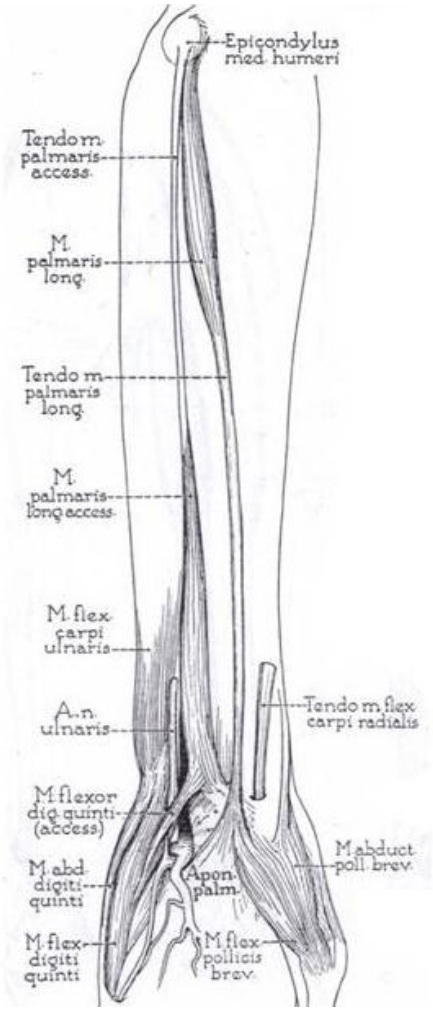


Figure 12: *Duplication of the palmaris longus muscle (Reimann et al., 1944)*

Tiengo and co-workers (2006) reported a case of an accessory palmaris longus muscle, which originated from the deep fascia, intermuscular and subcutaneous septa (see figure 12). The origin was at the level between the middle and distal third of the forearm. This palmaris longus muscle inserted on the central part of the palmar aponeurosis with fine, short tendon fibres. Thus, in short, this muscle was located in the epifascial plane. This is a rare variation and may be due to the unusual location of mesenchymal cells during the development of the muscular and fibrous structures of the forearm. The belly of this muscle was distally placed which may lead to median nerve compression during exercise (see figure 13) (Tiengo *et al.*, 2006).

De Smet (2002) reported a similar case of 'palmaris accessorius', where a connection was found between the palmaris longus and the hypothenar muscles. In this specific case the palmaris accessorius passed through carpal tunnel (Guyon's tunnel) and may possibly compress the ulnar nerve.

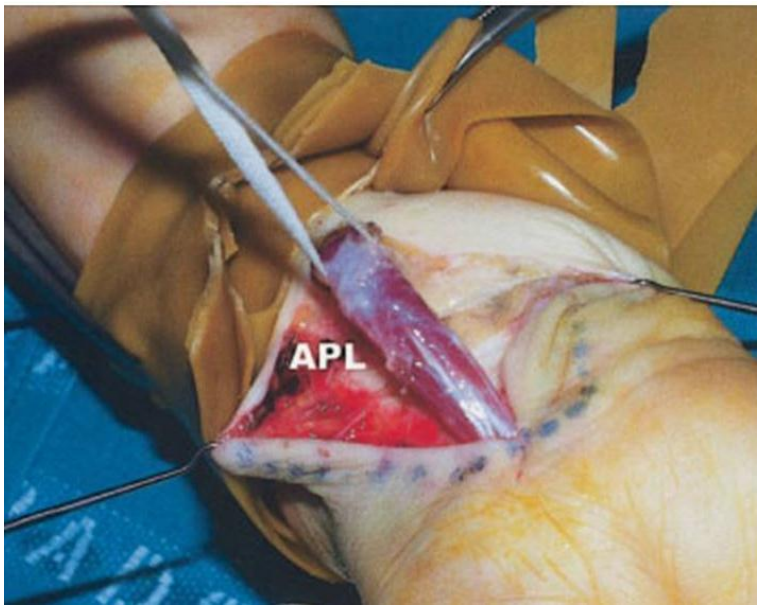


Figure 13: *An operative view. After elevation of the skin flaps, a muscle belly was found in the epifascial plane. (APL) Accessory palmaris longus (Tiengo* et al., *2006)*

Reimann and co-workers (1944) reported that single or double palmaris longus muscles have a 32.6% chance of containing accessory slips. The tendon may even split to insert on the antebrachial fascia as well. They also reported a case of a small accessory muscle that originated from the palmaris longus and inserted on the abductor digiti minimi muscle.

Mobbs and Chandran (2000) reported a case where the tendon of the palmaris longus fanned out into four slips. The palmaris longus tendon passed deep to the flexor retinaculum, but superficial to the median nerve.

Rubino and co-workers (1995) reported a case where an individual had a small accessory muscle that originated from the palmaris longus tendon. The location, course and attachment supported it to be an accessory slip of the palmaris longus muscle.

2.1.1.5 Unique characteristics

The palmaris longus tendon allows stretching without splitting. This tendon may stretch up to 50 mm in width (Vanderhooft, 1996) (see figure 14)

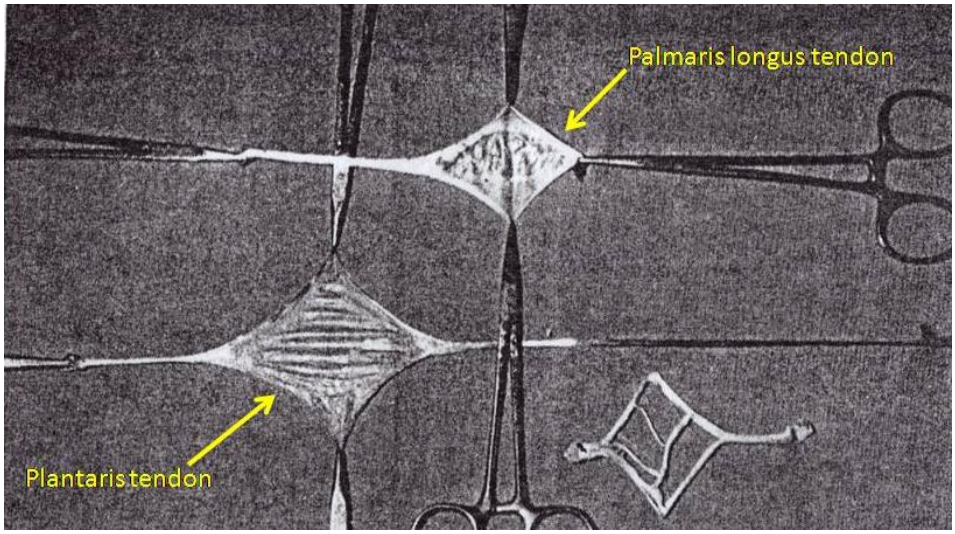


Figure 14: *The ability to stretch laterally without tearing is characteristic of the palmaris longus (above) and the plantaris (below) tendons (White, 1960).*

2.1.1.6 Actions of the palmaris longus muscle

Several actions of the palmaris longus muscle are listed in the literature: thumb abduction or anteposition (Gangata, 2009; Gangata et al., 2010), slight pronation (Gangata, 2009), traction of palmar aponeurosis (Gangata, 2009), stabilization of the superficial structures in the palm (for preparation of abduction of the thumb) tensing of superficial fascial system of the subcutaneous tissue (Stecco *et al.,* 2009), anchoring skin and fascia of the hand as well as resisting horizontal sharing forces in a distal direction (Williams, 1995; Sinnatamby, 1999; Oluyemi *et al.,* 2008) and weak flexion of the wrist (Sinnatamby, 1999).

Mangala *et al.* (2008) observed that the distal tendinous part of the palmaris longus muscle helps in fixing the distal end of the long axis around which supination is performed.

Gangata and co-workers (2010) investigated the function of the palmaris longus muscle in thumb abduction and concluded that the force of abduction the thumb is stronger in individuals with the palmaris longus present. Sebastin *et al.* (2005) did a similar study in which the absence of the palmaris longus muscle affected the grip and pinch strength of an individual, was investigated. They concluded that the absence or presence of this muscle does not affect the grip or pinch strength.

2.1.2 Plantaris

2.1.2.1 General overview of the anatomy

The plantaris is a small, spindle shaped muscle (Daseler & Anson, 1943) located in the posterior compartment of the leg (see figure 15). The plantaris muscle is not visible or palpable through the skin (Harvey *et al.,* 1983). The muscular belly ends in a long, slender tendon (Daseler & Anson, 1943; Williams, 1995), which descends between the gastrocnemius and soleus muscles, towards the medial border of the calcaneal tendon (Daseler & Anson, 1943; Williams, 1995). This flattened tendon has slight variations in thickness along its length (Carlson *et al.,* 1993) and in most of the cases the plantaris tendon ends in a fan-shaped aponeurotic expansion (Daseler & Anson, 1943).

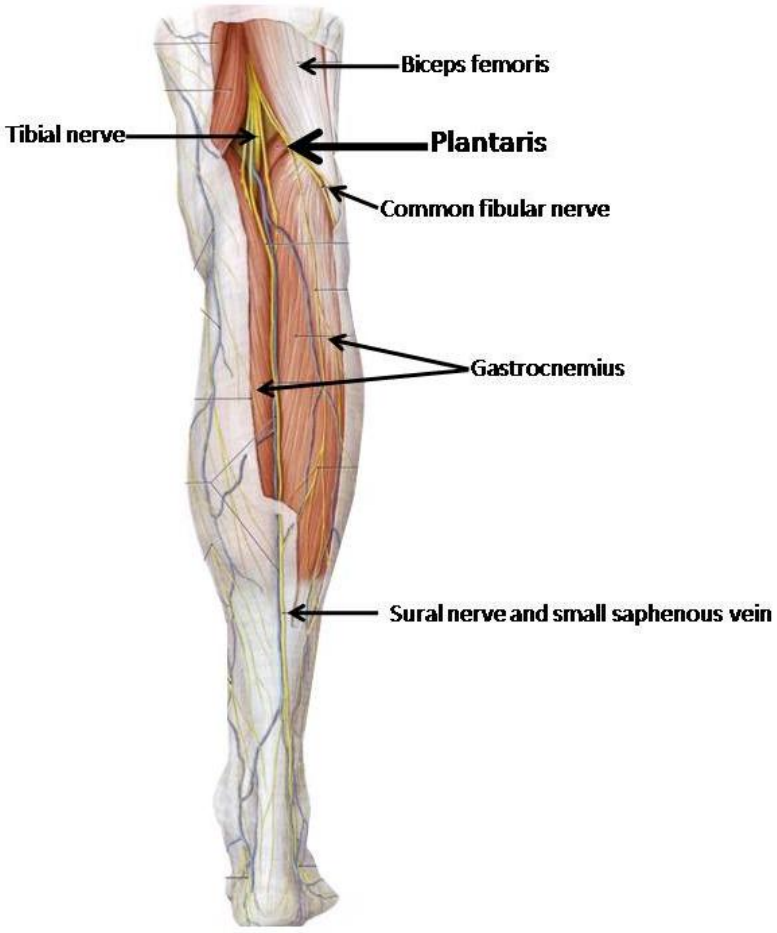


Figure 15: *Relations of the plantaris muscle in the posterior compartment of the leg. Illustration from: Atlas of Anatomy (Gilroy* et al., *2008)*

In some reports the long tendon of the plantaris muscle has been mistaken for a nerve (McGeorge *et al.*, 1992; Rana *et al.,* 2006; Moore *et al*.; 2010) and therefore is also named the “freshman’s nerve” (Moore *et al*., 2010). The plantaris muscle is also said to be an organ of proprioception for the larger plantar flexors, which contain a high concentration of muscle spindles (Moore *et al*., 2010). The plantaris muscle receives its nerve supply form the tibial nerve with root values of S1 and S2 (Williams, 1995).

White (1960) reported that the length of the muscular belly of the plantaris muscle seldom exceeds 100mm and that the length of the tendon is about three to four times longer, thus 300-400mm (Carlson *et al.,* 1993). Williams (1995) and Daseler and Anson (1943) reported a belly length of between 70 and 100mm.

2.1.2.2 Variation in form

The plantaris muscle is vestigial and subject to variation (Incavo *et al.,* 1987) that may be brought about by “functional evolutionary influences” (Pai *et al.,* 2008). The proximal part of the plantaris muscle may vary from a muscular belly to a thin fibrous structure (Daseler and Anson, 1943).

2.1.2.3 Variation in attachment

Various attachments of the plantaris muscle are mentioned in the literature. Freeman and co-workers (2008) stated that the areas of attachment of the plantaris muscle is in fact larger than what is mentioned in the literature, which results in an improved influence over the function and stability of the knee joint. The most common origin of the plantaris muscle is above the lateral condyle of the femur or supracondylar line (Pilcher, 1939; Daseler and Anson, 1943; Williams, 1995) (see figure 16).

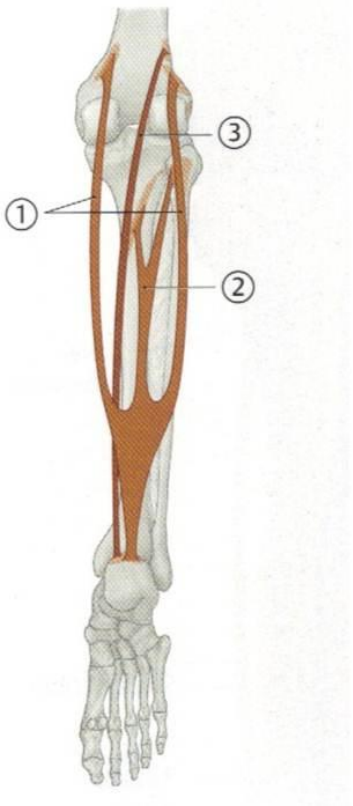


Figure 16: *The origin, course and insertion of the plantaris muscle (3), according to textbooks. Illustration from: Atlas of Anatomy (Gilroy* et al., *2008)*

Other origins include the posterior ligament of the articular capsule (Daseler & Anson, 1943; Incavo *et al.,* 1987; Carlson *et al.,* 1993), the inferior extremity of the external limb of the linea aspera (Pilcher, 1939; Incavo *et al.,* 1987; Schlicht & Morrison, 1992; Wong *et al.,* 2005), the fascia that covers the popliteus muscle (Daseler & Anson, 1943) the fibula between the flexor hallucis longus and peroneus longus, the oblique line of the tibia under the soleus muscle (Daseler & Anson, 1943), the fascia of the leg (Daseler & Anson, 1943), interdigitations with the lateral head of gastrocnemius (Freeman *et al.,* 2008) (see figure 17), and the oblique popliteal ligament (Williams, 1995).

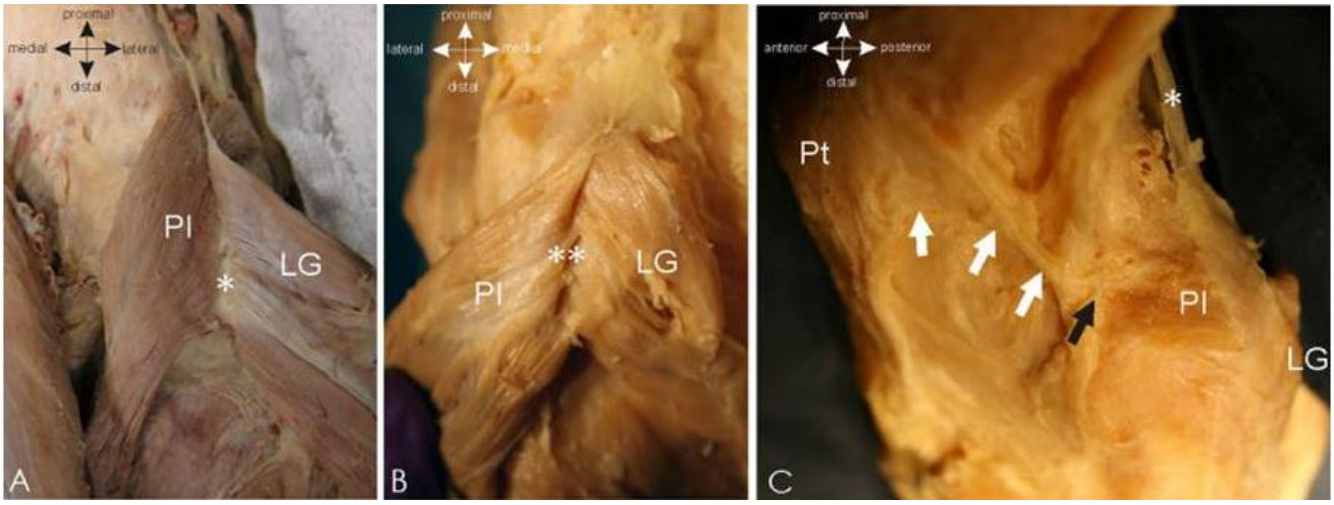


Figure 17: *The proximal attachment of the plantaris muscle. (a) The "normal" plantaris (Pl) muscle covering the majority of the length of the lateral femoral condyle, with a distinct separation from the lateral head of the gastrocnemius (LG). (b) The interdigitation (**) between the two muscles. (c) The anterior fibrous extension (white arrows) from the plantaris muscle through the fibromuscular connection (black arrow) to the patella (Pt) (Freeman* et al., *2008).*

The insertions most frequently mentioned in the literature are the dorsal surface of the calcaneus (Daseler & Anson, 1943; Schlicht & Morrison, 1992), neighbouring tissues (Daseler & Anson, 1943; Schlicht & Morrison, 1992), and the inner or medial border of the calcaneal tendon (Pilcher, 1939; Daseler & Anson, 1943; Schlicht & Morrison, 1992). Other insertions include the bursa between the calcaneal tendon and calcaneus (Daseler & Anson, 1943), a small tuberosity on the superior surface of the calcaneus (Daseler & Anson,

1943), the internal portion of the laciniate ligament (Daseler & Anson, 1943), the superior surface of the calcaneus (Daseler & Anson, 1943), the plantar aponeurosis (Daseler & Anson, 1943), the deep fascia of the leg (Pilcher, 1939; Wiliams, 1995), the internal annular ligament (Pilcher, 1939), and the flexor retinaculum (Williams, 1995) (see figure 18).

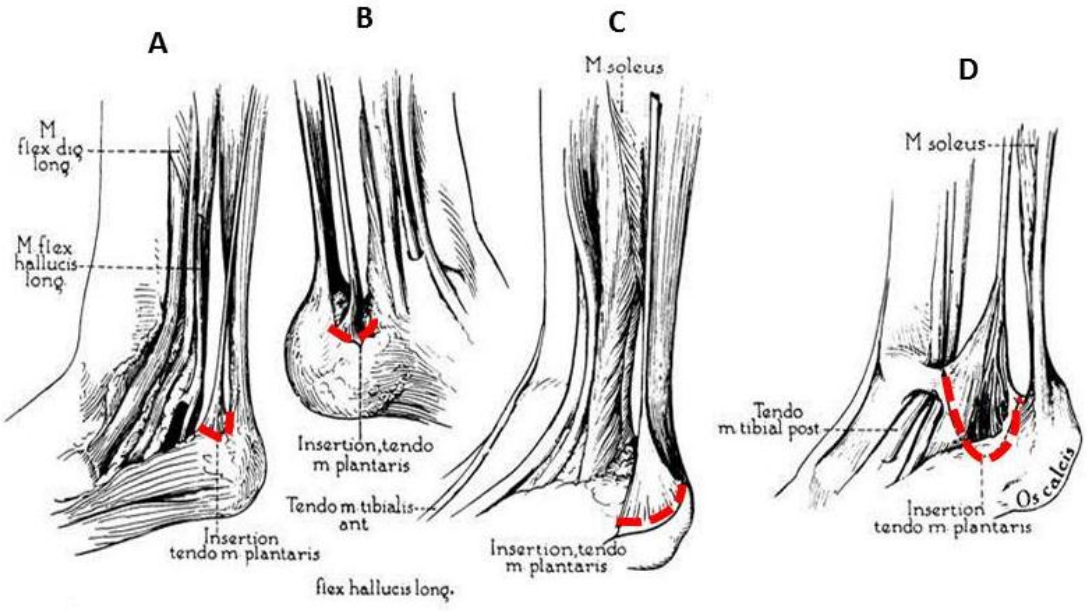


Figure 18: *Types of tendinous insertions of the plantaris muscle on the medial aspect of the leg. A indicates the insertion of the plantaris tendon, by means of a short fan-shaped expansion, into the medial extremity of the superior tuberosity of the calcaneus. B indicates the insertion of the tendon into the calcaneus. C indicates the insertion of the plantaris tendon into the adjacent calcaneal tendon. D indicates the tendon radiating in a fan-shaped manner to the laciniate ligament and the fascia overlying the medial aspect of the calcaneus. (Daseler & Anson, 1943)*

2.1.2.4 Duplication, accessory slips and substitute structures

Rana and co-workers (2006) reported a case of a double plantaris muscle on both legs in a 45 year old male. The outer belly was much thicker and fleshier than the one found on the medial side, and about 100mm in length. The outer belly originated from the lower part of the lateral extension of the linea aspera, just above the origin of the gastrocnemius muscle. This belly merged with the lateral side of the common tendon of the gastrocnemius and soleus muscles.

The inner belly of the double plantaris muscle was much thinner and about 50mm in length. This belly originated from the fascia that covers the popliteus muscle, just medial to the origin of the lateral head of gastrocnemius. It inserted on a small tuberosity of the superior surface of the calcaneus (Rana *et al.,* 2006) (see figure 19).

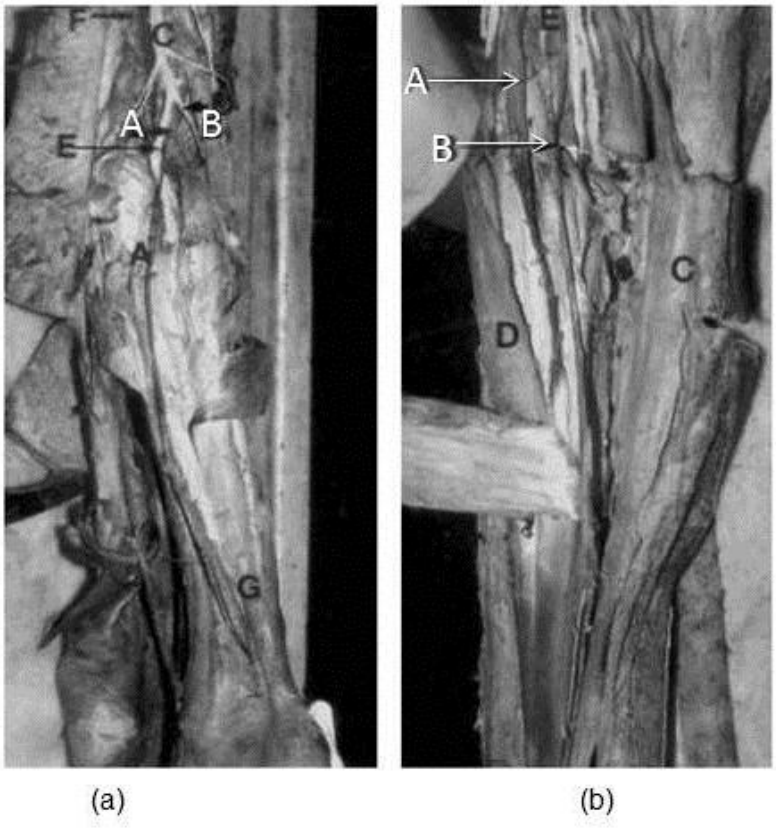


Figure 19: *Photographs of dissected specimens of the (a) right leg and (b) left leg. (a) The A indicates the inner plantaris muscle, and B the outer plantaris muscle. G indicates the calcaneal tendon. (b) The outer fleshy belly of plantaris (A), inner belly of plantaris (B) (Rana* et al., *2006)*

2.1.2.5 Unique characteristics

The tendon of the plantaris muscle has the ability to stretch laterally without splitting (Pilcher, 1939), and has more tensile strength than an identical sized portion of fascia latae (Wong et al., 2005) (see figure 14).

2.1.2.6 Actions of the plantaris muscle

It is said that the plantaris muscle contributes to plantar flexion of the ankle joint (Freeman *et al.,* 2008), flexion of the knee joint (Freeman *et al.,* 2008), as well as acting with gastrocnemius (Williams, 1995; Moore *et al*., 2010). Moore and co-workers (2010) maintain that the contribution of the plantaris muscle is insignificant to the flexion of both the ankle and the knee joints

2.1.3 Comparison of the morphology of the palmaris longus and plantaris muscles

The palmaris longus muscle is said to not be homologous with the plantaris muscle and that there is no correlation between the two muscles (Vanderhooft, 1996). Others contend that the palmaris longus and plantaris have much in common (White, 1960) and are each other's equivalent (Williams, 1995). Daseler and Anson (2007) stated that there is substantial genetic similarity between these muscles.

The anatomical relationship is fairly similar between them. The bellies of both muscles are small, round and give rise to long, slender tendons. The tendons of both of these muscles are able to stretch laterally without splitting, causing them to be equally good for tendon grafts (White, 1960).

2.1.4 Vascular anatomy of the palmaris longus and plantaris

The blood supply to the palmaris longus is the following arteries: ulnar artery, superior and inferior ulnar collateral arteries (variable), the anterior and posterior ulnar recurrent arteries and branches from the ends of the superficial palmar arch (Williams, 1995) (refer to Figure 20).

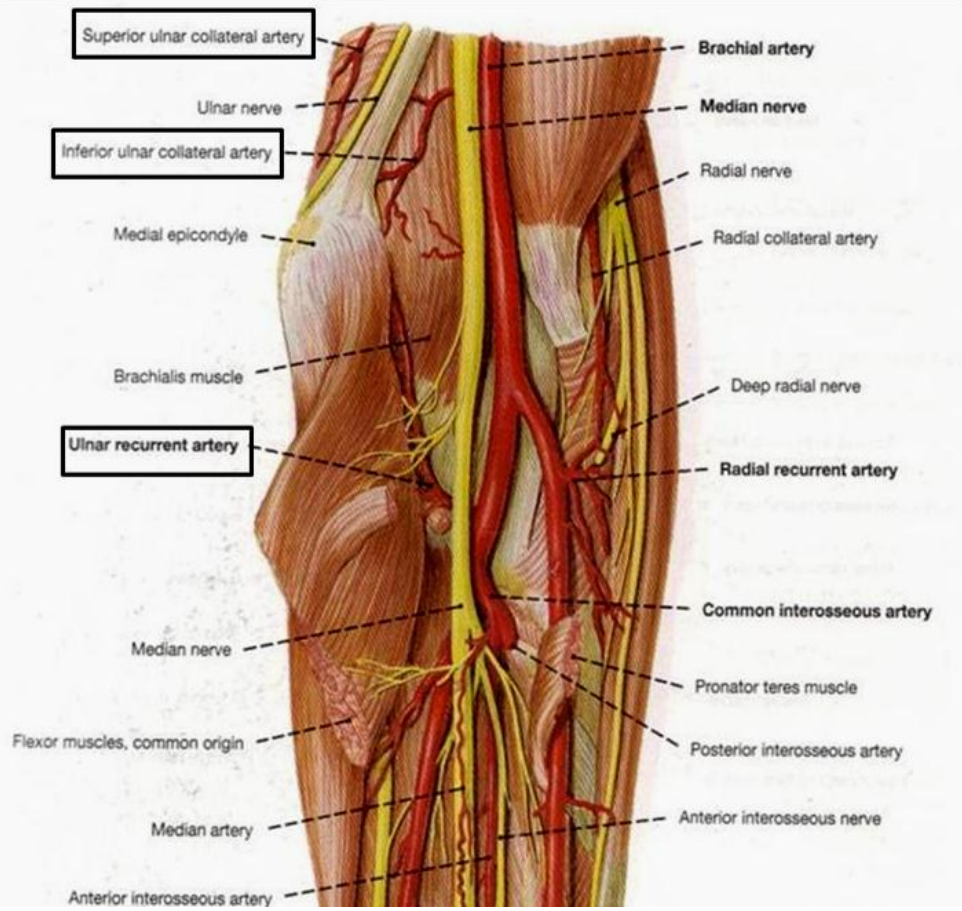


Figure 20: *The vascular supply of the anterior or flexor compartment of the fore-arm, according to textbooks (Velker, 1997)*

The plantaris muscle is supplied by the sural arteries, the fibular artery and the upper and lower communicating arteries (see figure 21). The tendon is supplied by the malleolar arteries and the calcaneal branches from the posterior tibial, fibular and lateral plantar arteries (Williams, 1995).

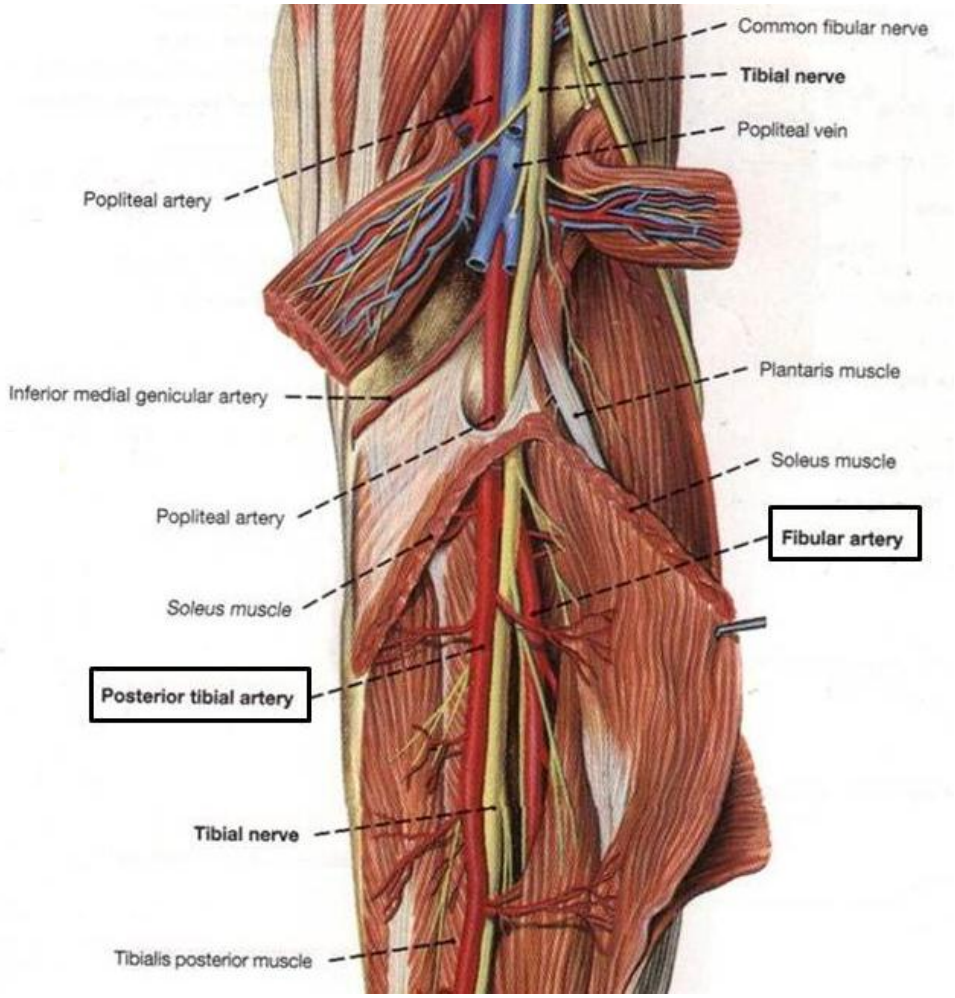


Figure 21: *The vascular supply of the posterior or flexor compartment of the leg, according to textbooks (Velker, 1997)*

Mathes and Nahai (1981) made a detailed study of the vascular anatomy of muscles and subsequently proposed a classification of flaps based on the type of vascularisation (Chrysopoulo, 2008) (see figure 22). In order to mobilize a muscle flap, a precise knowledge of the location of the vascular pedicle is needed. Should there be more than one vascular pedicle for the muscle; the importance of the other pedicles must be assessed to determine the viability of the muscle (Masquelet & Gilbert, 1995).

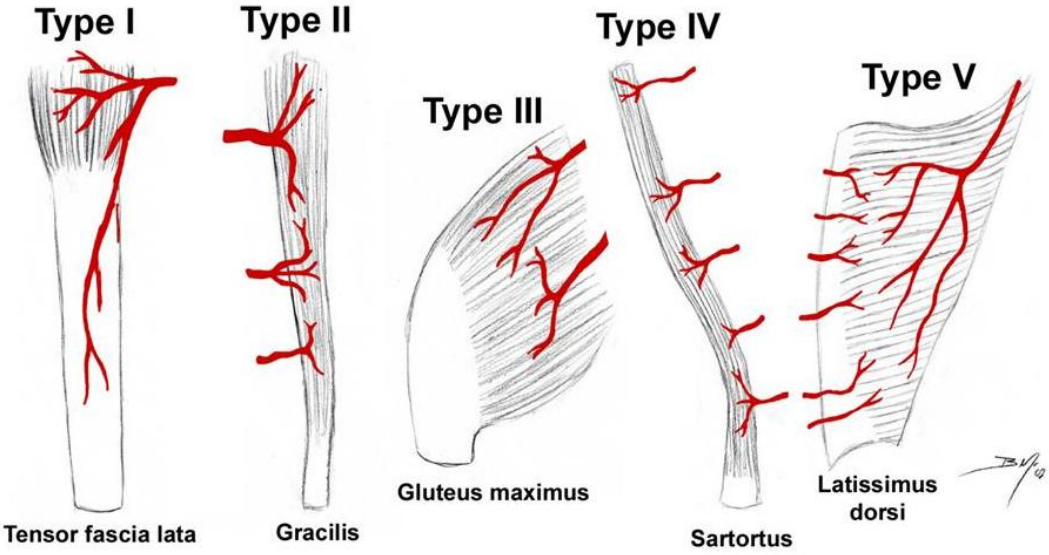


Figure 22: *Patterns of muscle flap vascular anatomy (Chrysopoulo, 2008)*

Five types of vascularisation of muscles have been described. Type 1 is characterized by a single vascular pedicle which penetrates the muscle belly at its proximal end, for example gastrocnemius, rectus femoris and tensor fascia lata muscles. Type 2 consists of one major vascular pedicle, which is enough to supply the entire muscle, when the minor pedicles are divided. Examples of type 2 are gracilis, soleus and biceps femoris muscles. In type 3, two dominant pedicles are equally distributed to the muscle. Examples include gluteus maximus, rectus abdominis and semimembranosus muscles. Type 4 vascularisation is where the muscle is supplied by multiple equivalent pedicles, for example tibialis anterior, extensor hallucis longus and Sartorius muscles. The last type, type 5, is described to have one dominant pedicle that supplies the whole muscle when secondary pedicles are divided. Examples of such muscles include latissimus dorsi and pectoralis major muscles (Masquelet & Gilbert, 1995; Chrysopoulo, 2008).

There is no mention of the classification of the blood supply of the palmaris longus and plantaris muscles in the literature.

2.2 Prevalence of the palmaris longus and plantaris muscles

2.2.1 Palmaris longus

The literature reports that the absence of the palmaris longus muscle is a sex-linked dominant trait (Reimann *et al.,* 1943; Gangata, 2009; Pai *et al.,* 2008), more absent in females (Machado & Di Dio, 1967) and also influenced by the side of the body (Kapoor *et al.,* 2008; Thompson *et al.,* 1921) (see figure 23). Not everyone agrees with this. Incavo and co-workers (1987) stated that there is little distinction in the prevalence of the palmaris longus tendon between the sexes or sides of the body.

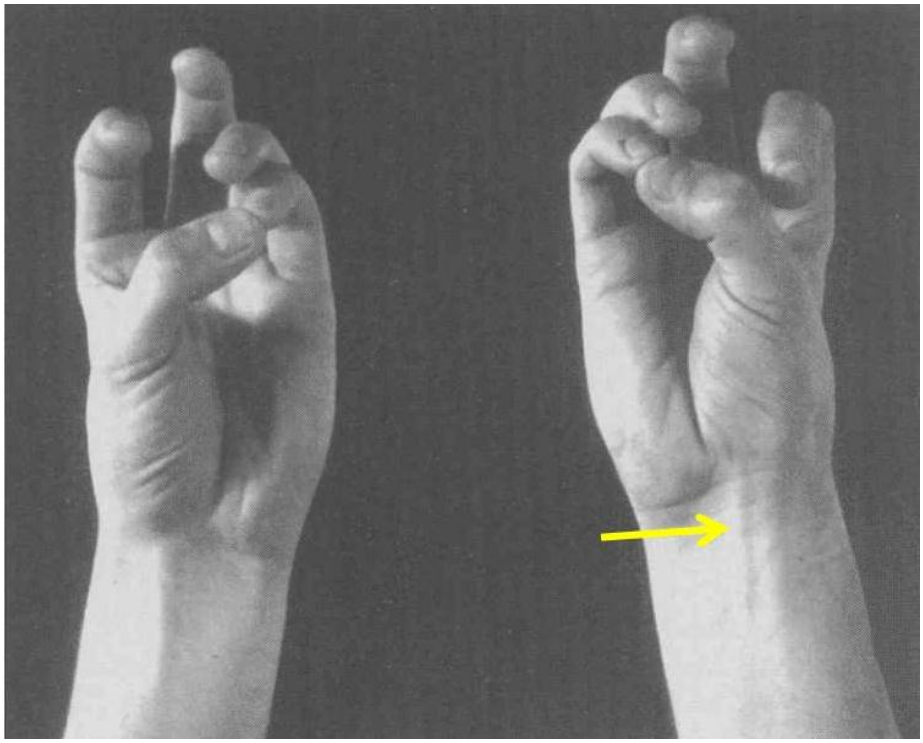


Figure 23: *Subject demonstrating unilateral absence of the palmaris longus muscle (left) (Thompson* et al., *2002).*

There is also mention of the racial (Vanderhooft, 1996) and population (Roohi *et al.,* 2007; Gangata, 2009) variations in the frequency of the prevalence of the palmaris longus muscle. Sebastin and co-workers (2005) reported that the absence of the palmaris longus is not correlated with a decrease in the strength of one's grip or pinch.

A bilateral absence of the palmaris longus was noted in 8.3% of cases, 3.6% was absent in the left arm only and 4.7% in the right arm only (Reimann *et al.,* 1944). A bilateral absence of 0.6% was recorded for a Zimbabwean population (Gangata, 2009) compared to the results obtained from a study done on an Amazon Indian population, which revealed a bilateral absence of 2.6% of this muscle (Machado et al., 1967). Sebastin and co-workers (2005) reported on a study done on subjects of Asian descent and found a bilateral absence of 2%. Unilateral absence was found in 2.9% of the cases in the left arm and 1.2% in the right arm.

Thompson *et al.,* (2002) studied Caucasian subjects and reported a bilateral absence of 8.7% of the palmaris longus muscle. Unilateral absence of this muscle was noted in 6.7% of the left arm and 9.7% of the right arm. Wehbé and Mawr (1992) reported a bilateral absence of 5% in a sample made up of mainly Caucasian subjects. Another study done on Caucasian subjects reported a bilateral absence of 9.7% of the palmaris longus muscle. This muscle was absent in the right arm only (2.2%) (Vanderhooft, 1996).

Kapoor and co-workers (2008) studied the palmaris longus muscle in an Indian population and found a bilateral absence of 17.2%; unilateral absence consisted of 6.2% on the left side and 3% on the right side. The author noted that the method used was not entirely reliable and therefore a weak tendon could be mistaken for an absent tendon. The findings from the above studies are summarized in Table 1.

Table 1: *Prevalence of the palmaris longus muscle, a comparison between the different studies found in the literature.*

Author	Total sample	Present bilaterally		Absent bilaterally		Unilateral absence (left)		Unilateral absence (right)	
		n	%	n	%	n	%	n	%
North American population (Reimann *et al*., 1944)	362	302	83.4	30	8.3	13	3.6	17	4.7
Amazon Indian population (Machado & Di Dio, 1967)	379	-	-	10	2.6	-	-	-	-
North American population (Wehbé & Mawr, 1992)	120	-	-	6	5	-	-	-	-
North American population (Vanderhooft, 1996)	186	156	83.9	18	9.7	0	0	4	2.2
European population (Thompson *et al.*, 2002)	300	228	76	26	8.7	20	6.7	29	9.7
Asian population (Sebastin *et al.*, 2005)	418	394	94.3	7	2	12	2.9	5	1.2
Malaysian population (Roohi *et al.,* 2007)	450	-	-	13	2.9	-	-	-	-
Indian population (Kapoor *et al.,* 2008)	500	414	82.8	40	17.2	31	6.2	15	3
Iranian population (Mobarakeh *et al*., 2008)	64	-	-	5	7.8	-	-	-	-
Nigerian population (Oluyemi *et al*., 2008)	600	188	31.3	112	18.75	150	25	150	25
Southern Indian population (Pai *et al.,* 2008)	30	-	-	1	3.3	3	10	-	0
Zimbabwean population (Gangata, 2009)	890	-	-	5	0.6	-	-	-	-

2.2.2 Plantaris

Vanderhooft (1996) reported that the prevalence of the plantaris muscle may be different for different races. Little (Incavo *et al.,* 1987) or no difference (Harvey *et al.,* 1983) between the sexes are noted for the prevalence of this

muscle. Simpson and co-workers (1991) stated that one cannot predict the presence of the plantaris muscle before an operation.

It has been reported that the congenital absence of the plantaris muscle may have significant consequences (Freeman *et al.,* 2008). Freeman and co-workers (2008) stated that the presence of the plantaris muscle in a young individual may be important for the development of athletic and mechanical skills. They further stated that the absence of this muscle may cause weakness in the initial flexion and an increased risk of injury to the primary stabilizing ligaments of the knee.

A study on the prevalence of the plantaris muscle in an American population revealed a bilateral absence of 13%. In 4.1% of the cases the plantaris was absent on the left side and 2.5% on the right side (Daseler & Anson, 1943). Harvey and co-workers (1983) studied a sample of subjects with European origin and reported a bilateral absence of the plantaris muscle in 12.8%. 4.9% of the subjects had the plantaris muscle absent in the left leg and 6.1% in the right leg.

Vanderhooft (1996) reported a bilateral absence of the plantaris muscle in 3.23% of the study population. 2.15% was absent of the left and 1.08% was on the right side. The findings from similar studies are summarized in Table 2.

Table 2: *Prevalence of the plantaris muscle, a comparison between the different studies found in the literature.*

Author	Total sample	Present bilaterally		Absent bilaterally		Unilateral absence (left)		Unilateral absence (right)	
		n	%	n	%	n	%	n	%
Daseler & Anson (1943)	375	338	90.13	13	3.46	18	4.8	6	1.6
Harvey *et al.,* (1983)	658	502	76.29	84	12.77	32	4.86	40	6.08
Vanderhooft (1996)	186	174	93.55	6	3.23	4	2.15	2	1.08

2.2.3 Simultaneous occurrence of the palmaris longus and plantaris muscles

Vanderhooft (1996) stated that there is no significant correlation between the palmaris longus and plantaris muscles. However Harvey *et al.* (1983) hypothesized that the absence of the palmaris longus may be associated with the absence of the plantaris muscle, but later concluded that no significant relationship was found between the prevalence of the palmaris longus and the plantaris muscles.

It is reported that the proportion of absence of the plantaris to the palmaris longus is 1:3 (Harvey *et al.,* 1983). Wehbé and Mawr (1992) maintain that by comparing different tendons, the plantaris tendon is a good predictor of the length of the palmaris longus tendon.

Vanderhooft (1996) reported a bilateral absence of 2.2%, for both the palmaris longus and plantaris muscles, in the same individual. Harvey *et al.* (1983) noted a 1.4% bilateral absence of both muscles in the same individual. The remainder of the samples, in both studies, had either one of the muscles absent or all muscles present.

2.3 Degeneration of palmaris longus and plantaris muscles

2.3.1 Palmaris longus

The literature reports that the palmaris longus muscle is only found in mammals in which the forelimbs are weight-bearing extremities (Reimann *et al*., 1944). Reimann and co-workers (1944) further reported that the regression of the palmaris longus muscle may be linked with the development of prehension. Terms used in the literature to describe the waning of this muscle include retrogressive (Rubino *et al*., 1995; Vanderhooft, 1996) or phylogenetic degenerative (Williams, 1995; Sebastin et al., 2005; Pai *et al.,* 2008).

Certain characteristics of the palmaris longus suggest that this muscle is degenerating. It is said to be a "phylogenetic degenerative metacarpo-phalangeal joint flexor" (Williams, 1995). Sebastin and co-workers (2005) stated that the short muscular belly and long tendon is characteristic of phylogenetic degeneration of this muscle. They further stated: "The absence of a difference in strength in the normal population may indicate the gradual phylogenetic degeneration of this muscle…" and that in those individuals without the palmaris longus, the function of the palmaris longus is taken over by other flexors in the forearm (Sebastin *et al.,* 2005). Mobbs and Chandran (2000) reported that the palmar aponeurosis is replacing the distal tendon of the palmaris longus. Mangala *et al.* (2008) stated that the palmaris longus is a primitive muscle with its fibrofascial component characterises phylogenetic degeneration.

The diversity of origin is indicated by the variation in the frequencies of the absence of the palmaris longus muscle, in different races (Thompson *et al.,* 1921). Kapoor and co-workers (2008) supports this statement by stating that the palmaris longus muscle is not diminishing as fast in the Indian population as in other races.

2.3.2 Plantaris

The plantaris muscle is said to be vestigial in man. It has lost its insertion onto the plantar aponeurosis and gained a new attachment to the calcaneal tendon or calcaneus. However, many of the lower animals kept the insertion into the plantar aponeurosis. The plantaris muscle today is the degenerated remains of a primitive, second layer of flexors of the proximal interphalangeal joints of the toes (Daseler & Anson, 1943).

Harvey and co-workers (1983) further claim that the plantaris muscle is generally absent in anthropoid apes, but very well developed in most mammals and monkeys. In humans, the plantaris muscle is said to be a rudiment of a large muscle (not specified). In some of the lower animals this larger muscle continues over the calcaneus and inserts onto the plantar aponeurosis (Shuhaiber & Shuhaiber, 2003).

2.4 Detection methods

2.4.1 Palmaris longus

The most commonly used method to detect the palmaris longus in an individual is the inspection of the forearm. Schaeffer's test was developed and constitutes of flexion of the wrist and opposition of the thumb and little finger (Roohi *et al.,* 2007). This is one of the most frequently used tests, utilized by various authors (see figure 24) (Sinnatamby, 1999; Roohi *et al.* 2007).

Figure 24: *Opposition of the thumb and little finger (Schaeffer's test) (Oudit* et al., *2005).*

The "two finger sign" was later developed by Allison and Titley (2003). This method required the index and middle fingers to the fully extended. The wrist is then flexed and the thumb is opposed and flexed. The palmaris tendon will then be stretched and easily seen and palpated (see figure 25) (Allison and Titley, 2003).

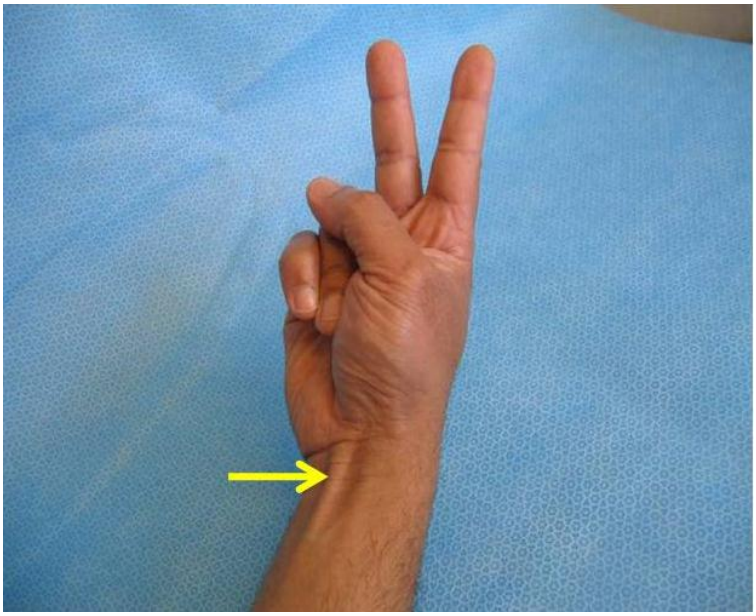


Figure 25: *Demonstrating the palmaris longus, using the "Two finger" technique (Allison & Titley, 2003)*

Another method is the "four-finger sign" (Oudit *et al.,* 2005). This is a combination of forced anteposition and flexion of the thumb, with simultaneous extension of the second to fifth digits. This method is said to create maximum tension on the palmaris longus tendon, as the palmaris longus and the palmar aponeurosis act as a single component (see figure 26).

Figure 26*: The four-finger sign is the most effective way of demonstrating the palmaris longus tendon (Oudit* et al., *2005).*

Recently Gangata (2009), proposed a technique of identifying the palmaris longus tendon that uses a combination of resisted thumb abduction and wrist flexion (see figure 27)

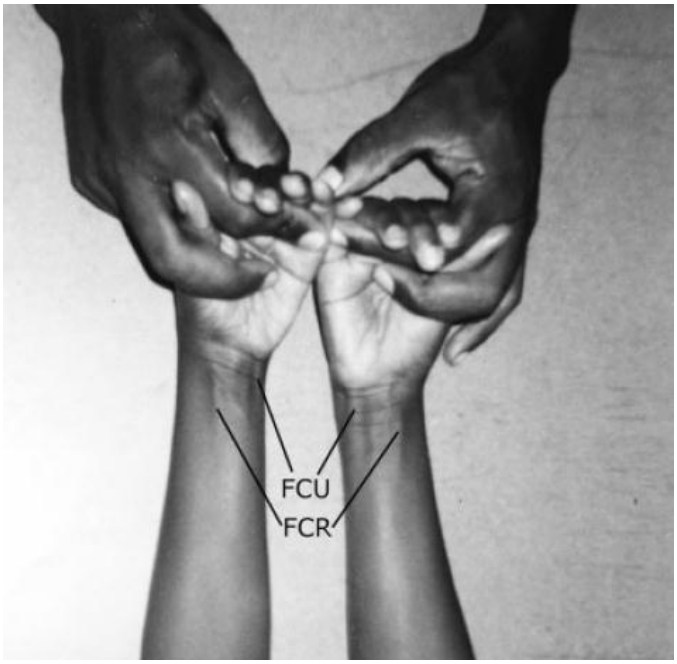


Figure 27: *Detection of the palmaris longus tendon using a combination of resisted thumb abduction and wrist flexion (Gangata, 2009)*

2.4.2 Plantaris

2.4.2.1 MRI

A MRI study was done by Saxena and Bareither (2000), which consisted of 63 MRI's and 86 ankles in total. The presence of the plantaris muscle was confirmed with surgery in 13 cases where the muscle could not be demonstrated radiographically. The authors concluded that an axial MRI of less than 5mm could be helpful in determining the presence of the plantaris muscle (see figure 28).

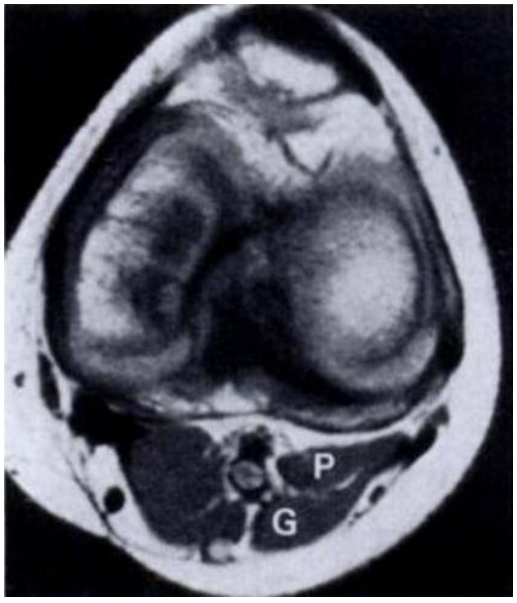


Figure 28: *Axial proton-density-weighted MRI in a man, showing a normal plantaris tendon (P) at the knee. G=lateral head of the gastrocnemius muscle (*Saxena and Bareither, 2000)

2.4.2.2 Ultrasound

Simpson and co-workers (1991) did an ultrasound study on the plantaris muscle with a sample of 26 legs of 25 patients. The patients were placed in the prone position and the ultrasound was done on the posterior aspect of the legs. In order to optimize the focal length, an intravenous (IV) bag was placed between the transducer and the leg. The plantaris muscle was only considered present if the tendon could be visualized in both (transverse and longitudinal) planes; otherwise it was noted as absent. They further stated that if the plantaris muscle is not seen, there is a 70-80% chance that this muscle is not present or functional for tendon grafting. The advantages of using ultrasound as a detection method for the plantaris muscle include that it is non-invasive, there is no radiation involved, and it is easy to do and allows comparison of both legs in one consultation (Simpson *et al*., 1991).

2.5 Uses in reconstructive surgery

2.5.1 Palmaris longus

The advantages of using the palmaris longus muscle in reconstructive surgery, include that it is easy to harvest (Carlson *et al.,* 1993), it is expendable (Carlson *et al.,* 1993),, it has a nonessential function (White, 1960) and is readily available (White, 1960). The palmaris longus is a popular tendon graft (Carlson et al., 1993), that is used in various reconstructive surgery procedures, which include total maxillectomy (Askar *et al.,* 2003), ptosis correction in children (Lam *et al.,* 1998; Wong *et al.,* 2005), eyelid reconstruction that include frontal suspension of the upper eyelid (Ueda *et al*., 2007), total mandible and chin reconstruction (Jeng *et al.,* 2004; Carroll *et al.,* 2000), second stage flexor tendon reconstruction (Wurtz & Hanington, 1991) and reconstructive hand surgery (Jaffe & Weckesser, 1967; Wurtz & Hanington, 1991; Taylor *et al*., 2004), which includes tendon transfer for thumb extension in high radial nerve palsy (Sanghavi & Ali, 2009; Zeineh & Wilhelmi, 2009), secondary to chronic carpal tunnel syndrome (Zeineh & Wilhelmi, 2009) and to improve tip pinch in ulnar nerve palsy (Sanghavi & Ali, 2009).

2.5.2 Plantaris

The following procedures make use of the plantaris muscle in reconstructive surgery: hernia repair (Pilcher, 1939; Daseler & Anson, 1943), tendon transplants (Daseler & Anson, 1943), grafting in hand surgery (Harvey *et al.,* 1983; Jaffe & Weckesser, 1967), surgical treatment of a ruptured Calcaneal tendon (achilles tendon) (Lynn, 1966; Incavo *et al.,* 1987; Boer *et al.,* 2009), a tendo-osseus graft (Schlicht & Morrison, 1992), lateral ankle ligament reconstruction (Burnner & Gaechter, 1991; Pagenstert *et al.,* 2005), repair of the fibular ligaments (Saeed & Kay, 1993), a proposed atrioventricular valve repair (Shuhaiber & Shuhaiber, 2003) and reconstructive hand surgery (White, 1960).

2.6 Removal of the palmaris longus and plantaris muscles during reconstructive surgery

2.6.1 Palmaris longus

During the correction of an ulnar claw, the palmaris longus tendon is removed by means of the four-tailed (PL4T) method (see figure 29) (Taylor *et al*., 2004). It is said to be a successful technique in supple and hyper-mobile hands. The palmaris longus tendon is detached at its insertion through a small transverse incision. The tendon is withdrawn 5cm up the forearm through a second incision. One should keep in mind not to pull to hard on the palmaris longus tendon, otherwise it becomes overstretched.

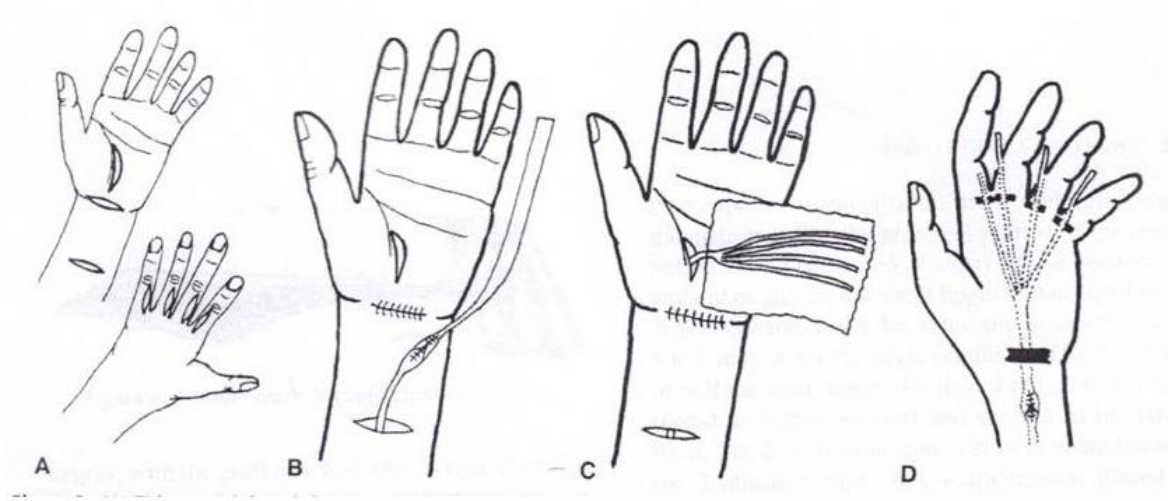


Figure 29: *PL4T procedure in removing the palmaris longus muscle. (a) Palmar and dorsal skin incision for the PL4T procedure. (b) Palmaris longus tendon lengthened with a graft from fascia lata. (c) Tendon with graft rerouted through carpal tunnel to midpalmar incision and divided into 4 slips. (d) Each tendon slip is tunnelled to a finger (Taylor* et al., *2004).*

Saeed and Kay (1993) used a modified Bunnell's technique. The presence of the palmaris longus muscle is firstly determined before the procedure. A 0.5cm incision is made that overlies the distal end of the palmaris longus tendon, just proximal to the wrist crease. The tendon is

separated from surrounding tissue and then lifted free with a retractor. It is pulled upward and distally to show the course of the tendon in the mid-forearm. The proximal end of the tendon is cut with a stab incision. It is important to keep the palmaris longus tendon taut throughout the whole procedure; this avoids damage to the surrounding structures. During this study there was no damage to the median nerve.

A radial forearm flap with the palmaris longus was used in total maxillectomy. The radial forearm flap with the palmaris longus tendon was lifted, the flap included venae commitantes and the radial artery (Askar *et al.,* 2003).

Ptosis correction in children was also done with the modified Bunnell's technique. The patient was asked to oppose the thumb and little finger to detect the presence of the palmaris longus (Schaeffer's test). The whole course of the palmaris longus was marked out on the forearm. The forearm was then rested, in a supinated position, on the arm table. A bloodless surgical field was created and a 1cm transverse cut was made over the proximal wrist crease. It is suggested that the palmaris longus tendon can be harvested from adults under local anaesthesia, which is safer and easier and there is a low risk of nerve damage (Lam *et al.,* 1998).

During eyelid reconstruction a 2.5x6cm left radial forearm flap with a vascularised palmaris longus tendon was made. Ueda and co-workers (2007) stated that the palmaris longus tendon can support the forearm flap (static suspension) or it could provide muscle movement to the forearm flap (dynamic suspension).

In total lower lip reconstruction the flap is folded over the palmaris longus tendon which is transected about 5cm from both ends of the flap. Carroll and co-workers (2000) transected the proximal and distal ends of the palmaris longus tendon about 2cm from the composite radial forearm flap. The flap contained two venous systems, a cutaneous forearm nerve and the tendon of the palmaris longus. (see figure 30).

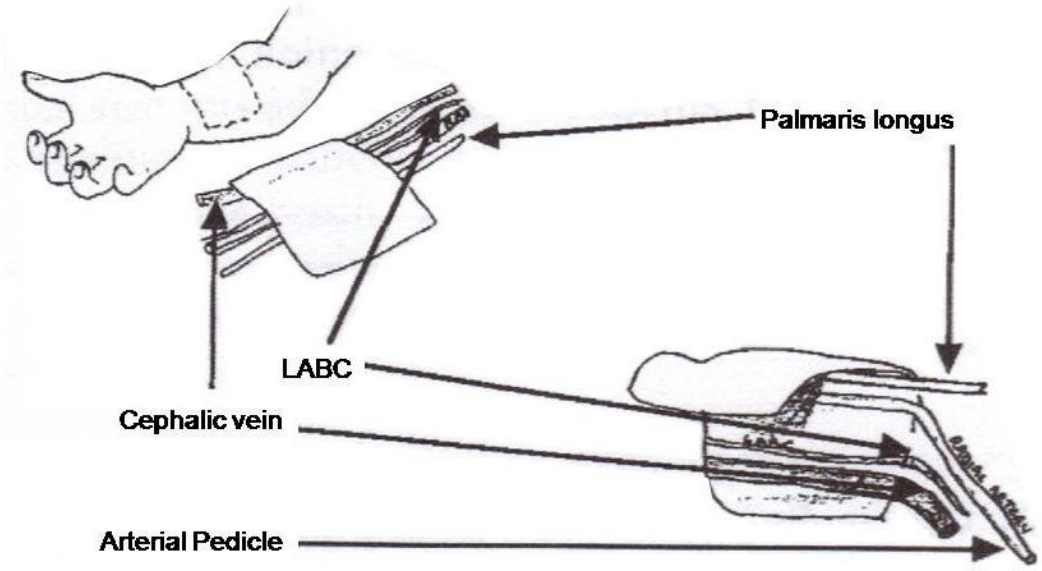


Figure 30: *Schematic drawing of radial forearm flap showing the relation of the palmaris longus tendon, cephalic vein, the lateral antebrachial cutaneous nerve (LABC) and the arterial pedicle (Carroll* et al., *2000).*

A small transverse incision at the wrist will expose the palmaris longus tendon during reconstructive hand surgery; this will allow dissection of the distal segment of the tendon. After the tendon is divided it is passed through a cutting loop of a tendon stripper. The tendon is gripped firmly with a strong clamp and wound up on the clamp one full turn. The stripper is then forced up the forearm while counteraction is applied to the tendon. The course of the palmaris longus can easily be followed beneath the skin. As soon as the muscular belly is reached a strong counter pull is required, the stripper is forced upward and the muscle is cut. The tendon of the palmaris longus can then be extracted (White, 1960).

Through the procedure where the palmaris tendon is transferred to allow thumb extension, in high radial nerve palsy, the tendon is cut at the wrist and separated proximally. The palmaris longus tendon is then rerouted, over the dorsal compartment, to the extensor pollicis longus (Zeineh & Wilhelmi, 2009; Sanghavi & Ali, 2009) (see figures 31 and 32).

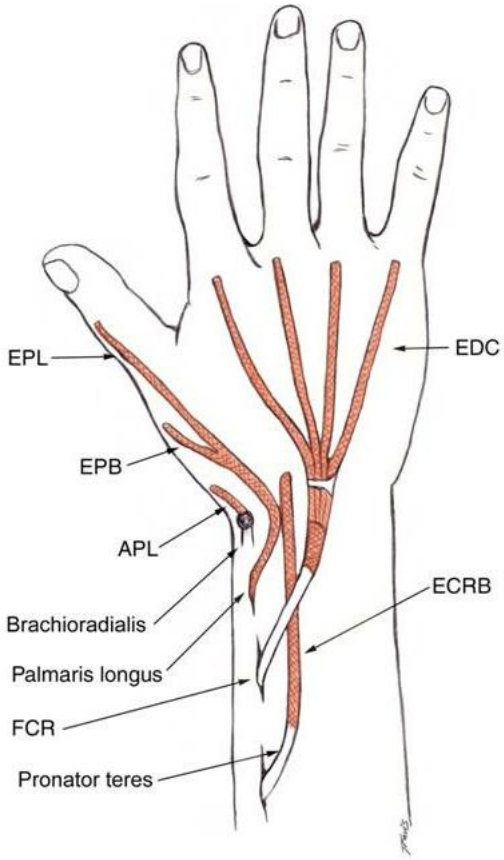


Figure 31: *Tendon transfer for high radial nerve palsy. The palmaris longus tendon (PL) inserts onto the extensor pollicis longus (EPL) and the extensor pollicis brevis (EPB) (Zeineh & Wilhelmi, 2009).*

Figure 32: *Tendon transfer from the palmaris longus (PL) to the extensor pollicis longus (EPL) (Zeineh & Wilhelmi, 2009).*

The palmaris longus tendon transfer is useful for thenar paralysis in carpal tunnel syndrome (Zeineh & Wilhelmi, 2009). This tendon is transferred to the abductor pollicis brevis muscle, in a subcutaneous tunnel. To increase the length of the palmaris longus tendon, the distal palmar fascia is also harvested. This procedure, called the Camitz abductorplasty, provides abduction of the thumb (see figure 33).

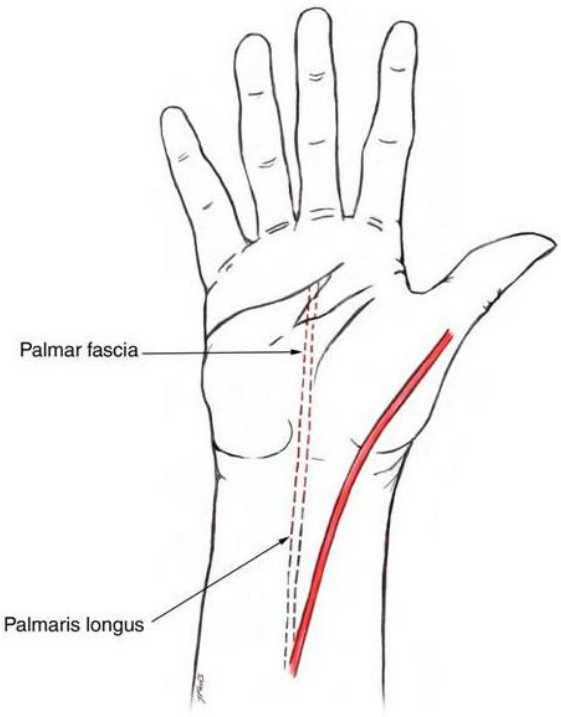


Figure 33: *Camitz abductorplasty, in which the palmaris longus (PL) is, transferred to the abductor pollicis brevis (APB) (Zeineh & Wilhelmi, 2009).*

Improvement of tip pinch for ulnar nerve palsy includes that a slip of the abductor pollicis longus muscle is elongated by a tendon graft form the palmaris longus or plantaris muscles. The tendon is then inserted on the first dorsal interosseous muscle (see figure 34) (Sanghavi & Ali, 2009).

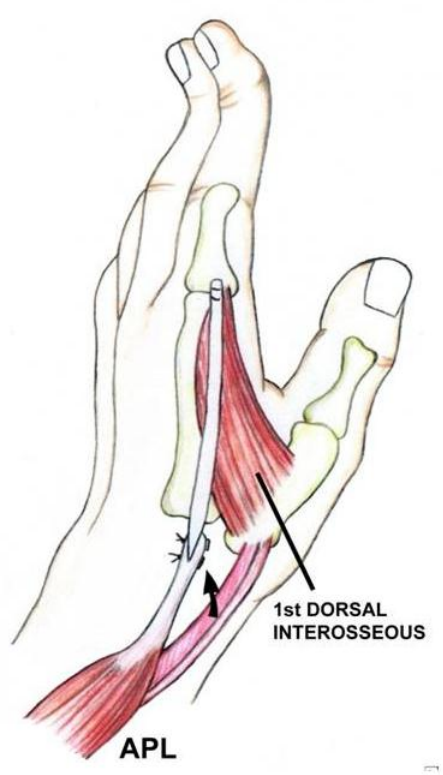


Figure 34: *Tip pinch. A slip of the abductor pollicis longus (APL) is elongated with a free tendon graft from the palmaris longus (PL) or plantaris and inserted into the tendon of the first dorsal interosseus (Sanghavi & Ali, 2009).*

2.6.2 Plantaris

Glissan (1932) reported a method for extracting the plantaris tendon for reconstructive surgery. A 5cm incision is made parallel to the medial border of the Calcaneal tendon (achilles tendon), just above its insertion to the calcaneus bone. The plantaris tendon will be located just medial to the Calcaneal tendon (achilles tendon). The tendon is freed by gentle dissection. A second 7.5cm incision is made along the upper third of the inner aspect of the calf. Dissect through the deep fascia and gastrocnemius until the plantaris is reached. The tendon is freed, as far proximally and distally as possible, by means of careful dissection. A pair of curved blunt pointed scissors is used to cut the plantaris tendon as close to the belly as possible. The plantaris tendon can be withdrawn through the lower incision, with firm traction.

The plantaris tendon can be used when repairing a ruptured Calcaneal tendon (achilles tendon) (Lynn, 1966; Incavo *et al.,* 1987; Boer *et al.,* 2009) (see figure 35). The plantaris tendon is freed and firstly detached proximally. The tendon is then used as a tendon weave to enhance the repair of the Calcaneal tendon (achilles tendon) (Incavo *et al.,* 1987).

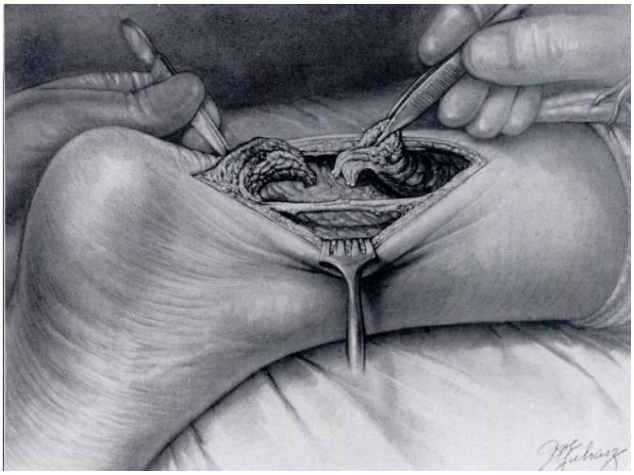


Figure 35: *Torn ends of fresh rupture of Calcaneal tendon (achilles tendon) and intact plantaris tendon (Lynn, 1966)*

With lateral ankle ligament reconstruction, a 2-7cm incision is made medial to the insertion of the calcaneal tendon (Pagenstert *et al.,* 2005). Another incision is made at the medial border of the triceps surae (consisting of the gastrocnemius and soleus muscles), about 25-30 cm proximal to the medial malleolus. The plantaris tendon is the only rigid structure found between the gastrocnemius and soleus muscles. The tendon is then fixed with a clamp, cut and anchored with Bunnell's stitch technique. A blunt tendon stripper is used to dissect the tendon in a distal direction; the inner cylinder is rotated to cut the tendon without another incision. This method produces consistent results with a good long-term outcome (see figure 36).

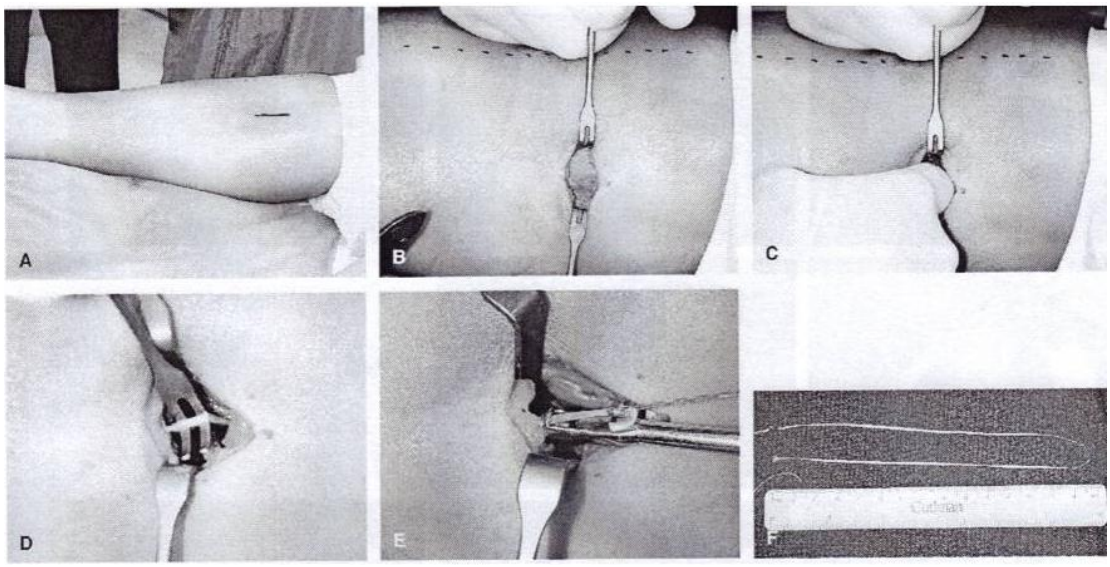


Figure 36: *Overview and skin incision to harvest the plantaris tendon (Pagenstert* et al., *2005).*

A modified Weber's technique is used when repairing the fibular ligaments. The plantaris tendon is detached with a tendon stripper, and the tendon of choice in this type of reconstructive surgery (Saeed & Kay, 1993).

When repairing hernias with the plantaris muscle, a 2.5 cm incision is made at the medial portion of the Calcaneal tendon (achilles tendon). The tendon is found, cleaned in length and cut as low as possible. The cut end of the plantaris tendon is passed through a tendon stripper and pushed up the leg. It is important to maintain tension on the cut end. A second incision of 2.5cm is made over the medial part of the tibia, near its upper end. The deep fascia is dissected and the muscles separated to identify the tendon and cut it as high as possible. The plantaris tendon with the stripper is withdrawn through the lower incision (Pilcher, 1939).

White (1960) reported a method to extract the plantaris muscle for reconstructive hand surgery. A single vertical incision is made on the medial aspect of the Calcaneal tendon (achilles tendon), 2.5cm proximal to the insertion of the plantaris tendon. The tendon is cut close to its insertion and the end is passed through a tendon stripper, and grasped securely. While keeping the knee fully extended, the tendon stripper is forced up the leg. The

muscle is cut proximally and the plantaris tendon can be pulled free and withdrawn (White, 1960).

As time goes by, researchers realise that there will always be a need for replacement tissue, for example tendons, has been and will always be present. The literature indicates that there is a difference in the morphology as well as the prevalence of these muscles between different population groups or races. Thus the standards for one population would not necessarily apply to another. This M.Sc. Anatomy thesis will look at the prevalence, morphology and possible anatomical variations of the palmaris longus and plantaris muscles in a South African population. This will directly influence the use of these muscles as grafts or flaps in reconstructive surgery in South Africa.

3. MATERIALS AND METHODS

3.1 Determining the macroscopic structure of the palmaris longus and plantaris muscles

3.1.1 Palmaris longus

The palmaris longus muscle was exposed from its origin at the medial epicondyle of the humerus to its insertion on the palmar aponeurosis. The sample consisted of 108 cadavers from the Departments of Anatomy at the University of Pretoria as well as the University of Limpopo (MEDUNSA campus). If a tendon or muscular belly was damaged in any way, it was excluded from the sample. The sample included 74 males and 34 females between the ages of 19 to 99 years.

Proximally, a coloured pin was placed into the origin of the palmaris longus muscle and the distal pin was placed at the point of insertion. The origin is defined as the medial epicondyle of the humerus, most commonly known as the common flexor origin. The insertion is the distal half of the flexor retinaculum, at the apex of the palmar aponeurosis. High quality digital photographs were then taken of the forearm and exposed muscle. A scale of known distance was placed on top of the dissected area (without covering any of the relevant structures) in order to enable digital measurements of the photograph.

The photographs were then imported into *UTHSCSA* Image Tool Ver. 3, which was used to analyse the photographs. Using the *Calibrate Spatial Measurements* function, the known scale found on each photograph was converted into a pixel format. This allowed for accurate measurements of the photographs by means of the *Distance* function, which converts the length of a straight line – drawn between two points on the photograph – into millimetres. These measurements were then inserted into an MS Excel™ worksheet and subsequent statistical analysis of the data was done.

Measurements included the length and width of both the fleshy belly and tendon of palmaris longus. The origin, insertion and possible variations were observed and documented (see figure 37).Each measurement was done twice (at different times) and the average of the two measurements was taken. The length of the belly was measured from the proximal pin to the most proximal aspect of the tendon, while the length of the tendon was measured from the most proximal aspect of the tendon to the distal pin. The width of both the belly and tendon was taken at their widest parts.

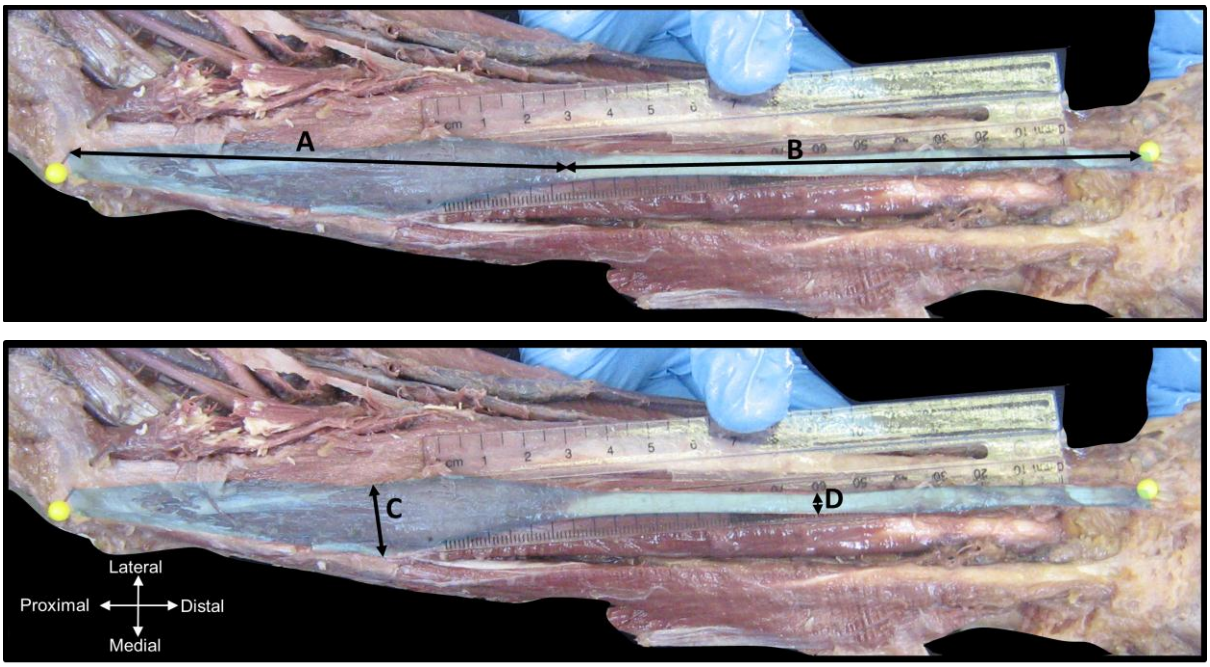


Figure 37: *Measurements of the palmaris longus muscle. A: muscular belly length, B: tendon length, C: muscular belly width and D: tendon width.*

Statistical analysis included the mean, standard deviation, median, range, and confidence interval, with a 95% confidence level, of the measurements obtained from the dissections. A paired t-test was used to compare the left and right sides of the sample.

3.1.2 Plantaris

The plantaris muscle was dissected on both sides in a sample of 60 cadavers, from the Departments of Anatomy at the University of Pretoria and University of Limpopo (MEDUNSA campus). If a tendon or muscular belly was damaged in any way, it was excluded from the sample. The sample included 29 males and 31 females between the ages of 19 and 99 years.

Proximally, a coloured pin was placed into the origin of the plantaris muscle and distally a pin was placed at the insertion. The origin of the plantaris muscle is defined as the inferior end of the lateral supracondylar line on the femur. The insertion is on the posterior surface of the calcaneus, via the calcaneal tendon. High quality digital photographs were then taken of the leg together with a scale of known distance, which was placed on top of the dissected area (without covering any of the relevant structures) in order for digital measurements of the photograph to be possible (see figure 38). The *Distance* function of Image Tool Ver. 3 was used to measure the length and width of both the fleshy belly and tendon of the plantaris muscle. Each measurement was done twice (at different times) and the average of the two measurements was taken.

These measurements were then inserted into an MS Excel™ worksheet and subsequent statistical analysis of the data was done. Statistical analysis included the mean, standard deviation, median, range, and confidence interval, with a 95% confidence level, of the measurements obtained from the dissections. A paired t-test was used to compare the left and right sides of the sample. The origin, insertion and possible variations was also observed and documented.

Figure 38: *Measurements of the plantaris muscle. A: muscular belly length, B: tendon length, C: tendon width and D: muscular belly width.*

3.2 Determining the prevalence of the palmaris longus and plantaris muscles

3.2.1 Palmaris longus

To determine the prevalence of the palmaris longus muscle, 545 participants were randomly selected from various age groups. The sample included students currently studying at the University of Pretoria, as well as learners from Kathstan College. Informed consent (See Appendix A) was obtained from the participants (individuals older than 18 years of age) or the parent(s)/guardian(s) (individuals younger than 18 years of age). Even with consent from the parent/ guardian, participants younger than 18 years of age were also asked whether they would like to participate in the study (See Appendix B: Assent from). The following were recorded on the sample of participants: age, sex, hand dominance and whether the palmaris longus muscle were absent, present on one or on both sides.

Schaeffer's test was used in order to visualize or palpate the palmaris longus tendon. Participants were asked to oppose their thumb and little finger with slight flexion of the wrist. If the palmaris longus tendon was present, it would be visible at the distal aspect of the forearm (see figure 39).

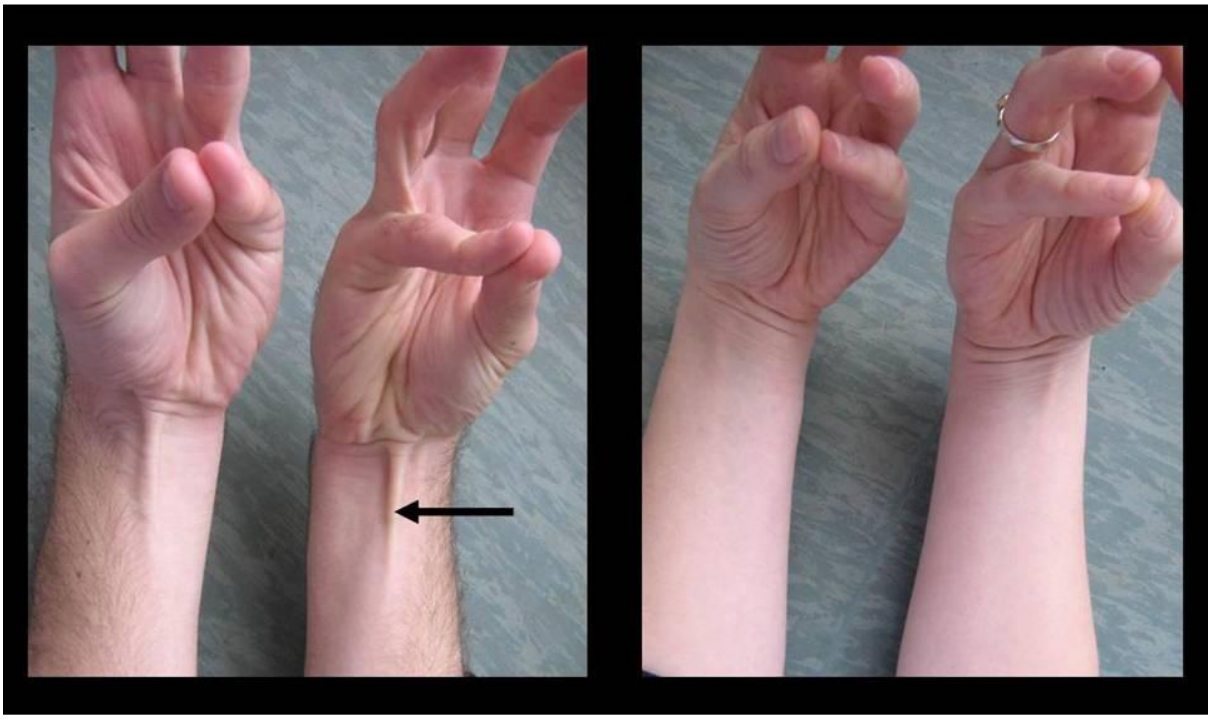


Figure 39: *Prevalence of the palmaris longus muscle. The individual on the left side have both the palmaris longus muscles and the individual on the right side has none.*

Further information regarding the prevalence of the palmaris longus muscle was obtained from a sample of 161 cadavers from the Department of Anatomy at the University of Pretoria and the University of Limpopo (MEDUNSA Campus). The muscle was carefully dissected out and the age, sex as well as whether the muscle is present or not was documented (see figure 40).

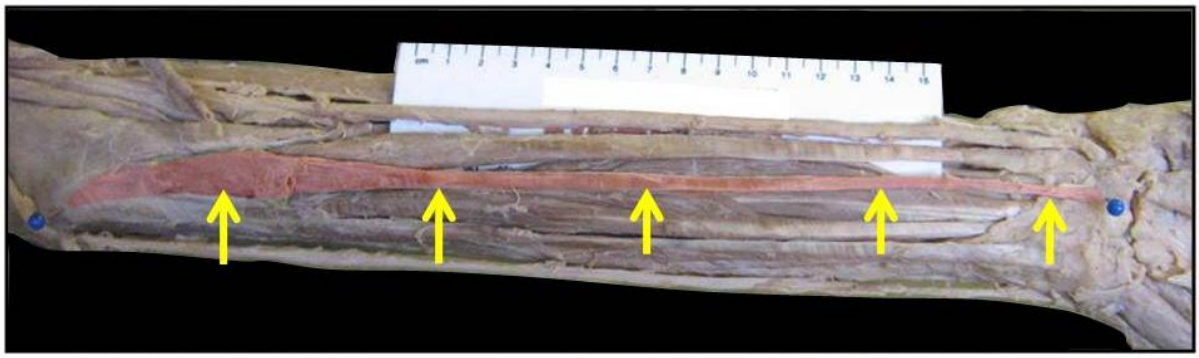


Figure 40: *The palmaris longus muscle dissected.*

Therefore, a total sample of 706, comprising living participants as well as cadavers, was used to determine the prevalence of the palmaris longus muscle. The sample consisted of 363 males and 343 females between the ages of 5 and 99 years, from various ethnicity groups.

3.2.2 Plantaris

To the investigator's knowledge there is no palpable way of determining the presence of plantaris without the use of other imaging modalities such as MRI or Ultrasound. There is also no reference to this in the literature. The prevalence of this muscle was therefore only determined in a sample of 151 cadavers. These cadavers were obtained from the Departments of Anatomy at the University of Pretoria and the University of Limpopo (MEDUNSA Campus).

The muscle was carefully dissected out and the age, sex as well as whether the muscle is present or not was documented. All dissections were done according to the regulations stated in the Human Tissues Act, Act 65 of 1983 (see figure 41).

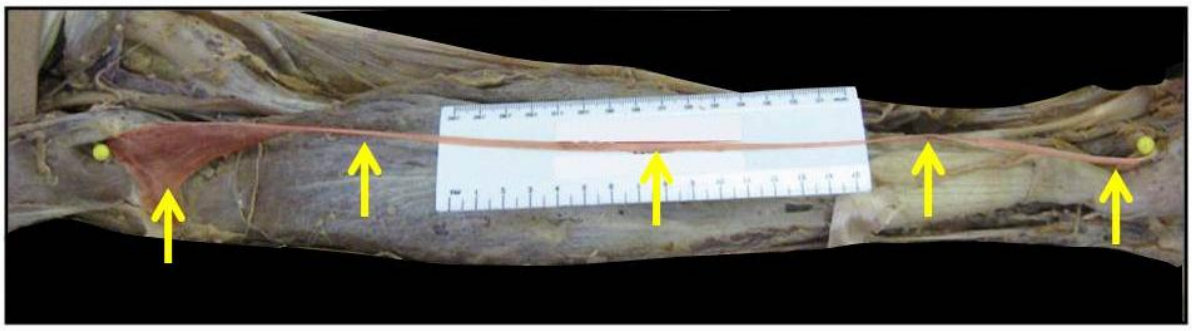


Figure 41: *The plantaris muscle exposed in a dissected cadaver*

3.2.3 Determining the relationship of the simultaneous occurrence of the palmaris longus and plantaris muscles in the same individual

In the previous aims, palmaris longus and plantaris muscles were dissected out on both sides of a sample of 151 cadavers. The prevalence of both these muscles was documented for each cadaver.

A Chi-square test was used to determine a possible correlation between the sex of the cadaver and the prevalence of the palmaris longus and plantaris muscles. The hypothesis states that the sex of the cadaver, whether male or female, is related to the prevalence of the palmaris longus or plantaris muscles. A McNemar test for symmetry was used to determine whether the presence or absence of the palmaris longus muscle will predict the presence of absence of plantaris in the same individual.

3.3 Determining a possible phylogenetic trend of the palmaris longus muscle

To determine the prevalence of the palmaris longus muscle, five groups representing different age intervals, was used (see table 3). The 706 participants from the second aim were used for this study. The following demographic data of the sample population were recorded: age, sex and whether the palmaris longus is absent or present on one or both sides. The sample consisted of 363 males and 343 females between the ages of 5 and 99 years, from various ethnic groups.

Table 3: *Table showing the distribution of the sample in the various age groups.*

	Group 1 (0-20 yrs)	**Group 2** (21-40 yrs)	**Group 3** (41-60 yrs)	**Group 4** (61-80 yrs)	**Group 5** (81-99 yrs)
n	361	151	93	64	37

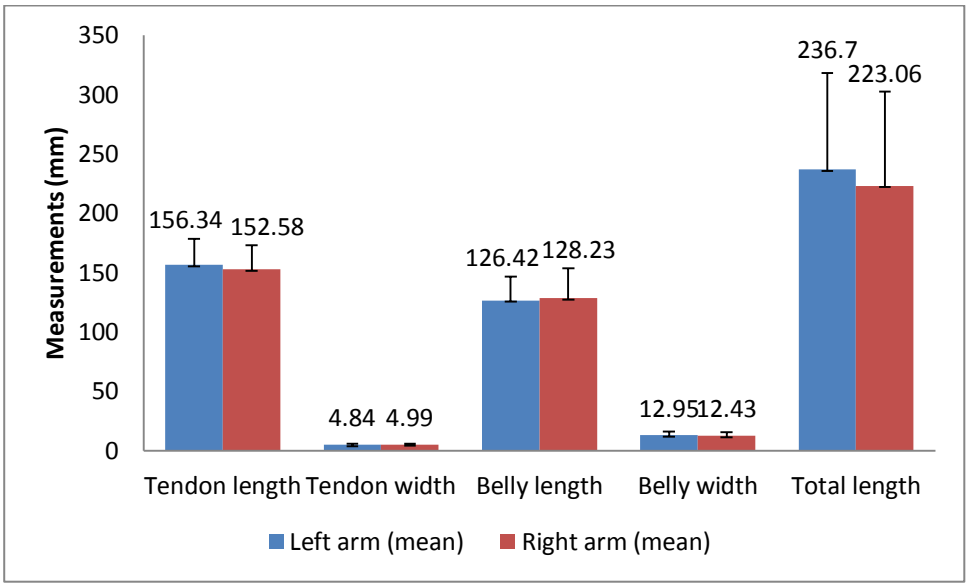
To determine a possible phylogenetic degenerative trend for the palmaris longus muscle, the data obtained from the five groups were statistically analysed by means of a Chi-squared test. The hypothesis states that a possible phylogenetic trend can be established in this sample of 706 individuals, which are divided into five age groups. The prevalence of the muscle was also compared between the five groups.

4. RESULTS (See Appendix C and D for omitted tables and raw data)

4.1 Morphology of the palmaris longus and plantaris muscles

4.1.1 Palmaris longus

A total of 167 forearms were dissected for this study, which consisted of 81 left arms and 86 right arms. The measurements of palmaris longus are illustrated in graph 1.

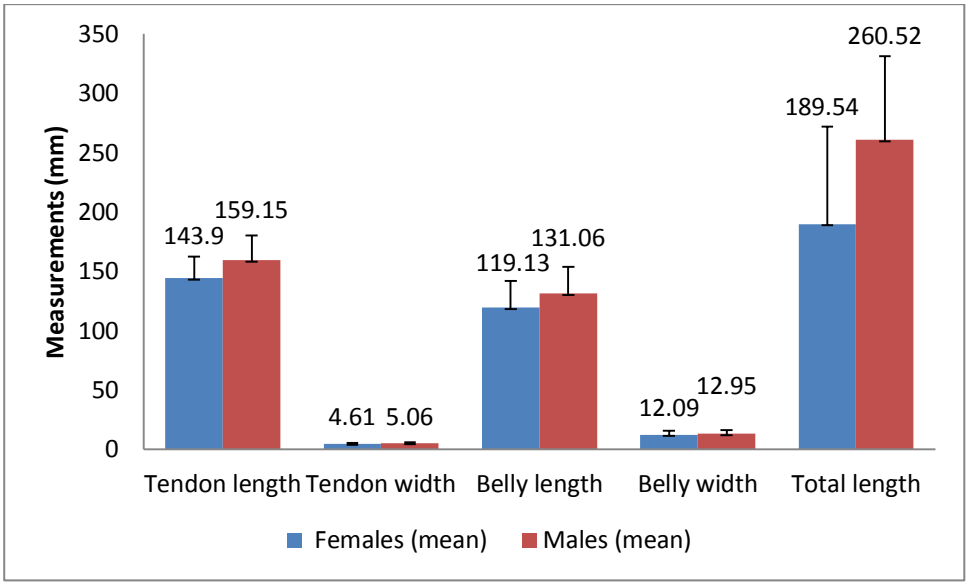


Graph 1: *Measurements taken for palmaris longus in the left and right arms, respectively.*

For the palmaris longus muscle on the left, the tendon length measured 156.34 mm (SD=22.18), the tendon width measured 4.84 mm (SD=0.88). The length of the muscular belly was 126.42 mm (SD=20.3) and the belly width was 12.95 mm (SD=3.14). The total length of the palmaris longus measured 236.7.81 mm (SD=81.37) for the left arm.

On the right the palmaris longus tendon measured 152.58 mm (SD=20.3) long and 4.99 mm (SD=0.89) wide. The length of the belly is 128.23 mm (SD=25.56) and the width is 12.43 mm (SD=3.09). The total length for this muscle in the right arm is 223.06 mm (SD=79.12)

It was found that there is no statistically significant difference between the left and right arms, and the data from both sides were pooled together for a total sample of 167. In graph 2, the differences in the measurements of males and females are shown.



Graph 2: *Measurements taken for palmaris longus in the female and male population, respectively.*

In the total sample of 74 males, the average length of the palmaris longus tendon is 159.15 mm (SD=20.75) compared to the 34 females with an average tendon length of 143.9 mm (SD=18.56). There is a statistically significant difference between the male and female tendon length (p-value=0.00)

A statistically significant difference was found between the male and female samples concerned with the width of the palmaris longus tendon (p-value=0.04). The tendon width measured 5.06 mm (SD=0.91) for the males and 4.61 mm (SD=0.75) for the females.

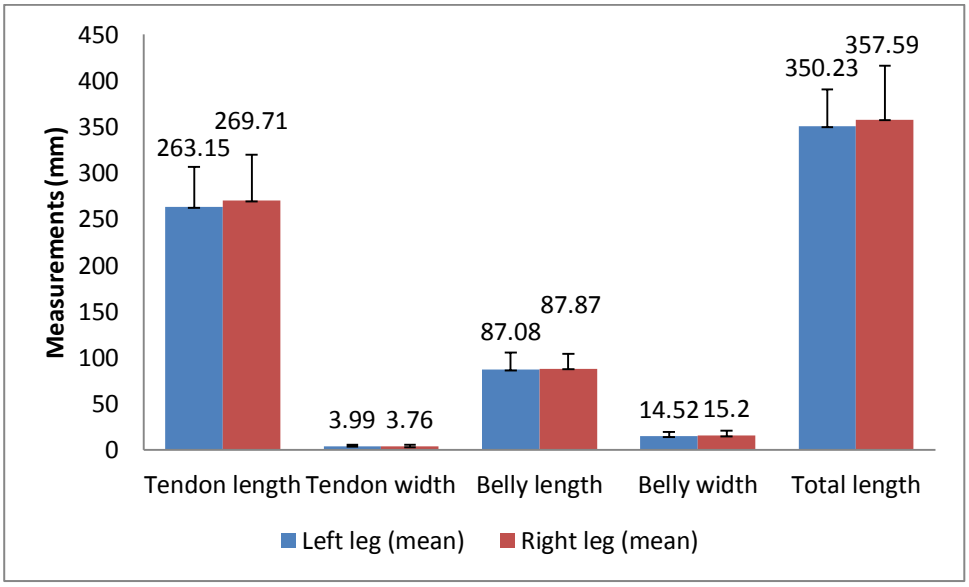
Another statistically significant difference was found between the males and females for the length of the muscular belly of palmaris longus (p-value=0.03). In the male sample the length of the belly measured 131.06 mm (SD=22.39) compared to the female sample with a belly length of 119.13 mm (SD=22.37).

The width of the muscular belly of the palmaris longus muscle measured 12.95 mm (SD=3.01) in males and 12.09 mm (SD=3.3) in females. A statistically significant difference was found between the male and female samples (p-value=0.74).

The fact that there were statistically significant differences for all the measurements between males and females, indicates a statistically significant difference in the total length of the palmaris longus muscle (p-value=0.00). The total length is 260.52 mm (SD=70.33) for the males and 189.54 mm (SD=82.01) for the females.

4.1.2 Plantaris

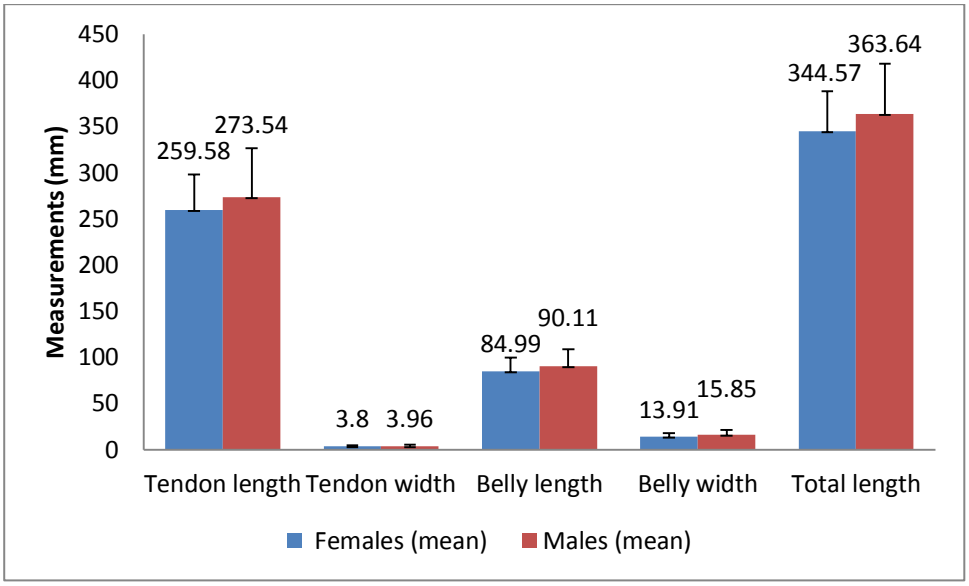
In the total sample of 60 cadavers 89 legs were dissected, which consisted of 46 left legs and 43 right legs. The measurements of the plantaris muscle are illustrated in graph 3.



Graph 3: *Measurements taken for plantaris muscle in the left and right legs, respectively.*

In the sample of the left legs, the average length of the plantaris tendon is 263.15 mm (SD=43.15) compared to the right leg sample with an average tendon length of 269.71 mm (SD=49.7). There is no statistically significant difference between the male and female tendon length (p-value = 0.55)

No statistically significant difference was found between the left and right legs concerning the width of the plantaris tendon (p-value = 0.42). The left plantaris tendons had a width of 3.99 mm (SD=1.26) and the right tendons 3.76 mm (SD=1.32). The length of the muscular belly measured 87.08 mm (SD=18.04) on the left side and 87.87 mm (SD=15.95) on the right side. Still no statistically significant difference between the left and right bellies of the plantaris muscle (p-value = 0.90). The width of the plantaris belly is 14.52 mm (SD=4.43) on the left side and 15.2 mm (SD=5.57) on the right. There is no statistically significant difference between the left and the right side (p-value = 0.89). The length of the muscle measured 350.23 mm (SD=40.11) for the left leg and 357.59 mm (SD=58.29) for the right leg and still no statistically significant difference in the total length of the plantaris muscle, between the left and right legs (p-value = 0.57). In graph 4, the differences in the measurements of males and females are shown.



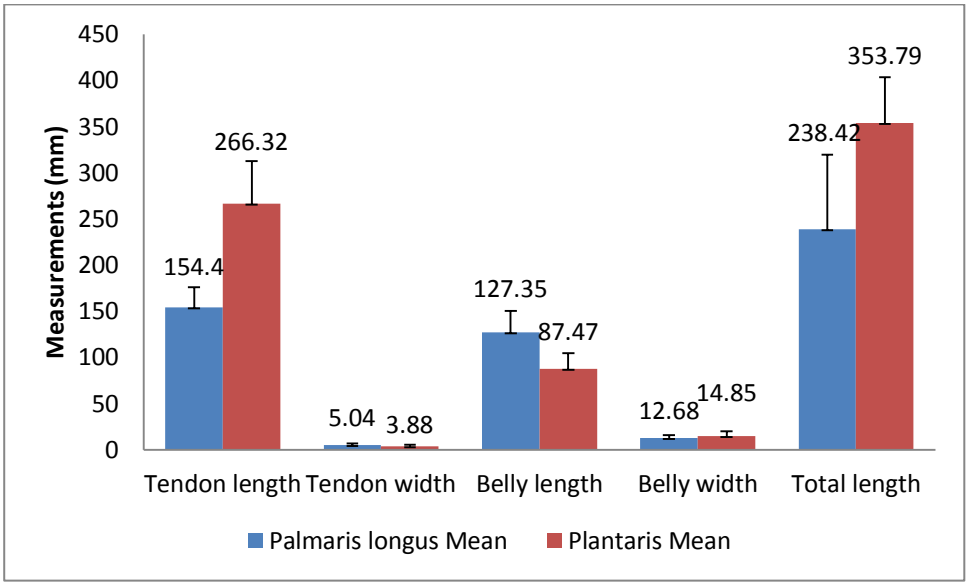
Graph 4: *Measurements taken for plantaris muscle in the female and male population, respectively.*

The male sample of 29 cadavers (see graph 4) had a plantaris tendon length of 273.54 mm (SD=53), and a tendon width of 3.96 mm (SD=1.36). The length of the belly of the plantaris muscle is 90.11 mm (SD=18.84) and the width of the belly is 15.85 mm (SD=5.57).

The average tendon length of the female sample of 31 cadavers is 259.58 mm (SD=38.36), and the average width of the tendon is 3.8 mm (SD=1.23). The belly length is 84.99 mm (SD=14.8) and the belly width was 13.91 (SD=4.24). No statistically significant difference was found between the male and female samples for the plantaris measurements: between the total length of the muscle (p-value=0.06). The total length for the female sample measured 344.57 mm (SD=43.47) and the male sample 363.64 mm (SD=54.15).

4.1.3 Comparison of the morphology of the palmaris longus and plantaris muscles

Paired t-tests were done to investigate whether a significant difference exists, in the morphology of the palmaris longus and plantaris muscles. Graph 5 compares the morphology of the palmaris longus with those measurements taken of the plantaris muscle (this is for the total sample).



Graph 5: *Comparison of the measurements taken for the palmaris longus and plantaris muscles.*

The average tendon length for palmaris longus was154.4 mm (SD=21.25) compared to the plantaris tendon, with a length of 266.32 mm (SD=46.28). There is a statistically significant difference between the tendon lengths of the different muscles (p-value = 0.00). The average width of the palmaris longus tendon is 5.04 mm

(SD=1.84) and the plantaris tendon width is 3.88 mm (SD=1.29). A statistically significant difference was found between the widths of the tendons (p-value of 0.00).

The length of the belly of the palmaris longus muscle is 127.35 mm (SD=22.99) compared to the belly length of the plantaris muscle of 87.47 mm (SD=16.97). A statistically significant difference, with a p-value of 0.00 was found between the bellies of the palmaris longus and plantaris muscles. The width of the palmaris longus belly measured 12.68 mm (SD=3.12) compared to the width of the plantaris belly of 14.85 mm (SD=4.99). There is a statistically significant difference between the belly widths of the palmaris longus and plantaris muscles (p-value = 0.00).

The average length of the palmaris longus measured 238.43 mm (SD=80.93) compared to the longer plantaris muscle, with a length of 353.79 mm (SD=49.58). A p-value of 0.00 indicates a statistically significant difference in the lengths of the palmaris longus and plantaris muscles.

4.2 Prevalence of the palmaris longus and plantaris muscles

4.2.1 Palmaris longus

The prevalence of the palmaris longus muscle is summarized in table 4, of the sample of 706 participants.

Table 4: *Table showing the prevalence of the palmaris longus muscle for the sample examined.*

	Total sample (n=706)	**Males (n=363)**	**Females (n=343)**
Bilateral absence	11.9 %	6.52 %	5.38 %
Absent on left side	7.65 %	3.54 %	4.11 %
Absent on right side	6.94 %	4.25 %	2.69 %
Bilateral presence	73.51 %	34.28 %	39.24 %

Out of the 706 participants, 73.51% (n=519) had the palmaris longus muscle on both the left and the right sides. 11.90% (n=84) did not have the palmaris longus muscle at all – meaning that the muscle was absent bilaterally. The muscle was absent on the left side in 7.65% (n=54) of the cases and on the right side in 6.94% (n=49) of the cases.

In table 5, the prevalence of the palmaris longus muscle is indicated for males and females.

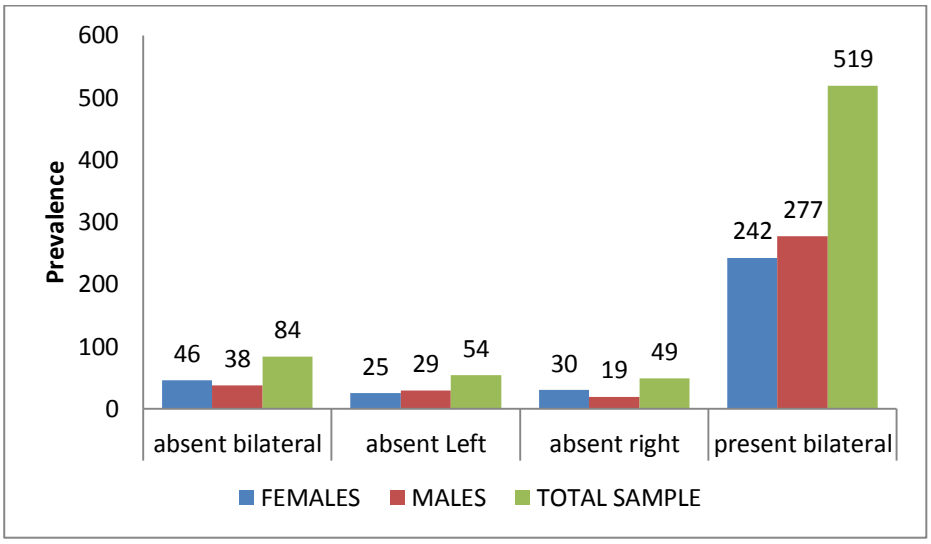
Table 5: *Table showing the prevalence of the palmaris longus muscles in the male and females samples, respectively.*

	Males		Females	
	n	%	n	%
Bilateral absence	38	10.47	46	13.41
Absent on left side	29	7.99	25	7.29
Absent on right side	19	5.23	30	8.75
Bilateral presence	277	76.31	242	70.55

In the sample of 363 males, 76.31% (n=277) had the palmaris longus muscle on both the left and the right sides. In the sample population, 10.47% (n=38) had a bilateral absence of palmaris longus. The muscle was absent on the left side in 7.99% (n=29) of the cases and on the right side in 5.23% (n=19) of the cases.

For the 343 females, the palmaris longus muscle was present in 70.55% (n=242) of the total population. Bilateral absence of the muscle was found in 13.41% (n=46) of the sample. Unilateral absence on the left side was found in 7.29% (n=25) of the cases and on the right side in 8.75% (n=30) of the cases.

Graph 6 shows the distribution of the prevalence of the palmaris longus muscle between males, females and the total sample.



Graph 6: *Graph showing the distribution of the prevalence of the palmaris longus muscle for the total sample, males and females*

Out of the total sample of 706 participants, the bilateral presence of the palmaris longus muscle was found in 39.24% (n=277) of males and 34.28% (n=242) of females. The bilateral absence of this muscles consisted of 5.38% (n=38) of males and 6.52% (n=46) of females. Unilateral absence of the left palmaris longus was made up of 4.11% (n=29) of males and 3.54% (n=25) of females. The unilateral absence of this muscle on the right was found in 2.69% (n=19) of males and 4.25% (n=30) of females.

4.2.2 Plantaris

The prevalence of the plantaris muscle in a sample of 151 cadavers is summarized in table 6.

Table 6: *Table showing the prevalence of the plantaris muscle for the sample examined.*

	Total sample	
Bilateral absence	13	8.61 %
Absent on left side	5	3.31 %
Absent on right side	4	2.65 %
Bilateral presence	129	85.43 %

The bilateral presence of the plantaris muscle was documented in 85.43% (n=129) of the cases. This muscle was absent bilaterally in 8.61% (n=13) of the cadavers. The plantaris muscle was absent in 3.31% (n=5) of the cases on the left and in 2.65% (n=4) of the cases on the right.

Table 7 shows the prevalence of the plantaris muscle for males and females.

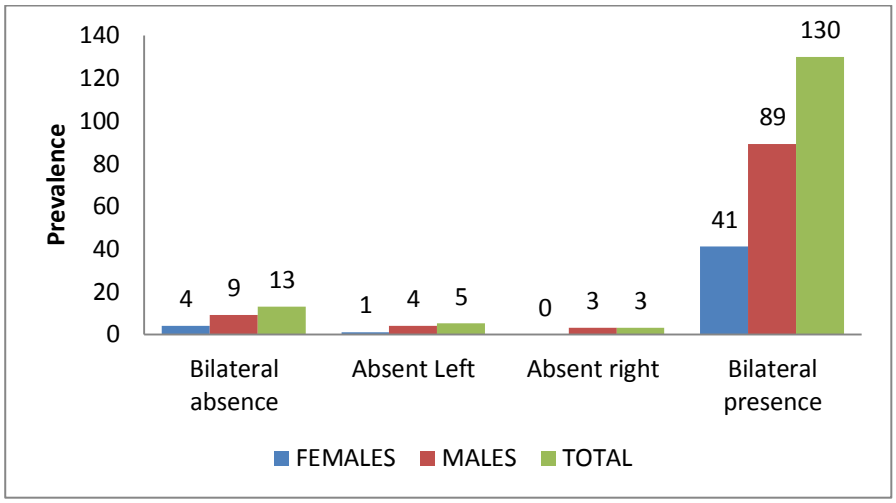
Table 7: *Table showing the prevalence of the palmaris longus muscles in the male and females samples, respectively.*

	Males		Females	
	n	%	n	%
Bilateral absence	9	8.57	4	8.7
Absent on left side	4	3.81	1	2.17
Absent on right side	3	2.86	0	0
Bilateral presence	89	84.76	41	89.13

In the male population of 105 cadavers, 84.76% (n=89) had the plantaris muscle present in both legs. The plantaris was found to be completely absent in 8.57% (n=9) of the cadavers. In 3.81% (n=4) of the cadavers the plantaris muscle was absent on the left side, and 2.86% (n=3) on the right side.

Out of the 46 females, 89.13% (n=41) of the cadavers had the plantaris muscle bilaterally (in both legs), and 8.70% (n=4) did not have this muscle at all. The plantaris muscle was absent in the left leg in 2.16% (n=1). None of the females had a plantaris muscle missing in the right leg.

Graph 7 shows the distribution of the prevalence of the plantaris muscle between males, females and the total sample.

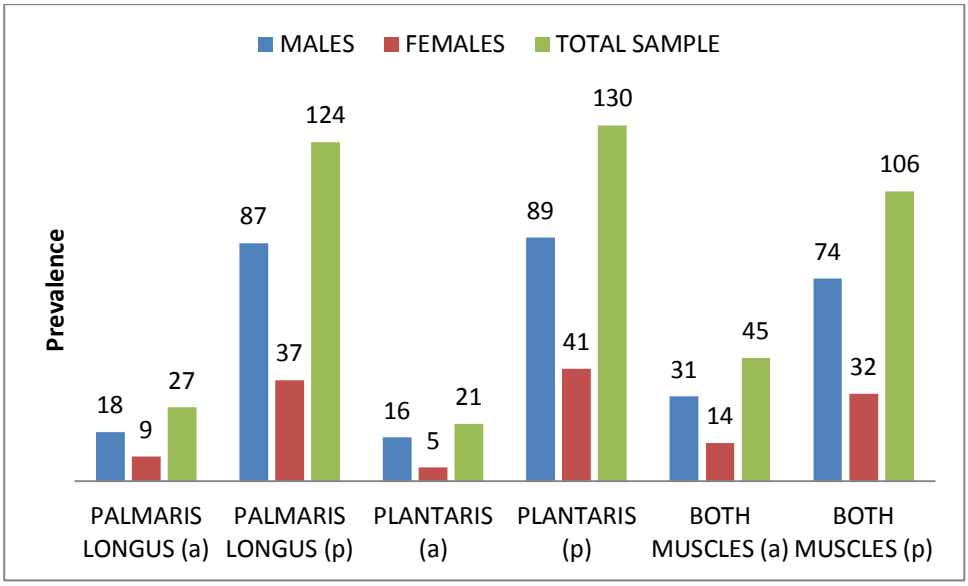


Graph 7: *Graph showing the distribution of the prevalence of the plantaris muscle for the total sample, males and females.*

Out of the total sample of 151 cadavers, the bilateral presence of the plantaris muscle was found in 89 of the males and 41 of the females, thus 130 cadavers had both the plantaris muscles present. The bilateral absence of this muscle was found in 9 of the males 4 of the females, meaning 13 cadavers did not have a plantaris muscle at all. Unilateral absence of the left plantaris was found in 4 of the males and only in one female. The unilateral absence of this muscle on the right was found in 3 males and in none for the females.

4.2.3 Correlation between sex and the prevalence of the palmaris longus and plantaris muscles.

Graph 8 illustrates the prevalence of the palmaris longus and plantaris muscles correlated with the sex of the cadavers.



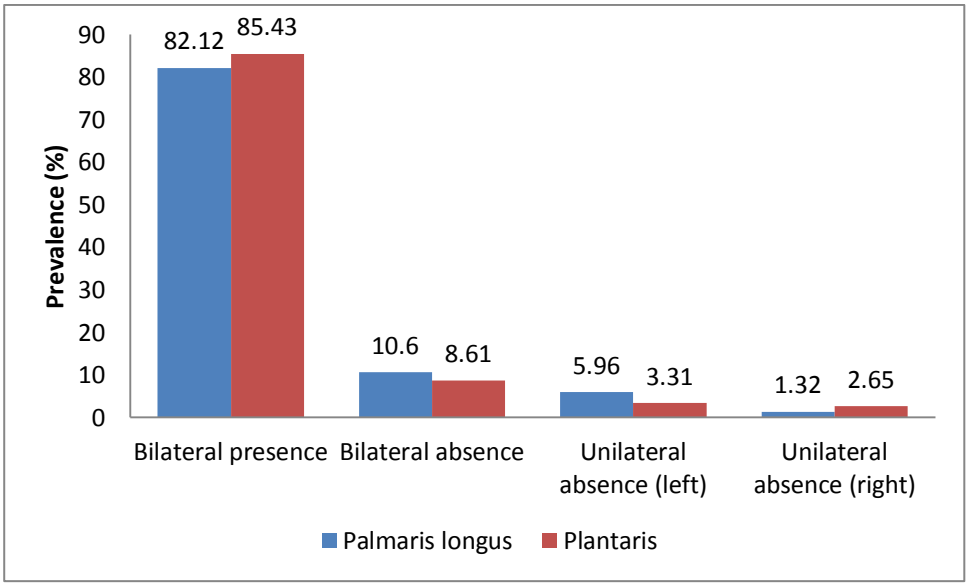
Graph 8: *Prevalence of the palmaris longus and plantaris muscles correlated with the sex of the cadavers. (a) Absent, (p) present.*

Concerning the palmaris longus muscle, 27 cadavers did not have a palmaris longus muscle: 18 were absent in the male population and 9 absent in the female population. Hundred and twenty four of the muscles were present, which consisted of 87 males and 37 females. No correlation was found between the sex of the cadavers and the presence and / or absence of the palmaris longus muscle (p-value = 0.82) and thus the hypothesis is rejected.

Twenty-one individuals lacked the plantaris muscle in this study. Sixteen were males compared to the 5 females. However, 130 of the individuals had the plantaris muscle present, which consisted of 89 males and 41 females. No correlation was found between the sex of the cadavers and the presence and / or absence of the plantaris muscle (p-value = 0.61).

4.2.4 Simultaneous occurrence of the palmaris longus and plantaris muscles

Refer to graph 9 for the prevalence of the palmaris longus and plantaris muscles of this sample of 151 cadavers.



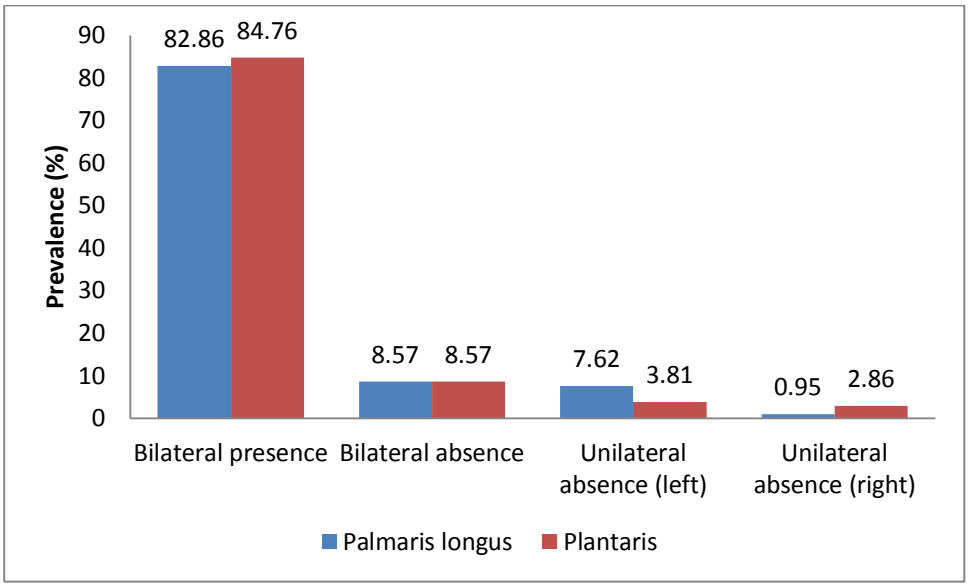
Graph 9: *Comparison of the prevalence of both the palmaris longus and plantaris muscles for the total sample.*

A bilateral presence of the palmaris longus muscle was observed in 82.12% (n=124) of the sample, while the bilateral presence of the plantaris muscle was found in 85.43% (n=129) of the sample. The palmaris longus muscle was not present in 10.60% of the combined cadaver sample and living participants, (n=16) of the arms and the plantaris was completely absent in 8.61% (n=13) of the legs.

The palmaris longus muscle was absent in the left arms in 5.96% (n=9) compared to the plantaris, absent in the left legs, in 3.31% (n=5) of the cadavers.

Absence of these muscles in the right limbs was found to be 1.32% (n=2) for palmaris longus and 2.65% (n=4) for the plantaris muscle.

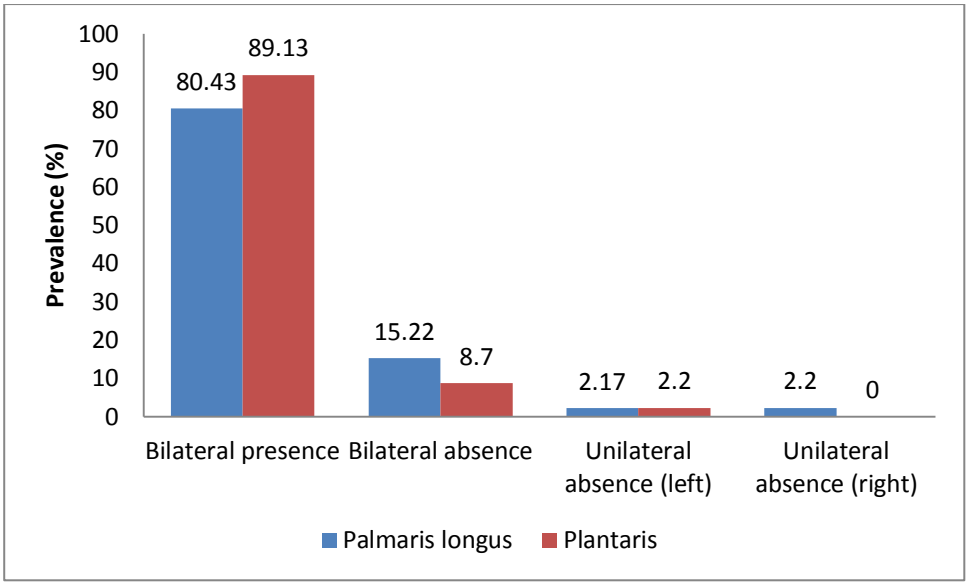
The prevalence of these muscles, for the 105 male cadavers, is illustrated in graph 10.



Graph 10: *Comparison of the prevalence of both the palmaris longus and plantaris muscles for the male sample.*

In the male population of cadavers, 82.86% (n=87) had both the palmaris longus muscles and 84.76% (n=89) had both the plantaris muscles. Both these muscles were completely absent in 8.57% (n=9) of this sample. The palmaris longus was absent in the left arms of 7.62% (n=8) of the males and the plantaris in 3.81% (n=4) of the left legs. Absence of these muscles in the right limbs was 0.95% (n=1) for palmaris longus and 2.86% (n=3) for the plantaris muscle.

Graph 11 shows the prevalence of the palmaris longus and plantaris muscles in the female sample of 46 cadavers.



Graph 11: *Comparison of the prevalence of both the palmaris longus and plantaris muscles for the female sample.*

The female sample showed a bilateral presence of the palmaris longus in 80.43% (n=37) and 89.13% (n=41) of the plantaris muscles. The muscles were completely absent in 15.22% (n=7) of the arms and 8.7% (n=4) of the legs. 2.2% (n=1) of both muscles were absent in the left limbs. Only one (2.2%) of the palmaris longus muscles were absent in the right arms. There were no plantaris muscles absent in the right leg, of the female cadaver population.

In tables 8 and 9, the simultaneous occurrence of palmaris longus and plantaris are shown for the left and right limbs.

Table 8: *Simultaneous occurrence of the palmaris longus and plantaris muscles for the left limbs, in the cadaver population.*

Palmaris longus	Plantaris				Total sample
	Absent		Present		
	n	%	n	%	
Absent	3	1.99	22	14.57	25
Present	15	9.93	111	73.51	126
Total	18		133		151

On the left side of the body, 73.51% (n=111) of the cadavers had both the palmaris longus and plantaris muscles present. 1.99% (n=3) had no palmaris longus or plantaris muscles. The palmaris longus muscle was present, but the plantaris muscle absent in 9.93% (n=15) of the cadavers. 14.57% (n=22) of the cadavers had the palmaris longus muscle absent, but the plantaris muscle present.

In total, the palmaris longus muscle was present in 126 of the cadavers and absent in 25 of the left limbs. The plantaris muscle was present in 133 of the cases and absent in 18 of the cadavers.

Table 9: *Simultaneous occurrence of the palmaris longus and plantaris muscles for the right limbs, in the cadaver population.*

Palmaris longus	**Plantaris**				**Total sample**
	Absent		**Present**		
	n	%	n	%	
Absent	1	0.66	17	11.26	18
Present	16	9.93	117	77.48	133
Total	17		134		151

In the right limbs of the cadaver population, 77.48% (n=117) had both the palmaris longus and plantaris muscles present. 0.66% (n=1) has none of these muscles present. The palmaris longus muscle is present, and the plantaris muscle absent in 9.93% (n=16) of the cadavers.11.26% (n=17) of the cadavers does not have a palmaris longus muscle, but has a plantaris muscle in the right leg.

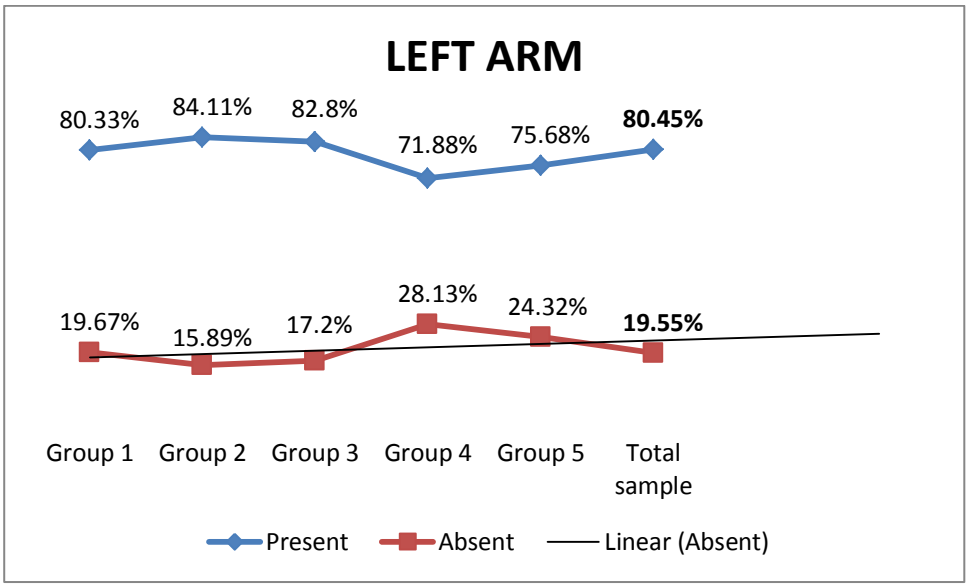
In total, the palmaris longus muscle was present in 133 of the cadavers but absent in 18 of right limbs. The plantaris muscles could be located in 134, but was not found in 17 of the cadavers.

Out of the sample of 151 cadavers, only 1 (a 54 year old male) did not have any palmaris longus or plantaris muscles at all. Hundred and five of the cadavers had both the palmaris longus and plantaris muscles, in the left and right limbs.

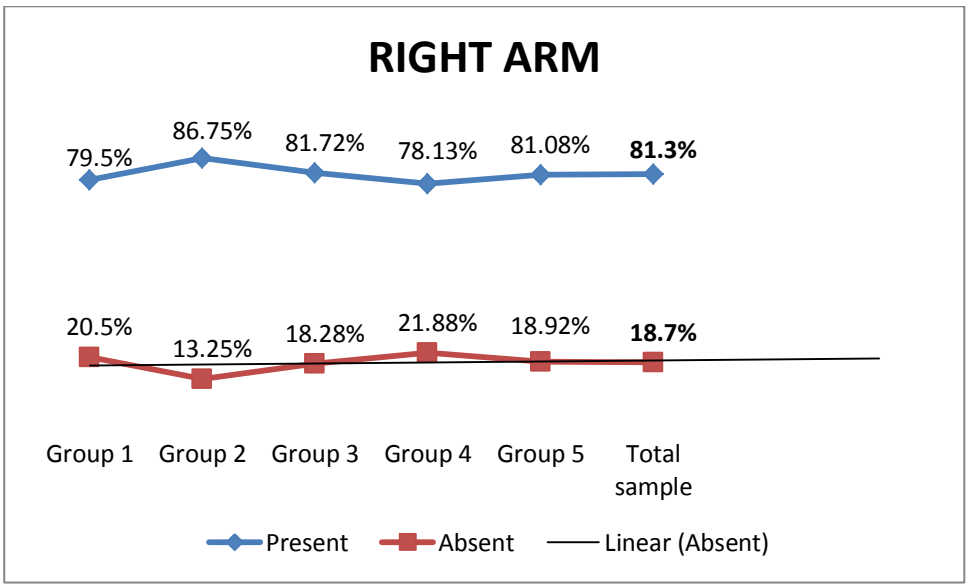
The McNemar test for symmetry yielded a p-value of 0.25 for the left limbs, and a p-value of 0.72 for the right limbs. This indicates that there is no significant relationship between the simultaneous occurrence of the palmaris longus and plantaris muscle in any given individual of this study.

4.3 A possible phylogenetic degenerative trend of the palmaris longus muscle

Graphs 12 and 13 indicate the prevalence of the palmaris longus muscle, for both the left and right arms, in the different age groups.



Graph 12: *Prevalence of the palmaris longus muscle, in the different age groups, for the left arm.*



Graph 13: *Prevalence of the palmaris longus muscle, in the different age groups, for the right arm.*

In age group 1, 361 individuals were investigated. It was found that 80.33% (n=290) of these muscles were present in the left arm and 79.5% (n=287) present in the right arm. Nineteen point seven percent (n=71) were absent on the left and 20.5% (n=74) on the right side.

The second age group consisted of 151 individuals. 84.11% (n=127) were present in the left arm and 86.75% (n=131) in the right arm. The palmaris longus muscle was absent in 15.89% (n=24) of the individuals on the left and 13.25% (n=20) of the individuals on the right.

Age group number 3 had 93 individuals. The muscle was present in 82.8% (n=77) of the individuals on the left side, and 81.72% (n=76) on the right side. The palmaris longus muscle lacked in 17.2% (n=16) individuals for the left arm and 18.28% (n=18) for the right arm.

In the fourth age group, the sample size was 64 individuals. Seventy one point nine percent (n=46) individuals had the palmaris longus muscle present on the left side. On the right side, 78.13% (n=50) of the muscles were present. In 28.13% (n=18) of the cases the palmaris longus muscle was absent in the left arm. The muscle also absent in 21.88% (n=14) of the individuals in the right arm.

The fifth and final age group consisted of 37 individuals. 75.68% (n=28) individuals had the palmaris longus muscle present on the left side. The muscle was present in 81.08% (n=7) individuals on the right side. Twenty four point three percent (n=9) individuals lacked a palmaris longus muscle on the left side and 18.7% (n=7) individuals on the right side.

In total, 80.45% (n=568) individuals had the palmaris longus muscle present in the left arm, compared to the right arm with a presence of 81.3% (n=574) individuals. The palmaris longus muscle lacked in 19.55% (n=138) individuals on the left side and 18.7% (n=132) individuals on the right side.

The chi-square tests, concerned with the different age groups, revealed a p-value of 0.27 for the left arm and for the right arm a p-value of 0.39. In graphs 12 and 13, a linear trend-line was inserted to indicate a possible trend in the absence of the palmaris longus muscle in the different age groups. However the trend-line should be directed in the opposite direction in order to indicate a possible phylogenetic degenerative trend of the palmaris longus muscle. The hypothesis is thus rejected, meaning that no trend could be established for the phylogenetic degeneration of the palmaris longus muscle, in this study representing a South African population.

5. 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 South African population. 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 in a South African population.

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 prevalence of these muscles yielded the same results when compared to past studies conducted on samples / populations other than South Africans. A possible phylogenetic degeneration trend for the palmaris longus was also investigated for the first time.

5.1. Morphology of palmaris longus and plantaris muscles

5.1.1 Palmaris longus

The palmaris longus is a slender, fusiform muscle (Williams, 1995) with a long tendon (Carlson *et al.,* 1993; Sinnatamby, 1999), and is likely to show variations in its structure, origin and implantation (Incavo *et al.,* 1987; Vanderhooft, 1996). Therefore one should expect some form of dissimilarity when investigating this particular muscle. It is also said that the tendon of the palmaris longus develops in proportion to the length of the forearm and this is determined genetically before birth (Masaaki *et al.,* 2001).

The morphology of the palmaris longus and plantaris muscles, examined on the cadaver specimens, correlated to that stated in the literature. White (1960) reported the length of the palmaris longus tendon to be between 100mm and 150 mm long, compared to the study conducted by Carlson and co-workers (1993) which had a slightly longer tendon, approximately 160mm.

The length and width of the palmaris longus tendon was also measured in paediatric patients undergoing ptosis correction (Lam *et al.,* 1996). The tendon lengths ranged from 90-120mm and the width ranged from 2-3mm, depending on the age of the patient. Masaaki and co-workers (2001) reported that the average tendon length for adult Japanese males is 124.6mm, 108.3mm in females and 116.6mm in the total sample. They further stated that the average tendon width is 4.5mm in males, 4mm in females and 4.2 mm for the study.

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 4mm. Stecco *et al.* (2009) measured the palmaris longus muscle and found that the muscle in total was 225-315mm long. The muscular belly measured 95-230 mm long and the tendon between 80-155mm. It was further stated that the length of the tendon represents about half of the total length of the palmaris longus muscle.

In table 10 the measurements taken for the palmaris longus muscle (tendon length, tendon width, belly length, belly width and total length) is shown and compared to the measurements recorded in the literature.

Table 10: *Comparison of the measurements of the palmaris longus muscle to that described in the literature. The measurements are in millimetres.*

	Tendon length	**Tendon width**	**Belly length**	**Belly width**	**Total length**
White (1960)	100-150	-	-	-	-
Carlson and co-workers (1993)	160	-	-	-	-
Lam (1998)	90-120	2-3	-	-	-
Masaaki and co-workers (2001)	116.6	4.2	-	-	-
Mobarakeh (2008)	136.2	4	-	-	-
Stecco *et al.,*(2009)	80-155	-	95-230	-	225-315
Current study (min – max)	**81.75-206.85**	**2.86-8.66**	**68.32-208.7**	**6.09-20.68**	**186.15-352.33**

The measurements given for the tendon length of the palmaris longus muscle, in the literature, were slightly shorter than what is obtained in the current study, with the exception of Carlson and co-workers (1993). The width of the tendons measured, were wider than those described in the literature. Wehbé (1992) suggested that one should consider that an increase of 1mm in the width of a tendon could have a significant influence in its strength. The average width of the palmaris longus tendon in a South African population met the requirements necessary for a graft to be viable in reconstructive surgery and might even work better as a plantaris tendon graft, because of its width.

The belly length fell within the range given in the literature, however it would appear that this study was the first to record the width of the muscular belly. Lastly the total length of the palmaris longus was located within the range seen in the literature. Thus, overall the measurements obtained from a South African population in the current study coincide well with similar measurements obtained in previous studies.

When comparing the total length of the palmaris longus muscle between males and females, it was found that there is a statistical significant difference (See Table 5). Masaaki and co-workers (2001) reported a statistical significant difference between males and females, in a Japanese population, but only for the length of the palmaris longus tendon, and not the muscle as a whole. Therefore only the length of the tendon could be compared to the literature. They reported an average of 124.6 mm for males and 108.3mm for females (Masaaki *et al.,* 2001) while the current study found the average length to be 260.52mm for males and 189.54mm for females. This can possibly be explained by the fact that the Japanese population on average is smaller in stature compared to other population groups, and thus the length of their palmaris longus muscles will be shorter.

Mobarakeh and co-workers (2008) reported a difference between males and females, in an Iranian population. This was found to be not statistically significant: the tendon length of the palmaris longus muscle measured 142 mm for males and 128mm for females. This shows a difference in measurements between Japanese, Iranian and a South African population.

Variation of the morphology in the palmaris longus muscle was found only in a few cadavers for the current study. Two cases of 'reversed' palmaris longus were noted. Similar variations have been described in previous studies on the palmaris longus muscle conducted by Reimann and co-workers (1955), Carlson and co-workers (1993), Depuydt and co-workers (1998), Oommen (2002), Tiengo and co-workers (2006), Natsis and co-workers (2007) and Mobarakeh and co-workers (2008).

The first case was a 94 year old female cadaver, who showed this variation in both the left and right arms (see figure 42). The second was found in the left arm of a 74 year old female cadaver.

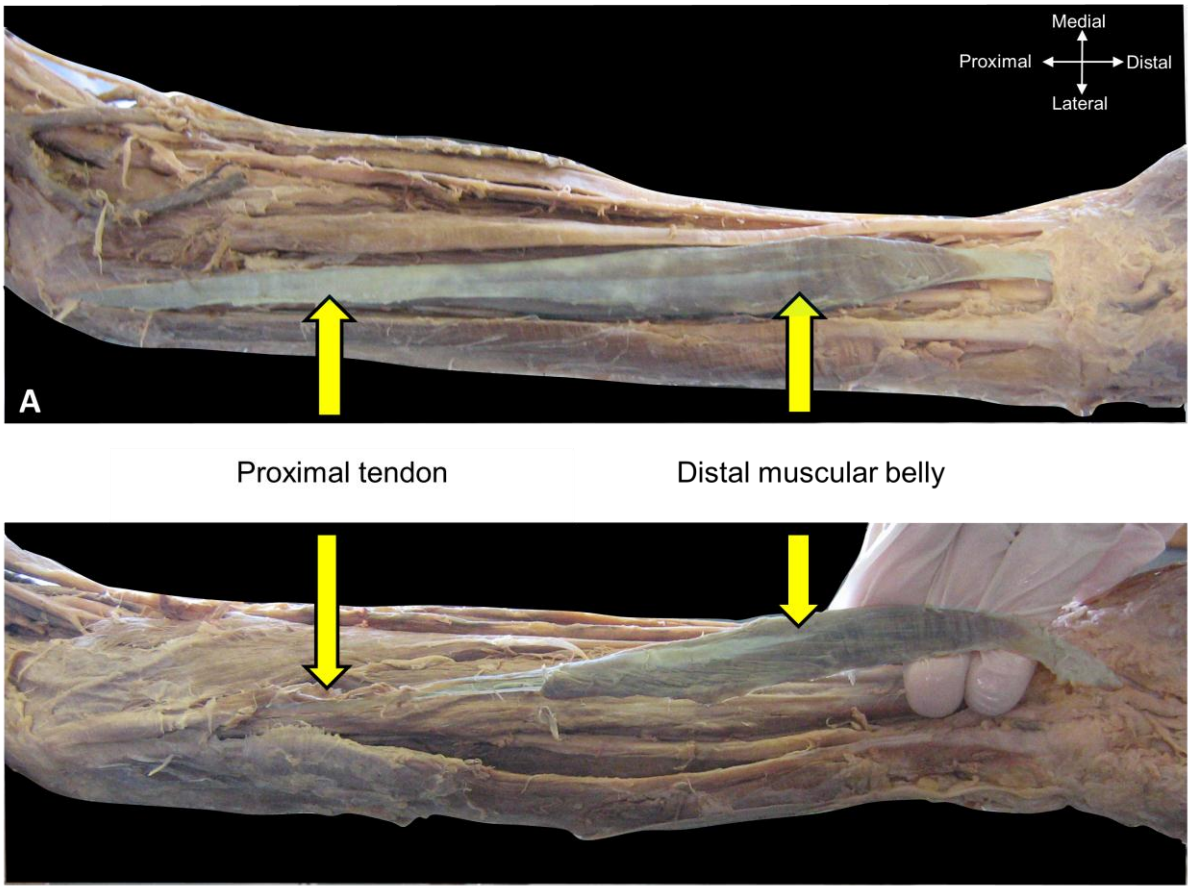


Figure 42: *'Reversed' palmaris longus muscles in both the left (A) and right (B) arms of a 94 year old female.*

Another variation of the palmaris longus muscle was found in an 85 year old female cadaver. The muscular belly was found to be in the middle, with a proximal and distal tendon (see figure 43). Similar variations were described by Reimann and co-workers (1955), Carlson and co-workers (1993) and Stecco and co-workers (2009).

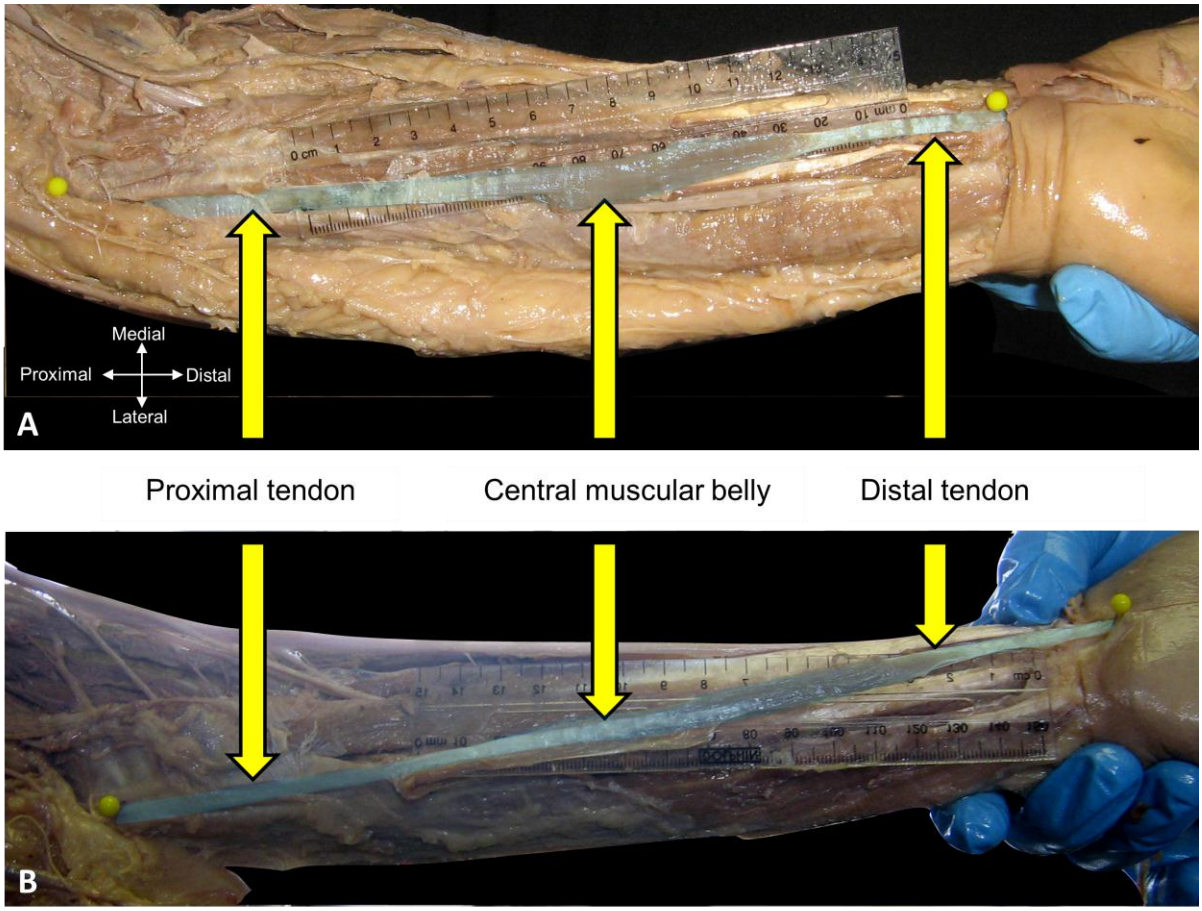


Figure 43: *Palmaris longus muscle with centrally placed bellies in both the left (A) and right (B) arms of an 85 year old female.*

Distally, the palmaris longus muscle attached mostly on the palmar aponeurosis of the hand (Reimann *et al.,* 1944; Williams, 1995; Thejodhar *et al*., 2008). However, other points of insertion have been described in the literature. One of interest is an insertion onto the antebrachial fascia (Stecco *et al.,* 2009) as seen in Figure 44.

Figure 44: *Palmaris longus with an insertion on the antebrachial fascia.*

Masaaki and co-workers (2001) stated that there are advantages to know the length of the palmaris longus tendon: firstly the usefulness in planning preoperatively and to determine the proximal site for incision during the grafting procedure. The literature and current study showed that the palmaris longus muscle has the ideal length and width for the use in reconstructive surgery but is subject to variation in both shape and attachment.

5.1.2 Plantaris

The plantaris muscle is vestigial and may show variation in its structure, as well as in its points of origin and insertion (Incavo et al., 1987). This is important to realize when it is planned to use the plantaris tendon in reconstructive surgery.

The anatomy of the plantaris muscle, examined on the cadaver specimens, correlated to that stated in the literature. In Table 11 the measurements taken for the plantaris muscle is shown and compared to the measurements found in the literature.

Table 11: *Comparison of the measurements of the plantaris muscle to that described in the literature. The measurements are in millimetres*

	Tendon length	Tendon width	Belly length	Belly width	Total length
White (1960)	300-400	-	100	-	-
Carlson and co-workers (1993)	334	-	-	-	-
Williams (1995)	-	-	70-100	-	-
Daseler and Anson (1947)	-	-	75-100	-	-
Current study (min-max)	**38.51-335.6**	**1.56-7.55**	**44.16-150.28**	**6.8-30.47**	**313.16-446.55**

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

The length of the plantaris tendon measured in a South African cadaver population is shorter than described in the literature (353.79 mm). The average width of the plantaris muscle tendon was found to be 3.88mm, 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 literature. The total length of the plantaris muscle was, on average, 341.04 mm. 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) 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 300-400mm (Carlson *et al.,* 1993). Daseler and Anson (1943) and Williams (1995) and reported a belly length of between 70 and 100mm.

Variation was noted in the insertion of the plantaris muscle. In both cases the plantaris muscle had a short tendon and inserted either on the gastrocnemius or soleus muscles. In the first case, a 46 year old male had a very short plantaris tendon that inserted onto the soleus muscle (see figure 45).

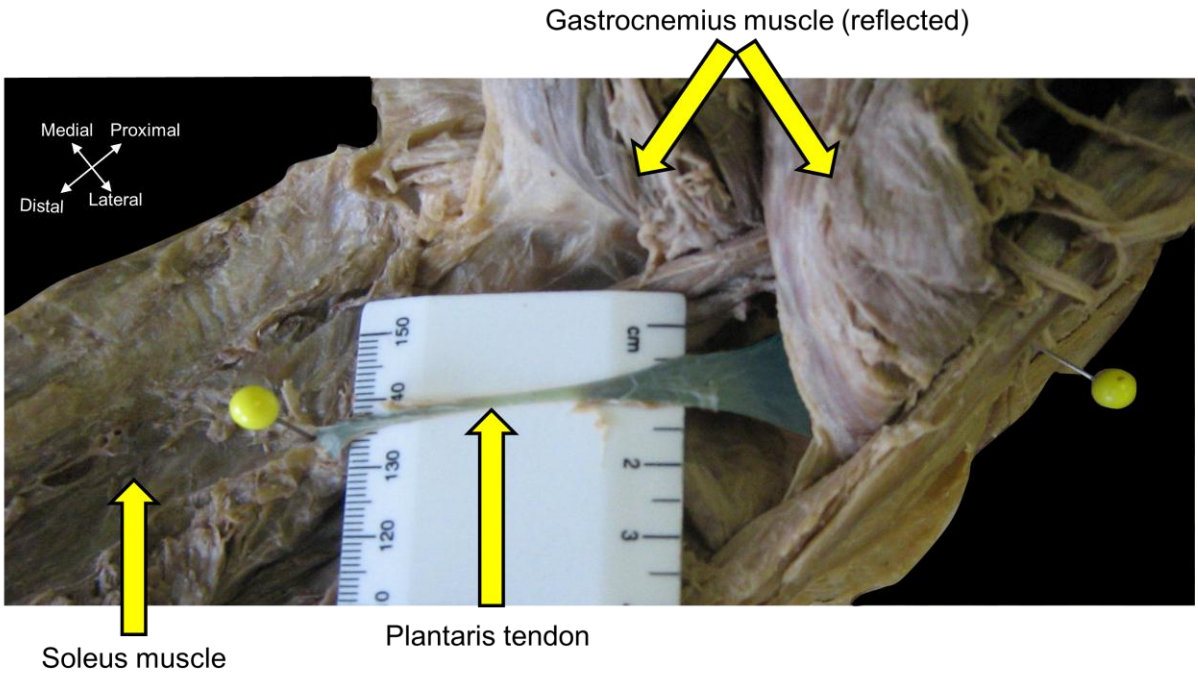


Figure 45: *The plantaris muscle, with an insertion on the soleus muscle.*

The second case, a 31 year old male had a similar short plantaris tendon which inserted on the gastrocnemius muscle (see figure 46).

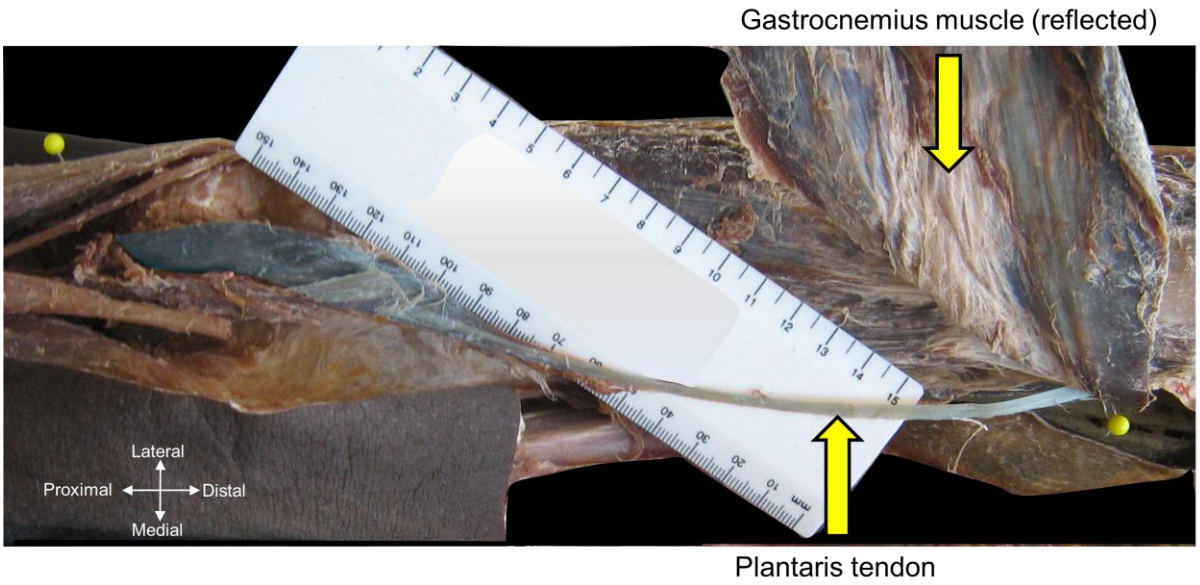


Figure 46: *The plantaris muscle, with an insertion on the gastrocnemius muscle.*

Some of the characteristics of the plantaris muscle make it a fitting donor tendon for grafting procedures (Harvey *et al.,* 1983). The plantaris tendon can be used for a variety of reconstructions, because of its length (Harvey *et al.,* 1983; Simpson *et al.,* 1991). 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 (White, 1960; Carlson *et al.,* 1993).

5.1.3 Comparison of the morphology of the palmaris longus and plantaris muscles

It is said that the palmaris longus and plantaris muscles have a lot in common (Daseler & Anson, 1943; White, 1960; Williams, 1995), while Vanderhooft (1996) maintained that there is no correlation between these muscles.

There are several similarities between the palmaris longus and plantaris muscles. Daseler and Anson (1943) found them to be genetically similar, while White (1960) contends that they are similar in structure and relationship and also equally suited as tendon grafts.

The measurements taken (tendon length, width and belly length and width) for the palmaris longus and plantaris muscles were compared and it was found that there is a statistically significant difference between these muscles. Thus the plantaris tendon is significantly longer than the palmaris longus tendon (268.91mm *vs.* 154.40mm), and the palmaris longus tendon is significantly wider than the tendon of the plantaris muscle (4.92mm *vs.* 3.90mm).

One can accept that the relative sizes of these muscles are linked, most of the time. If the particular muscle had a short muscular belly, the tendinous portion would be relatively longer, and vice versa. The results of this study confirms that in a South African population suggest the palmaris longus tendons would be of ideal width and strength for use as grafts in reconstructive surgery. However, the tendons of the plantaris muscle are preferable when a longer tendon is required.

5.2 Prevalence of the palmaris longus and plantaris muscles

5.2.1 Palmaris longus

Since the palmaris longus is an expendable muscle, its absence will not affect the function of the wrist significantly (Roohi *et al*, 2007). However, the congenital absence of this muscle can be seen as a disadvantage when the use of this muscle is indicated for use in reconstructive surgery (White, 1960; Carlson et al., 1993). The prevalence of the palmaris longus muscle has been shown to differ between various population groups (Roohi *et al*, 2007).

Upon investigation of the prevalence of palmaris longus, it was found that the percentage values, obtained in this study, correlated well with what has been reported in the literature (See Table 12).

Most of the literature only gives the bilateral absence of the palmaris longus muscle in a percentage value: 0.6% (Gangata, 2009), 2.6% (Machado *et al.,* 1967), 5% (Wehbé & Mawr, 1992), 13% (Sinnatamby, 1999), just to name a few. Other studies revealed the bilateral absence as well as the unilateral absence of the palmaris longus, whether it was on the left or right side. In such studies the bilateral absence varied from 2-18.75% (Vanderhooft, 1996; Thompson *et al*., 2002; Sebastin *et al*., 2005; Kapoor *et al*., 2008; Oluyemi *et al.,* 2008). The absence of the palmaris longus muscle on the left side was reported to be 0-25%, and on the right side 1.2-25%, for the same studies.

If one should disregard population variation and combine the results of all the above-mentioned studies, where a total of 5005 subjects were examined, the results show that on average the palmaris longus is present in 75.0% (bilateraly), absent in 7.6% (bilaterally), absent on the left in 7.8% and on the right in 6.6% of people worldwide.

Table 12: *Prevalence of the palmaris longus muscle, a comparison between different studies.*

Author	Total sample	Present bilaterally		Absent bilaterally		Unilateral absence (left)		Unilateral absence (right)	
		n	%	n	%	n	%	n	%
North American population (Reimann *et al*., 1944)	362	302	83.4	30	8.3	13	3.6	17	4.7
Amazon Indian population (Machado & Di Dio, 1967)	379	-	-	10	2.6	-	-	-	-
North American population (Wehbé & Mawr, 1992)	120	-	-	6	5	-	-	-	-
North American population (Vanderhooft, 1996)	186	156	83.9	18	9.7	0	0	4	2.2
European population (Thompson *et al.*, 2002)	300	228	76	26	8.7	20	6.7	29	9.7
Asian population (Sebastin *et al.*, 2005)	418	394	94.3	7	2	12	2.9	5	1.2
Malaysian population (Roohi *et al.,* 2007)	450	-	-	13	2.9	-	-	-	-
Indian population (Kapoor *et al.,* 2008)	500	414	82.8	40	17.2	31	6.2	15	3
Iranian population (Mobarakeh *et al*., 2008)	64	-	-	5	7.8	-	-	-	-
Nigerian population (Oluyemi *et al*., 2008)	600	188	31.3	112	18.75	150	25	150	25
Southern Indian population (Pai *et al.,* 2008)	30	-	-	1	3.3	3	10	-	0
Zimbabwean population (Gangata, 2009)	890	-	-	5	0.6	-	-	-	-
Current study	**706**	**519**	**73.5**	**84**	**11.9**	**54**	**7.7**	**49**	**6.9**
Global prevalence (average %)	5005	-	75.0	-	7.6	-	7.8	-	6.6

Although palmaris longus is completely present on both or at least one arm in 88.1% of the South African population, the presence of the palmaris longus muscle does not guarantee its usefulness in reconstructive surgery (Pilcher, 1939); 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.

5.2.2 Plantaris

Harvey (1983) contended that the dispensability of the plantaris makes it a fitting donor tendon for reconstructive surgery. However, the prevalence of this muscle must first be determined before it's suitability for grafting can be established. It is reported that the prevalence of the plantaris muscles may differ between different races (Vanderhooft, 1996). South Africa consists of a multi-racial population, so one would expect that the prevalence of the plantaris muscle would differ between the different races. However this study did not investigate the prevalence between the different races, rather the population as a whole.

The prevalence of the plantaris muscle was similar to what has been reported in previous studies (see Table 13).

Table 13: *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)	375	338	90.13	13	3.46	18	4.8	6	1.6
Harvey *et al.,* (1983)	658	502	76.29	84	12.77	32	4.86	40	6.08
Vanderhooft (1996)	186	174	93.55	6	3.23	4	2.15	2	1.08
Current study	**150**	**128**	**85.33**	**13**	**8.67**	**5**	**3.33**	**4**	**2.67**
Global prevalence	1369	1142	83.4	116	8.47	59	4.31	52	3.80

Once again the bilateral absence of the plantaris muscle was mostly mentioned in the literature. Very few studies included their total sample with a breakdown of the prevalence for the plantaris muscle. Daseler and Anson (1943) studied 750 leg specimens (375 individuals) and reported a bilateral absence of 3.5%. Wehbé and Mawr (1992) mentioned a bilateral absence of the plantaris muscle to be 4%. 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 83.4% of the population (1142/1369) and absent in 8.47% (116/1369). Globally the muscle is absent only on the left in 4.31% (59/1369) and on the right in 3.80% (52/1369). Other studies included more information regarding the morphology of the plantaris muscle, as seen in Table 20.

The literature reported a minor difference in the prevalence of plantaris between males and females (Harvey *et al.,* 1983; Incavo *et al.,* 1987). The results of the current study compared well with that reported in the literature, as there was a difference in the prevalence between the sexes, but not regarded as statistically significant.

5.2.3 Simultaneous occurrence of the palmaris longus and plantaris muscles

Vanderhooft (1996) reported only a 2.2% (n=4) absence of both the palmaris longus and plantaris muscles, while Harvey and co-workers (1983) reported a bilateral absence of both muscles in 1.4% (n=9). Both these studies concluded that there is no statistically significant relationship in the simultaneous occurrence of the palmaris longus and plantaris muscles in the same individual.

The present study found that only 0.66% (n=1) of the studied sample had a bilateral absence of both the palmaris longus and plantaris. This study could not demonstrate a significant relationship in either the simultaneous presence or absence of the palmaris longus and plantaris muscles in the same individual, which coincides with that reported in the literature.

In other words, should the palmaris longus muscle be absent or present in either the right or left arm, it does not necessarily mean that the plantaris muscle will be present or absent in the right and left leg within the same individual. Thus the hypothesis is rejected and one cannot predict the presence or absence of the plantaris muscle by merely looking at the presence or absence of the palmaris longus muscle.

5.3 Degeneration of the palmaris longus

The literature mentions various characteristics of the palmaris longus muscle that are disappearing with time (Reimann *et al.,* 1944; Rubino *et al.,* 1995; Vanderhooft *et al.,* 1996; Sebastin *et al.,* 2005; Kapoor *et al.,* 2008).This includes: it was a metacarpo-phalangeal joint flexor (Williams, 1995), the substitution of the distal tendon by the palmar aponeurosis (Mobbs & Chandran, 1995) and different frequencies of the muscle among different races (Thompson *et al.,* 1921).

A bilateral absence of the palmaris longus muscle was found in 11.9% of the South African sample which, 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%) is slightly higher when compared to previous studies which yielded a bilateral absence that ranged between 2 – 9.7% (Reimann *et al*., 1944; Vanderhooft, 1996; Thompson *et al.,* 2002; Sebastin *et al.,* 2005).

As seen in Graphs 12 and 13, age groups number four and five have the highest incidence of absence of the palmaris longus muscle. These were individuals between the ages of 61 and 99 years old. Should a degenerative trend be established, one would expect the absence of this muscle to be more prevalent in the ‘younger’ age groups (i.e., age groups one and two) and should have a higher incidence of absence of the palmaris longus muscle, when compared to age groups four and five. By investigating the prevalence of the palmaris longus muscle, the results obtained in this study do not support a degenerative trend of the palmaris longus muscle in a South African population. In other words the hypothesis is rejected and in this point in time there is no degeneration of the palmaris longus muscle in a South African population.

The position of the insertion of the palmaris longus muscle might have changed, the tendon might have become longer, or the difference in the frequency of the absence of this muscle between different races are all indications that the palmaris longus muscle is phylogenetic degenerative. However the reconstructive surgeon, working with South African patients, is more likely to come across patients that have both their palmaris longus muscles present. It appears that the palmaris longus muscle will be around for a couple more years in the South African population and is not disappearing as quickly as was expected at the start of the study.

6. CONCLUSION

The palmaris longus and plantaris muscles are indeed subject to variation, whether in the general anatomy, form, attachment, actions and/or prevalence. A statistical significant difference was found between the male and female sample when considering the length of the palmaris longus muscle.

Variation in form and attachment of the palmaris longus muscle was found in two female cadavers, and in two male cadavers for the plantaris muscle. When comparing the palmaris longus muscle to the plantaris muscles, it was found that there is a statistical significant difference between them. Therefore, 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.

The prevalence of the palmaris longus and plantaris muscles compared well with studies done on other population groups. No correlation was found between the sex of the cadaver and the prevalence of the palmaris longus and plantaris muscles. In addition it was established that there is no relationship between the prevalence of the palmaris longus and plantaris muscles in the same individual.

A possible phylogenetic degenerative trend for the palmaris longus muscle was also examined. After studying various age groups, it was determined that such a trend could not be established for this sample.

This study was limited by the fact that the researcher could not do all the dissections herself. We had to rely mostly on dissections done by second year medical students. However the students were informed and cautioned about this specific study before they started on the related regions of the human body. The race of an individual is currently a sensitive subject in South Africa which consists of a multi-racial population. Ethical clearance could not be obtained for the race of the individuals and/or cadavers used in this study and therefore it is regarded as a limiting factor. The researcher could only use of the sex and age as part of the demographic information of the participants. However the researcher feels that one should compare the measurements and prevalence of the palmaris longus and plantaris muscles between the different races that make up the South African population. One would find a difference in these measurements, as previous studies in the literature indicates with multi-racial population groups. Further research is therefore needed where emphasis on the race of the individual is taken into account.

In conclusion, based on the morphology and prevalence of the palmaris longus and plantaris muscles in a South African population, 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, working on South African patients, 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 acquired.

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8. APPENDICES

Appendix A: Consent form

8.1 Information leaflet: Parent/ Guardian

Dear Parent or Guardian

VASCULARIZATION OF PALMARIS LONGUS AND PLANTARIS EMPLOYED AS FLAPS IN RECONSTRUCTIVE SURGERY

I am a **M.Sc. Anatomy student** at the Department of **Anatomy,** University of Pretoria. Your child is invited to participate in the M.Sc. (Anatomy) research project on **the vascularisation of palmaris longus and plantaris muscles employed as flaps in reconstructive surgery.**

Before you agree to give consent for your child to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this document, do not hesitate to contact the researcher.

The purpose of the study is to **see how many people in South Africa has the palmaris longus muscle, found in the forearm of the human body. This muscle is sometimes absent in an individual, although there is no clinical significance for the absence or presence of this muscle. If a person doesn't have this muscle, it is because the body can function without it.**

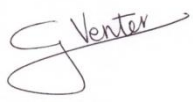
The researcher will examine the forearm of your child and determine whether the relevant muscle is present and mark it on an Information Sheet. The completion of the examination will not take more than **two minutes** and the researcher will only ask your child to present his/ her forearms.
Please remember, even with your consent, we will require your child to give us permission to be a participant in this study (please see the attached Assent form). Your child will therefore not participate in this study against their will.

Data that may be reported in scientific journals will not include any information that identifies your child, as all information or data will remain strictly anonymous. You must understand, however that you will not be able to recall your consent, as your child's information will not be traceable.

If you have any questions regarding this study, please do not hesitate to contact me via email at: gerda_venter@yahoo.com

Thank you in advance for your consent.

Yours faithfully,



_____

Mrs G. Venter (B.Sc (Hons))

8.2 Informed consent form: Parent/ Guardian

AUTHORISATION FOR MY CHILD TO PARTICIPATE IN THE RESEARCH PROJECT

1) THE NATURE AND PURPOSE OF THIS STUDY

The purpose of the study is to survey the incidence of the palmaris longus found in the human body (in the forearm) in a South African population. Although this muscle may sometimes be absent in individuals, there is no clinical significance to its absence. It is merely an indication that the body doesn't need it and can function without it.

2) EXPLANATION OF PROCEDURES TO BE FOLLOWED

With consent, your child will be part of a sample of 300 participants in this study. Your child will remain fully clothed during the examination, but may be asked to remove heavy jackets or jerseys that are concealing his/ her forearms. The whole examination will not take more than two minutes. See Assent form for a description of the examination.

3) RISK AND DISCOMFORT INVOLVED

The inspection will not cause your child any discomfort and the only inconvenience will be the two minutes taken to complete the examination of your child's forearms. The study will be conducted with permission from the principle of Kathstan College and with approval from the Faculty of Health Sciences Student Ethics Committee of the University of Pretoria (**References nr.:S33/08)**.

4) CONFIDENTIALITY

All information obtained during the course of this study is strictly confidential. Data that may be reported in scientific journals will not include any information, which identifies your child as a participant in this study.

5) CONSENT TO PARTICIPATE IN THIS STUDY

I have read or had the above information read to me in a language that I understand before signing this consent form. The content and meaning of this information have been explained to me. I have been given the opportunity to ask questions and I am satisfied that they have been answered satisfactorily**. I understand that my child's participation in this study is entirely voluntary and I can refuse their participation without stating any reason**.

I hereby give consent for (Name of child)_____ to participate in this M.Sc. research study.

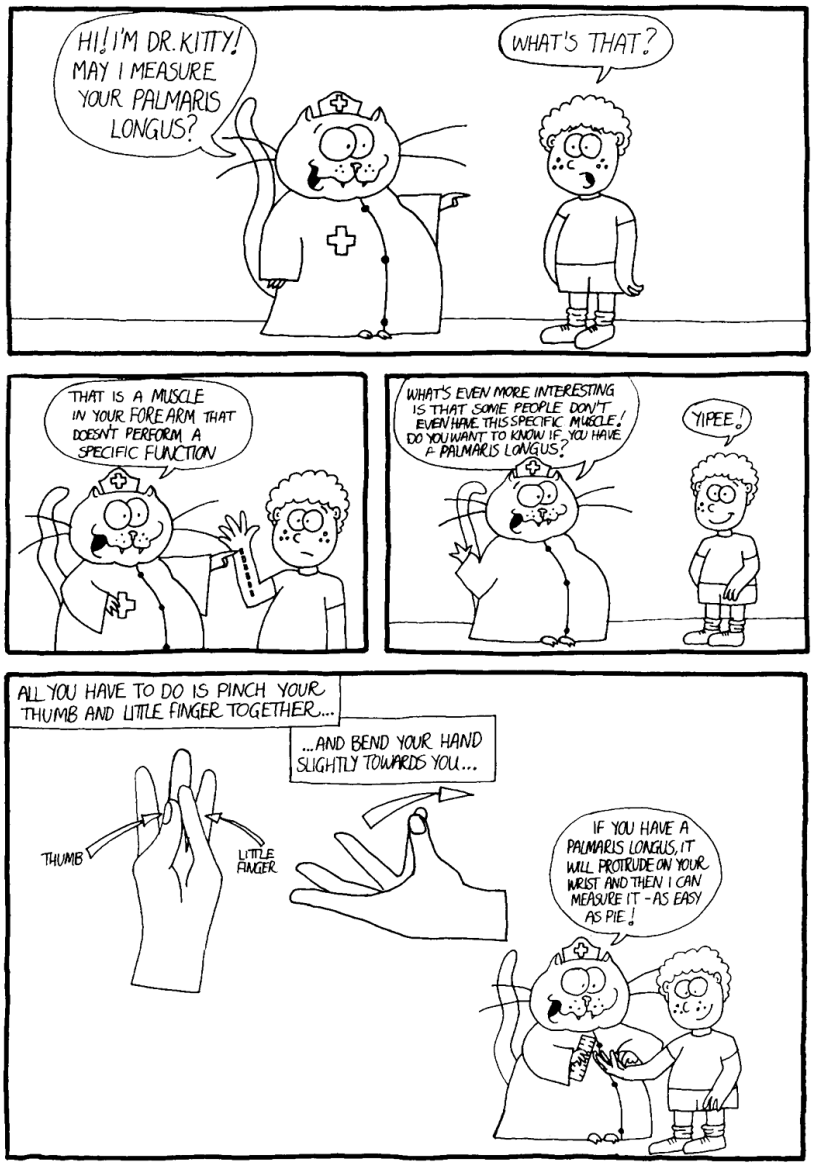
Parent/ Guardian's name _____
(Please print)

Parent/ Guardian's signature _____ Date _____

Witness's name _____
(Please print)

Witness's signature _____ Date _____

Appendix B: Assent form



Will you help us (please indicate with a ✓)?

YES _____ NO _____

Investigator's name:_____	Witness's name:_____
Investigator's signature:_____	Witness's signature:_____
Date: _____	Date: _____

Appendix C: Tables omitted from results

Table 1: *Measurements taken for palmaris longus in the left and right arms, respectively. The values given are in millimeters*

(X = no significant difference)

	Left arm (mean)	SD	Right arm (mean)	SD	Significant difference	p-value
Tendon length	156.34	22.18	152.58	20.3	X	0.29
Tendon width	4.84	0.88	4.99	0.89	X	0.50
Belly length	126.42	20.3	128.23	25.56	X	0.65
Belly width	12.95	3.14	12.43	3.09	X	0.09
Total length	236.7	81.37	223.06	79.12	X	0.37

Table 2: *Measurements taken for palmaris longus in the female and male population, respectively. The values given are in millimeters.*

(√ = significant difference, X = no significant difference)

	Females (mean)	SD	Males (mean)	SD	Significant difference	p-value
Tendon length	143.9	18.56	159.15	20.75	√	0.00
Tendon width	4.61	0.75	5.06	0.91	√	0.04
Belly length	119.13	22.37	131.06	22.39	√	0.03
Belly width	12.09	3.3	12.95	3.01	X	0.74
Total length	189.54	82.01	260.52	70.33	√	0.00

Table 3: *Measurements taken for plantaris muscle in the left and right legs, respectively. The values given are in millimeters.*

(√ = significant difference, X = no significant difference)

	Left leg (mean)	SD	Right leg (mean)	SD	Significant difference	p-value
Tendon length	263.15	43.15	269.71	49.7	X	0.55
Tendon width	3.99	1.26	3.76	1.32	X	0.42
Belly length	87.08	18.04	87.87	15.95	X	0.90
Belly width	14.52	4.43	15.2	5.57	X	0.88
Total length	350.23	40.11	357.59	58.29	X	0.57

Table 4: *Measurements taken for plantaris muscle in the female and male population, respectively. The values given are in millimeters.*

(√ = significant difference, X = no significant difference)

	Females (mean)	SD	Males (mean)	SD	Significant difference	p-value
Tendon length	259.58	38.36	273.54	53	X	0.19
Tendon width	3.8	1.23	3.96	1.36	X	0.68
Belly length	84.99	14.8	90.11	18.84	X	0.23
Belly width	13.91	4.24	15.85	5.57	X	0.98
Total length	344.57	43.47	363.64	54.15	X	0.06

Table 5: *Comparison of the measurements taken for the palmaris longus and plantaris muscles. The measurements are in millimeters.*

(√ = significant difference, X = no significant difference)

	Palmaris longus		Plantaris		Significant difference	p-value
	Mean	SD	Mean	SD		
Tendon length	154.4	21.25	266.32	46.28	√	0.00
Tendon width	5.04	1.84	3.88	1.29	√	0.00
Belly length	127.35	22.99	87.47	16.97	√	0.00
Belly width	12.68	3.12	14.85	4.99	√	0.00
Total length	238.42	80.93	353.79	49.58	√	0.00

Table 6: *Comparison of the prevalence of both the palmaris longus and plantaris muscles for the total sample*

	Palmaris longus		Plantaris	
	n	%	n	%
Bilateral presence	124	82.12	129	85.43
Bilateral absence	16	10.6	13	8.61
Unilateral absence (left)	9	5.96	5	3.31
Unilateral absence (right)	2	1.32	4	2.65

Table 7: *Comparison of the prevalence of both the palmaris longus and plantaris muscles for the male sample.*

	Palmaris longus		Plantaris	
	n	%	n	%
Bilateral presence	87	82.86	89	84.76
Bilateral absence	9	8.57	9	8.57
Unilateral absence (left)	8	7.62	4	3.81
Unilateral absence (right)	1	0.95	3	2.86

Table 8: *Comparison of the prevalence of both the palmaris longus and plantaris muscles for the female sample.*

	Palmaris longus		Plantaris	
	n	%	n	%
Bilateral presence	37	80.43	41	89.13
Bilateral absence	7	15.22	4	8.7
Unilateral absence (left)	1	2.17	1	2.2
Unilateral absence (right)	1	2.2	0	0

Table 9: *Prevalence of the palmaris longus muscle, in the different age groups, for the left and right arms.*

Age groups	Left arm				Right arm			
	Present		Absent		Present		Absent	
	n	%	n	%	n	%	n	%
1	290	80.33	71	19.67	287	79.5	74	20.5
2	127	84.11	24	15.89	131	86.75	20	13.25
3	77	82.8	16	17.2	76	81.72	17	18.28
4	46	71.88	18	28.13	50	78.13	14	21.88
5	28	75.68	9	24.32	30	81.08	7	18.92
Total sample	568	80.45	138	19.55	574	81.3	132	18.7

Appendix D: Complete dataset

Measurements of the palmaris longus muscle

Dataset Key: Actual measurements values in mm

- Table – For purpose of keeping person anonymity, corresponding dissection table numbers were assigned for each individual
- Age – Indicates the age of the person whose measurements are recorded
- Sex – Sex of the individual
    - M = Male
    - F = Female
- TL1 – First measurement of the length of the palmaris longus tendon
- TL2 – Second tendon length measurement
- TL-A – Average of the two measurements taken for the tendon length
- TW1 – First measurement of the width of the palmaris longus tendon
- TW2 – Second tendon width measurement
- TW-A – Average of the two measurements taken for the tendon width
- BL1 – First measurement of the length of the palmaris longus belly
- BL2 – Second measurement of the belly length
- BL-A – Average of the two measurements taken for the belly length
- BW1- First measurement of the width of the palmaris longus belly
- BW2 – Second measurement of the belly width
- BW-A – Average of the two measurements taken for the belly width
- TOTAL-L – The total length measured for the palmaris longus muscle

TABLE	AGE:	SEX:	PALMARIS LONGUS - LEFT ARM												
			TL 1	TL 2	TL - A	TW 1	TW 2	TW - A	BL 1	BL 2	BL - A	BW 1	BW 2	BW - A	TOTAL L
1a	45	F	171.01	165.86	168.44	5.21	4.01	4.61	123.51	122.81	123.16	10.86	8.04	9.45	291.60
1b	45	M	146.47	139.37	142.92	4.47	5.09	4.78	130.80	118.80	124.80	8.74	9.37	9.06	267.72
2	30	M	169.99	171.87	170.93	6.13	6.11	6.12	122.67	120.08	121.38	11.84	12.50	12.17	292.31
3a	39	M	136.31	143.13	139.72	4.99	4.46	4.73	126.65	126.26	126.46	12.41	10.25	11.33	266.18
3b	75	F	154.56	150.49	152.53	3.35	3.85	3.60	101.93	99.24	100.59	10.06	8.19	9.13	253.11
4	40	M	163.91	164.86	164.39	4.04	5.71	4.88	182.39	144.98	163.69	7.99	8.57	8.28	328.07
5a	59	F	142.01	136.40	139.21	3.57	4.33	3.95	112.20	110.93	111.57	11.98	12.24	12.11	250.77
5b	65	M	163.74	151.57	157.66	6.45	6.25	6.35	140.83	130.24	135.54	8.72	11.06	9.89	293.19
6a	31	M	155.67	150.61	153.14	4.18	4.68	4.43	101.72	101.49	101.61	10.55	9.93	10.24	254.75
6b	51	F	148.72	155.84	152.28	3.24	4.17	3.71	135.80	121.74	128.77	6.50	6.81	6.66	281.05
7	51	M	166.09	178.23	172.16	4.76	5.40	5.08	150.51	132.62	141.57	11.11	14.97	13.04	313.73
8a	38	M	153.95	153.67	153.81	4.97	5.57	5.27	118.77	111.41	115.09	7.35	7.35	7.35	268.90
8b	53	F	112.11	124.85	118.48	4.03	4.81	4.42	129.09	139.40	134.25	4.63	7.54	6.09	252.73
9	60	M	153.31	147.49	150.40	5.55	4.12	4.84	101.66	96.90	99.28	9.22	11.10	10.16	249.68
10	50	M	179.12	208.11	193.62	4.71	4.69	4.70	147.66	127.13	137.40	9.31	13.34	11.33	331.01
14	60	M	179.66	178.32	178.99	4.93	5.24	5.09	121.90	122.20	122.05	29.49	8.12	18.81	301.04
15	51	M	170.07	164.69	167.38	4.96	4.71	4.84	137.86	132.34	135.10	9.68	15.07	12.38	302.48
16	52	F	149.33	154.63	151.98	4.59	3.87	4.23	112.98	112.06	112.52	9.46	10.70	10.08	264.50
17	53	M	169.42	184.45	176.94	4.29	4.39	4.34	119.02	128.56	123.79	8.87	15.77	12.32	300.73
18	40	M	178.84	186.60	182.72	5.44	5.50	5.47	140.80	139.77	140.29	12.83	16.82	14.83	323.01
22	46	M	192.51	191.01	191.76	5.85	5.65	5.75	105.09	101.25	103.17	12.66	12.81	12.74	294.93
23	55	M	212.45	201.24	206.85	4.66	4.73	4.70	111.92	106.43	109.18	14.42	14.98	14.70	316.02
24	51	M	180.91	182.30	181.61	3.48	3.52	3.50	124.51	188.52	156.52	12.16	13.21	12.69	338.12
26	54	F	173.40	192.93	183.17	6.38	7.21	6.80	117.10	188.77	152.94	9.10	11.88	10.49	336.10

TABLE	AGE:	SEX:	PALMARIS LONGUS - LEFT ARM												
			TL 1	TL 2	TL - A	TW 1	TW 2	TW - A	BL 1	BL 2	BL - A	BW 1	BW 2	BW - A	TOTAL L
27	55	M	169.22	165.79	167.51	6.59	6.24	6.42	135.52	126.08	130.80	12.51	14.39	13.45	298.31
28	28	M	182.26	191.15	186.71	6.01	5.03	5.52	130.87	141.95	136.41	14.57	15.67	15.12	323.12
29	44	M	162.36	168.80	165.58	4.12	5.26	4.69	135.92	130.36	133.14	8.07	10.15	9.11	298.72
30	19	M	183.13	177.89	180.51	5.08	4.73	4.91	144.92	135.91	140.42	10.13	10.41	10.27	320.93
31	55	M	141.26	155.04	148.15	3.35	3.02	3.19	109.41	110.46	109.94	9.14	9.18	9.16	258.09
33	99	M	191.80	191.36	191.58	6.28	3.86	5.07	94.11	95.46	94.79	11.14	13.48	12.31	286.37
45	34	M	152.15	160.08	156.12	4.67	4.75	4.71	140.56	143.47	142.02	16.19	16.15	16.17	298.13
46	60	M	155.43	128.44	141.94	5.25	5.43	5.34	154.93	149.03	151.98	14.50	14.83	14.67	293.92
47	48	M	191.49	189.74	190.62	4.35	4.60	4.48	113.74	104.65	109.20	11.50	11.88	11.69	299.81
48	37	M	159.12	152.76	155.94	4.43	4.60	4.52	151.91	143.33	147.62	13.59	13.05	13.32	303.56
53	42	M	151.68	156.13	153.91	6.78	6.00	6.39	145.78	121.54	133.66	14.32	11.34	12.83	287.57
54	41	M	192.94	187.64	190.29	6.55	5.22	5.89	113.44	119.00	116.22	12.49	11.58	12.04	306.51
55	20	M	182.26	172.94	177.60	5.52	5.34	5.43	122.73	112.87	117.80	17.80	17.58	17.69	295.40
56	21	M	170.61	163.62	167.12	5.80	5.70	5.75	176.80	171.47	174.14	17.34	18.74	18.04	341.25
103	91	M	181.70	178.75	180.23	6.24	5.46	5.85	128.59	121.42	125.01	8.75	10.30	9.53	305.23
110	32	M	80.65	104.11	92.38	5.58	6.21	5.90	212.02	197.89	204.96	10.86	16.32	13.59	297.34
112	67	M	166.11	164.36	165.24	4.88	4.31	4.60	144.83	134.25	139.54	9.42	13.87	11.65	304.78
113	43	M	114.63	173.16	143.90	3.33	3.60	3.47	180.23	139.60	159.92	14.03	11.81	12.92	303.81
115	81	M	151.88	173.97	162.93	4.13	4.57	4.35	127.31	137.45	132.38	12.52	14.12	13.32	295.31
118	86	F	109.67	115.08	112.38	4.74	5.37	5.06	107.89	118.12	113.01	10.44	9.23	9.84	225.38
124	93	F	124.27	119.89	122.08	4.57	4.34	4.46	142.39	145.32	143.86	10.26	8.44	9.35	265.94
125	50	M	148.24	163.22	155.73	4.77	5.95	5.36	143.67	124.16	133.92	10.22	14.29	12.26	289.65
201	3	M	135.15	153.29	144.22	4.98	4.48	4.73	126.62	101.53	114.08	7.80	11.30	9.55	258.30
202a	25	F	154.59	154.18	154.39	5.83	4.85	5.34	117.90	114.51	116.21	12.37	10.61	11.49	270.59

TABLE	AGE:	SEX:	PALMARIS LONGUS - LEFT ARM												
			TL 1	TL 2	TL - A	TW 1	TW 2	TW - A	BL 1	BL 2	BL - A	BW 1	BW 2	BW - A	TOTAL L
202b	65	F	134.22	134.05	134.14	4.52	4.79	4.66	130.65	122.47	126.56	17.10	18.57	17.84	260.70
203	89	M	147.56	148.64	148.10	7.12	6.30	6.71	134.56	127.91	131.24	13.55	14.52	14.04	279.34
204	73	F	141.26	137.58	139.42	4.81	5.91	5.36	119.58	121.02	120.30	17.44	16.55	17.00	259.72
205a	75	F	137.36	146.82	142.09	5.21	5.07	5.14	116.63	105.13	110.88	11.78	13.65	12.72	252.97
205b	80	F	144.45	142.89	143.67	5.41	4.44	4.93	132.70	132.08	132.39	9.84	10.20	10.02	276.06
206	89	M	158.62	151.15	154.89	4.74	5.43	5.09	120.09	121.01	120.55	17.51	16.26	16.89	275.44
207a	42	F	139.31	141.21	140.26	3.89	4.42	4.16	107.69	108.19	107.94	15.58	14.28	14.93	248.20
207b	58	M	143.12	144.07	143.60	5.67	4.72	5.20	130.95	128.79	129.87	14.77	17.69	16.23	273.47
208	87	F	137.46	134.46	135.96	4.00	4.24	4.12	106.00	106.79	106.40	10.59	11.10	10.85	242.36
209	92	M	160.71	162.50	161.61	5.10	5.40	5.25	113.05	114.25	113.65	15.59	16.19	15.89	275.26
210	50	M	208.81	201.79	205.30	4.07	3.89	3.98	92.04	89.96	91.00	17.19	21.54	19.37	296.30
211a	77	F	126.23	120.17	123.20	3.61	2.75	3.18	143.55	135.83	139.69	11.77	9.97	10.87	262.89
211b	79	M	162.49	163.32	162.91	5.68	5.95	5.82	107.67	107.95	107.81	21.36	20.00	20.68	270.72
212	38	M	130.70	128.52	129.61	2.63	3.31	2.97	149.97	160.25	155.11	13.46	15.08	14.27	284.72
213a	54	M	163.30	176.73	170.02	2.28	3.44	2.86	127.03	136.31	131.67	14.40	17.63	16.02	301.69
213b	74	F	139.61	140.20	139.91	4.93	4.63	4.78	115.80	113.28	114.54	12.76	12.46	12.61	254.45
215	29	F	146.56	148.66	147.61	4.27	4.30	4.29	105.45	103.74	104.60	17.74	18.93	18.34	252.21
217a	50	M	130.95	143.25	137.10	5.46	6.48	5.97	164.85	144.44	154.65	11.89	15.12	13.51	291.75
217b	74	M	169.44	169.77	169.61	5.54	5.12	5.33	134.61	134.29	134.45	13.65	13.65	13.65	304.06
219	64	M	131.13	131.12	131.13	5.89	5.71	5.80	134.09	133.09	133.59	11.47	12.23	11.85	264.72
220	77	M	141.18	155.35	148.27	4.79	4.87	4.83	141.52	140.72	141.12	16.53	17.06	16.80	289.39
221a	74	F	181.28	181.30	181.29	3.87	4.93	4.40	96.37	98.02	97.20	10.31	14.49	12.40	278.49
221b	87	F	135.99	132.58	134.29	4.88	4.88	4.88	86.83	86.84	86.84	13.21	13.42	13.32	221.12
222	83	M	164.64	168.25	166.45	5.53	6.56	6.05	153.73	152.08	152.91	17.24	17.96	17.60	319.35

TABLE	AGE:	SEX:	PALMARIS LONGUS - LEFT ARM												
			TL 1	TL 2	TL - A	TW 1	TW 2	TW - A	BL 1	BL 2	BL - A	BW 1	BW 2	BW - A	TOTAL L
223	91	F	150.91	148.58	149.75	3.99	4.56	4.28	122.05	123.46	122.76	14.58	14.72	14.65	272.50
224a	23	F	121.34	121.79	121.57	4.88	5.13	5.01	124.15	123.52	123.84	14.39	14.61	14.50	245.40
224b	80	F	117.70	120.32	119.01	3.30	2.55	2.93	142.73	133.47	138.10	10.86	11.36	11.11	257.11
225	67	M	180.00	178.45	179.23	3.61	3.24	3.43	101.43	95.57	98.50	12.10	13.40	12.75	277.73
305	36	M	161.69	159.73	160.71	3.96	4.25	4.11	112.90	107.94	110.42	8.43	9.73	9.08	271.13
306	40	M	115.41	137.23	126.32	4.21	4.42	4.32	108.13	103.16	105.65	14.21	13.79	14.00	231.97
307	27	F	158.70	143.60	151.15	3.68	4.07	3.88	128.24	123.43	125.84	13.52	14.78	14.15	276.99
308	41	M	161.37	170.70	166.04	6.02	4.77	5.40	107.52	109.28	108.40	19.66	18.93	19.30	274.44
309	75	M	141.75	140.77	141.26	4.71	6.21	5.46	121.95	117.33	119.64	17.86	16.91	17.39	260.90

TABLE	AGE:	SEX:	PALMARIS LONGUS - RIGHT ARM												
			TL 1	TL 2	TL - A	TW 1	TW 2	TW - A	BL 1	BL 2	BL - A	BW 1	BW 2	BW - A	TOTAL L
1	45	F	150.82	152.02	151.42	4.58	4.17	4.38	155.73	144.03	149.88	13.50	13.95	13.73	301.30
2a	30	M	147.14	149.41	148.28	4.66	4.46	4.56	134.17	130.15	132.16	11.24	12.05	11.65	280.44
2b	38	M	160.24	164.83	162.54	5.30	5.00	5.15	132.65	132.94	132.80	11.21	10.90	11.06	295.33
4	40	M	138.92	155.47	147.20	5.49	5.55	5.52	156.18	143.27	149.73	8.22	7.58	7.90	296.92
5a	59	F	179.53	181.99	180.76	3.40	4.33	3.87	87.49	99.95	93.72	7.17	7.78	7.48	274.48
5b	65	M	148.66	136.83	142.75	6.51	4.25	5.38	136.40	130.74	133.57	8.55	8.79	8.67	276.32
6a	31	M	159.42	159.39	159.41	4.31	4.49	4.40	103.12	106.26	104.69	8.27	9.18	8.73	264.10
6b	51	F	154.84	151.46	153.15	3.95	4.00	3.98	115.10	110.14	112.62	8.71	9.61	9.16	265.77
7a	35	F	148.21	144.84	146.53	5.66	5.35	5.51	144.03	112.18	128.11	14.14	13.32	13.73	274.63
7b	51	M	178.44	176.86	177.65	5.23	4.79	5.01	135.20	128.95	132.08	12.00	11.25	11.63	309.73
8	53	F	115.62	130.80	123.21	4.43	4.80	4.62	151.03	147.03	149.03	9.10	10.57	9.84	272.24
9	60	M	148.70	156.43	152.57	5.73	4.57	5.15	123.87	134.19	129.03	7.16	8.56	7.86	281.60
11	34	F	127.00	137.24	132.12	4.10	4.00	4.05	105.11	109.78	107.45	7.71	7.51	7.61	239.57
14	60	M	152.77	145.52	149.15	5.30	5.00	5.15	121.75	118.46	120.11	10.57	12.68	11.63	269.25
15	51	M	125.94	138.23	132.09	5.45	4.11	4.78	167.82	159.86	163.84	10.92	12.03	11.48	295.93
16	52	F	153.70	155.68	154.69	3.41	4.09	3.75	105.92	102.88	104.40	5.98	6.90	6.44	259.09
17	53	M	161.17	157.69	159.43	3.75	4.31	4.03	113.16	120.93	117.05	10.87	10.60	10.74	276.48
20	49	M	157.28	151.10	154.19	3.94	3.70	3.82	132.39	124.40	128.40	8.49	9.78	9.14	282.59
21	24	F	154.44	148.07	151.26	3.65	3.74	3.70	91.57	93.01	92.29	6.08	9.25	7.67	243.55
23	55	M	193.13	195.92	194.53	3.11	5.06	4.09	100.26	99.46	99.86	9.85	12.22	11.04	294.39
24	51	M	174.69	170.64	172.67	4.94	4.24	4.59	154.19	140.62	147.41	13.35	12.17	12.76	320.07
26	54	F	167.44	170.36	168.90	5.17	6.48	5.83	110.56	113.21	111.89	8.58	9.30	8.94	280.79
28	28	M	181.53	185.54	183.54	4.05	4.70	4.38	130.33	132.23	131.28	13.59	16.29	14.94	314.82
29	44	M	165.07	163.25	164.16	5.38	4.71	5.05	128.46	125.77	127.12	9.55	9.19	9.37	291.28

TABLE	AGE:	SEX:	PALMARIS LONGUS - RIGHT ARM												
			TL 1	TL 2	TL - A	TW 1	TW 2	TW - A	BL 1	BL 2	BL - A	BW 1	BW 2	BW - A	TOTAL L
30	19	M	144.74	156.69	150.72	5.57	3.64	4.61	154.44	154.71	154.58	9.84	11.98	10.91	305.29
31	55	M	146.60	138.33	142.47	3.96	4.15	4.06	94.93	91.13	93.03	10.27	10.52	10.40	235.50
34	51	M	125.51	133.28	129.40	6.53	5.56	6.05	138.42	138.80	138.61	10.19	11.88	11.04	268.01
45	34	M	143.99	155.63	149.81	4.37	4.74	4.56	118.15	124.75	121.45	10.00	11.69	10.85	271.26
46	60	M	138.30	140.55	139.43	4.55	5.91	5.23	148.10	145.61	146.86	10.76	11.47	11.12	286.28
47	48	M	184.93	179.87	182.40	5.12	4.75	4.94	110.42	107.05	108.74	11.78	14.31	13.05	291.14
48	37	M	143.27	150.93	147.10	4.25	3.65	3.95	142.88	143.79	143.34	11.01	12.36	11.69	290.44
54	41	M	196.42	186.63	191.53	5.11	5.10	5.11	128.86	107.65	118.26	12.05	16.85	14.45	309.78
102	78	F	161.69	166.84	164.27	4.43	4.42	4.43	117.95	116.62	117.29	11.20	13.70	12.45	281.55
104	77	M	173.72	177.10	175.41	4.45	3.19	3.82	130.30	124.20	127.25	11.92	15.26	13.59	302.66
106	31	M	147.30	153.78	150.54	5.15	5.08	5.12	151.15	157.76	154.46	15.38	11.02	13.20	305.00
107	86	M	148.35	152.82	150.59	6.47	4.88	5.68	140.69	127.23	133.96	14.53	15.38	14.96	284.55
108	77	F	156.22	160.67	158.45	4.11	4.67	4.39	109.31	110.40	109.86	10.47	11.86	11.17	268.30
109	60	M	167.18	164.56	165.87	3.83	5.07	4.45	127.37	126.69	127.03	9.59	15.89	12.74	292.90
110	32	M	156.65	155.70	156.18	3.05	5.21	4.13	136.66	125.14	130.90	8.79	9.54	9.17	287.08
112	67	M	167.81	174.30	171.06	5.94	5.60	5.77	172.41	179.09	175.75	16.29	16.18	16.24	346.81
113	43	M	154.30	150.65	152.48	7.01	5.48	6.25	135.22	123.55	129.39	8.51	10.66	9.59	281.86
114	52	F	142.55	150.35	146.45	4.52	6.03	5.28	110.48	97.77	104.13	9.99	12.07	11.03	250.58
117	42	M	160.64	182.03	171.34	4.28	4.19	4.24	125.00	141.04	133.02	8.49	11.21	9.85	304.36
119	77	M	136.69	154.06	145.38	3.50	4.13	3.82	128.51	132.99	130.75	7.23	11.47	9.35	276.13
120	85	M	97.49	115.33	106.41	4.93	4.40	4.67	186.81	182.62	184.72	10.47	11.28	10.88	291.13
123	40	M	179.45	17.76	98.61	4.39	3.81	4.10	87.57	87.52	87.55	10.75	14.42	12.59	186.15
201a	3	M	159.50	130.35	144.93	4.39	8.75	6.57	106.95	120.72	113.84	8.06	7.09	7.58	258.76
201b	23	M	149.88	145.18	147.53	6.50	6.47	6.49	137.19	134.35	135.77	13.77	13.15	13.46	283.30

TABLE	AGE:	SEX:	PALMARIS LONGUS - RIGHT ARM												
			TL 1	TL 2	TL - A	TW 1	TW 2	TW - A	BL 1	BL 2	BL - A	BW 1	BW 2	BW - A	TOTAL L
202a	25	F	126.86	136.27	131.57	3.60	3.45	3.53	102.33	113.17	107.75	8.47	7.58	8.03	239.32
202b	65	F	146.67	147.97	147.32	3.97	4.44	4.21	117.59	119.81	118.70	14.74	12.20	13.47	266.02
203	89	M	142.82	140.89	141.86	6.69	5.83	6.26	130.54	130.30	130.42	14.08	12.34	13.21	272.28
204	73	F	135.58	138.33	136.96	5.27	5.27	5.27	106.54	106.00	106.27	15.67	15.70	15.69	243.23
205	80	F	153.07	154.36	153.72	4.03	5.03	4.53	85.24	84.43	84.84	15.56	15.17	15.37	238.55
206a	47	M	199.19	190.73	194.96	5.36	5.22	5.29	147.14	130.82	138.98	16.71	15.37	16.04	333.94
206b	89	M	160.26	159.82	160.04	5.97	5.41	5.69	102.85	100.31	101.58	14.88	14.45	14.67	261.62
207a	42	F	136.07	136.99	136.53	4.73	4.29	4.51	121.71	128.88	125.30	18.06	20.61	19.34	261.83
207b	58	M	168.60	162.79	165.70	7.03	6.60	6.82	154.88	142.51	148.70	13.97	18.60	16.29	314.39
208	87	F	121.82	125.49	123.66	5.14	3.99	4.57	152.23	149.69	150.96	12.83	11.46	12.15	274.62
209a	49	M	152.00	156.33	154.17	4.94	4.53	4.74	146.21	140.33	143.27	6.75	7.31	7.03	297.44
209b	92	M	175.29	173.03	174.16	6.56	6.23	6.40	114.88	116.02	115.45	16.26	17.50	16.88	289.61
210	50	M	168.95	169.40	169.18	7.09	4.86	5.98	135.23	119.23	127.23	17.10	17.63	17.37	296.41
211a	77	F	193.53	145.26	169.40	5.89	5.33	5.61	147.89	158.93	153.41	9.81	13.77	11.79	322.81
211b	79	M	192.17	195.62	193.90	6.57	7.03	6.80	120.12	120.34	120.23	17.67	18.21	17.94	314.13
212a	38	M	139.54	139.34	139.44	4.29	4.42	4.36	152.68	148.92	150.80	10.41	15.16	12.79	290.24
212b	80	F	158.86	158.91	158.89	6.48	6.48	6.48	92.56	100.52	96.54	14.33	11.97	13.15	255.43
213a	54	M	150.01	147.12	148.57	4.40	4.27	4.34	146.57	141.80	144.19	11.58	12.01	11.80	292.75
213b	74	F	144.25	144.27	144.26	5.35	5.63	5.49	108.08	109.80	108.94	10.14	9.58	9.86	253.20
214	35	M	166.46	164.62	165.54	5.01	4.93	4.97	118.16	115.43	116.80	15.99	15.74	15.87	282.34
215	29	F	136.01	135.99	136.00	5.53	4.73	5.13	115.16	115.70	115.43	12.82	12.52	12.67	251.43
217a	50	M	145.95	145.29	145.62	3.99	5.49	4.74	200.60	198.46	199.53	17.05	16.82	16.94	345.15
217b	74	M	170.44	173.33	171.89	4.84	5.23	5.04	115.97	116.00	115.99	12.93	11.16	12.05	287.87
218	67	F	142.99	144.28	143.64	4.95	4.72	4.84	207.02	210.37	208.70	16.00	19.35	17.68	352.33

TABLE	AGE:	SEX:	PALMARIS LONGUS - RIGHT ARM												
			TL 1	TL 2	TL - A	TW 1	TW 2	TW - A	BL 1	BL 2	BL - A	BW 1	BW 2	BW - A	TOTAL L
219	64	M	138.49	137.28	137.89	5.81	5.01	5.41	105.53	105.61	105.57	15.76	14.99	15.38	243.46
220a	77	M	148.89	139.42	144.16	7.05	5.63	6.34	180.28	163.00	171.64	14.19	14.90	14.55	315.80
220b	82	F	80.85	82.62	81.74	5.39	4.69	5.04	155.68	157.57	156.63	12.87	13.02	12.95	238.36
221	87	F	125.56	124.47	125.02	4.96	5.35	5.16	105.35	106.64	106.00	14.61	14.29	14.45	231.01
222	83	M	155.42	152.16	153.79	5.94	5.94	5.94	181.80	179.36	180.58	16.23	14.47	15.35	334.37
223a	62	M	152.78	163.80	158.29	3.95	4.72	4.34	140.41	148.22	144.32	10.29	13.29	11.79	302.61
223a	91	F	145.02	150.00	147.51	3.96	5.06	4.51	95.01	94.74	94.88	12.70	13.48	13.09	242.39
224	23	F	154.37	159.58	156.98	4.60	4.91	4.76	91.04	79.15	85.10	19.74	19.87	19.81	242.07
305	36	M	188.41	183.22	185.82	5.07	4.04	4.56	57.99	78.65	68.32	9.61	11.18	10.40	254.14
306	40	M	146.18	151.54	148.86	6.03	5.44	5.74	107.38	106.51	106.95	16.05	15.00	15.53	255.81
307	86	M	104.68	104.86	104.77	8.86	8.46	8.66	150.17	150.05	150.11	16.28	15.31	15.80	254.88
308	41	M	162.45	165.49	163.97	6.57	5.26	5.92	135.83	135.10	135.47	18.24	21.19	19.72	299.44
309	75	M	143.16	136.80	139.98	4.62	3.71	4.17	153.17	145.88	149.53	15.49	15.38	15.44	289.51
311	77	M	168.83	162.16	165.50	5.12	4.49	4.81	126.19	120.91	123.55	12.62	12.18	12.40	289.05

Measurements of the plantaris muscle

Dataset Key: Actual measurements values in mm

- Table – For purpose of keeping person anonymity, corresponding dissection table numbers were assigned for each individual
- Age – Indicates the age of the person whose measurements are recorded
- Sex – Sex of the individual
    - M = Male
    - F = Female
- TL1 – First measurement of the length of the plantaris tendon
- TL2 – Second tendon length measurement
- TL-A – Average of the two measurements taken for the tendon length
- TW1 – First measurement of the width of the plantaris tendon
- TW2 – Second tendon width measurement
- TW-A – Average of the two measurements taken for the tendon width
- BL1 – First measurement of the length of the plantaris belly
- BL2 – Second measurement of the belly length
- BL-A – Average of the two measurements taken for the belly length
- BW1- First measurement of the width of the plantaris belly
- BW2 – Second measurement of the belly width
- BW-A – Average of the two measurements taken for the belly width
- TOTAL-L – The total length measured for the plantaris muscle

TABLE	AGE:	SEX:	PLANTARIS - LEFT LEG												
			TL 1	TL 2	TL -A	TW 1	TW 2	TW -A	BL 1	BL 2	BL -A	BW 1	BW 2	BW -A	TOTAL L
25	62	M	309.69	305.21	307.45	2.73	3.43	3.08	52.68	44.23	48.46	7.80	8.27	8.04	355.91
26	54	F	268.77	264.34	266.56	3.81	4.15	3.98	118.71	115.30	117.01	15.64	16.44	16.04	383.56
27	55	M	289.29	284.91	287.10	3.75	3.46	3.61	88.68	89.73	89.21	16.46	16.06	16.26	376.31
30	19	M	304.47	300.15	302.31	2.67	2.72	2.70	90.16	89.93	90.05	18.63	19.00	18.82	392.36
31	55	M	262.96	255.05	259.01	4.91	5.26	5.09	99.64	93.86	96.75	22.20	29.15	25.68	355.76
34	51	M	225.26	226.50	225.88	2.82	2.77	2.80	95.30	93.79	94.55	24.20	23.28	23.74	320.43
46	60	M	267.59	276.60	272.10	7.24	7.25	7.25	109.73	104.37	107.05	18.89	12.89	15.89	379.15
47	48	M	316.40	314.73	315.57	3.30	3.95	3.63	93.58	93.25	93.42	19.78	18.35	19.07	408.98
48	37	M	242.19	236.97	239.58	3.75	4.04	3.90	117.50	116.29	116.90	22.82	23.89	23.36	356.48
101	34	M	315.73	316.11	315.92	3.46	3.66	3.56	82.57	85.49	84.03	13.84	13.92	13.88	399.95
102	79	F	253.89	255.62	254.76	1.47	1.65	1.56	61.11	61.40	61.26	6.79	6.80	6.80	316.01
103	72	M	253.69	250.82	252.26	4.50	4.56	4.53	90.65	89.01	89.83	14.19	13.35	13.77	342.09
104	61	F	238.83	240.80	239.82	6.71	6.14	6.43	65.14	67.62	66.38	7.77	7.57	7.67	306.20
105	83	F	196.69	200.47	198.58	3.51	4.63	4.07	86.00	85.45	85.73	13.82	13.51	13.67	284.31
106	31	M	118.72	114.67	116.70	3.34	3.59	3.47	172.20	128.35	150.28	15.57	14.44	15.01	266.97
109	75	F	286.78	288.93	287.86	6.47	6.52	6.50	83.90	83.41	83.66	16.02	16.35	16.19	371.51
110	32	M	238.77	239.91	239.34	3.81	3.68	3.75	88.72	88.72	88.72	15.65	18.00	16.83	328.06
111	47	M	299.06	200.07	249.57	4.18	4.51	4.35	71.61	71.14	71.38	11.66	11.89	11.78	320.94
113	39	F	256.65	257.35	257.00	5.48	7.52	6.50	81.93	82.89	82.41	13.21	13.20	13.21	339.41
114	65	M	282.02	279.38	280.70	3.11	3.44	3.28	109.50	112.64	111.07	20.51	19.60	20.06	391.77
115	61	F	265.54	264.48	265.01	3.55	3.82	3.69	68.93	69.90	69.42	15.72	16.65	16.19	334.43
116	74	F	255.44	256.69	256.07	2.53	1.58	2.06	92.78	93.99	93.39	13.18	12.50	12.84	349.45
117	95	M	276.11	276.86	276.49	4.14	5.56	4.85	103.25	100.55	101.90	15.22	17.86	16.54	378.39
118	86	F	280.19	281.97	281.08	3.28	3.25	3.27	107.10	98.83	102.97	13.96	12.44	13.20	384.05

TABLE	AGE:	SEX:	PLANTARIS - LEFT LEG												
			TL 1	TL 2	TL -A	TW 1	TW 2	TW -A	BL 1	BL 2	BL -A	BW 1	BW 2	BW -A	TOTAL L
119	40	M	323.42	315.53	319.48	3.92	4.19	4.06	77.95	82.02	79.99	22.74	28.24	25.49	399.46
120	29	F	263.14	261.49	262.32	4.00	3.33	3.67	94.08	93.37	93.73	14.33	13.19	13.76	356.04
124	92	F	280.24	280.97	280.61	4.15	5.72	4.94	88.02	79.72	83.87	12.09	12.86	12.48	364.48
201	3	M	267.11	264.98	266.05	3.76	2.94	3.35	86.58	91.93	89.26	11.46	12.88	12.17	355.30
202	25	F	263.74	254.99	259.37	4.07	4.52	4.30	96.75	97.08	96.92	7.80	7.86	7.83	356.28
203	89	M	303.84	304.26	304.05	4.67	5.27	4.97	68.04	65.23	66.64	11.00	12.16	11.58	370.69
204	73	F	266.82	263.26	265.04	4.79	3.88	4.34	79.47	79.97	79.72	13.86	14.50	14.18	344.76
205	80	F	327.55	327.57	327.56	2.26	3.41	2.84	69.31	67.73	68.52	11.10	7.95	9.53	396.08
208a	83	F	287.27	288.73	288.00	3.64	3.50	3.57	90.60	87.76	89.18	16.00	16.46	16.23	377.18
208b	87	F	266.29	268.09	267.19	2.14	2.60	2.37	73.98	78.03	76.01	10.54	11.71	11.13	343.20
209	92	M	303.65	305.80	304.73	1.92	3.10	2.51	95.38	91.96	93.67	14.18	18.57	16.38	398.40
210	88	F	299.21	300.85	300.03	5.66	6.43	6.05	100.04	97.75	98.90	9.81	9.06	9.44	398.93
213	74	F	264.39	262.68	263.54	3.66	4.00	3.83	81.05	81.01	81.03	16.98	17.32	17.15	344.57
218	74	F	212.62	211.64	212.13	4.49	4.51	4.50	92.83	95.34	94.09	13.62	15.38	14.50	306.22
219	64	M	314.21	319.05	316.63	5.96	5.91	5.94	91.06	86.78	88.92	9.40	9.40	9.40	405.55
220	82	F	288.15	288.20	288.18	3.33	2.69	3.01	64.03	61.97	63.00	16.76	15.39	16.08	351.18
221	87	F	215.16	217.43	216.30	2.87	2.54	2.71	81.09	75.58	78.34	9.06	10.42	9.74	294.63
305	36	M	267.74	268.38	268.06	3.89	3.80	3.85	81.19	82.82	82.01	13.19	12.96	13.08	350.07
308	41	M	293.56	294.11	293.84	3.81	4.07	3.94	41.57	46.75	44.16	16.79	17.85	17.32	338.00
309	75	M	224.66	225.69	225.18	1.95	1.97	1.96	91.46	92.42	91.94	11.53	12.33	11.93	317.12
310	83	F	153.80	143.26	148.53	4.78	4.00	4.39	82.00	85.01	83.51	12.42	12.89	12.66	232.04
312	94	F	132.49	230.60	181.55	4.93	4.73	4.83	88.84	84.60	86.72	9.62	13.55	11.59	268.27

TABLE	AGE:	SEX:	PLANTARIS - RIGHT LEG												
			TL 1	TL 2	TL -A	TW 1	TW 2	TW -A	BL 1	BL 2	BL -A	BW 1	BW 2	BW -A	TOTAL L
25	62	M	39.01	38.01	38.51	1.8	2.34	2.07	65.12	64.18	64.65	15.62	15.33	15.475	103.16
26	54	F	239.29	238.75	239.02	3.16	3.33	3.245	105.71	104.61	105.16	17.66	17.99	17.825	344.18
29	44	M	274.53	270.23	272.38	3.67	4.15	3.91	84.26	78.13	81.195	10.7	10.56	10.63	353.575
30	19	M	323.82	322.62	323.22	2.94	3.52	3.23	94.28	94.05	94.165	27.07	29.83	28.45	417.385
33	99	M	280.17	280.46	280.315	7.31	7.78	7.545	115.1	113.75	114.425	15.13	15.3	15.215	394.74
34	51	M	243.59	232.84	238.215	3.43	3.59	3.51	69.14	66.25	67.695	11.76	10.75	11.255	305.91
45	34	M	303.93	294.65	299.29	1.91	3.15	2.53	71.71	74.03	72.87	26.89	34.04	30.465	372.16
47	48	M	316.48	296.7	306.59	4.17	5.28	4.725	86.68	78.1	82.39	11.46	10.03	10.745	388.98
101	69	M	247.14	249.73	248.435	3.6	3.62	3.61	104.21	103.41	103.81	13.38	13.44	13.41	352.245
103	72	M	314.91	312.17	313.54	1.91	2.01	1.96	98.24	101.09	99.665	13.51	14.58	14.045	413.205
104	61	F	241.42	239.59	240.505	5.16	5.25	5.205	60	61.82	60.91	15.53	15.77	15.65	301.415
105	83	F	240.61	242.98	241.795	3.11	3.15	3.13	92.29	95.18	93.735	12.79	12.53	12.66	335.53
107a	72	F	288.18	286.46	287.32	6.32	6.52	6.42	92.97	97.21	95.09	10.85	11.58	11.215	382.41
107b	86	M	256.68	263.04	259.86	1.89	1.66	1.775	88.95	89.01	88.98	11.81	11.75	11.78	348.84
108	85	F	294.61	293.08	293.845	3.91	3.64	3.775	73.74	76.04	74.89	28.85	26.06	27.455	368.735
109	75	F	287.11	287.47	287.29	2.57	3.29	2.93	98.86	99.11	98.985	17.4	17.57	17.485	386.275
110a	32	M	304.1	309.4	306.75	5.11	4.9	5.005	89.09	90.61	89.85	9.62	8	8.81	396.6
110b	68	F	278.56	274.9	276.73	3.92	3.85	3.885	105.97	103.93	104.95	25.94	25.72	25.83	381.68
111	47	M	326.02	322.92	324.47	5.24	5.66	5.45	79.45	77.91	78.68	12.09	11.58	11.835	403.15
113	39	F	251.67	255.01	253.34	4.6	3.98	4.29	75.59	75.77	75.68	17.4	18.04	17.72	329.02
114	65	M	286.67	284.46	285.565	3.41	2.7	3.055	114.73	116.52	115.625	22.64	24.1	23.37	401.19
116	74	F	245.23	246.89	246.06	3.24	3.22	3.23	110.23	110.53	110.38	14.31	18.07	16.19	356.44
117	95	M	268.42	271.81	270.115	6.54	6.88	6.71	82.57	83	82.785	22.3	26.91	24.605	352.9
118	79	F	254.37	254.75	254.56	1.75	2.48	2.115	57.1	54.51	55.805	8.6	8.55	8.575	310.365

TABLE	AGE:	SEX:	PLANTARIS - RIGHT LEG												
			TL 1	TL 2	TL -A	TW 1	TW 2	TW -A	BL 1	BL 2	BL -A	BW 1	BW 2	BW -A	TOTAL L
119	40	M	333.07	330.21	331.64	5.71	5.77	5.74	115.93	113.89	114.91	12.83	14.03	13.43	446.55
120	29	F	282.29	272.34	277.315	3.78	3.41	3.595	101.61	92.04	96.825	9.63	10.01	9.82	374.14
124	92	F	282.62	282.62	282.62	3.51	3.86	3.685	86.59	82.36	84.475	16.16	16.79	16.475	367.095
204	73	F	289.77	282.65	286.21	4.87	4.5	4.685	84.01	85.66	84.835	14.93	14.98	14.955	371.045
205a	75	F	260.57	249.84	255.205	3.28	2.86	3.07	64.52	65.21	64.865	15.9	14.4	15.15	320.07
205b	80	F	319.6	324.09	321.845	3.7	4.16	3.93	104.88	103.65	104.265	15.12	14.31	14.715	426.11
208	83	F	269.18	268.84	269.01	3.8	3.12	3.46	91.66	91.17	91.415	16.17	17.27	16.72	360.425
209	49	M	293	291.43	292.215	3.92	4.04	3.98	92.11	97.74	94.925	13.46	13.88	13.67	387.14
210	88	F	245.63	248.9	247.265	2.3	1.97	2.135	93.76	91.16	92.46	9.33	8.22	8.775	339.725
218	74	F	184.96	174.7	179.83	2.69	2.44	2.565	80.81	77.9	79.355	14.02	17.91	15.965	259.185
219	64	M	282.43	288.15	285.29	3.46	3.46	3.46	92.26	88.04	90.15	11.54	11.18	11.36	375.44
220	82	F	277.8	278.53	278.165	4.62	4.62	4.62	100.46	99.93	100.195	19.09	18.24	18.665	378.36
221	87	F	205.58	204.95	205.265	3.99	3.99	3.99	64.94	60.2	62.57	7.05	8.05	7.55	267.835
222	83	M	316.28	313.57	314.925	4.4	5.2	4.8	111.07	110.74	110.905	13.25	16.92	15.085	425.83
223	91	F	303.55	303.19	303.37	2.18	2.9	2.54	68.74	72.16	70.45	8.74	11.73	10.235	373.82
305	36	M	278.93	279.45	279.19	2.38	2.35	2.365	78.61	76.08	77.345	7.53	8.24	7.885	356.535
307	27	F	335.4	335.8	335.6	2.68	2.58	2.63	97.77	97.09	97.43	16.51	17.22	16.865	433.03
309	75	M	253.28	253.88	253.58	4.53	4.84	4.685	80.6	78.47	79.535	14.05	14.24	14.145	333.115
310	83	F	211.71	210.94	211.325	2.46	2.43	2.445	72.41	66.22	69.315	11.25	11.2	11.225	280.64

Prevalence of the palmaris longus muscle

- Group – Indicates the different age group (as used for the fourth aim)
    - n = Sample size for the specific age group
- Age – Indicates the age of the person whose measurements are recorded
- Sex – Sex of the individual
    - M = Male
    - F = Female
- L. ARM – Presence or absence of the palmaris longus muscle in the left arm
    - 0 = Absence
    - 1 = Presence
- R. ARM – Presence or absence of the palmaris longus muscle in the right arm
    - 0 = Absence
    - 1 = Presence

GROUP 1 (n=361)											
AGE	SEX	L. ARM	R. ARM	AGE	SEX	L. ARM	R. ARM	AGE	SEX	L. ARM	R. ARM
5	F	0	0	7	F	1	1	9	F	1	1
5	M	0	1	7	F	1	1	9	F	1	1
6	F	0	0	7	M	1	1	9	F	1	1
6	M	0	0	7	M	1	1	9	F	1	1
6	M	0	0	7	M	1	1	9	M	1	1
6	M	1	0	7	M	1	1	9	M	1	1
6	M	1	0	7	M	1	1	9	M	1	1
6	M	1	0	7	M	1	1	9	M	1	1
6	F	1	1	7	M	1	1	9	M	1	1
6	F	1	1	8	F	0	0	10	F	0	0
6	F	1	1	8	F	0	0	10	M	0	0
6	F	1	1	8	M	0	0	10	M	0	0
6	M	1	1	8	M	0	1	10	M	0	0
6	M	1	1	8	M	1	1	10	F	1	0
6	M	1	1	8	M	1	1	10	F	1	0
6	M	1	1	8	M	1	1	10	F	1	0
6	M	1	1	8	M	1	1	10	F	1	0
6	M	1	1	8	M	1	1	10	F	1	1
6	M	1	1	9	F	0	0	10	F	1	1
6	M	1	1	9	F	0	0	10	F	1	1
7	F	0	0	9	F	0	0	10	F	1	1
7	M	0	0	9	M	0	0	10	M	1	1
7	F	0	1	9	M	0	0	10	M	1	1
7	F	0	1	9	F	0	1	10	M	1	1
7	F	0	1	9	F	0	1	10	M	1	1
7	M	0	1	9	M	0	1	10	M	1	1
7	M	0	1	9	M	0	1	10	M	1	1
7	M	1	0	9	F	1	0	10	M	1	1
7	M	1	0	9	F	1	1	10	M	1	1
7	F	1	1	9	F	1	1	11	M	0	0
7	F	1	1	9	F	1	1	11	M	0	0

AGE	SEX	L. ARM	R. ARM
11	M	0	1
11	F	1	0
11	F	1	0
11	F	1	1
11	F	1	1
11	F	1	1
11	F	1	1
11	F	1	1
11	F	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
11	M	1	1
12	F	0	0
12	F	0	1
12	F	0	1
12	F	0	1
12	M	0	1
12	M	0	1
12	M	0	1
12	F	1	0
12	M	1	0

AGE	SEX	L. ARM	R. ARM
12	F	1	1
12	F	1	1
12	F	1	1
12	F	1	1
12	F	1	1
12	F	1	1
12	F	1	1
12	F	1	1
12	F	1	1
12	M	1	1
12	M	1	1
12	M	1	1
12	M	1	1
12	M	1	1
12	M	1	1
12	M	1	1
12	M	1	1
12	M	1	1
12	M	1	1
13	F	0	0
13	M	0	0
13	M	0	1
13	F	1	1
13	M	1	0
13	M	1	0
13	F	1	1
13	F	1	1
13	F	1	1
13	F	1	1
13	F	1	1
13	M	1	1
13	M	1	1
13	M	1	1

AGE	SEX	L. ARM	R. ARM
13	M	1	1
13	M	1	1
13	M	1	1
13	M	1	1
13	M	1	1
13	M	1	1
14	M	0	0
14	M	0	1
14	M	0	1
14	M	1	0
14	M	1	0
14	F	1	1
14	F	1	1
14	F	1	1
14	M	1	1
14	M	1	1
14	M	1	1
14	M	1	1
14	M	1	1
14	M	1	1
14	M	1	1
15	F	0	0
15	F	0	0
15	M	0	0
15	M	1	0
15	M	1	0
15	F	1	1
15	F	1	1
15	F	1	1
15	F	1	1
15	F	1	1
15	F	1	1
15	M	1	1
15	M	1	1
15	M	1	1

AGE	SEX	L. ARM	R. ARM
15	M	1	1
15	M	1	1
15	M	1	1
15	M	1	1
16	F	0	0
16	M	0	1
16	M	0	1
16	F	1	0
16	F	1	0
16	M	1	0
16	F	1	1
16	F	1	1
16	F	1	1
16	F	1	1
16	F	1	1
16	F	1	1
16	F	1	1
16	F	1	1
16	F	1	1
16	F	1	1
16	M	1	1
16	M	1	1
16	M	1	1
17	F	0	0
17	F	0	0
17	M	0	0
17	M	0	1
17	F	1	0
17	M	1	0
17	F	1	1
17	F	1	1
17	F	1	1
17	M	1	1

AGE	SEX	L. ARM	R. ARM
17	M	1	1
17	M	1	1
17	M	1	1
17	M	1	1
17	M	1	1
17	M	1	1
18	F	0	0
18	F	0	1
18	M	0	1
18	M	0	1
18	F	1	0
18	F	1	0
18	F	1	0
18	F	1	0
18	M	1	0
18	F	1	1
18	F	1	1
18	F	1	1
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18	F	1	1
18	F	1	1
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18	F	1	1
18	F	1	1
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18	F	1	1
18	F	1	1
18	F	1	1
18	F	1	1
18	F	1	1
18	F	1	1
18	F	1	1
18	F	1	1

AGE	SEX	L. ARM	R. ARM
18	F	1	1
18	F	1	1
18	F	1	1
18	F	1	1
18	F	1	1
18	M	1	1
19	F	0	0
19	F	0	0
19	F	0	0
19	M	0	0
19	F	0	1
19	F	0	1
19	F	0	1
19	F	0	1
19	F	1	0
19	F	1	0
19	F	1	0
19	F	1	0
19	F	1	1
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19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1

AGE	SEX	L. ARM	R. ARM
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	F	1	1
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1

AGE	SEX	L. ARM	R. ARM
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1
19	M	1	1
20	F	0	0
20	F	0	0
20	F	0	1
20	F	0	1
20	F	1	0
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	F	1	1
20	M	1	1
20	M	1	1

AGE	SEX	L. ARM	R. ARM
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1
20	M	1	1

GROUP 2 (n=151)											
AGE	SEX	L. ARM	R. ARM	AGE	SEX	L. ARM	R. ARM	AGE	SEX	L. ARM	R. ARM
21	F	0	0	22	F	0	1	25	F	1	1
21	F	0	0	22	F	1	1	25	F	1	1
21	F	0	1	22	F	1	1	25	F	1	1
21	F	1	0	22	F	1	1	25	M	1	1
21	F	1	0	22	F	1	1	25	M	1	1
21	F	1	0	22	F	1	1	25	M	1	1
21	F	1	1	22	F	1	1	25	M	1	1
21	F	1	1	22	F	1	1	25	M	1	1
21	F	1	1	22	F	1	1	25	M	1	1
21	F	1	1	22	F	1	1	26	M	0	0
21	F	1	1	22	F	1	1	26	M	1	0
21	F	1	1	22	F	1	1	26	F	1	1
21	F	1	1	22	M	1	1	26	M	1	1
21	F	1	1	22	M	1	1	26	M	1	1
21	F	1	1	22	M	1	1	27	F	0	0
21	F	1	1	22	M	1	1	27	M	0	0
21	F	1	1	23	F	1	1	27	M	0	0
21	F	1	1	23	F	1	1	27	F	1	1
21	F	1	1	23	F	1	1	27	M	1	1
21	F	1	1	23	F	1	1	28	F	0	0
21	F	1	1	23	M	1	1	28	F	0	0
21	F	1	1	23	M	1	1	28	F	0	1
21	M	1	1	23	M	1	1	28	F	1	1
21	M	1	1	23	M	1	1	28	M	1	1
21	M	1	1	23	M	1	1	28	M	1	1
21	M	1	1	24	F	1	1	29	M	0	0
21	M	1	1	24	F	1	1	29	F	1	1
21	M	1	1	24	M	1	1	29	F	1	1
21	M	1	1	25	F	1	1	29	F	1	1
21	M	1	1	25	F	1	1	29	M	1	1
22	F	0	0	25	F	1	1	30	F	1	1

AGE	SEX	L. ARM	R. ARM
30	F	1	1
30	M	1	1
30	M	1	1
30	M	1	1
30	M	1	1
30	M	1	1
31	M	0	0
31	F	1	1
31	F	1	1
31	F	1	1
31	M	1	1
31	M	1	1
32	M	1	1
32	M	1	1
33	F	1	1
34	F	1	1
34	M	1	1
34	M	1	1
34	M	1	1
34	M	1	1
34	M	1	1
35	F	0	0
35	F	1	1
35	F	1	1
35	F	1	1
35	F	1	1
35	M	1	1
35	M	1	1
35	M	1	1
36	M	1	1
36	M	1	1
36	M	1	1

AGE	SEX	L. ARM	R. ARM
36	M	1	1
37	F	1	1
37	M	1	1
37	M	1	1
37	M	1	0
37	M	1	1
38	M	0	1
38	M	1	1
38	M	1	1
39	F	0	0
39	F	0	1
39	F	1	1
39	F	1	1
39	M	1	1
40	F	0	0
40	F	0	0
40	F	0	1
40	F	0	1
40	M	0	1
40	M	1	1
40	M	1	1
40	M	1	1
40	M	1	1
40	M	1	1
40	M	1	1

GROUP 3 (n=93)											
AGE	SEX	L. ARM	R. ARM	AGE	SEX	L. ARM	R. ARM	AGE	SEX	L. ARM	R. ARM
41	F	1	1	49	F	1	1	53	M	1	1
41	F	1	1	49	M	1	1	54	F	0	0
41	F	1	1	49	M	1	1	54	M	0	0
41	M	1	1	50	F	0	0	54	F	1	1
41	M	1	1	50	F	1	0	54	M	1	1
42	M	0	0	50	F	1	1	54	M	1	1
42	F	1	1	50	M	1	1	55	F	0	0
42	M	1	1	50	M	1	1	55	M	0	1
42	M	1	1	50	M	1	1	55	M	1	1
42	M	1	1	50	M	1	1	55	M	1	1
43	M	1	1	50	M	1	1	55	M	1	1
43	M	1	1	51	F	0	1	56	M	0	0
43	M	1	1	51	F	1	1	56	M	1	1
44	F	1	1	51	F	1	1	56	M	1	1
44	F	1	1	51	M	1	1	57	F	0	0
44	M	1	1	51	M	1	1	57	F	0	0
45	F	1	1	51	M	1	1	57	F	1	0
45	M	1	1	51	M	1	1	57	M	1	1
45	M	1	1	51	M	1	1	58	F	1	0
46	F	1	1	51	M	1	1	58	M	1	1
46	M	1	1	52	F	1	0	58	M	1	1
46	M	1	1	52	F	1	1	59	F	1	1
46	M	1	1	52	F	1	1	59	M	1	1
47	M	1	1	52	F	1	1	59	M	1	1
48	F	1	1	52	F	1	1	60	M	0	0
48	M	1	1	52	M	1	1	60	M	0	1
48	M	1	1	53	F	0	0	60	F	1	1
48	M	1	1	53	F	1	1	60	M	1	1
49	F	0	0	53	F	1	1	60	M	1	1
49	M	0	0	53	M	1	1	60	M	1	1
49	M	0	1	53	M	1	1	60	M	1	1

GROUP 4 (n=64)											
AGE	SEX	L. ARM	R. ARM	AGE	SEX	L. ARM	R. ARM	AGE	SEX	L. ARM	R. ARM
61	F	0	0	74	F	0	0	80	F	1	1
61	F	1	1	74	M	0	0	80	M	1	1
61	M	1	1	74	F	1	1				
62	M	0	1	74	M	1	1				
63	M	1	1	74	M	1	1				
63	M	1	1	75	M	0	0				
63	M	1	1	75	M	0	1				
63	M	1	1	75	F	1	1				
64	F	0	0	75	F	1	1				
64	M	0	0	75	F	1	1				
64	M	1	1	75	M	1	1				
65	F	1	1	75	M	1	1				
65	M	1	1	75	M	1	1				
65	M	1	1	76	F	0	1				
66	F	1	1	76	F	0	1				
67	F	1	1	77	M	0	1				
67	M	1	1	77	M	1	0				
67	M	1	1	77	F	1	1				
67	M	1	1	77	F	1	1				
68	M	0	0	77	M	1	1				
68	M	1	1	77	M	1	1				
69	M	1	1	77	M	1	1				
70	M	1	1	77	M	1	1				
71	F	1	0	78	F	1	1				
71	M	1	1	79	F	0	0				
72	M	0	0	79	M	0	0				
72	M	1	1	79	M	1	1				
72	M	1	1	79	M	1	1				
72	M	1	1	80	F	0	0				
73	M	0	0	80	M	0	0				
73	F	1	1	80	F	0	1				

GROUP 5 (n=38)			
AGE	SEX	L. ARM	R. ARM
81	F	1	1
81	M	1	1
82	F	1	0
83	F	1	1
83	F	1	1
83	M	1	1
83	M	1	1
83	M	1	1
85	M	0	0
85	M	0	1
85	F	1	1
86	F	1	1
86	M	1	1
86	M	1	1
87	F	1	1
87	F	1	1
88	F	0	0
88	F	0	0
88	M	0	0
88	F	1	1
89	M	1	1
89	M	1	1
89	M	1	0
89	M	1	1
90	M	0	1
90	M	1	1
91	M	0	1
91	M	1	1
91	M	1	1
92	F	1	1
92	M	1	1

AGE	SEX	L. ARM	R. ARM
92	M	1	1
93	F	1	0
94	F	1	1
95	M	1	1
96	M	0	0
99	M	1	1

Prevalence of the plantaris muscle

- Age – Indicates the age of the person whose measurements are recorded
- Sex – Sex of the individual
    - M = Male
    - F = Female
- L. LEG – Presence or absence of the plantaris muscle in the left leg
    - 0 = Absence
    - 1 = Presence
- R. LEG – Presence or absence of the plantaris muscle in the right leg
    - 0 = Absence
    - 1 = Presence

AGE	SEX	L. LEG	R. LEG
24	F	0	0
34	F	0	0
42	F	0	0
51	F	0	0
40	M	0	0
40	M	0	0
42	M	0	0
54	M	0	0
55	M	0	0
70	M	0	0
77	M	0	0
77	M	0	0
81	M	0	0
52	F	0	1
67	M	0	1
72	M	0	1
86	M	0	1
89	M	0	1
28	M	1	0
42	M	1	0
51	M	1	0
81	M	1	O
20	F	1	1
23	F	1	1
25	F	1	1

AGE	SEX	L. LEG	R. LEG
27	F	1	1
29	F	1	1
29	F	1	1
35	F	1	1
39	F	1	1
49	F	1	1
52	F	1	1
53	F	1	1
54	F	1	1
61	F	1	1
64	F	1	1
65	F	1	1
67	F	1	1
73	F	1	1
74	F	1	1
74	F	1	1
75	F	1	1
75	F	1	1
77	F	1	1
77	F	1	1
78	F	1	1
79	F	1	1
80	F	1	1
80	F	1	1
81	F	1	1

AGE	SEX	L. LEG	R. LEG
82	F	1	1
83	F	1	1
83	F	1	1
85	F	1	1
86	F	1	1
87	F	1	1
87	F	1	1
88	F	1	1
88	F	1	1
88	F	1	1
92	F	1	1
93	F	1	1
94	F	1	1
19	M	1	1
20	M	1	1
21	M	1	1
23	M	1	1
30	M	1	1
31	M	1	1
32	M	1	1
34	M	1	1
34	M	1	1
35	M	1	1
36	M	1	1
36	M	1	1

AGE	SEX	L. LEG	R. LEG
37	M	1	1
38	M	1	1
40	M	1	1
40	M	1	1
40	M	1	1
41	M	1	1
41	M	1	1
42	M	1	1
42	M	1	1
43	M	1	1
44	M	1	1
45	M	1	1
46	M	1	1
46	M	1	1
47	M	1	1
48	M	1	1
49	M	1	1
49	M	1	1
50	M	1	1
50	M	1	1
50	M	1	1
50	M	1	1
51	M	1	1
51	M	1	1
51	M	1	1

AGE	SEX	L. LEG	R. LEG
51	M	1	1
53	M	1	1
54	M	1	1
55	M	1	1
55	M	1	1
55	M	1	1
57	M	1	1
58	M	1	1
60	M	1	1
60	M	1	1
60	M	1	1
60	M	1	1
60	M	1	1
61	M	1	1
62	M	1	1
63	M	1	1
63	M	1	1
64	M	1	1
65	M	1	1
65	M	1	1
67	M	1	1
68	M	1	1
69	M	1	1
72	M	1	1
72	M	1	1

AGE	SEX	L. LEG	R. LEG
73	M	1	1
74	M	1	1
74	M	1	1
74	M	1	1
75	M	1	1
75	M	1	1
77	M	1	1
77	M	1	1
79	M	1	1
79	M	1	1
80	M	1	1
80	M	1	1
83	M	1	1
83	M	1	1
85	M	1	1
85	M	1	1
88	M	1	1
89	M	1	1
89	M	1	1
91	M	1	1
91	M	1	1
91	M	1	1
92	M	1	1
95	M	1	1
96	M	1	1

AGE	SEX	L. LEG	R. LEG
99	M	1	1

Simultaneous occurrence of the palmaris longus and plantaris muscles

- Age – Indicates the age of the person whose measurements are recorded
- Sex – Sex of the individual
    - M = Male
    - F = Female
- L. ARM – Presence or absence of the palmaris longus muscle in the left arm
    - 0 = Absence
    - 1 = Presence
- R. ARM – Presence or absence of the palmaris longus muscle in the right arm
    - 0 = Absence
    - 1 = Presence
- L. LEG – Presence or absence of the plantaris muscle in the left leg
    - 0 = Absence
    - 1 = Presence
- R. LEG – Presence or absence of the plantaris muscle in the right leg
    - 0 = Absence
    - 1 = Presence

AGE	SEX	Palmaris longus		Plantaris	
		L. ARM	R. ARM	L. LEG	R. LEG
19	M	1	1	1	1
20	F	1	1	1	1
20	M	1	1	1	1
21	M	1	1	1	1
23	F	1	1	1	1
23	M	1	1	1	1
24	F	1	1	0	0
25	F	1	1	1	1
27	F	1	1	1	1
28	M	1	1	1	0
29	F	1	1	1	1
29	F	1	1	1	1
30	M	1	1	1	1
31	M	1	1	1	1
32	M	1	1	1	1
34	F	1	1	0	0
34	M	1	1	1	1
34	M	1	1	1	1
35	F	1	1	1	1
35	M	1	1	1	1
36	M	1	1	1	1
36	M	1	1	1	1
37	M	1	1	1	1
38	M	1	1	1	1

AGE	SEX	Palmaris longus		Plantaris	
		L. ARM	R. ARM	L. LEG	R. LEG
39	F	0	1	1	1
40	M	0	1	1	1
40	M	1	1	0	0
40	M	1	1	0	0
40	M	1	1	1	1
40	M	1	1	1	1
41	M	1	1	1	1
41	M	1	1	1	1
42	M	0	0	1	1
42	F	1	1	0	0
42	M	1	1	0	0
42	M	1	1	1	0
42	M	1	1	1	1
43	M	1	1	1	1
44	M	1	1	1	1
45	M	1	1	1	1
46	M	1	0	1	1
46	M	1	1	1	1
47	M	1	1	1	1
48	M	1	1	1	1
49	F	0	0	1	1
49	M	0	1	1	1
49	M	1	1	1	1
50	M	1	1	1	1

AGE	SEX	Palmaris longus		Plantaris	
		L. ARM	R. ARM	L. LEG	R. LEG
50	M	1	1	1	1
50	M	1	1	1	1
50	M	1	1	1	1
51	F	1	1	0	0
51	M	1	1	1	0
51	M	1	1	1	1
51	M	1	1	1	1
51	M	1	1	1	1
51	M	1	1	1	1
52	F	1	1	0	1
52	F	1	1	1	1
53	F	1	1	1	1
53	M	1	1	1	1
54	M	0	0	0	0
54	F	1	1	1	1
54	M	1	1	1	1
55	M	0	1	0	0
55	M	1	1	1	1
55	M	1	1	1	1
55	M	1	1	1	1
57	M	1	1	1	1
58	M	1	1	1	1
60	M	0	1	1	1
60	M	1	1	1	1

AGE	SEX	Palmaris longus		Plantaris	
		L. ARM	R. ARM	L. LEG	R. LEG
60	M	1	1	1	1
60	M	1	1	1	1
60	M	1	1	1	1
61	F	0	0	1	1
61	M	1	1	1	1
62	M	1	1	1	1
63	M	1	1	1	1
63	M	1	1	1	1
64	F	0	0	1	1
64	M	0	0	1	1
65	F	1	1	1	1
65	M	1	1	1	1
65	M	1	1	1	1
67	M	1	1	0	1
67	F	1	1	1	1
67	M	1	1	1	1
68	M	1	1	1	1
69	M	1	1	1	1
70	M	1	1	0	0
72	M	0	0	0	1
72	M	1	1	1	1
72	M	1	1	1	1
73	F	1	1	1	1
73	M	1	1	1	1

AGE	SEX	Palmaris longus		Plantaris	
		L. ARM	R. ARM	L. LEG	R. LEG
74	M	0	0	1	1
74	F	1	1	1	1
74	F	1	1	1	1
74	M	1	1	1	1
74	M	1	1	1	1
75	M	0	1	1	1
75	F	1	1	1	1
75	F	1	1	1	1
75	M	1	1	1	1
77	M	0	1	1	1
77	M	1	1	0	0
77	M	1	1	0	0
77	F	1	1	1	1
77	F	1	1	1	1
77	M	1	1	1	1
78	F	1	1	1	1
79	F	0	0	1	1
79	M	1	1	1	1
79	M	1	1	1	1
80	F	0	0	1	1
80	M	0	0	1	1
80	F	1	1	1	1
80	M	1	1	1	1
81	M	1	1	0	0

AGE	SEX	Palmaris longus		Plantaris	
		L. ARM	R. ARM	L. LEG	R. LEG
81	F	1	1	1	1
81	M	1	1	1	O
82	F	1	1	1	1
83	F	1	1	1	1
83	F	1	1	1	1
83	M	1	1	1	1
83	M	1	1	1	1
85	M	0	0	1	1
85	M	0	1	1	1
85	F	1	1	1	1
86	M	1	1	0	1
86	F	1	1	1	1
87	F	1	1	1	1
87	F	1	1	1	1
88	F	0	0	1	1
88	F	0	0	1	1
88	M	0	0	1	1
88	F	1	1	1	1
89	M	1	1	0	1
89	M	1	1	1	1
89	M	1	1	1	1
91	M	0	1	1	1
91	M	1	1	1	1
91	M	1	1	1	1

AGE	SEX	Palmaris longus		Plantaris	
		L. ARM	R. ARM	L. LEG	R. LEG
92	F	1	1	1	1
92	M	1	1	1	1
93	F	1	0	1	1
94	F	1	1	1	1
95	M	1	1	1	1
96	M	0	0	1	1
99	M	1	1	1	1