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Morphological Analysis of Palmaris Longus Muscle And Its Anatomic Variations: A Cadaveric Study In North India

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Abstract

Palmaris longus is classified as a phylogenetically retrogressive muscle having a short belly with a long tendon. It varies in the incidence of its absence, form, attachment, duplication and its ability of having accessory slips and substitute structures. The muscle is of interest to hand surgeons because a number of cases have been reported with complaints of a volar distal forearm swelling and median nerve compression symptoms. Therefore, the present study was performed with the purpose to determine the morphology and the variations of PL in North Indian population. Material for the present study consisted of 62 limbs(20 Male and 11 Female) which were made available through a series of dissections performed for first year medical students at SGRDIMSAR, Amritsar, Punjab. The morphology and variations of PL and its relation with neighbouring structures were noted. The data thus collected was stored and compared to other studies. Of 62 limbs dissected 55(88.70%) showed normal morphology of palmaris longus muscle as per the standard textbook. 5 limbs(8.06%) showed complete agenesis. 1(1.61%) limb exhibited a fleshy fusiform PLM. A Reversed palmaris longus muscle(RPLM) along with accessory PL(1.61%) was observed in the same limb. Variations of the PL tendon may even confuse an experienced surgeon. Thus, it is important for the reconstructive surgeons or radiologists to be aware of the possibility of variations and its impact on the structures present at the wrist area especially one that might contribute to median or ulnar nerve compression.

Keywords

Palmaris longus, Carpal tunnel syndrome, Absent, Vestigial, Reversed, Accessory.

Introduction

Palmaris Longus is a slender fusiform muscle of the forearm, located just under the skin, subcutaneous fat and forearm fascia, superficial to Flexor Digitorum Superficialis (FDS) and between Flexor Carpi Radialis (FCR) laterally & Flexor Carpi Ulnaris (FCU) medially. (Ellis et al., 2005) The short muscular belly and the long tendon is characteristic of phylogenetic retrogressive degeneration of this muscle (Sebastin et al., 2005) which is evidenced by palmar aponeurosis representing the distal part of its tendon. (Bergman et al., 1984)

The muscle is subject to many variations both in morphology and number ranging from complete agenesis to duplication, triplication, variable location and accesso-

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ry slips. (Reimann et al., 1944;) The prevalence of the PL agenesis has been well-documented by many authors in different ethnic groups or populations. (Sebastin et al., 2005) It may have a proximal tendon or a distal tendon, or have a fleshy central belly with proximal and distal tendons, it maybe digastric or fleshy throughout or its tendon may be split and sometimes it maybe degenerated to such an extent it that may be simply represented by a tendinous band. (Reimann et al., 1944;) Generally variations in palmaris longus anatomy are thought to be asymptomatic. several authors have described variations of the reversed palmaris longus, many of which may cause symptomatic median nerve compression (Schlafly & Lister, 1987; Meyer and Pflaum, 1987; Depuydt et al., 1998; Schuurman & Van Gils, 2000).

Normally the fleshy part of Palmaris longus muscle arises from the medial epicondyle of humerus and tendinous part gets inserted into palmar aponeurosis. (Ellis et al., 2005) When it is tendinous proximally and has a fleshly distal belly it is called reverse PL or PL inversus. (Cope et al., 2009) A reversed palmaris longus, possessing a distal musculo-tendinous junction, was first reported by Captain John T. Morrison in 1916 as an incidental, post-amputation find-ing. (Morrison, 1916) The reversed muscle belly can hypertrophy or divide distally into 2 or 3 separate attachments. Accessory digitations have also been reported to insert most commonly deep to the flexor retinaculum (Bencteux et al., 2001).

The knowledge of such variations is not only desirable, but also essential as these have important influences on the predisposition to illness, clinical examination, investigations and patient management including operative surgery. Moreover, there are no comprehensive studies in the recent past on these variations hence the study was undertaken to have better understanding on their incidence and morphology. The present study was performed with the purpose to determine the morphology and anatomical variations of PLM and its impact on the neighboring nerves and more importantly its surgical significance in North Indian population.

Materials and methods

Material for the present study consisted of 62 limbs of North Indian origin of different age group and sex (20 Male and 11 Female). The limbs were made available through a series of dissections performed over a period of 6 years during the years 2014-19 for first year medical students at Sri Guru Ram Das Institute Of Medical Sciences and Research (SGRDIMSAR), Amritsar, Punjab. The flexor compartment of the forearm of the upper limb was dissected using standard procedure. (Romanes C J, 2012) A vertical incision was made in the center of the anterior surface of the forearm from the cubital fossa to the distal transverse crease of the wrist. Skin and superficial antebrachial fascia of the flexor compartment of the forearm was dissected layer-by-layer and lifted to expose the underlying superficial flexor muscles of the forearm. The origin, course and insertion (Morphology) of Palmaris longus Muscles (PLM) were observed. Variations of PLM and its relation with neighboring structures were noted. Photographs were taken to document the observed variations. The data thus collected was stored and compared with other studies. The presence, absence and morphological variations of PL, its nerve supply and its relation to flexor retinaculum and neighboring structures were noted.

Results

Out of 62 limbs dissected, 55(88.70%) limbs showed the typical anatomical features of the Palmaris longus muscle as described in the standard textbook being muscular in origin and tendinous in insertion and also being supplied by the median nerve (Figure 1).

Complete agenesis of the PLM was observed in 5 limbs (8.06%), of which, unilateral absence was found in 3 male subjects (7.5%), 2 on right side & 1 on left side and 2 female subjects (9.09%), both on left side. (Figure 2). Their numbers, incidence and laterality are shown in Table 1.

A Fleshy Fusiform PLM (1.61%) was also observed in the right UL of a 60-year-old male cadaver being muscular and fleshy in the proximal 2/3 and tendinous in

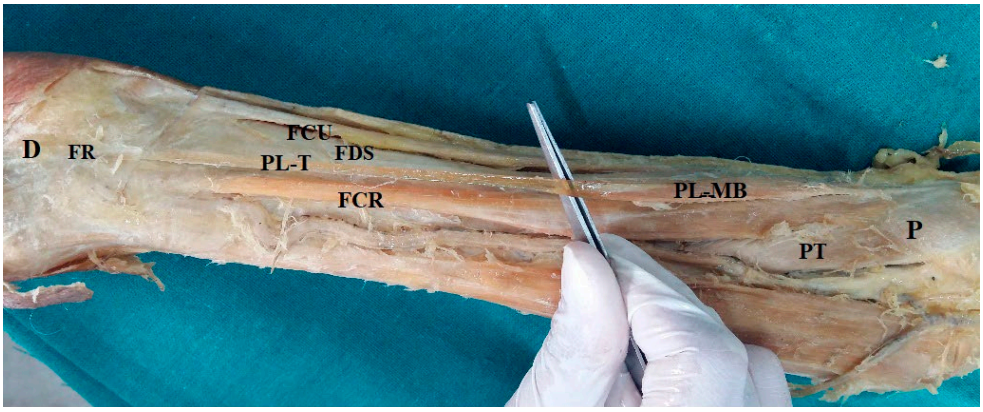

Figure 1. Showing Normal Palmaris Longus Muscle with Proximal Muscle Belly and Distal Tendon In the Left Upper Limb. P- Proximal; D-Distal; PL-Palmaris Longus; PT-Pronator Teres; FCU- Flexor Carpi Ulnaris; FCR-Flexor Carpi Radialis; FDS- Flexor Digitorum Superficialis; FR- Flexor Retinaculum.

Figure 2. Showing Agenesis/Absent Palmaris Longus Muscle In the Right Upper Limb. P- Proximal; D-Distal; PT-Pronator Teres; FCU- Flexor Carpi Ulnaris; FCR-Flexor Carpi Radialis; FDS- Flexor Digitorum Superficialis; FR-Flexor Retinaculum.

Table 1. Morphology of Palmaris Longus Muscle & its incidence.

S. No.	Morphology & Variations	Number of Variations	Side		Number of Limbs	Incidence (%)
			Right	Left		
1.	Normal	55	27	28	55	88.70%)
2.	Agenesis	5	2(M)	3(1M, 2F)	5	8.06%-(62 Limbs) M-7.5%-(40 Limbs) F-9.09%-(22 Limbs)
3.	Fleshy Fusiform PLM	1	1M	-	1	1.61%
4.	Accessory	1	1M	-	1	1.61%
5.	Bifid Reverse/ Inverted PLM	1	1M	-		

M-Male, F-Female.

the distal 1/3 part of the UL. The length of the MB was 16.4 cm and its width was 2.9 cm and the length of the tendon was 6.2 cm and it measured 0.47 cm at its widest part. The tendon was seen inserted into flexor retinaculum. No such variations were observed on the left side (Figure 3).

One limb exhibited an Accessory PLM (1.61%) on the right side of a 54-year-old male cadaver. The APLM was located medial to RPL and Lateral to FCU. It originated with a long, thick tendon from the medial epicondyle of the humerus which prolonged downward and forward in the forearm. Some of these bundles were attached to the flexor retinaculum, while others were seen inserted into the proximal points of origin of the muscles of the hypothenar muscles. The length of the APLM was found to be 23.6cm and width was measured as 0.8 cm (Figure 4).

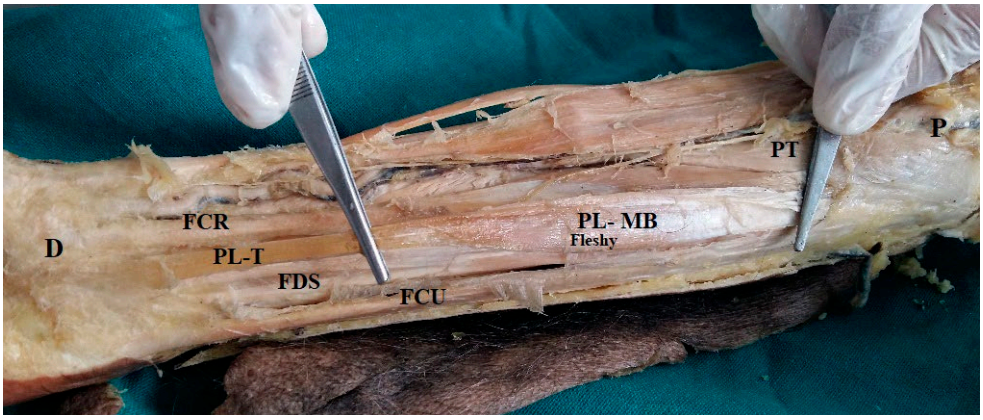

Figure 3. Showing Fleshy/Fusiform Palmaris Longus Muscle with 2/3rd Proximal Long Muscle Belly and 1/3rd Distal Tendon In the Right Upper Limb. P- Proximal; D-Distal; PL-MB-Palmaris Longus-Muscle Belly; PL-T- Palmaris Longus-Tendon; PT-Pronator Teres; FCU- Flexor Carpi Ulnaris; FCR-Flexor Carpi Radialis; FDS- Flexor Digitorum Superficialis.

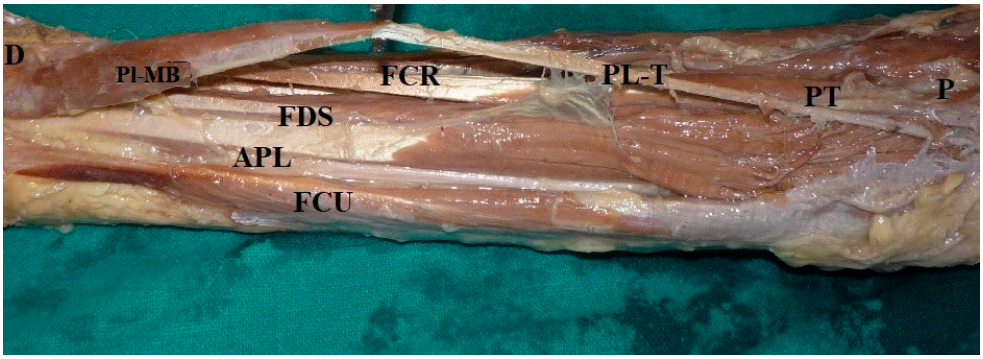

Figure 4. Showing Accessory Palmaris Longus Muscle (APLM) In the Right Upper Limb. P- Proximal; D-Distal; APL-Accessory Palmaris Longus; RPL-MB- Palmaris Longus -Muscle Belly; RPL-T- Reverse Palmaris Longus-Tendon; PT-Pronator Teres; FCU- Flexor Carpi Ulnaris; FCR-Flexor Carpi Radialis; FDS- Flexor Digitorum Superficialis.

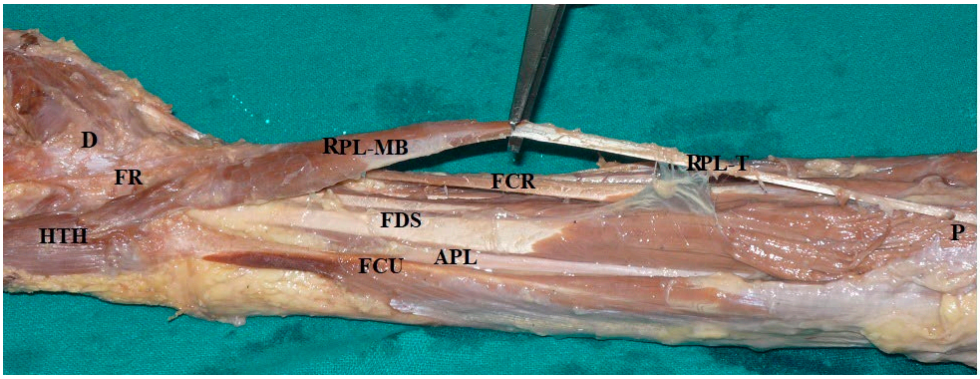

Figure 5. Showing Reverse Palmaris Longus Muscle (RPLM) In the Right Upper Limb. P- Proximal; D-Distal; RPL-MB- Reverse Palmaris Longus Muscle; RPL-T-Reverse Palmaris Longus Tendon; FCU- Flexor Carpi Ulnaris; FCR-Flexor Carpi Radialis; FDS- Flexor Digitorum Superficialis; APL-Accessory Palmaris Longus; FR- Flexor Retinaculum; HTH- Hypothenar Muscle.

A variant Bifid inverted or Reverse Palmaris Longus muscle (RPLM) was also discovered in the same right forearm of a 54-year-old male cadaver having APLM. The RPLM originated from the medial epicondyle of the humerus, being tendinous in the proximal 2/3 and muscular in the distal 1/3 part. The length of the proximal tendon was 18.0 cm that coursed superficial to FDS and changed to a muscular belly in distal 1/3rd of forearm. The length of the muscle belly (MB) was 10 cm and width at its middle part was found to be 2.2 cm. MB passed superficial to flexor retinaculum and bifurcated into a muscular and a fascial slip (Figure 5).

Discussion

Though Numerous variations of Palmaris longus muscle are reported in literature being variable both in number and form. Bergman has classified the PL variations as: Complete agenesis, Variation in location and form of its fleshy part, Aberrancy of attachment at its origin or insertion, Duplication and Triplication, Accessory slips, Replacing elements of a similar form or position. (Bergman et al., 1984). In the present study, Table 1 depicts the complete agenesis of the PLM was observed in 5 limbs (8.06%), of which, unilateral absence was found in 3 male subjects (7.5%), 2 on the right side and 1 on the left side and 2 female subjects (9.09%) on the left side (Figure 2).

Agenesis of the palmaris longus has been attributed to Mendelian principles, its absence is autosomal dominant and its presence is autosomal recessive. (Michael & Shaw, 1978). The prevalence of agenesis of the PL has been extensively studied following the first report of its absence recorded as early as 1559 by Colombo in De Re Anatomica Libri. (Realdi Columni C, 1559). An average of 10% absence has been universally accepted. An extensive research of 1600 cadaveric limbs conducted by Reimann and colleagues in 1944 found that incidence of agenesis of PL was 12.9% and an additional 9% had noticeable variations in the location and form of the muscle belly. (Reimann et al., 1944). In another study of 276 cadavers, palmaris longus was observed bilaterally in 216 (78.3%) cases, 17 (6.1%) cases on right side and 19 (6.9%) cases on left side whereas it was found absent on both the sides in 24 (8.7%) cases. (George, 1953) In a study of 800 living subjects the palmaris longus was absent on both the sides in 7.7% of cases, absent on the right side in 4.5% and on the left side in 5.2%. (Bergman et al., 1984) Schaeffer (1909) also reported its absence in 10% cases either unilaterally or bilaterally. According to Troha et al., (1990), Wehbe & Mawr, (1992), Thompson et al. (2001), Roohi et al. (2007) and Kose et al. (2009), In White Caucasians, Indian Dravidian, Malaysian and Turkish the prevalence of agenesis of PL ranges between 16-26.6% and as low as 4% in Mongloids in a study by Sebestin et al. (2005).

Kapoor et al. (2008) studied palmaris longus muscle in Indian population and found a bilateral absence of 17.2% with unilateral absence in left arm 6.2% and 3% in right arm. There is also mention of racial and ethnic population variation in frequency of prevalence of PL muscle as it has been reported that bilateral absence of palmaris longus occurs in 8-16% of individuals and unilateral in 4-14%. (Vanderhooft, 1996) As can be depicted from Table 2 that the frequency of agenesis of PL recorded in the present study is more than observed by Adachi (1910), Ceyhan & Mavt (1997), Igbigbi & Ssekitoleko (1998), Mbaka & Ejiwunmi (2009), and Gangata (2009) for other populations of the world. Some authors suggested that apart from its ethnic and racial variations, its absence is more common in women, bilateral absence being more common, and that unilateral absence occurs more frequently on the left side. (Schaffer, 1909) The present study supports the findings being unilateral absence more common on left side in females however no bilateral agenesis was found in the present study. From a viewpoint of phylogeny, it is notable that this almost functionless muscle is present in about 90 per cent of humans and is best developed in those where the forelimbs are used for ambulation. (Humphary, 1872) Degeneration has proceeded much further in the group of animals generally considered as phylogenetic forebears. (Jones, 1941). Some remnant of it is usually present in the gibbon and orangutan but less often in

Table 2. Showing incidence of Palmaris Longus Muscle (PLM) agenesis among different ethnic groups and populations.

S. No.	Author	Year	Ethnic group or population	Incidence (%)
1	Reimann et al.	1944	North America	12.9%
2	George	1953		24 (8.7%) cases BL 17 (6.1%) on Lt side 19 (6.9%) on Rt side
3	Adachi	1909	Japanese,	3.4% in Japanese,
4	Schaeffer	1909	-	10%
5	Troha et al.	1990	North American Caucasians	24%
6	Wahbe & Mawr	1992	Pennsylvania	23%
7	Vanderhooft	1996		8-16% BL 4-14%.UL
8	Ceyhan & Mavt	1997	Korean	0.6%
9	Igbigbi & Ssekitoleko	1998	Ugandas	1.02%
10	Thomposn et al.	2001	Northern Ireland	25%
11	Sebastin et al.	2005	Chienese	3.3% UL, 1.2% BL (4.6%)
12	Roohi et al.	2007	Malaysian	9.3%
13	Kapoor et al.	2008	Indian Delhi	17.2%-Bl, 6.2%-Ul-Lt., 3%-Ul-Rt.
14	Kose et al.	2009	Turkish	26.6
15	Mbaka & Ejiwunmi	2009	Yorubas	6.7%
16	Gangata	2009	Zimbabweans, Congolese	1.5% 3.0%
17	Present Study	2019	North India	8.06% (3.22%)-Rt. (4.83%)- Lt.

the chimpanzee and ape, and it is only present in about 25 per cent of gorillas. In this respect the palmaris longus belongs to a group of muscles which are more degenerate in the Apes and monkeys than in man. (Keith, 1899) According to developmental basis the PLM, as a skeletal muscle, originates from the mesoderm of the myotomes of the somites and these precursors follow an intrinsic program which allows them to differentiate into muscle cells, this process is controlled by environmental signals. During the early embryogenesis the absence of such signals in the ectoderm leads to premature differentiation of the precursors, which in turn may cause agenesis or incomplete genesis of the respective muscles (Holinshed, 1964).

Concerning the kind of muscle, PLM may be fleshy throughout its entire length or may have muscle belly located centrally in the forearm and tendon above & below or may be reduced to a mere tendinous band. (Bergman et al., 1984) In the present study a fleshy fusiform muscle having proximal 2/3rd MB and a distal 1/3rd Tendon PL was

Table 3. Showing incidence of accessory Palmaris Longus Muscle among different populations .

S. No.	Author	Population	Year	Incidence (%)
1.	Gruber	Russians	1868	3.1%
2.	Koganei et al	Japan	1903	1.9%
3.	Adachi	Japan	1910	2.1%
4.	Reimann et al	Americans	1944	0.8%
5.	Sato et al	Japanese	1974	2.5%
6.	Teingo et al	Itlay	2006	1 Accessory PL
7.	Present Study	North India	2019	1 Accessory PL

Table 4. Showing work reported by various authors on Reverse Palmaris Longus Muscle (RPLM).

S. No.	Worker/authors	Population	Year	No. of cases of RPLM
1.	Reimann et al	North America	1944	
2.	Schlafly & Lister	American	1987	1 bifid
3.	Meyer & Pflaum	American	1987	1
4.	Regan et al	British-Buckinghamshire	1988	1 bifid RPL
5.	Giunta et al	German	1993	1
6.	Depuydt et al	Netherlands	1998	2
7.	Schuurman &Van Gils	Netherlands	2000	4 (3F/1M)
8.	Yildiz et al.	Turkey	2000	3 Headed bilateral accessory muscle
9.	Oommen & Rajarajeshwari	South India/Manglore	2002	1
10.	Rawat & John.	Ludhiana/Punjab	2003	1
11.	Seyhan et al.	Turkey	2005	1three headed
12.	Natsis et al.	Greece	2007	Three headed PL
13.	Nayak et al.	South India/Karnatka	2008	1
14.	Present Study	North India	2019	1 Bifid Reverse palmaris longus

observed. (Figure 3) In this variation compression of both ulnar and median nerves in the forearm can occur.

An accessory PLM was observed having its origin from medial epicondyle of humerus and insertion at FR and being tendinous throughout its course. (Figure 4) A look at the comparative analysis of Table 3 elucidates that the incidence of APLM was found to be more than Reimann et al (1944) and less than the work done by Adachi (1910), Gruber (1868) and Sato et al., (1974). It is in concordance with the findings of Koganei et al. (1903) and Tiengo et al. (2006). Rubino et al (1995) reported a case where an individual had a small accessory muscle that originated from PL tendon.

The developmental basis for such type of variation is that the forearm muscles develop from a single precursor mass which divides into superficial component giving rise to the pronator teres, flexor carpi radialis, flexor carpi ulnaris and the PL. The deep component gives rise to the deep flexors of the forearm. The additional or accessory PLM can be embryologically explained on the basis of additional cleavage of the superficial mass (Holinshed, 1964).

A variant Bifid inverted or Reverse Palmaris longus muscle being tendinous in the proximal 2/3 and muscular in the distal 1/3 part was observed in the same Right limb of a 54 year old male cadaver having APLM and has been reported earlier. (Lalit and Singla 2014) A RPLM possessing a distal musculo-tendinous junction, was first reported by Captain John T. Morrison in 1916 as an incidental, post-amputation finding. (Morrison, 1916) It was originally described as musculus PL inversus and later was recognised as the term reverse PL. (Natsis, 2007). (Figure 5) Bifid RRL has also been reported by Schlafly & Lister (1987) and Regan et al (l988). Natsis (2007) reported a case where a female cadaver had three headed (radial, central and ulnar) reverse palmaris longus in the left forearm. Though three headed RPLM has also been reported by Yildiz et al. (2000) and Seyhan et al. (2005). A glance at Table 4 reveals the work done by Meyer & Pflaum (1987), Guinta et al. (1993), Depuydt et al. (1998), Oommen and Rajarjeshwari (2002), Rawat and John (2003) and Nayak et al. (2008) on RPLM. Schuurman and Van Gils (2000) also identified four patients in Netherlands who had reverse palmaris longus muscle causing activity related compression of the median nerve. Georgiev et al. (2009) reported a case of reverse palmaris longus with muscular belly at proximal end and the two tendons distally on his left forearm. The primitive function of PL is flexion of the metacarpo-phalangeal joints by means of a tendon that fans out in the palm to be inserted by a slip to the base of each proximal phalanx. In the development of the forelimb as a prehensile organ this function has been taken over by the intrinsic muscles of the hand and the palmaris longus muscle has become degenerated. This retrogression is considered to be due to the gradual development of prehension, achieved by diversion of muscular power for the independent motion of parts of hand. (Humphary, 1872)

Conclusion

PLM variations are described as one of the most common muscular variations in the human body, and their presence has specific clinical significance. Variations of PLM could cause nerve compression with slow progressive symptoms such as carpal tunnel syndrome more frequently than acute nerve compression. These symptoms include oedema on the palmar surface of the wrist, weakness and reduction of muscular strength, pain and numbness in the area. In clinical practice, the variant PLM could be incidentally found during clinical examination without provoking clinical symptoms and may simulate a soft tissue tumor. Therefore, the possible presence of PLM variations and their impact (particular RPLM) on the structures present at the wrist area must be considered by clinicians, hand surgeons, radiologists and all those who are involved in patient care during clinical examination of the forearm, during surgical interventions in that region, or while searching for an entrapment site of the median and ulnar nerve.

Conflict of interest

None

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