Polygastric flexor muscle of the index finger and its clinical implications

Andrés Riveros[1,2], Oscar Inzunza[3,4], Alvaro Burdiles[3], Emilio Farfán[3,4]

[1] Departamento de Ciencias Morfológicas, Facultad de Medicina y Ciencia, Universidad San Sebastián, Lientur 1457, Concepción 4080871, Chile
[2] Programa de Doctorado en Ciencias Morfológicas, Universidad de La Frontera, Temuco, Chile
[3] Departamento de Anatomía, Escuela de Medicina, Pontificia Universidad Católica de Chile, Santiago, Chile
[4] Morpho-Clinical Research Lab, Escuela de Medicina, Pontificia Universidad Católica de Chile, Santiago, Chile

SUMMARY

Although muscle variations in the forearm have been widely reported, the presence of supernumerary muscles in this compartment may be associated with compressive disorders of the nerves of the upper limb. The purpose of this study was to report the finding of a polygastric flexor muscle of the index finger (PFID), a supernumerary muscle associated with the anterior compartment of the forearm, the morphology and pathway of which are closely related to the median nerve. The PFID was found in a routine dissection of an upper right limb. Following a dissection methodology by planes, a narrow, polygastric muscle was identified, formed sequentially and interspersed by four tendons and three muscle bellies, that extended between the common flexor muscle mass of the anterior compartment of the forearm and the index finger. The sixth part of the PFID was partially in the carpal tunnel and established close relation with the median nerve, which was displaced superficially. Knowledge of this and other muscle variations that appear in the forearm and carpal tunnel are relevant when performing a differential diagnosis of carpal tunnel syndrome or in planning surgery on this canal.

Corresponding author:
Dr. Emilio Farfán Cabello. Departamento de Anatomía Escuela de Medicina, Pontificia Universidad Católica de Chile, Santiago de Chile, Av. Libertador Bernardo O'Higgins #340. Phone: +56223542189. E-mail: efarfanc@uc.cl

Key words: Forearm muscle – Carpal tunnel syndrome – Median nerve – Nerve entrapment – Supernumerary muscle

INTRODUCTION

The muscles of the forearm are located around the radius and ulna, anatomically organized in two anatomical compartments called anterior and posterior. However, clinically three are described considering a lateral compartment, this is relevant for example in compartment syndromes (Fröber and Linss, 1994; Standring, 2016). Of these, the muscles of the anterior antebrachial region have four muscle planes that contain eight muscles (Testut and Latarjet, 1967).

In a recent paper, Wilde et al. (2021) describe in human embryos that forelimb muscles develop in an orderly sequence, from proximal to distal and from superficial to deep. In effect, at Carnegie stage (Cs) 18 (44 days) in the forearm flexor compartment the most superficial muscular layer are distinguishable (pronator teres, flexor carpi radialis, palmaris longus, flexor carpi ulnaris and flexor digitorum superficialis); at Cs 19-20 (46-49

Submitted: September 28, 2022. **Accepted:** November 19, 2022

https://doi.org/10.52083/QITA7428

days), muscles of the deep layers become visible (flexor digitorum profundus). Later on, at Cs 22 (53 days), the intrinsic muscles of palmar region of the hand are detectable, including the thenar, hypothenar and lumbricals muscles. In line with this, in chick and mouse embryos, Tozer et al. (2007) provide evidence that the development of the vascular network precedes and delineates the future cleavage zones in the ventral muscle mass.

A morphological characteristic of most of the forearm muscles is that, at their proximal ends, they are mainly muscular, giving rise to long distal tendons that cross the radiocarpal, carpal, metacarpophalangeal and interphalangeal joints, mobilizing them remotely (Standring, 2016). These muscles can present numerical and morphological variations related to hereditary and evolutionary factors (Testut, 1884), which can have repercussions in aesthetic and functional aspects, and cause clinical disorders. In this sense, among the most frequent muscle variations in the anterior compartment of the forearm is the absence of the palmaris longus muscle (15% of population, Kapoor et al., 2008) and the presence of an accessory fascicle to the flexor pollicis longus (10% of population, Riveros et al., 2015) or flexor digitorum profundus (27% of population, Jones et al., 1997). In this regard, the accessory flexor digitorum profundus of the digiti minimi has been described, which originates in the distal third of the forearm to be inserted in the proximal phalange of the digiti minimi (Wahba et al., 1998), and which might compress the ulnar nerve or impede normal vascularization of the hand. In the same way, the bilateral absence of the flexor digitorum superficialis has been reported, a muscle that, in addition to contributing strength to the palmar-digital grasp, has been used in order to perform tendon transfers (Gupta & Kumar, 2014). Consequently, multiple variations have been described associated with the presence of accessory fascicles, absences as already mentioned, or attachments to other muscles of this compartment (Tountas and Bergmann, 1993; Tubbs et al., 2016).

Based on the muscle variations described and their clinical relevance, the purpose of the present report was to describe the anatomical aspects of a supernumerary muscle associated with of the anterior compartment of the forearm, which we did not find described in the literature.

CASE REPORT

In this case, we describe a unilateral supernumerary muscle located in the flexor compartment of the forelimb, observed in a routine dissection of an upper right limb of a female cadaver an 82-year-old cadaver. In the anterior compartment of the forearm, a polygastric, narrow muscle was detected, formed sequentially and interspersed by four tendons and three muscle bellies (Fig. 1), making a total length of 342.98 mm. The biometric measurements of width and length are summarized in Table 1. This variation originated independently from the medial epicondyle, extended between the common flexor muscle mass and the index finger, located in the forearm between the flexor digitorum superficialis and the flexor digitorum profundus. In the carpal tunnel, the muscle variation was located superficially to the flexor digitorum profundus, medially to the tendon of the flexor pollicis longus and laterally to the tendon of the flexor digitorum superficialis that goes to the index finger. In the mid-palmar region, the supernumerary muscle was located superficially and laterally to the first lumbrical, ending by adding to the tendon of the first lumbrical (Fig. 2).

With respect to the particularities of this finding, we can emphasize that in the carpal tunnel the distal end of the second muscle belly of this muscle was attached to the tendon of the flexor digitorum superficialis muscle (Fig. 3). From this belly, which entered the carpal tunnel, a tendon originated from which an additional muscle belly emerged, adding a total of three muscle bellies. It is worth mentioning that the third belly was located between two areas, in the carpal tunnel and in the middle palmar region. In the first of these two zones, it had a length of 22.2 mm, where its superficial and lateral location to the tendon that the flexor digitorum superficialis muscle supplies to the index finger and deep to the median nerve stood out. On the other hand, the muscle portion available in the mid-palmar region had a length of 38.93 mm (Fig. 3). According to what was observed, this supernumerary muscle corresponds to a polygastric flexor for the index finger.

The median nerve in the forearm had a superficial trajectory with respect to the polygastric flexor muscle of the index finger and deep to the flexor digitorum superficialis muscle. From the biometric point of view, prior to entering the carpal tunnel, the transverse diameter of this nerve was 3.89 mm and the anteroposterior diameter was 2.13 mm. In the carpal tunnel, at the midpoint between the proximal and distal edge of the transverse ligament of the carpus, its transverse and anteroposterior diameters were 4.54 mm and 1.63 mm, respectively. On leaving the carpal tunnel, the median nerve was located superficially to the third belly of the muscle variation, presenting a transverse diameter of 5.45 mm and an anteroposterior diameter of 2.17 mm (Fig. 2).

Table 1. Biometry of the polygastric flexor muscle of the index finger. Values are expressed in mm.

Portion	Type	Length	Width
1	Tendon	57.38	1.13
2	Muscle	71.12	4.84
3	Tendon	32.97	1.84
4	Muscle	72.22	12.15
5	Tendon	21.82	2.01
6	Muscle	61.13	6.46
7	Tendon	26.34	1.33
Total		**342.98**	

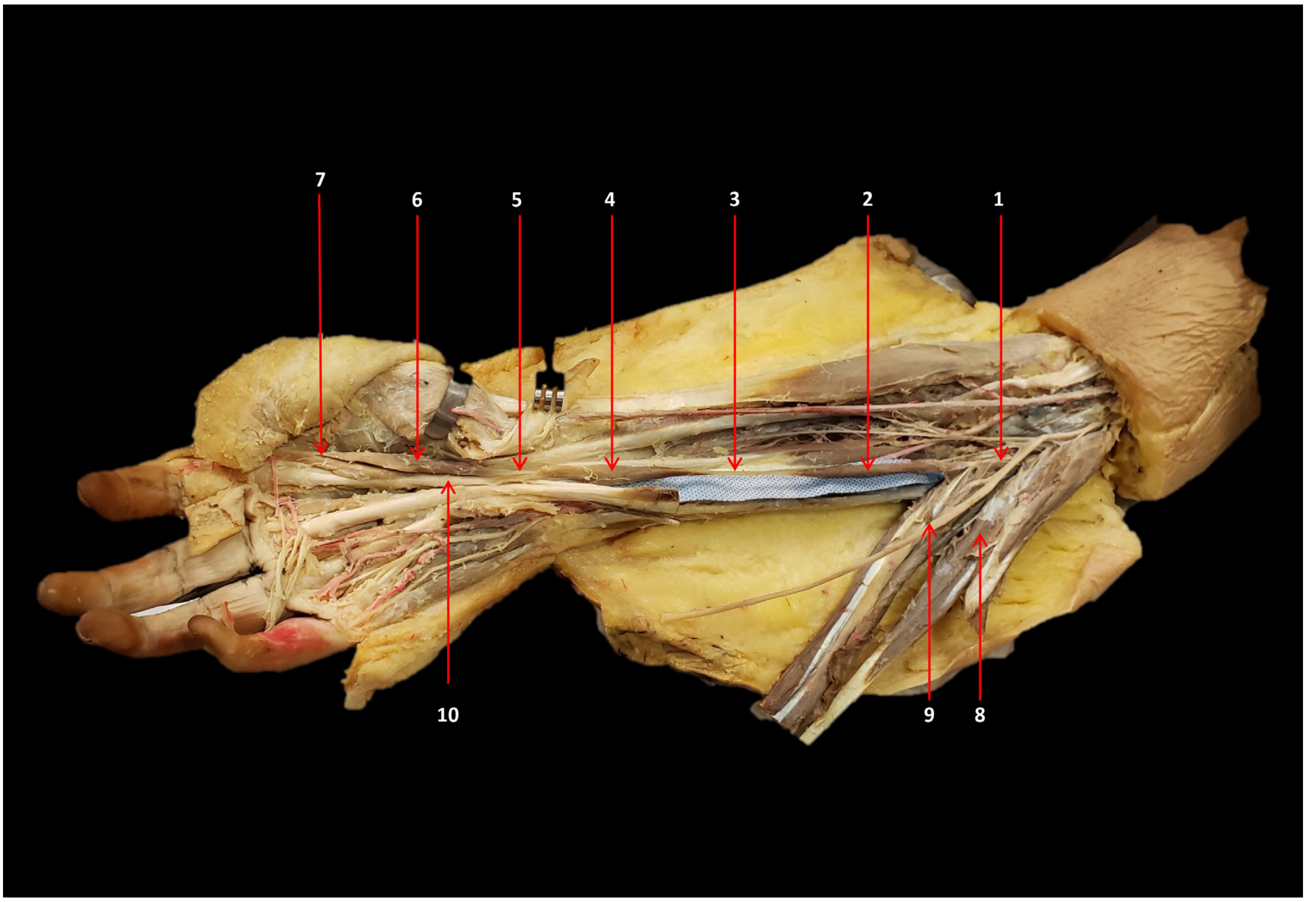

Fig. 1.- Panoramic photograph of the anterior compartment of the right forearm. The muscle is formed by 4 tendons and 3 muscle bellies arranged sequentially: 1. First tendon; 2. First muscle belly; 3. Second tendon; 4. Second muscle belly; 5. Third tendon; 6. Third muscle belly; 7. Fourth tendon; 8. Belly of the flexor digitorum superficialis muscle; 9. Median nerve; 10. Tendon of the flexor digitorum superficialis muscle of the index finger.

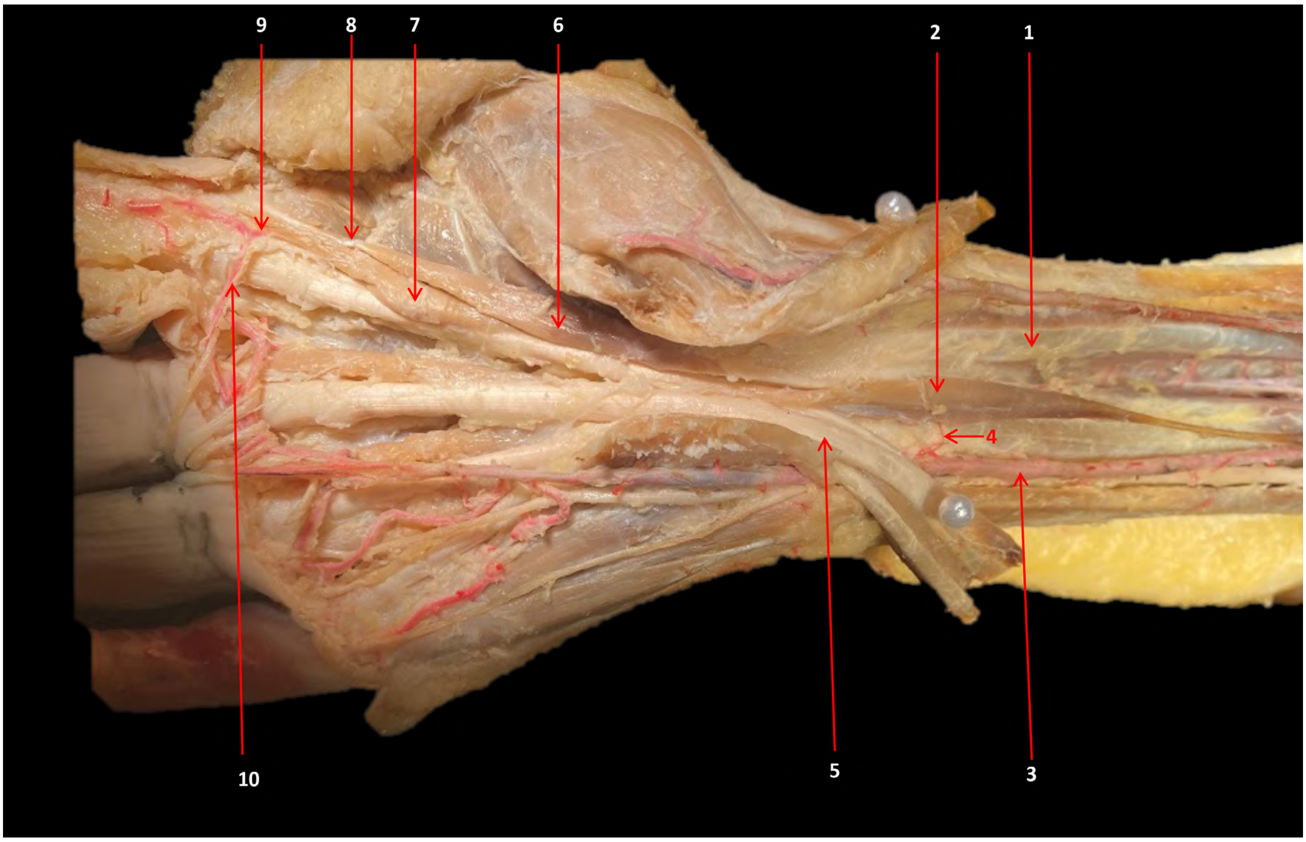

Fig. 2.- Photograph of the right palmar region, palmar aponeurosis moved aside: 1. Flexor pollicis longus tendon; 2. Second muscle belly; 3. Ulnar artery; 4. Muscular branches of the ulnar artery; 5. Flexor digitorum superficialis tendon; 6. Third muscle belly; 7. First lumbrical muscle originating from the flexor digitorum superficialis tendon for the index finger; 8. Fourth tendon; 9. Muscular branches of the radial artery; 10. Superficial palmar arch (radial contribution).

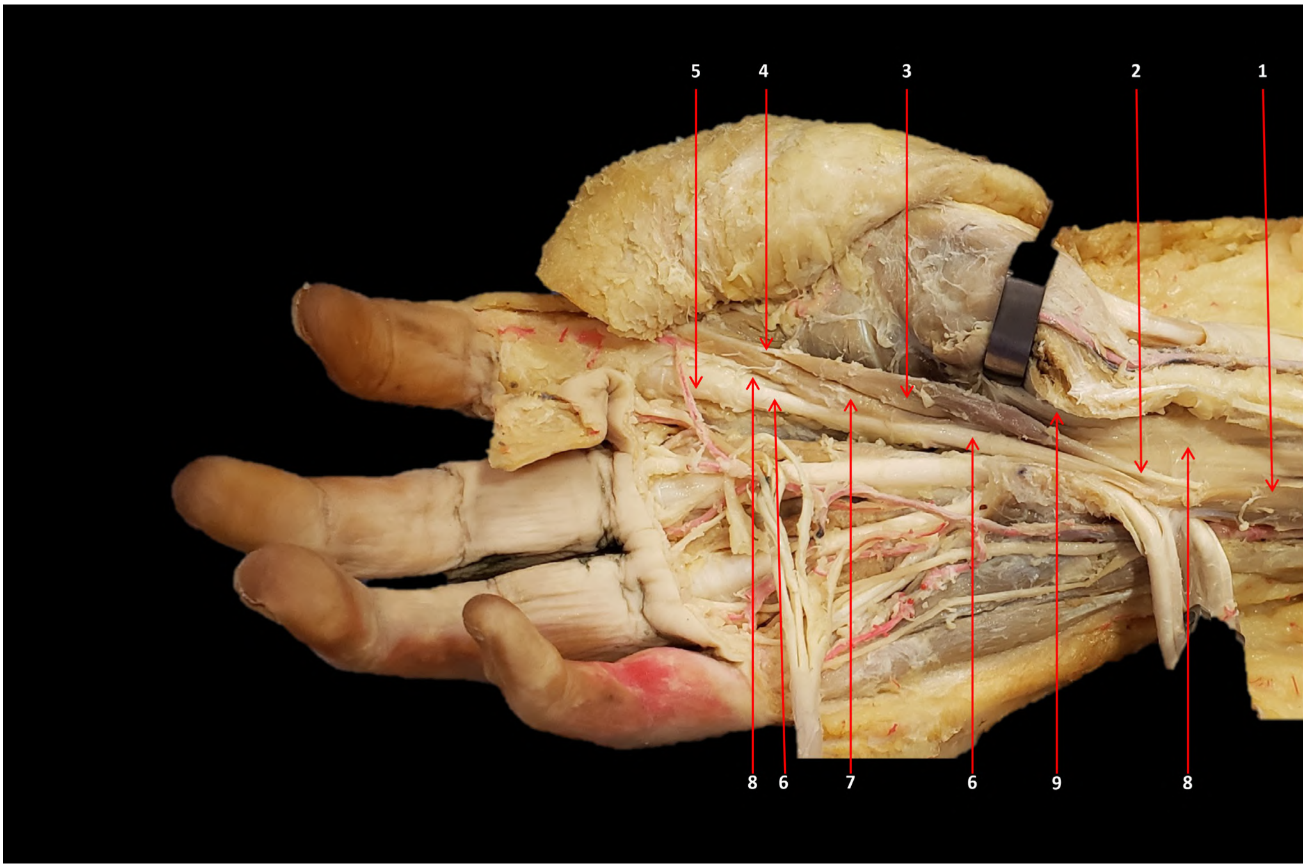

Fig. 3.- Photograph of the right palmar region, the median nerve moved aside: 1. Second muscle belly; 2. Third tendon; 3. Third muscle belly; 4. Fourth tendon; 5. Synovial sheath of the flexor tendons; 6. Flexor digitorum superficialis tendon for the index finger; 7. First lumbrical muscle originating from the flexor digitorum superficialis tendon for the index finger; 8. Flexor digitorum profundus tendon for the index finger; 9. Flexor pollicis longus tendon.

The innervation and vascularization of the polygastric flexor muscle of the index finger was sectorial, differing according to the part analyzed. The first belly of this muscle was innervated by a branch of the median nerve originating in the upper third of the forearm, which entered by the proximal third of the aforementioned muscle belly. On the other hand, it was vascularized by the ulnar artery, which supplied branches to it as it travelled through the deep side of this muscle belly. The second muscle belly also received a branch of the median nerve originating in the distal third of the forearm, which entered by the superficial side of this part. The vascularization for this muscle belly also came from the ulnar artery, which contributed fine branches that medially approached the aforementioned belly. Finally, the third belly of the muscle variation was innervated from a branch of the median nerve originating in the carpal tunnel. This branch entered through the proximal third of this muscle portion. In addition, the irrigation of this muscle belly was provided by the superficial palmar branch of the radial artery (Fig. 2).

DISCUSSION

In the anterior compartment of the forearm, the muscle variants described with greatest frequency include the palmaris longus, flexor pollicis longus and flexor digitorum profundus (Jones et al.,1997; Kapoor et al., 2008; Riveros et al., 2015). In the variations referring to the palmaris longus muscle, this muscle has been described as a variant of the deep palmar muscle, which generally enters the carpal tunnel to be inserted on the deep side of the palmar aponeurosis. This variation, called Palmaris profundus (Reimann et al., 1944), and its clinical implications have been seen on several occasions (Ortiz et al., 2022). Multiple origins have been described for the flexor carpi radialis, as well as variants derived from it, among which the short radial flexor muscle of the carpus stands out: the belly may originate in the medial epicondyle or at the medial edge of the brachial biceps tendon, to be inserted distally in the second metacarpal bone and in the tubercles of the scaphoid bone and trapezium, which could potentially cause compression on the carpal tunnel, as occurs with other muscles in the palm. This variant is characterized as being more present in the Asian population, where it reaches a prevalence of 6.8% (Tubbs et al., 2016; Cheng et al., 2020; Zhou et al., 2020). Regarding the flexor pollicis longus, the presence of accessory fascicles has been reported in 10% of cases, emphasizing the presence of bellies parallel to the flexor pollicis longus, which can pass through the carpal tunnel to enter the palmar region of the hand to be inserted in this finger, which could cause compression on the anterior interosseous nerve, or some of its branches extend to the deep muscles of the anterior compartment of the forearm or of the median nerve itself in the carpal tunnel (Riveros et al., 2015; Gurvich et al., 2022). With respect to the flexor digitorum superficialis muscle, it has been proven that a digastric muscle can emerge from its deep plane, the so-called digastric flexor of the index finger (Chudzinski, 1898). In the same way, a case has been described where the entire flexor digitorum superficialis was digastric (Le Double, 1897). A muscle belly derived from this same muscle or directly from the coronoid process has also been reported, which ends in a tendon connected to the tendons of the flexor digitorum profundus or to the flexor pollicis longus, a variant known as the Gantzer muscle (Caetano et al., 2015).

It is well documented that the forelimb muscles develop in a proximal to distal and in a superficial to deep sequence (Wilde et al., 2021); and, according to Tozer et al. (2007), the vascular network precedes and delineates the future splitting of the ventral muscle mass. Considering these facts, we can assume that this supernumerary polygastric muscle in the flexor compartment of the forelimb develop during de embryonic period (*circa* 46-49 days), and the vasculature of this segment participate in it by segregation from the ventral muscle mass.

Regarding the variants mentioned in the forearm, the supernumerary polygastric muscle found in the present work originates independent in the medial epicondyle just like the short radial flexor muscle of the carpus (Tubbs et al., 2016); however, in this case it is located deep to the median nerve. It has three bellies and four tendons, but does not look like any of those described; in fact, the most similar could be the digastric flexor muscle of the index finger. It has no relation of origin with the flexor digitorum superficialis, however, which also differentiates it from the Gantzer muscle. There are detailed reports on the connections between the superficial and deep planes of the forearm (Ohtani, 1979; Yamada, 1986), in fact, the occasional separation of the bellies of individual muscles has been considered a progressive variation, although very rarely the muscles are digastric (Tubbs et al., 2016).

In the hand, specifically, with respect to the first lumbrical muscle, supernumerary muscles emerge from the flexor digitorum superficialis tendon for the index finger (Wood, 1866; Le Double, 1897). In this case, the third belly of the supernumerary muscle emerged together with the flexor digitorum superficialis tendon of the index finger and was positioned next to the first lumbrical muscle. However, this belongs to a muscle originating independently in the medial epicondyle of the humerus; it does not originate from the flexor digitorum superficialis, flexor digitorum profundus or flexor pollicis longus (Figs. 1 and 3).

The sectorial innervation observed for the belly of this muscle is consistent with that observed in other polygastric muscles. An example of this is the case of the rectus abdominis muscle, which reveals the different myotomes that give rise to the muscle. Consequently, it is to be expected that different roots of the median nerve (C6-T1) come from the segmental innervation described in this case, as occurs with the innervation of the omohyoid muscle (Standring, 2016).

The descriptions of supernumerary or muscles variations in the carpal tunnel are frequent (Henry et al., 2015), and they can be the primary cause of carpal tunnel syndrome (Choo et al., 2017). Its finding during clinical imaging will be useful in surgical planning, improving the surgical results in the long term (Castillo et al., 2018). For this reason, it is important in the imaging studies to include a careful and targeted assessment of the fibro- osseous canals, such as the carpal tunnel, looking for accessory muscle bellies that can produce compressive symptoms (Sookur et al., 2008), both with the use of ultrasound and nuclear magnetic resonance, without forgetting that a simple revision of the carpal tunnel may not be sufficient (Jones, 2006).

CONCLUSIONS

Knowledge of this supernumerary muscle, which we did not find reported in the literature, enhances clinical and surgical practice, highlighting the importance of anatomy in medical practice. With this work it is hoped that there is a contribution to the knowledge of the anatomical variations of the forearm, and to the knowledge and better performance of specialists in attending patients with symptoms in this region.

ACKNOWLEDGEMENTS

The authors sincerely thank those who donated their bodies to science so that anatomical research and teaching could be performed. Results from such research can potentially increase scientific knowledge and can improve patient care. Therefore, these donors and their families deserve our highest respect.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The body was obtained through the donation program of the Faculty of Medicine at the Pontifical Catholic University of Chile (PUC), which complies fully with the World Medical Association's Declaration of Helsinki and national legal and ethical requirements. Consequently, the study was approved by the MED-UC Scientific Ethics Committee of the Pontifical Catholic University of Chile (No: 190115002).

REFERENCES

CAETANO EB, SABONGI JJ, VIEIRA LÂ, CAETANO MF, MORAES DV (2015) Gantzer muscle an anatomical study. *Acta Ortop Bras*, 23(2): 72-75.

CASTILLO R, SHETH K, BABIGIAN A, SCOLA C (2018) Recurrent carpal tunnel syndrome associated with extension of flexor digitorum muscle bellies into the carpal tunnel: A case series. *Arch Plast Surg*, 45(5): 474-478.

CHENG BLY, YAU ELK, YIP NWC (2020) Prevalence of flexor carpi radialis brevis in chinese patients with volar wrist plating performed for distal radius fracture. *J Hand Surg Asian Pac*, 25(3): 328-331.

CHOO H, LEE S, PARK Y, KIM DW (2017) Distally extended muscle belly of the flexor digitorum within the carpal tunnel: is it a risk factor for carpal tunnel syndrome? *Acta Radiol*, 58(10): 1269-1275.

CHUDZINSKI T (1898) *Observations sur les variations musculaire dans les races humaines*. Mem Soc D`Ántropol París. Sér. 3, T. 2(2), Masson & C, Paris, p 37.

FRÖBER R, LINSS W (1994) Anatomic bases of the forearm compartment syndrome. *Surg Radiol Anat*, 16(4): 341-347.

GURVICH A, SHRIDHAR N, FELMAN A, SHI M, PINKAS A, DOWNIE SA, MISHALL PL (2022) A novel accessory muscle in the flexor compartment of anterior forearm inserting into the tenosynovium of the flexor pollicis longus. *Folia Morphol (Warsz)*, 81(2): 515-519.

GUPTA A, KUMAR V (2014) Bilateral absence of flexor digitorum superficialis (FDS) tendon of the little finger: clinical significance. *J Clin Diagn Res*, 8(2): 135-136.

HENRY BM, ZWINCZEWSKA H, ROY J, VIKSE J, RAMAKRISHNAN PK, WALOCHA JA, TOMASZEWSKI KA (2015) The prevalence of anatomical variations of the median nerve in the carpal tunnel: a systematic review and meta-analysis. *PloS One*, 10(8): e0136477.

JONES M, ABRAHAMS PH, SAÑUDO JR, CAMPILLO M (1997) Incidence and morphology of accessory heads of flexor pollicis longus and flexor digitorum profundus (Gantzer's muscles). *J Anat*, 191(3): 451-455.

JONES DP (2006) Bilateral palmaris profundus in association with bifid median nerve as a cause of failed carpal tunnel release. *J Hand Surg Am*, 31(5): 741-743.

KAPOOR SK, TIWARI A, KUMAR A, BATHIA R, TANTUWAY V, KAPOOR S (2008) Clinical relevance of palmaris longus agenesis: common anatomical aberration. *Anat Sci Int,* 83(1): 45-48.

LE DOUBLE AF (1897) *Traité des variations du système musculaire de l'homme*. Schleicher Frères, París, pp 85-102.

OHTANI O (1979) Structure of the flexor digitorum superficialis. *Okajimas Folia Anat Jap*, 56(5): 276-288.

ORTIZ A, ARANDA E, SANUDO JR, ARAGONÉS P (2022) Palmaris profundus and carpal tunnel syndrome: is it really a palmaris muscle? *Eur J Anat*, 26(3): 347-353.

REIMANN AF, DASELER EH, ANSON BJ, BEATON LE (1944) The palmaris longus muscle and tendon. A study of 1600 extremities. *Anat Rec,* 89(4): 495-505.

RIVEROS A, OLAVE E, SOUSA-RODRIGUES C (2015) Estudio anatómico del fascículo accesorio del músculo flexor largo del pulgar y su relación con el nervio interóseo anterior en individuos brasileños. *Int J Morphol*, 33(1): 31-35.

STANDRING S (2016) *Gray's Anatomy. The anatomical basis of clinical practice*. 41th ed. Elsevier, London, pp 848-851.

SOOKUR PA, NARAGHI AM, BLEAKNEY RR, JALAN R, CHAN O, WHITE LM (2008) Accessory muscles: anatomy, symptoms, and radiologic evaluation. *Radiographics*, 28(2): 481-499.

TESTUT L (1884) *Les anomalies musculaires chez l'homme, expliquées par l'anatomie comparée: leur importance en anthropologie*, vol 3. G. Masson Editeur, Paris, pp 497-509.

TESTUT L, LATARJET A (1967) *Anatomía Humana*, Tomo I. 9th ed. Ed. Salvat, Barcelona, p 1026.

TOUNTAS CP, BERGMAN RA (1993) Anatomic variations of the upper extremity. Churchill Livingstone, New York, pp 147-153.

TOZER S, BONNIN MA, RELAIX F, DI SAVINO S, GARCÍA-VILLALBA P, COUMAILLEAU P, DUPREZ D (2007) Involvement of vessels and PDGFB in muscle splitting during chick limb development. *Development,* 134(14): 2579-2591.

TUBBS RS, SHOJA MM, LOUKAS M (2016) *Bergman's comprehensive encyclopedia of human anatomic variation*. Ed. Wiley Blackwell, New Jersey, pp 298-308.

WAHBA M, SINGH G, LOZANOFF S (1998) An anomalous accessory flexor digiti minimi profundus muscle: a case study. *Clin Anat*, 11(1): 55-59.

WILDE S, FENECK EM, MOHUN TJ, LOGAN MPO (2021) 4D formation of human embryonic forelimb musculature. *Development,* 148(4): dev194746.

WOOD J (1866) Variations in human myology observed during the winter session of 1865-66 at King´s College, London. *Proc Roy Soc Lond B*, 15: 229-244.

YAMADA TK (1986) Re-evaluation of the flexor digitorum superficialis. *Acta Anat Nippon*, 61: 283-298.

ZHOU M, ISHIZAWA A, AKASHI H, SUZUKI R, KANATSU Y, ABE H, BANDO Y (2020) An anomalous case of the flexor carpi radialis with an excessive muscular bundle. *Anat Sci Int*, 95(2): 293-296.