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**ORIGINAL ARTICLE****Morphometry of accessory head of flexor pollicis longus: A cadaveric study***Shwetha K<sup>1</sup>, Uma Shivanal<sup>1\*</sup>, Pushpalatha K<sup>1</sup>**<sup>1</sup>Department of Anatomy, JSS Medical College, Mysuru-570015 (Karnataka) India*

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**Abstract**

*Background:* The flexor pollicis longus muscle is present in the deep layer of the front of the forearm. Sometimes an extra head arises from the ulnar coronoid process which is known as the Accessory Head of Flexor Pollicis Longus (AHFPL), also known as Gantzer's muscle. *Aim and Objectives:* The present study was conducted to know the morphological features and morphometry of the AHFPL with its clinical importance. *Material and Methods:* The present study was conducted on 50 upper limb specimens (25 right and 25 left) of 23 male and 2 female cadavers, fixed in 40% formalin collected from the donated bodies under voluntary body donation program in the Anatomy department, JSS medical college, Mysore. The forearm was dissected, the deep group of muscles was exposed, and the flexor pollicis longus muscle was studied. If an extra head was present, its shape, origin, insertion, nerve supply, and blood supply were noted. Its muscular and tendinous length and breadth were measured using the digital vernier caliper. *Result:* Among 50 specimens, accessory head was present in 14 (28%) specimens. Most commonly the muscle was originating from the medial epicondyle and less common was from the coronoid process. Most commonly observed insertion was to the tendon of the flexor pollicis longus. All were supplied by the anterior interosseous nerve. The length of the muscle belly was ranging from 8.2 cm to 15.1 cm and the mean was 11.54 cm. The tendon length ranged from 0.2 to 6.44cm and the mean was 2.33cm. The thickness was ranging from 2.1mm to 8.8 mm. and the mean was 4.57mm. *Conclusion:* The accessory head of flexor pollicis longus is not a rare occurrence. The anatomical knowledge of this variation plays an important role in the diagnosis and surgical intervention of nerve entrapment syndrome like anterior interosseous nerve syndrome.

**Keywords:** Flexor Pollicis Longus, Accessory Head, Nerve Entrapment, Anterior Interosseous Nerve

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**Introduction**

The forearm muscles are arranged in two strata, superficial stratum and deep stratum. The muscles of the deep stratum are Flexor Digitorum Profundus (FDP), Flexor Pollicis Longus (FPL) and Pronator Quadratus (PQ). The FPL is a unipennate muscle arising from the anterior surface of the radius and the interosseous membrane. Its tendon runs below the flexor retinaculum in the carpal tunnel and get inserted to base of the distal phalanx of the thumb. It is supplied by the Anterior Interosseous Nerve (AIN) branch of median nerve [1]. Variations of FPL muscle have been noted, like additional head, which is named as accessory head of FPL (AHFPL) or Gantzer's muscle. It was described by Karl

Friedrich Gantzer in 1813, as an accessory muscle present in the deep stratum of the front of forearm, which may originate from the medial epicondyle of the humerus or ulnar coronoid process and gets inserted to FPL or FDP. However, the muscle was described a century earlier by Kaplan in Albinus [2]. The median nerve and AIN may show variations in the relation with the muscle. The AIN may present posterior to the muscle. In such cases, it may lead to the compression of the nerve causing AIN syndrome. The muscle variations in the forearm region are clinically significant as its awareness helps clinicians and surgeons in operative procedures like tendon transfer, and correction of

hand deformities [3]. In this study the AHFPL muscle occurrence, its origin, insertion, nerve supply, different shapes, length and breadth were studied to add knowledge about the muscle and to correlate with the clinical conditions.

### Material and Methods

The study was conducted on 25 cadavers (50 upper limb specimens; 25 right and 25 left) of which 23 were male and 2 were female cadavers. They were fixed in 10% formalin and collected from the donated bodies under voluntary body donation program in the Anatomy Department, JSS Medical College, Mysore. The limbs were dissected according to the Cunningham's manual. Firstly the superficial group of muscles were identified. Then these muscles were cut and retracted to appreciate the deep group of muscles. FPL was studied for extra head and if present, its shape, origin, insertion, and nerve supply were noted. Muscular and tendinous length and thickness were measured using the digital vernier caliper. Muscular length was taken from its origin to the beginning of tendon and the length of the tendon was measured from its beginning to its insertion.

### Results

Among 50 specimens, accessory head was present in 14 (28%) specimens of which 8 (16%) were

from right limb and 6 (12%) from left limb. In 12 cadavers, it was unilateral and in one cadaver it was bilaterally present. Twelve limbs had one belly and in 2 limbs we observed 2 bellies. In 11 (78.5%) specimens, the shape of the belly was fusiform, triangular shape was seen in 2 specimens (14.2%), and band shaped belly was observed in 1 (7.14%) specimen (Figure 1). In 12 specimens (85.7%), the muscle was originating from the medial epicondyle of humerus along with the superficial group of flexor muscles of forearm, and in 2 specimens (14.2%) it was originating from the ulnar coronoid process (Figure 2). All were inserted to the tendon of the FPL except in two specimens which had two muscle bellies, one was inserting to tendon of FPL and another belly was inserting to tendon of FDP (Figure 2). All were innervated by the AIN branch of median nerve. In 12 specimens (85.7%), the nerve was present lateral to the muscle and in 2 specimens (14.2%), it was present posterior to the muscle (Figure 3). The muscle belly length was ranging from 8.2 cm to 15.1 cm and the mean was 11.54 cm. The tendon length ranged from 0.2 to 6.44cm and the mean was 2.33cm. The thickness was ranging from 2.1mm to 8.8 mm and the mean was 4.57mm.

**Table 1: Comparison of occurrence of the muscle between the right and left sides of the limbs**

AHFPL	Total	Right	Left
Occurrence	14 (28%)	8(16%)	6(12%)
Morphometric measurements of AHFPL			
AHFPL	Length		Thickness (mm)
	Muscle belly (cm)	Tendon (cm)	
Range	8.2 to 15.1	0.2 to 6.44	2.1 to 8.8
Mean	11.54	2.33	4.77

*AHFPL: Accessory head of flexor pollicis longus*



Figure 1: Specimens showing the different types of shapes A: fusiform, B: band, C: triangular



Figure 2: A- Origin of muscle from medial epicondyle of humerus  
B- Origin of muscle from coronoid process of ulna  
C- Insertion to tendon of FPL and FDP (Type iii – AHFPL and AHFDP)



Figure 3: The relation of AIN A: Lateral to the muscle, B: Posterior to the muscle

**Table 2: The comparison of incidence and morphometry between the various studies**

Author	Year	Incidence (%)	Muscle length	Tendon length	Thickness
Pai <i>et al.</i> [5]	2008	46.03	8 ± 1.5 cm	-	-
Kara <i>et al.</i> [21]	2012	34.5	7.4 ± 1.2 cm	0.7 ± 0.2 cm	-
Gunnal <i>et al.</i> [13]	2013	51.11	80.47 ± 10.1 mm	19.04 mm	6 mm
Caetano <i>et al.</i> [ 2]	2015	68	-	-	-
Ballesteros <i>et al.</i> [11]	2019	32.1	6-8.4 cm	0.8-2.7 cm	6.9-7.8 mm
Jayan <i>et al.</i> [29]	2021	46.7	10.3 ± 1.7 cm	-	R: 0.63 ± 0.4 cm L: 0.57 ± 0.3 cm
Oliveira <i>et al.</i> [30]	2022	50	10.5 cm	-	0.3 cm
Banu <i>et al.</i> [15]	2024	63.33	9 ± 2.63 cm	2.81 ± 2.5 cm	2.81 ± 2.5 cm
<b>Present study</b>	2024	28	8.2-15.1 cm Mean-11.54	0.2-6.44 cm Mean-2.33	2.1-8.8 mm Mean-4.77

## Discussion

The embryological development of the anterior compartment of the forearm could explain the occurrence of the muscle. The common flexor mass initially differentiate into superficial and deep strata [4-5]. Later the deep layer in turn differentiates into the FDP, the FPL, and PQ [6]. An incomplete cleavage of the deep layer gives origin to the AHFPL [7]. In primates, the FPL muscle may be absent or primitive [8]. Humans gained the FPL during evolution and the introduction of FPL into the flexor compartment allowed the thumb to move independently in three different planes [9]. Four fundamental phases have been described in the ontogenesis of muscle patterns. Some muscle primordia disappear through cell death despite the fact that cells within them have differentiated to the point of having myofilaments. Persistence of some cells superficial or deep to AIN may be responsible

for the accessory or additional head of the FPL. Another theory suggests that the muscles of a limb typically develop as two separate elements, which later fuse to form a single muscle. An accessory muscle may result from an incomplete or improper fusion of these elements [10].

The incidence of AHFPL vary in different populations. The frequency ranges from 25% to 73.6%. In our present study, we have observed 28% incidence of the muscle. In North-American population, studies reveal a consolidated frequency of 53.82% and in Asians 52.12%. Accordingly, AHFPL could be considered as a normal pattern and not as an anatomical variation among them [11]. Table 3 shows the comparison of incidence and morphometry between various studies.

In the present study, we observed the bilateral presence in one cadaver, while in the remaining

cadavers it was present unilaterally and more on the right-sided limbs. But Oh *et al.* [12], Mahakkanukrauh *et al.* [4], Jones *et al.* [7], Gunnal *et al.* [13], Caetano *et al.* [2], Hemmady *et al.* [14] noted more bilateral occurrence of the muscle than the unilateral.

Regarding the origin, the muscle arises from the medial epicondyle, ulnar coronoid process or from the under surface of FDS. In the current study, we observed the medial epicondyle along with the superficial flexor muscles were the most common sites (85.7%). In 2 specimens (14.2%), we noted the muscle was arising from the coronoid process of ulna.

The study done by Aarabhy Jayan *et al.* [14], Mustafa A *et al.* [15], Riveros A *et al.* [16], Mahakkanukrauh *et al.* [4], Shirali S *et al.* [17], have reported the medial epicondyle of the humerus as the most frequent site, and Gunnal *et al.* [13], Oh *et al.* [12], Uyaroglu [18] have noted that the ulnar coronoid process is the common site and Ballestos [11], Jones *et al.* [7], El Domiaty *et al.* [19], Kara *et al.* [20] and Caetano *et al.* [2] reported the flexor digitorum superficialis muscle as the most common site of origin. Banu *et al.* reported the muscle arising from the radial tuberosity [21]. However, a meta-analysis by Roy *et al.* done on 24 cadaveric studies showed that in 43.6% of specimens, the AHFPL was originating from the medial epicondyle of the humerus, in 25.8% of specimens from the coronoid process and in 16.1% of specimens, the AHPFL was noted to have dual origin from both medial epicondyle of humerus and coronoid [22]. These variations may be explained by the fact that the muscle is closely associated with other structures of the flexor mass at its origin, which can lead to possible misidentification by authors. To avoid

this, meticulous dissection is required to accurately determine its origin [11].

Asghar, depending on its morphology and attachment classified the AHFPL muscle into three types [23]. According to that classification, the type III is a rare occurrence, i.e. presence of both AHFPL and Accessory head of Flexor Digitorum Profundus (AHFDP).

In the above classification, the type III has a rare occurrence. In the present study, we observed Type Ib was most common (87.2%), and in two specimens (14.2%) we noted the type III variation. There were two muscle bellies with the common origin from the medial epicondyle, and one tendon was inserting to the FPL tendon and the other one was inserting to the FDP tendon (Figure 2). Caetano *et al.* [2] observed two bellies in 3 specimens in 54 limbs, Shirali *et al.* [18] in 4 specimens out of 60 limbs and Oh *et al.* [12] in one limb out of 72 limbs. The relation of the muscle and the nerve must be considered, as it can lead to compression of the nerve. Variations in the innervation and positions of the median nerve and AIN in relation to AHFPL have been observed in many studies. AHFPL was predominantly innervated by AIN 80.43%, and by the median nerve in 19.56% [13]. Banu *et al.* [21] observed that in 90.9% of cases, the innervation was by AIN and 9.1% by the median nerve. In a study conducted by Pushpalatha, the muscle was found to run anterior to the ulnar nerve and vessels, but deep to the median nerve, and was innervated by branches from the ulnar nerve [10]. In our study, we noted all the muscles were supplied by AIN.

In a study done by Mahakkanukrauh *et al.* on 240 limbs, they found the prevalence of AHFPL in 149 specimens. They classified the relation of AIN and AHFPL into four types [4].

In the study by Bagoji *et al.* observed that the AIN was anteriorly related in 1.72%, posteriorly in 9%, laterally in 5.17%, and posterolaterally in 6.89% of the specimens [24]. Banu *et al.* [15] noted that in 91.67% specimens, the AIN was posterior to the AHFPL and in 8.3% anterior to it. In our study, the nerve was located lateral to the muscle in 85.7% of specimens, while in 14.3% of specimens, it was observed posterior to the muscle (Figure 3).

Various studies have mentioned different shapes of the muscle [11]. Jones *et al.* [7] were the first to classify the morphology of the AHFPL in four groups: slender, voluminous, triangular and fusiform. Subsequently Oh *et al.* [12] described three different morphological groups: papillary, spindle and band type. Pai *et al.* [5] classified the morphology in three groups: strap like (slender), fusiform and voluminous. Bagoji *et al.* [24] found that the muscle predominantly exhibited a spindle-shape (20.68%) or papillary (8.62%) appearance. Gunnal *et al.* [13] described the shape as fusiform in 83.69% of cases, while in 16.31%, it exhibited a broad and thick appearance. In our study, the different shapes like fusiform, triangular and strap were observed. Among all these, the fusiform shape was more commonly observed (78.5%), triangular shape was observed in two specimens (14.2%) and in one specimen (7.4%), we noted band shaped muscle (Figure 1).

Several studies have reported the total length of the AHFPL to be around 10 cm [15]. Gunnal *et al.* [13] observed the average length of the GM to be  $80.47 \pm 1.01$  mm, with the tendon measuring an average length of  $1.09 \pm 0.09$  mm. Banu [21], observed that the muscle belly mean length was  $9 \pm 2.63$  cm, the tendon was  $2.81 \pm 2.5$  cm. and the width of the muscle belly was  $7.62 \pm 1.11$  mm. Ballesteros *et al.*

reported the width to be in the range of 6.9 to 7.8 mm [11]. In our study, the muscle mean length was 10.23cm, the tendon length was 3.23 cm and the thickness was 4.57 mm.

The hypertrophied Gantzer muscle can compress the nerve and lead to AIN syndrome [2]. Tabit *et al.* reported a clinical case with incomplete AIN syndrome, with paralysis of the FPL only, which during surgery proved to be caused by the Gantzer muscle [25]. Dellon and Mackinnon reported that the hypertrophied Gantzer muscle, passing anterior to the AIN, may compress the nerve between the Gantzer muscle and the aponeurotic muscle structures of the pronator teres muscles and flexor digitorum superficialis [26]. In our study, we observed the muscle thickness ranging from 2.1 to 8.8 mm and also the nerve passing posterior to the muscle which can lead to compression of the nerve.

Additional heads of muscles have been identified in various other muscles as well. A study done by Lingaswamy *et al.* observed 32.73% specimens showing supernumerary heads of sternocleidomastoid muscle [27]. Babaee *et al.* described a solitary supernumerary muscle in the right hand, originating from one of the tendons of flexor digitorum superficialis muscle that went to the index finger and then traversed 5 cm distally to attach to the same tendon [28]. The architecture of the skeletal muscle belly and its tendon is important in determining muscle function, especially range of motion, even with the respect to its shape and size of the muscle [25]. The Gantzer's muscle is made of fusiform muscle fibers in most of the cases whereas the FPL is made of unipennate muscle fibres. The function of fusiform muscle fibres is in direct opposition to unipennate fibres. This could in turn lead to loss of precise and

skilful movements [29]. The morphometry of the muscle is essential in procedure like muscle transfer to restore function in multiple nerve palsies in crush injuries, Hansen's disease, and compartment syndrome [30].

### Conclusion

With human evolution, the use of the thumb has significantly diverged from that of primates. This evolutionary shift could contribute to the obser-

ved FPL muscle variations. In our study, an AHFPL was frequently observed, indicating it is not uncommon. The anatomical knowledge of these variations must be considered in the diagnosis and surgical intervention of nerve entrapment syndrome like AIN syndrome. The morphological variations of the muscle also must be kept in mind during the assessment of the functional aspect of the muscle.

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