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Original Article

Anatomy Section

Accessory Head of the Flexor Pollicis Longus: A Cadaveric Study on the Gantzer's Muscle

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ABSTRACT

Introduction: The anterior interosseus nerve syndrome is a compression neuropathy affecting the anterior interosseus nerve, resulting in motor weakness of the long tendons to the index finger and thumb. Of the many conditions leading to this syndrome, one of the more common yet most overlooked aetiologies is the presence of accessory head of the flexor pollicis longus muscle, also called the Gantzer's muscle. Even though numerous studies have been done in both Indian and international populations regarding the frequency of the Gantzer's muscle, there are hardly any studies involving the South Indian population.

Aim: To analyse the frequency and morphology of the Gantzer's muscle in the sub-population of Malabar region, Kerala.

Materials and Methods: This descriptive observational study was performed in Department of Anatomy at Malabar Medical College, Atholi, Kerala, India, from July 2021 to August 2021. Study included 60 upper limbs from the cadavers provided for undergraduate medical education. In the limbs where the muscle was identified, parameters such as proximal and distal attachments, shape and length of muscle and tendon, relation to adjacent median and anterior interosseus nerves were studied. Frequencies of each of these parameters were analysed using Statistical Package for the Social Sciences (SPSS) software version 21.0. Percentages obtained were compared with existing studies.

Results: The Gantzer's muscle was found in 28 of the 60 limbs dissected. It was more common on the right side (17 limbs), and the most common origin was the medial epicondyle (53.6%). All the cases identified were inserted onto the ulnar aspect of the Flexor Pollicis Longus tendon, mostly in the upper third. In all cases, the Median Nerve was superficial and the Anterior Interosseus Nerve was deep to the accessory head. In majority of the cases, the Anterior Interosseus Nerve was related to the posterior aspect of the belly of the Gantzer's muscle (82.1%).

Conclusion: Clinicians and surgeons should be conscious of the possibility of the Gantzer's muscle being the aetiology, in cases of isolated Anterior Interosseus nerve palsies.

Keywords: Anterior interosseus nerve, Compression neuropathy, Forearm, Nerve palsy

INTRODUCTION

Embryology of Forearm Musculature

Myogenic precursor cells develop from the somites of the paraxial mesoderm around the 7th week of intra-uterine life. They then migrate into the limb buds and subsequently subdivide to form flexor-extensor groups of muscles. Connective tissue laminae then divide these groups into individual muscles [1].

Evolution

Early primate ancestors possessed a single deep flexor muscle homologous to the FDP (Flexor Digitorum Profundus), which supplied all five digits. This pattern is still evident in great apes of today. The FPL (Flexor Pollicis Longus) is a relatively new acquisition in modern humans, and was developed as a separate muscle for the sole purpose of stabilising the distal phalanx of the thumb, giving humans an evolutionary edge by allowing forceful tool activity, such as stone-chipping and hammering [2]. Therefore the FPL and FDP accessory heads may be a reflection of this primitive arrangement, where all the deep flexors formed a single muscle mass [3].

History

The accessory head of the Flexor Pollicis Longus (FPLah), more commonly called the Gantzer's muscle, derives its eponym from Karl Frederick Gantzer, who first described it, along with the accessory head of the Flexor Digitorum Profundus (FDPah) in 1813. But the Gantzer's muscle is reported to have been first illustrated by German born Dutch anatomist Bernard Siegfried Albinus almost a century prior [4,5]. The FPLah which bears K.F Gantzer's name, is more prevalent compared to the FDPah.

Normal Anatomy

The FPL belongs to the deep group of forearm flexors, taking origin from the anterior surface of the radial shaft and adjacent interosseus membrane, between the radial tuberosity above and the attachment of the Pronator Quadratus (PQ) below. Its flat tendon inserts at the base of the distal phalanx of the thumb [1].

Clinical Relevance

The Kiloh-Nevin syndrome alternately called the anterior interosseus nerve syndrome is a compression neuropathy of the anterior interosseous nerve in the flexor compartment of the forearm [6]. Of the many causes of this compression neuropathy, the presence of the accessory head of the FPLah, or the Gantzer's muscle, is a significant aetiology [1].

Consequently, numerous studies have been performed to determine the frequency of this particular muscle variation in different populations and ethnicities, including the Indian Subcontinent, though only a couple of these have studied the populations of the Southern most states of India [7-22].

The present study aimed to analyse the frequency and morphology of the Gantzer's muscle in the Malabar sub-population of Kerala region.

MATERIALS AND METHODS

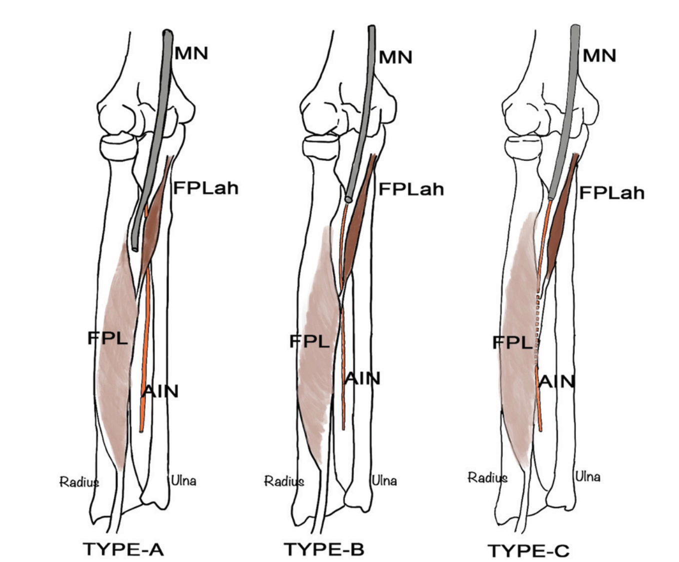
This descriptive observational study was performed in Department of Anatomy at Malabar Medical College, Atholi, Kerala, India, from July 2021 to August 2021. Study included 60 upper limbs from the cadavers provided for undergraduate medical education. Ethics Committee clearance was obtained (MMCH&RC/IEC/2021/08).

Inclusion and Exclusion criteria: A complete enumeration of all the cadavers, which were provided for academic teaching during the last five years from 2016 to 2021 was done, and were included. Severely damaged limbs were excluded from the study.

Procedure

Dissection of the forearm was performed as per the dissection protocol in Cunningham's Manual [23]. The muscles of the antebrachium were exposed via a single longitudinal incision over the ventral aspect of the forearm. The superficial flexors were reflected towards their origins and the Flexor Digitorum Superficialis (FDS) was detached from its radial attachments and reflected medially to expose the deep flexors. The Flexor Pollicis Longus (FPL) muscle was studied, and presence of accessory heads was noted. Wherever such variations appeared, their morphology, including proximal {whether from the Medial Epicondyle (ME), Coronoid Process (CP), dual origins from both medial epicondyle and coronoid, or from the deep intermuscular plane between FDS and profundus} and distal attachments (whether to the ulnar aspect of flexor pollicis longus tendon, or by a separate tendon; and when inserting onto the FPL tendon, whether inserting at the upper-third, the middle-third or the lower-third of the same) were studied.

Dimensions of the accessory head (total length of the muscle belly measured from the origin to the beginning of the tendon, and width of muscle belly measured at the widest part), nerve supply, as well as the relation to the adjacent Median (MN) and Anterior Interosseus Nerves (AIN) were also studied. The relation of the AIN to the FPLah was classified into three types, as per the classification suggested by Oh C et al., [Table/Fig-1] [8]. All observations were recorded and photographed using a digital camera. All measurements were taken using digital vernier callipers.



[Table/Fig-1]: Figure redrawn from Oh C et al., classification of relation of AIN to the FPLah and to FPL [8]. Type-A=AIN lying posterior to the muscle component of the FPLah. Type-B=AIN posterior to the tendon component of the FPLah. Type-C=AIN lying posterior to the FPL muscle.
AIN: Anterior interosseus nerve; FPLah: Flexor pollicis longus accessory head; FPL: Flexor pollicis longus; MN: Median nerve

STATISTICAL ANALYSIS

Frequencies of each of these parameters were analysed using Statistical Package for the Social Sciences (SPSS) software version 21.0. Percentages obtained were compared with existing studies.

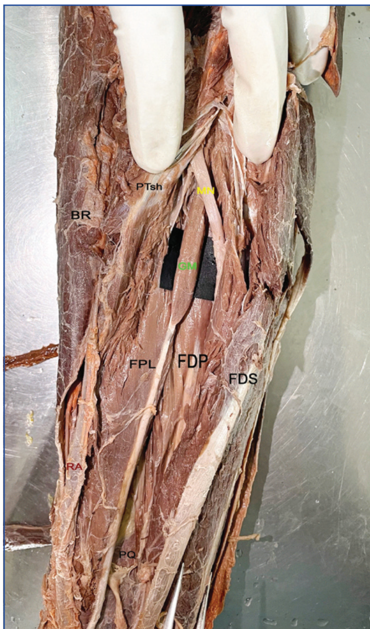
RESULTS

Of the 60 limbs dissected, the Gantzer's muscle was found in 28 limbs (46.7%). Majority of the findings were on the right side, 17 out of 28 (60.7%), 11 were from the left side (39.2%). As the study was conducted in free upper limbs, bilaterality could not be determined. The most common site of origin was the medial epicondyle, seen in 15 specimen (53.6%), followed by the intermuscular plane between FDS and FDP, seen in 9 specimen (32.1%) [Table/Fig-2]. All the specimen in the present study were inserted onto the ulnar aspect of the FPL tendon, the upper third of the same being slightly more favoured (16 of 28), compared to the middle third (12 of 28, 42.9%) [Table/Fig-2].

Variables	Right side	Left side	Total
Shape			
Fusiform	12	6	18 (64.3%)
Slender	5	5	10 (35.7%)
Voluminous	0	0	0
Origin			
Medial epicondyle	8	7	15 (53.6%)
Coronoid process	3	1	4 (14.3%)
Intermuscular plane between FDS and FDP	6	3	9 (32.1%)
Others	0	0	0
Insertion			
Upper 1/3 FPL tendon	11	5	16 (57.1%)
Middle 1/3 FPL tendon	6	6	12 (42.9%)
Lower 1/3 FPL tendon	0	0	0
Others	0	0	0
Length of muscle belly (cm)	10.3±1.7 (7 to 12.9 cm)	10±0.7 (8.7-11.2 cm)	
Width of muscle belly (cm)	0.63±0.4 cm	0.57±0.3 cm	

[Table/Fig-2]: Observations of the present study

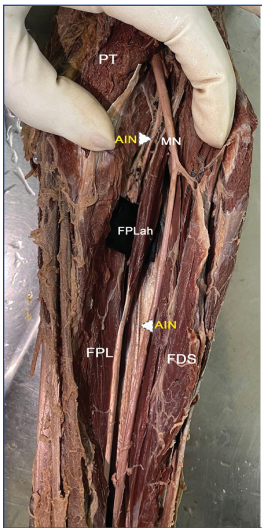
Regarding the morphology of the Gantzer's muscle, length of the muscle belly ranged from 7 to 12.9 cm on the right side, averaging 10.3±1.7 cm. On the left side, the range was much narrower, averaging 10±0.7 cm. Two variations in the shapes of the muscle bellies were noted. A total of 64.3% of the cases showed a fusiform appearance [Table/Fig-2,3], while the remaining showed a slender morphology [Table/Fig-2,4]. These were classified based on the categories suggested by Pai MM et al., [7].

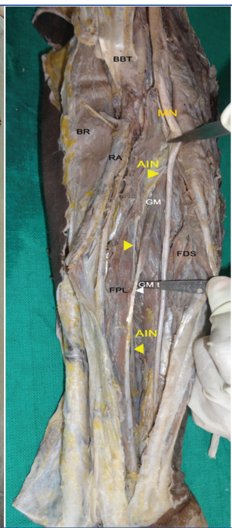


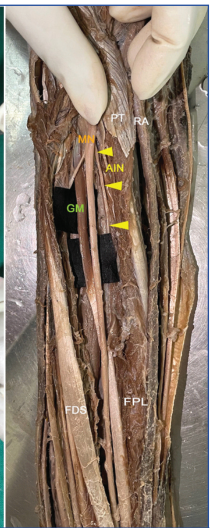
[Table/Fig-3]: Right forearm with superficial flexors reflected, showing a fusiform Gantzer's muscle.
BR: Brachioradialis; PTSH: Pronator teres superficial head; FPL: Flexor pollicis longus; FDP: Flexor digitorum profundus; FDS: Flexor digitorum superficialis; MN: Median nerve; GM: Gantzer muscle; RA: Radial artery; PQ: Pronator quadratus
[Table/Fig-4]: Right forearm with superficial flexors reflected, showing a slender Gantzer's muscle attaching to medial epicondyle and supplied by a branch from the median nerve (blue arrows). (Images from left to right)
FDS: Flexor digitorum superficialis; FDP: Flexor digitorum profundus; FCU: Flexor carpi ulnaris; MN: Median nerve; GM: Gantzer muscle; ME: Medial epicondyle; UV: Ulnar vessels;

The main source of innervation was the AIN, which supplied 23 specimen (82.1%). The remaining were supplied by a branch given off from the trunk of the MN, close to the origin of the AIN.

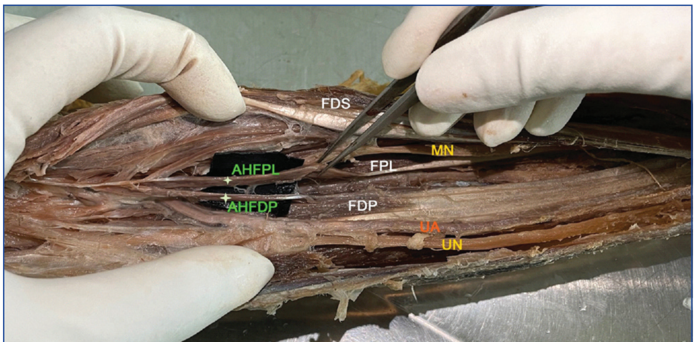
In all cases obtained, the Gantzer's muscle lay deep to the MN, and superficial to the AIN. The posteriorly passing AIN was seen to be variably related to the FPLah, and an attempt was made to classify the same based on Oh C et al., [8] [Table/Fig-1]. In the present study, the most common relation was the type-A, where the AIN passes behind and is related to the muscle component of the FPLah. This was seen in 23 cases (82%). The type-B variety, where the AIN lies behind and in relation to the tendon component, was seen in four limbs (14.3%), and only one limb showed a type-C relation, where the AIN lay behind the tendon and belly of the FPL. [Table/Fig-1,5-7]. In one specimen, the FPLah and FDPah were seen together [Table/Fig-8].







[Table/Fig-5]: Right forearm with superficial flexors reflected, showing a Gantzer's muscle showing a type-A relation to the anterior interosseus nerve (white arrows).
FDS: Flexor digitorum superficialis; FPL: Flexor pollicis longus; FPLah: Flexor pollicis longus accessory head; PT: Pronator teres; MN: Median nerve; AIN: Anterior interosseus nerve
[Table/Fig-6]: Right forearm with superficial flexors reflected, with a Gantzer's muscle showing a type-B relation to the anterior interosseus nerve (yellow arrows).
FDS: Flexor digitorum superficialis; FPL: Flexor pollicis longus; GM: Gantzer muscle; GMT (white arrow): Gantzer muscle tendon; BR: Brachioradialis muscle; BBT: Biceps brachii tendon; MN: Median nerve; AIN: Anterior interosseus nerve; RA: radial artery
[Table/Fig-7]: Left forearm with superficial flexors reflected, showing a Gantzer's muscle with a type-C relation to the anterior interosseus nerve (yellow arrows).
(Images from left to right)
FDS: Flexor digitorum superficialis; FPL: Flexor pollicis longus; PT: Pronator; GM: Gantzer muscle; MN: Median nerve; AIN: Anterior interosseus nerve; RA: Radial artery



[Table/Fig-8]: Left forearm with superficial flexors reflected, showing an accessory head of flexor pollicis longus (AHFPL) (Gantzer's muscle) co-existing with an accessory head of flexor digitorum profundus (AHFDP) (green stars).
FDS: Flexor digitorum superficialis; FPL: Flexor pollicis longus; FDP: Flexor digitorum profundus; UN: Ulnar nerve; UA: Ulnar artery; MN: Median nerve.

DISCUSSION

The frequency of the FPLah in the present study population is 46.6% (28 cases among 60 upper limbs). This is comparable to the frequencies found in studies conducted by Dellon A and Mackinnon S et al., Jones M et al., and Mustafa A et al., who all obtained a 45% frequency in their respective samples [11-13], [Table/Fig-9]. Studies have revealed a wide range of frequencies of the Gantzer's muscle, ranging from 74%-36% in Caucasian studies, 45% to 52% in Middle-Eastern studies, and 62-67% in studies conducted in Asian populations. Regarding studies conducted in the Indian subcontinent, frequencies were seen to range from 76.3% to 18%. The closest comparable Indian study is Pai MM et al., with a frequency of 46.03% [7] [Table/Fig-10].

Author, year	Population studied	Numbers obtained/ Sample size	Frequency of Gantzer's muscle
Mangini U, (1960) [9]	North American	56/76	74%
Dellon A and Mackinnon S, (1987) [11]	Canadian	14/31	45%
Al Qattan M, (1996) [14]	Saudi-Arabia	13/25	52%
Jones M et al., (1997) [12]	British	36/80	45%
Oh C et al., (2000) [8]	South Korean	48/72	66.7%
Mahakannukrauh P et al., (2004)[15]	Thai	149/240	62.1%
Uyaroglu FG et al., (2006) [17]	Turkish	27/52	51.9%
Riveros A et al.,(2015)[10]	Brazilian	3/30	10%
Mustafa A et al., (2016) [13]	Saudi Arabia	9/20	45%
Present study (2021)	Malabar region, Kerala	28/60	47%

[Table/Fig-9]: Comparison of frequencies of the Gantzer's muscle obtained in international studies with present study

Author and year	Population	Cases obtained/ Sample Size	Frequency of Gantzer
Malhotra VK et al., (1982) [18]	Maharashtra	130/240	54.16%
Hemmady M et al., (1993) [16]	Indian	36/54	66%
Pai MM et al., (2008) [7]	Karnataka, India	58/126	46.03%
Gunnal SA et al., (2013) [22]	Maharashtra, India	92/180	51.1%
Tamang B et al., (2013) [21]	Gangtok, India	15/60	25%
Jadhav SD and Zambare BR (2015) [19]	Maharashtra, India	87/114	76.31%
Bajpe R et al., (2019) [20]	Bengaluru, India	9/50	18%
Present study (2021)	Malabar region, Kerala	28/60	47%

[Table/Fig-10]: Comparison of frequencies of the Gantzer's muscle obtained in other Indian studies with present study

Authors from the past studies are divided regarding the origin of the FPLah. The most common source in the present study is the medial epicondyle (53.6%) followed by the intermuscular plane between FDS and FDP (32.1%), the coronoid process was the least common point of attachment (four out of 28 cases) [Table/Fig-2]. Five studies reported the medial epicondyle as the most common origin [10,13-16]. However, Oh C et al., and Uyaroglu FG [8,17], opine that the coronoid is the most common. A combined point of origin from both medial epicondyle and coronoid was also observed by Mangini U, Jones M et al., Hemmady M et al., and Malhotra VK et al., though no instances of such dual origin were obtained in the present study [9,12,16,18].

All FPLah were observed to be inserted at the ulnar border of the FPL tendon with the upper third being the most favoured site (16 cases, 57.1%). This is in concurrence with the findings of Pai MM et al., Jones M et al., Al-Qattan MM, Mahakannukrauh P et al., and Jadhav SD and Zambare BR [7,12,14,15,19]. Mustafa A et al., and Bajpe R et al., mentioned a small percentage of insertion into FDS tendon, but the present study author obtained no such findings [13,20].

Regarding the nerve supply of the accessory head, multiple authors have reported the AIN as the almost exclusive source [11,14,13,17,21]. In the present study, the accessory head received innervation from the AIN in 82% (23 of 28 cases). The median nerve may also supply a twig to the accessory head, literature showing frequencies ranging from 1% to 44% [18,20]. In present study also five cases of such innervation were found [Table/Fig-4].

Since the Gantzer's muscle is associated with compression neuropathy of the AIN, an attempt was made to classify the relation of the nerve to the accessory head in to three types, following system has been suggested by Oh C et al.,[8] [Table/Fig-1]. The most common relation observed, as in the study by Oh C et. al., was the AIN lying deep to the muscle component (belly) of the FPLah (type-A), which was seen in 23 limbs [Table/Fig-5]. Oh C et.al., observed type-C as the second most frequent, the least frequent being type-B. The present study however, is contradictory to Oh C et al., type-B relation was observed in four limbs (14.3%) [Table/Fig-6], and type-C was encountered in only one case. [Table/Fig-7].

Though, the review showed a few studies reporting that the accessory head always lay posterior to both the MN and AIN (Jones M et al., Mahakkanukrauh P et al., [12,15], in all specimen observed in the present study, the Gantzer's muscle lay deep to the median nerve and above the AIN, as evidenced by the classification above.

The shape of the Gantzer's muscle has been variously described in different studies, but in the present study, only two shapes were clearly identified, fusiform and slender. Fusiform FPLah was seen in 64.3% and slender form in 35.7% limbs. This is in accordance with the findings of Pai MM et al., Mahakannukrauh P et al., Uyaroglu FG et al., Gunnal SA et al., Tamang B et al., and Bajpe R et al., [7,15,17,21,20,22]. The average length of the FPLah belly was observed to be comparable on both left and right sides, being 10.3±1.7cm on the right and 10±0.7 cm on the left. The muscle was also found to be thicker on the right side (0.63±0.4 cm), compared to the left (0.57±0.3cm) [Table/Fig-2].

Two instances of FDPah were also observed during the course of dissection. In one of these, the FDPah was seen existing simultaneously with the FPLah [Table/Fig-8]. This further re-enforces the common embryology of these muscles, where they initially formed a single muscle body in the deep strata of the flexor compartment of the forearm [3].

Compression neuropathy of the AIN, the Kiloh-Nevin Syndrome, is named after Leslie. G Kiloh and Samuel Nevin who first described the condition in 1952 [6]. The clinical presentations include inability to pick up small objects with the thumb and index finger, and subsequent pain in the flexor muscles of the forearm [6]. The classic sign observed is when the patient is asked to make the "OK" sign, touching his thumb to his index finger. In the case of AIN palsy due to compression, the patient will be unable to do so, hyperextending the thumb and index finger, giving a positive Spinner test [24].

Limitation(s)

The study population is restricted to a limited population of the North Kerala region. The cadavers donated to the Institute were unknown or unclaimed bodies procured from Government Medical Colleges in the region, and so, the parameters studied could not be adequately correlated to the age, or occupation of the individual, as such history could not be obtained.

CONCLUSION(S)

Clinically, among the many conditions leading to AIN palsy, the FPLah is an often overlooked cause. But, authors who have studied the Gantzer's muscle, have expressed a wide difference of opinion and discrepancies in findings, not only between different population groups of the world, but also within the same populations. This makes it difficult to generalise findings regarding the anatomical features of the FPLah. Orthopaedic and hand surgeons should keep in mind the possibility that in cases of isolated AIN palsy, in the absence of other aetiology in clinical history, the possibility of the presence of the FPLah could be a reason for the confounding clinical presentation.

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