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Anatomy of gantzer muscle revisited: A descriptive study in south Indian cadavers

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ABSTRACT

Background and Aim: Gantzer muscle (GM) is the accessory muscle associated with the flexor pollicis longus. GM could be used for muscle transfer to restore function in multiple nerve palsies. GM could be one of the causes of compressive neuropathy. This study aims to revisit the anatomy of GM and provide a detailed analysis of the morphology, dimensions, and innervation of GM in cadavers of South Indian origin.
Materials and Methods: This descriptive observational study utilized 60 upper limbs from 30 cadavers that were available during the study period from June 2018 to June 2023. The shape, origin, and insertion of the GM were recorded. The length of the muscle and the tendon was measured with a digital vernier caliper. The innervation of the GM and its relation to the anterior interosseous nerve was observed.
Result: The mean length of the muscle belly and tendon were 9±2.63 cm and 2.81±2.5 cm, respectively. The GM originated from the undersurface of the flexor digitorum superficialis, the coronoid process, radial tuberosity, and medial epicondyle. In 90.9% of cases, GM was innervated by the anterior interosseous nerve and 9.1% by the median nerve.
Conclusion: Present study describes the morphology of GM in South Indian cadavers. Orthopaedic and hand surgeons must exercise caution when considering GM involvement in isolated anterior interosseous nerve palsy, especially when no other obvious cause is evident in the patient's clinical history. Recognizing the possibility of GM involvement is crucial in the subsequent management of compressive neuropathy.

1. Introduction

Accessory muscles refer to anatomical variations that involve additional muscles encountered alongside the normal set of muscles. Gantzer muscle (GM) is the accessory muscle associated with the flexor pollicis longus, named after Karl Friedrich Gantzer in 1813, although Albinus initially described it in the 18th century.[1] The origin of GM may vary, arising from the medial epicondyle of the humerus, the coronoid process of the ulna, or the deep surface of the flexor digitorum superficialis (FDS).[2] Despite variations in its origin, GM consistently inserts at the ulnar portion of the flexor pollicis longus (FPL). The morphology of the GM exhibited a slender, strap-like configuration characterized by a fusiform shape and could present as voluminous or occasionally triangular.[3] Innervated by the anterior interosseous nerve (AIN), which has a posterior relationship with the muscle, and occasionally, GM receives innervation from the median nerve (MN).

Anterior interosseous nerve syndrome is a compression neuropathy that impacts the AIN, causing motor weakness in the long tendons responsible for movement in the index finger and thumb. Among the various factors contributing to this syndrome, one frequently underestimated cause is the existence of an accessory head of the flexor pollicis longus muscle. Compression at this nerve-muscle junction can lead to neuropathy, resulting in the Kiloh-Nevin syndrome.[1,2] Thus, GM could be one of the causes of compressive

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neuropathy and should be considered in the management of compartment syndrome. This study aims to revisit the anatomy of GM and provide a detailed analysis of the morphology, dimensions, and innervation of the GM, in cadavers of South Indian origin, specifically from Tamil Nadu and Puducherry region.

2. Materials and Methods

This descriptive observational study utilized 60 upper limbs from 30 cadavers (Male – 28; Female - 2). Cadavers with reasonable preservation of limb structure that were available during the study period from June 2018 to June 2023 were included. The cadavers with faulty dissection of limbs or any history of surgery in the forearm were excluded. These cadavers were donated to the Department of Anatomy through the Body Donation Program and were approved for Medical Education and Research.

The dissection of the front of the forearm was done following Cunningham's dissection manual.[4] After reflecting the skin, the superficial muscles of the forearm were carefully dissected, and the presence of GM was identified. The shape, origin, and insertion of the GM were recorded. The length of the muscle and the tendon was measured with a digital vernier caliper. The innervation of the GM and its relation to AIN was observed. Descriptive statistics and comparisons between sides were analyzed using SPSS version 19.

3. Results

GM was observed in 38 (63.33%) of the limbs (Figure 1). The bilateral presentation of GM was observed in 11 cadavers (40.74%) and unilateral in 16 cadavers (59.26%) (Right-10; left-6). The shape of the GM was papillary, flat, or slender. The origin of the GM muscle was found to vary across specimens, with 25 originating from the undersurface of the FDS, five from the coronoid process, two from the radial tuberosity, and eight from the medial epicondyle. Additionally, one specimen showed the GM originating from the coronoid process and FDS (Figure 1).

Two separate GM muscles, inserted individually into the FPL and flexor digitorum profundus (FDP), were observed bilaterally in one cadaver and unilaterally on the right side in another (Figure 2). GM was inserted unilaterally into FDP in three specimens (Right- 2; Left- 1). In the rest of the specimen, GM was inserted into the tendon of FPL. Thus, a total of 41 GM was observed in the 60 limbs.

The AIN was posterior to GM in 36 specimens and lateral in five specimens. Notably, in 90.9% of cases, the anterior interosseous nerve supplied the GM, with the remaining 9.1% receiving direct innervation from the MN, whereas one specimen received innervation from AIN and MN (Figure 3). The mean length of the muscle belly was 9±2.63 cm (R- 8±2.06; L-9.5±3.38), and the tendon was 2.81±2.5

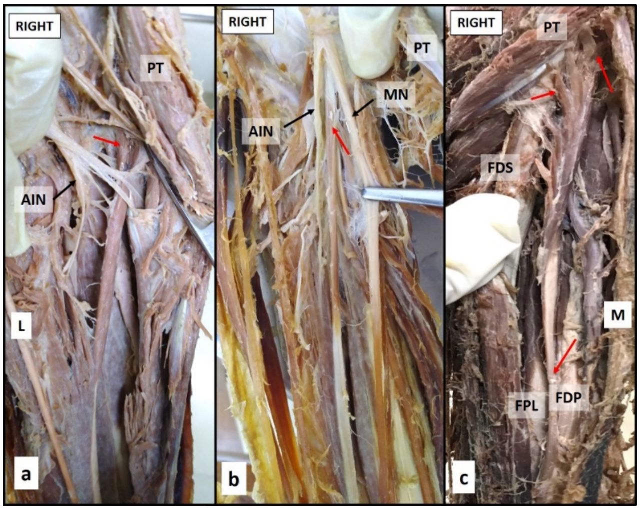

Figure 1: Attachments of Gantzer muscle (GM). **a**): Origin from the medial epicondyle along with other superficial muscles. **b**): From the coronoid process of the ulna. **c**): FDS and PT are reflected laterally to show the origin from the coronoid process and a few fibers attached to FDS. GM is inserted into FDP. FDS: Flexor digitorum superficialis; FDP: Flexor digitorum profundus

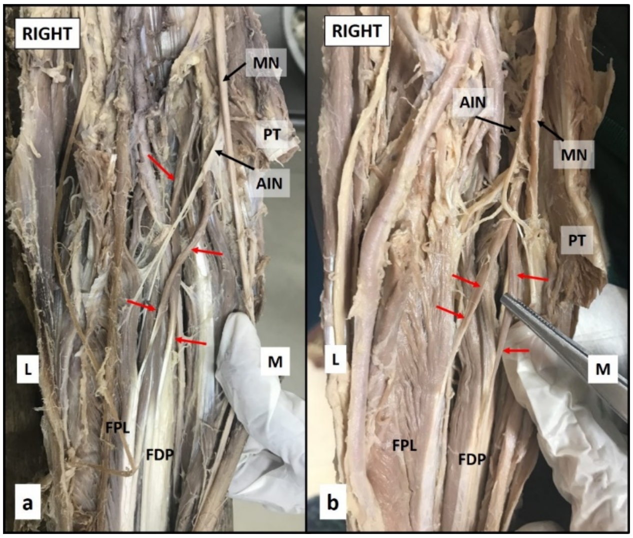

Figure 2: Dissection of double Gantzer Muscle on the right side in two cadavers. **a and b**): Shows the insertion into flexor pollicis longus (FPL) and flexor digitorum longus (FDL). AIN: Anterior interosseous nerve; MN: Median nerve; PT: Pronator teres; M: Medial; L: Lateral

cm (R- 2.68±2.52; L-3.02±2.58). There were no statistically significant differences in the length of the muscle belly (p-value 0.192) or the tendon (p-value 0.367) between the right and left sides.

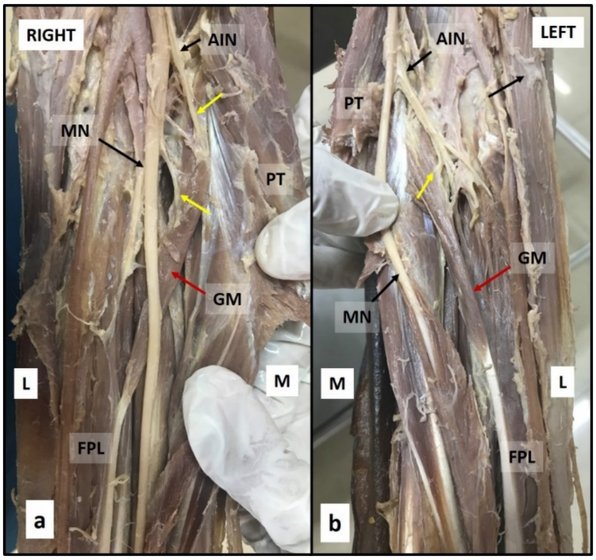

Figure 3: Innervation of Gantzer muscle (GM) in the forearm. **a**): Right forearm shows innervation from AIN and MN. **b**): Left forearm shows innervation from AIN. FPL: Flexor pollicis longus; PT: Pronator teres; AIN: Anterior interosseous nerve; MN: Median nerve; M: medial; L: Lateral

4. Discussion

Disruption in the preliminary cleavage process during the development of muscles may result in variations in muscle formation.[5] In the seventh week of embryonic development, myogenic precursor cells originating from the somites of the paraxial mesoderm migrate into the limb buds, where they begin to organize and form the flexor-extensor muscle groups. As development progresses, connective tissue laminae emerge, partitioning these muscle groups into individual muscles. In the forearm, the flexor muscles originate from flexor mass, which undergoes subsequent division into two distinct layers: superficial and deep. It is within the deep layer that muscles such as the FDS, FDP, and FPL arise. The presence of accessory muscles that establish connections between the flexor muscles can be attributed to the incomplete separation of the flexor mass during this developmental phase. Therefore, improper separation of the superficial and deep layers of the forearm muscle mass during embryonic development offers a possible explanation for the origin of accessory muscles like the GM.[6]

GM is described as originating from the FDS and inserted into the ulnar aspect of the FPL. The muscle follows a downward and oblique course toward the ulnar aspect of the FPL and its tendon.[7] At its proximal attachment, the fibers of the GM could merge with the common flexor origin of other forearm muscles. However, GM was found to originate from the FDS and was inserted into the FPL. Additionally, it has been noted to arise from the coronoid process. Sometimes it is inserted into the deep surface of the FDP.[8]

In the present study, the predominant origin of the GM was from the FDS, with a few cases originating from the coronoid process, radial tuberosity, or medial epicondyle. Similarly, a study from Brazil involving 84 limbs reported the GM to originate from the FDS in 42 cases, from the coronoid process of the ulna in eight cases, and the medial condyle in seven cases.[1] Kara et al. examined the forearms of 45 fetuses and 24 cadavers and reported the incidence of GM as 32% in fetal specimens and 39% in adult specimens. They found that the proximal attachment of the GM was predominantly from the undersurface of the FDS in 82.7% of fetuses and 45% of adult cadavers.[9] Dual origins from the medial epicondyle and the coronoid process have also been reported.[10] In a study from Saudi Arabia, GM was present in 66.66% of specimens, with 55.55% arising from the medial epicondyle and 16.66% from the coronoid process of the ulna, whereas a study from South India found them to be 10.38% and 18.9% respectively.[7,11]

Gunnal et al. observed the bilateral presence of GM in 72% and unilateral in 60%, which was mostly on the right side.[12] Caetano et al. reported two-headed GM, whereas in the present study, two separate muscles were inserted individually into FPL and FDP.[1] In a study on the South Indian population, 46.03% of specimens exhibited an accessory head of the FPL, while 14.28% inserted into the FDP, and similarly in the present study, six GMs were observed to insert into FDP (14.63%).[3]

The prevalence of GM ranged from 20% to 68%, with a bilateral or unilateral presentation with regional variations, as shown in Table 1. Ballesteros et al. reported that the South American population had a lower prevalence when compared to North American and Asian populations.[5] Several studies conducted across different regions of India have reported varying prevalence of GM, as shown in Table 2. The highest prevalence of 76% was observed in Maharashtra, and the lowest prevalence of 25% and 18% in Gangtok and Karnataka, respectively.[13–15] Findings in the present study suggest a widespread variation in the prevalence of GM across various regions, with a higher prevalence noted in South India. However, it is important to note that there are variations in population sizes across different studies. This suggests that there may be a potential correlation with these varying population numbers, which underscores the need for further investigation.

The morphology of the GM has been described as strap-like, fusiform, slender, voluminous, papillary, spindle, band-like, and triangular.[3,16,17] Bagoji et al. identified that the

Table 1: Prevalence of the Gantzer muscle in various populations

Study	Population	Sample size	Prevalence	Bilateral presentation	Unilateral presentation Right	Left
Al Qattan[7] 1996	Saudi Arabia	25 limbs (cadavers)	52%	-	-	-
Jones et al.[16] 1997	Europe - Spain	40 cadavers	60%	16.7%	50%	12.6%
Oh et al.[17] 2000	Korea	72 cadavers	66.7	50%	33%	
Uyaroglu et al.[18] 2006	Turkey	52 cadavers	51.9%	74%	26%	
Caetano et al.[1] 2015	Brazil	40 cadavers	68%	-	-	-
Kara et al.[9] 2017	Turkey	45 fetuses 24 cadavers	32% 39%	10 fetuses 8 cadavers	-	-
Ballesteros et al.[5] 2018	Colombia	106 limbs	32.1%	47.8%	52.2%	
Oleiveira et al.[19] 2022	Brazil	34 limbs	50%	88.23%	-	
Munguti et al.[20] 2022	Kenya	43 limbs	45%	11%	44%	46%
Torun et al.[21] 2022	Turkey	473 extremities MRI study	20.3%	22.9%	40%	37.1%
Present study 2024	India	60 limbs	63.33%	40.74%	42.11%	15.8%

Table 2: Prevalence of the Gantzer muscle in different regions of India

Study	Indian Population	Sample size	Prevalence	Bilateral presentation	Unilateral presentation Right	Left
Pai et al.[3] 2008	South India	58/126	46.16%	58		
Gunnal et al.[12] 2013	India (Maharashtra)	180 specimens	51.1%	71.73% (33 cadavers)	16 specimens	10 specimens
Tamang et al.[13] (2013)	Gangtok, India	15/60	25%	10%	46.6%	26.66%
Jadhav & Zmbare[14] 2015	Maharashtra, India	87/114	76.31%	71.73%	28.26%	
Bajpe et al.[15] 2015	Karnataka, India	9/50	18%	-	66.67%	11.11%
Bagoji et al.[11] 2017	South India	58 limbs	29.3%	12.06%	5.17%	
Jayan et al.[22] 2021	India (Kerala)	60 limbs	46.7%	0	60.7%	39.2%
Vedapriya et al.[23] 2022	India, Telangana	50 limbs	58%	40%	10%	8%
Present study 2024	India (Tamil Nadu & Puducherry)	60 Limbs	63.33%	40.74%	42.11%	15.8%

muscle predominantly exhibited a spindle-shaped (20.68%) or papillary (8.62%) appearance.[11] Gunnal et al. described the shape as fusiform in 83.69% of cases, while in 16.31%, it exhibited a broad and thick appearance.[12] The present study identified three shapes: papillary, flat, and slender.

Several studies have reported the total length of the GM to be around 10 cm, as shown in Table 3. Gunnal et al. observed the average length of the GM to be 80.47 ± 1.01 mm, with the tendon measuring an average length of 1.09 ± 0.09 mm.[12] In the present study, the mean length of the muscle belly was 9 ± 2.63 cm, which is consistent with previous studies in the literature. However, the tendon was 2.81 ± 2.5 cm, which is comparatively higher than previous studies.

Variations in the innervation and positions of the median nerve and anterior interosseous nerve in relation to GM have been observed in many studies. In the study by Bagoji et al., all the muscles were innervated by the AIN and exhibited various relationships with GM. It was anteriorly related in 1.72%, posteriorly in 9%, laterally in 5.17%, and posterolaterally in 6.89% of the specimens.[11] Al-Qattan et al. reported that both nerves were anterior to the GM.[7] In the

Table 3: Comparison of dimensions of the Gantzer muscle

Author	Length of the muscle	Width of the muscle	Length of the tendon
Hemmandy et al.[8] 1993	5 to 8 cm	1 to 2.5 cm	-
Jones et al.[16] 1997	68 ± 17 mm	-	11.7±13 mm
Pai et al.[3] 2008	Total length - 8 ± 1.5 cm (Muscle belly -three-fourths)	-	One-fourth of the total length
Kara et al.[9] 2012	7.4 ± 1.2 cm (total length including tendon 8.2±1.26 cm)	0.7 ± 0.2 cm	-
Gunnal et al.[12] 2013	80.47 ± 10.1 mm	6 mm	19.04 mm
Bellasteros et al.[5] 2018	84.42 ± 9.27 mm	7.62 ± 1.11 mm	9.68 ± 1.86 mm
Jayan et al.[22] 2021	10.3±1.7 cm	R -0.63±0.4 cm L – 0.57±0.3 cm	-
Oleiveira et al.[19] 2022	10.5 cm	0.3 cm	-
Present study 2024	9±2.63 cm	-	2.81±2.5 cm.

present study revealed that in 91.67%, the AIN was posterior to the GM and in 8.3% anterior to it. Gunnal et al. observed that the innervation of GM was predominantly from AIN, at 80.43%, and by the median nerve at 19.56%.[12] Similarly, in the present study, in 90.9% of cases, GM was innervated by AIN and 9.1% by the median nerve.

The GM helps in muscle transfer to restore function in multiple nerve palsies in crush injuries, Hansen's disease, and compartment syndrome.[24] Abnormal tendinous attachment into the FDP slip at the index finger can cause difficulty in the distal forearm movements and inability to flex the distal interphalangeal joint of the thumb without flexing the distal phalanx of the index finger.[2] The above condition should be clearly excluded from the condition called trigger finger.[25] The GM could cause AIN compression syndrome or Kiloh-Nevin syndrome leading to neuropathy.[11,26]

5. Conclusion

The present study describes the anatomy of GM in South Indian cadavers. Studies investigating GM have revealed significant disparities in findings, both among different global population groups and even within the same populations, making it challenging to generalize anatomical features related to GM. Consequently, orthopedic and hand surgeons must exercise caution when considering GM involvement in cases of isolated AIN palsy, especially when no other obvious cause is evident in the patient's clinical history. Recognizing the possibility of GM involvement is crucial as it could greatly impact the clinical presentation and subsequent management decisions.

6. Source of Funding

None.

7. Conflict of Interest

None.

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