Original Article

Anatomical Variations of the Anterior Belly of the Digastric Muscle in Thai Cadavers: A Cross-Sectional Study

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ABSTRACT

Aim: Because the digastric muscle is considered as an anatomical landmark, its variations may emphasize clinicians to be cautious during surgery. However, previous studies from different ethnicities reported a wide range of occurrence and several types of this muscle variation, pointing the necessity of the data from local population to better treatment decisions. Thus, this study aimed to explore the variations of the anterior belly of the digastric muscle in Thai cadavers. **Materials and Methods:** This cross-sectional study investigated the submental region of 91 cadavers by convenient sampling method. The characteristics of the variation in the anterior belly were recorded in accordance with sex and side of the cadavers. Multiple logistic regression was calculated for determining the association of occurrence of muscle variation with sexes and sides ($\alpha = 0.05$). **Results:** Among 91 cadavers, the accessory bundles were observed in 16 cadavers (10 males and 6 females). The presence of the additional belly was sex and side independent. Three variation types were observed; the arrowhead type and the double-headed type have been previously reported, whereas the asymmetrical fan-shaped type is the new variant that has never been described before. **Conclusions:** The variation of the anterior belly of the digastric muscle including the new variant can be seen in Thais with low occurrence. To our knowledge, the present study is the first report of the aberrations of the digastric muscle in the Southeast Asian population. Therefore, our study provides the basis for anatomical study of muscular variants and helps surgeons plan the operation to prevent iatrogenic injuries.

Keywords: *Anatomic variation, cadaver, digastric muscle*

Introduction

The digastric muscle is a component of the suprahyoid muscles and demarcates the submandibular and submental triangles. Traditionally, the anterior belly of the digastric muscle is a fusiform bundle that serves as the lateral boundary of the submental triangle of the neck and also lies superficial to the mylohyoid muscle. Originating from the digastric fossa close to the midline of the mandible, the anterior belly extends downward and backward to join the posterior belly in an intermediate tendon, which is anchored to the body and the greater horn of the hyoid bone.[1] The digastric muscle functions in jaw opening by depressing the mandible and elevates the hyoid bone when chewing and swallowing. However, the variations of the anterior belly of the digastric muscle have been reported from many regions of the world with the wide range from 1.3%–69.6%.[2-4] The variations can be found in a variety of types including bilaterally or unilaterally multiple-headed bundles,[5-7] crossover and X-shaped

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bundles,[7-9] the bundles attaching to the median raphe of the mylohyoid muscle[7,10,11] and other complex types of variations,[7,8,12] or even an absence of the anterior belly.[5] Because this muscle in the submental triangle generally serves as an anatomical landmark for radiological and surgical procedures, more varieties of the muscle variants raise more clinical concerns.[13] Despite being asymptomatic, muscular variation can lead to the radiographic misinterpretation and also cause difficulty during surgical approach involving the submental region.[14]

As aforementioned, the variations of the digastric muscle show the differences among ethnic groups, as well as several types of variants indicating the need of studies particularly in each population for improving the clinical treatment. In Asian population, the variations of this muscle have also been investigated; however, they were entirely reported from the East Asian population such as Taiwanese, Japanese, or Korean.[9,12,15] No information has ever been reported from Thais or other Southeast Asian populations. Therefore, this study aimed to investigate the variations in the anterior belly of the digastric muscle in the Thai population to raise concerns about the aberration of this muscle and provide data for therapeutic intervention.

Materials and Methods

Study design

This cross-sectional study was performed at the Gross Anatomy Laboratory, Faculty of Dentistry, Mahidol University, during academic years 2015–2020. All cadavers were donated for educational purpose. Convenient sampling of cadavers was used as a sample selection method. The minimum sample size required in this study was 70 cadavers determined by estimating proportion formula[16] using the occurrence of variation (23.5%) according to Kim *et al.*[17] with 95% confidence interval and 10% margin of error. The additional 21 cadavers were also dissected in routine anatomical dissection laboratory and were included in this study. Moreover, sex of the cadavers and side of the muscle variant were also noted to determine the association with the presence of muscle variation.

Selection criteria

Thai male and female cadavers as evidently recorded in the death certificate were included. Then, the cadavers with facial malformation, evidence of surgical operations, or any macroscopic pathologic lesions in the submental and/or submandibular areas were excluded from our study.

Dissection method

In each cadaver, the submental region was investigated. Skin incision was performed bilaterally from the mastoid process to the sternal end of the clavicle and continued laterally to the acromial end. Median incision was performed from the mental protuberance to the suprasternal notch. The platysma muscle was reflected by making an incision along the clavicles. Deep fascial layer was removed to expose the muscles, the inferior border of the mandible, and the hyoid bone. Then, the muscles in the submental triangle were cleaned and scrutinized in detail. The accessory anterior belly of the digastric muscle was examined twice independently by two investigators.

Ethical statement

This study was granted exemption from ethics approval by the Faculty of Dentistry and the Faculty of Pharmacy, Mahidol University, Institutional Review board (MU-DT/PY-IRB), reference number COE. No. MU-DT/PY-IRB 2020/030.3107 and was conducted in accordance with the ethical principles mentioned in the Declaration of Helsinki (2013).

Statistical analysis

The analyses of sex and side dependency and the presence of the additional anterior bellies of the digastric muscle were performed using a binary logistic regression in IBM SPSS Statistics for Windows, version 27.0 (IBM Corp, Armonk, NY, USA) with a 95% confidence limit. *P* values less than 0.05 were considered statistically significant.

Results

Demographic data and logistic analysis

Ninety-one cadavers were included in this study. According to the death certificates, the cadavers were 55 Thai males and 36 Thai females. The age at death of the cadavers ranged from 47 to 96 years. Binary logistic regression showed that sex and side were not statistically related to the presence of the additional bellies as shown in Table 1.

The variations of the anterior belly of the digastric muscle

From 91 cadavers, the aberrant anterior bellies of the digastric muscle were found in 16 cadavers (17.6%; 10 males and 6 females). The additional muscles could be classified into three types according to their origin and the muscle arrangement as described below. The occurrence of each type is summarized in Table 2. In all cadavers, the anterior belly of the digastric muscle including the additional muscles was innervated by the branches of the mylohyoid nerve. In addition, the

posterior bellies of all cadavers were normal and no other variations were observed in the neck region.

Asymmetrical fan-shaped type

This type was found in a male cadaver (1.1%). The additional muscle emerged along the mylohyoid line, instead of the digastric fossa, covering the anterior half of the submental triangle before forming a bundle and attaching the left intermediate tendon of the digastric muscle [Figure 1A and B]. This aberrant muscle did not fuse with the mylohyoid or attach to the mylohyoid raphe. The right anterior belly was in a normal muscle form.[1] In another aspect, this variation might be described as a hybrid of accessory muscles composing of the mylohyoid in the anterior half and the anterior belly of the digastric muscle in the posterior half.

Arrowhead type

This type was found bilaterally in six cadavers (6.6%; 3 males and 3 females). The thin muscles arose from the anterior half of the mylohyoid raphe, extended posterolaterally, and inserted into their ipsilateral intermediate tendon. The bilateral aberrant muscles were in a triangular shape and symmetrical, resembling an arrowhead [Figure 1C].

Double-headed type

This type was the most common type in our study, which was found unilaterally or bilaterally in nine cadavers (9.9%; 6 males and 3 females). Two anterior bellies ran in parallel from the digastric fossa to the ipsilateral intermediate tendon without attaching to the mylohyoid [Figure 1D].

Discussion

Regarding the various appearances of the anterior belly of the digastric muscle, a complete classification of the muscular variants is difficult to be established, and the standard criteria for classification are not yet available. Kim and Loukas summarized the common variations and categorized them into 12 types as a guideline for physicians.[4] According to their study, our arrowhead type can be classified as the bilateral accessory anterior belly with the origin at the mylohyoid raphe. This arrowhead type has been recently reported by Zdilla *et al.*[11] with an additional bundle extending from the midpoint of the mylohyoid raphe to the mandible, which was in agreement with earlier observations by Reyes *et al.*[10] and Sakamoto and Akita.[7] In addition, the double-headed type was also demonstrated in several studies[5,6] and can be categorized as unilateral or bilateral accessory anterior belly with the origin at the digastric fossa based on Kim and Loukas or the digastric fossa type based on the study by Ozgur *et al.*[6] Although other common types of aberrations, such as the crossover and the X-shaped types,[7-9] were not observed in our study, we found the asymmetrical fan-shaped belly which, to our knowledge, has never been reported by previous studies. This type of accessory belly can thus be classified as a new type of muscle variant.

A study of comparative anatomy revealed that in some genera of nonprimates, such as *Rattus* and *Tupaia*, and higher-level primates, such as *Gorilla* and *Pan*, the anterior belly of both sides contacts each other at the

Table 1: The presence of the additional anterior belly of the digastric muscle with respect to sex and side

Parameter	Normal	Additional	Total	*P* value	Adjusted odds ratio	95% confidence interval
Sex						
Male	45 (81.8)	10 (18.2)	55 (100)	0.757	0.876	0.377–2.032
Female	30 (83.3)	6 (16.7)	36 (100)			
Total	75 (82.4)	16 (17.6)	91 (100)			
Side						
Right	79 (86.8)	12 (13.2)	91 (100)	1.000	1.000	0.436–2.295
Left	77 (84.6)	14 (15.4)	91 (100)			
Total	156 (81.7)	26 (14.3)	182 (100)			

The percentages are shown in parentheses.

Table 2: The type of the additional anterior belly of the digastric muscle with respect to sex and side

Type	Total	Sex		Unilateral		Bilateral
		Male	Female	Right	Left	
Asymmetrical fan-shaped	1 (1.1)	1 (1.1)	-	-	1 (1.1)	-
Arrowhead	6 (6.6)	3 (3.3)	3 (3.3)	-	-	6 (6.6)
Double-headed	9 (9.9)	6 (6.6)	3 (3.3)	2 (2.2)	3 (3.3)	4 (4.4)
Normal	75 (82.4)	45 (49.4)	30 (33.0)	-	-	-
Total	91 (100)	55 (60.4)	36 (39.6)	2 (2.2)	4 (4.4)	10 (11.0)

The percentages are shown in parentheses.

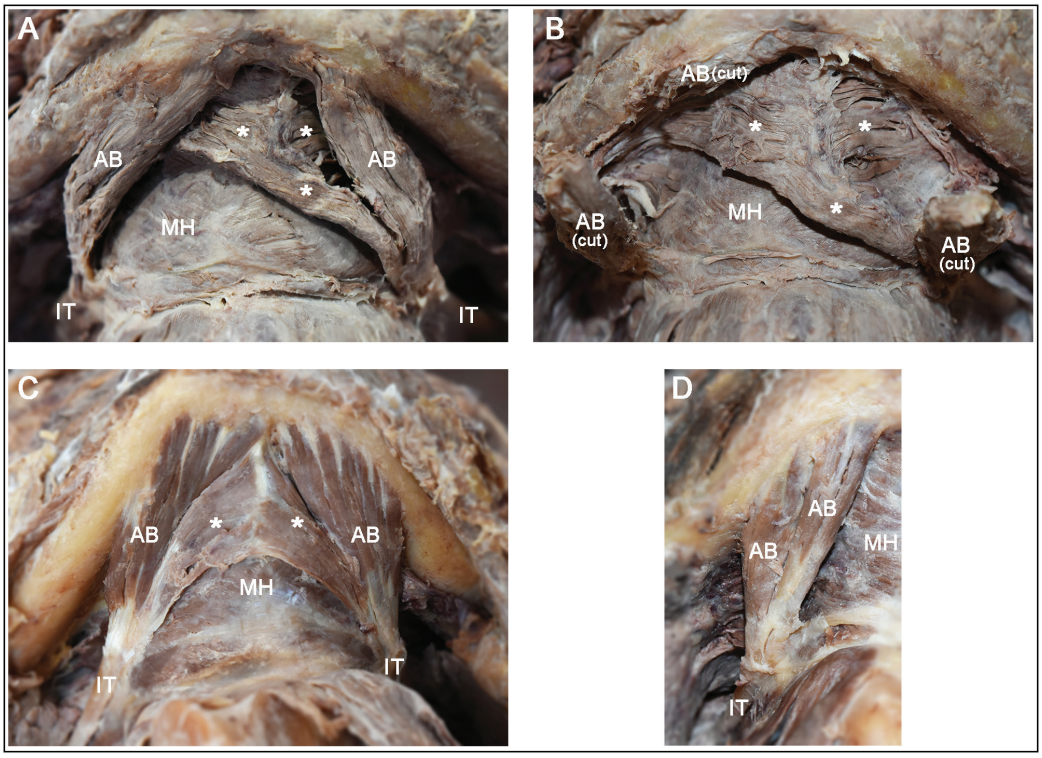

Figure 1: Accessory anterior bellies of the digastric muscle. A and B Fan-shaped type. B The normal bellies were cut to reveal the origin of the aberrant muscle. C Arrowhead type. D Double-headed type. AB = normal anterior belly, IT = intermediate tendon, MH = mylohyoid muscle. *An aberrant anterior belly

midline for most of the bundle.[18] However, this contact was not observed in *Homo* and other primate genera such as *Cynocephalus* and *Lemur*, and the muscle is usually absent in *Pongo*.[18] Therefore, the accessory bundle of the anterior belly found in human can possibly be considered as a transitional form of muscle evolution. Moreover, a variety of variation types might also be explained by the embryonic basis.

Because it is well documented that the anterior belly of the digastric muscle and the mylohyoid muscle were derived from the first branchial arch, both muscles receive the same innervation from the mylohyoid nerve, a branch of the mandibular nerve. Sakamoto and Akita[7] studied the innervation pattern of the mylohyoid nerve to the digastric, the mylohyoid, and the accessory bundle in the submental region and highlighted that the mylohyoid nerve travelled between these normal muscles before separating inferiorly to supply the anterior belly from its deep surface and superiorly to supply the mylohyoid from its superficial surface. Accordingly, the aberrant bundles were also innervated by the mylohyoid nerve in a similar manner that the bundle superficial to the nerve was innervated from its deep surface and the bundle deep to the nerve was innervated from its superficial surface. By the aforementioned pattern of mylohyoid innervation, they proposed the common primordial hypothesis that the muscle primordium from the first branchial arch separates into two layers: the superficial and deep layers, which develop into the anterior belly of the digastric muscle and the mylohyoid muscle, respectively, giving the aberrant muscle in the intermediate layer as a remnant of the separation. When the remnant of muscle primordium develops unilaterally or bilaterally without merging together at the midline, it becomes the double-headed type. On the other hand, when the bilateral remnants merge together at the midline, it becomes the arrowhead type or the fan-shaped type. Because this midline merging phenomenon of the muscle remnants seems to occur seldomly compared with the nonmerging type, this may explain why the double-headed type is more often seen than the other types in this study. Owing to their hypothesis, it is also likely that there is a common attachment of the aberrant bundle and the anterior belly of the digastric or the mylohyoid muscles, and this assumption may be true due to the locations and the characteristics of the variants, as shown in three types of variants in our study.

Based on our knowledge, this is the first report of an accessory bundle of the anterior belly of the digastric muscle in the Thai population with low occurrence

(17.6%). Compared with other ethnicities, our study shows slightly lower occurrence than the other Asian populations, such as Taiwanese (20.0%)[9] and Korean (23.5%),[17] but markedly lower than the Anatolian population (66.7%)[6] as shown in Table 3. The reason behind the wide range of the finding among different ethnicities can possibly be explained in a similar manner as the variations of skin pigmentation or disease susceptibility among ethnic groups[19] reflecting the differences in genetic control between the Thai and East Asian population or other regions in the world. Nevertheless, increasing sample size may lead to more precise outcome and more information about genetic regulation to be discussed. Moreover, epigenetic factors may also play roles in muscular variation. Environment and diet are relatively different between the East and Southeast Asian populations. Several studies have shown that diet could affect signaling molecules involving in myoblast migration.[20-22] However, the majority of studies were performed using myoblast cell culture models and focused on muscular regeneration. The factors controlling the presence or absence of the accessory muscle, as well as its arrangement, thus remained to be investigated.

In functional aspect, due to its close proximity to the anterior belly of the digastric and the mylohyoid muscles, it is likely that the supernumerary bundles provide an additional force to these muscles during mastication.[1] While the arrowhead type may support the floor of the mouth symmetrically, the unilateral additional belly can probably cause an imbalance when elevating the hyoid bone or depressing the mandible.[11,12] The fan-shaped type may help distribute the force along the anterior part of the inner surface of the mandible and facilitate the function of the mylohyoid muscle when swallowing.[1]

In clinical practice, the anterior belly of the digastric muscle provides a direction to the midline and the inferior border of the mandible.[23] However, this muscle can be mobilized or partially removed for functional and esthetic reasons. The digastric muscle, together with its intermediate tendon and a part of posterior belly, is used to reconstruct the depressor muscles of the lower lip in patients with marginal mandibular branch of the facial nerve paralysis, thereby restoring the symmetry of the lower face when smiling.[24] Partial excision of the anterior belly of the digastric muscle or medial displacement of the anterior bellies followed by anchoring them to the mylohyoid (digastric corset) is a technique, apart from inter-digastric fat removal, performed to rejuvenate the anterior neck region.[25,26] When the surgeries are complicated by the supernumerary bundles, partial or complete removal of these bundles may be an option to facilitate the procedure.[27]

To prevent any complications, radiological imaging, such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound, can be used to detect an accessory belly of the digastric muscle prior to the surgery.[14,28] Notably, the clinicians should be more careful in interpreting the radiographs as the aberrations may appear similar to soft tissue masses, especially in the unilateral type. This can be overcome by using T2-weighted MRI where a tumor shows higher signal intensity.[29,30] Positron emission tomography/CT is also an effective combination to differentiate lymph nodes from muscles and show the relationship between lymph nodes and surrounding tissues.[31] However, the use of contrast-enhanced CT alone may not be suitable to differentiate the supernumerary muscle from other masses due to insufficient contrast and tissue location.[30,32]

The submental space is one of the fascial spaces often involved in mandibular odontogenic infection. This space can become directly infected from infection in lower anterior teeth or indirectly through the spread from sublingual or submandibular spaces. In Ludwig's angina, the infection can involve these spaces, leading to airway obstruction.[33] The characteristics of both arrowhead and asymmetrical fan-shaped types, which are sheet-like muscles and superficial to the mylohyoid, may partially compartmentalize the submental area into two spaces with a connection anterior to the hyoid bone.[11] The arrowhead type may further subdivide the space by its attachment at the raphe. It is possible that the compartmentalization could cause some difficulties

Table 3: Examples of the studies of the anterior digastric variants from different ethnicities with similar classification

Study	Population	Number of variations observed/total number of cadavers				Overall
		Arrowhead	Multiple headed	Crossover	Others	
Kim *et al.*[17]	Korean	-	3/34 (8.8)	5/34 (14.7)	-	8/34 (23.5)
Hsiao and Chang[9]	Taiwanese	-	1/15 (6.7)	2/15 (13.3)	-	3/15 (20.0)
Ozgur *et al.*[6]	Anatolian	-	15/30 (50.0)	5/30 (16.7)	-	20/30 (66.7)
Present study	Thai	6/91 (6.6)	9/91 (9.9)	-	1/91 (1.1)	16/91 (17.6)

The percentages of occurrence are shown in parentheses.

in the management of Ludwig's angina by obstructing pus draining from the infected area.[34]

Our study showed that sex and side were not associated with the presence of variations in the anterior belly of the digastric muscle. We also presented the new type of the anterior digastric variant in Thai cadavers, which has never been reported by other studies from Asian or non-Asian countries. Although this type can be considered as a rare variant by the cadaveric study, it is possible that this variant is encountered more often in a clinical setting where the number of cases greatly exceeds the number of cadavers in an anatomical laboratory. Therefore, it is important for radiologists or surgeons to be cognizant of this variation to avoid unwarranted complications.

Future scope/clinical significance

The variations in the anterior digastric muscle in the Thai population were revealed in this study by dissecting the cadavers. However, substantial amount of research from other countries is required to draw a conclusion about this muscular variation in the Southeast Asian population. In addition, this cadaveric study can be reinforced by further clinical studies or case reports from clinical practices to raise concerns of the variations in the submental triangle.

Conclusion

The present study has demonstrated three types of variations in the anterior belly of the digastric muscle together with their occurrence in the Thai population. Despite our study showing lower occurrence than other studies, the additional bundle is of importance because it can be misinterpreted as a lymph node or a tumor in radiography and cause difficulty in surgery. Although their development and function need further investigation, prior knowledge in anatomical variations can facilitate diagnosis and prevent any complications during surgical procedures.

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Conflicts of interest

There are no conflicts of interest.

Authors' contributions

Tawepong Arayapisit has contributed in conceptualization, data acquisition, data analysis, manuscript writing, and editing; Chakorn Vorakulpipat, in manuscript writing and editing; Natchalee Srimaneekarn, in data analysis and manuscript editing; Anupong Songsaad, in manuscript editing; and Varunya Chantadul, in data acquisition, data analysis, manuscript writing, and editing.

Ethical policy and institutional review board statement

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Patient declaration of consent

Not applicable.

Data availability statement

Data are available on request from Dr. Varunya Chantadul (e-mail: varunya.chn@mahidol.edu).

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