The human digastric muscle: Patterns and variations with clinical and surgical correlations

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Summary. The digastric muscle is located in the suprahyoid region on each side and frequently exhibits two muscular bellies (anterior and posterior) linked by an intermediate tendon. The paired digastric muscles act together either depressing the mandible or elevating the hyoid bone; therefore acting as a single muscle with important physiological roles. In the present study, the digastric muscle has been analyzed bilaterally in 74 adult human cadavers. A computerized morphometrical investigation of the digastric muscles has been performed (Image Pro Plus software package, Media Cybernetics, USA) and the resulting quantitative data have been statistically assessed (SPSS 11.0 for Windows, USA). We hereby propose an original morphological classification that encompasses five types (I–V) for the anterior belly (AB); three types (I–III) for the intermediate tendon (IT); and two types (I–II) for the posterior belly (PB) of the human digastric muscle. In each digastric muscle, the aforementioned anatomical types have been characterized according to the muscular bellies and intermediate tendon. Consequently, as a result of the combinations of those diverse types, individual digastric muscles have been considered as pertaining to distinctive morphological patterns (named from A to J). Cases with absence of either AB or PB have been included in patterns K and L and would be more appropriately defined as monogastric muscles. This innovative classification provides clear-cut anatomical parameters for interpreting morphological variants of the digastric muscle with relevant clinical and surgical correlations.

Key words: Anatomical variants – Skeletal muscle – Neck – Suprahyoid – Hyoid

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Introduction

Anatomical literature provides a relatively small amount of data on the variations of the digastric muscle and also does not focus on modern clinical and imaging aspects of human anatomy (Larsson and Lufkin 1987; Uzun et al. 2001). The digastric muscle has two bellies, of distinct embryological origins, linked by an intermediate tendon (Artiushkevich and Kholodnyi 1991; Sargon et al. 1999; Radianski et al. 2001). The digastric muscle lies below the mandible, and extends from the mastoid notch of the temporal bone to the digastric fossa of the mandible (Rouviere and Delmas 1985). The posterior belly, which is longer than the anterior one, is attached to the mastoid notch of the temporal bone, and slopes inferiorly and anteriorly to the intermediate tendon. The anterior belly is attached to the digastric fossa of the mandible close to the midline region, and slopes inferiorly and posteriorly in the direction of the intermediate tendon. The two bellies converge into a rounded tendon, which constitutes a fibrous sling that is attached to the body and greater horn of the hyoid bone (Testut and Jacob 1981). The paired digastric muscles act together either depressing the mandible or elevating the hyoid bone (Widmalm et al. 1988).

Anatomical variations of the digastric muscle are possibly implicated in pathological conditions as observed in CT and MR imaging (McMurtry and Yahr 1966; Michna 1989; Norton 1991; Holibkova and Machalek 1999; Peker et al. 2000; Uzun et al. 2001; Celik et al. 2002). Surgical advances in reconstructive buccomaxillofacial techniques have led to an increasing demand for more information concerning muscle variations that may provide an anatomical basis essential for therapeutic approaches. Therefore, it is necessary to recognize anatomic variants of the digastric muscle in order to avoid misjudgements when diagnosing abnormal lesions either on the floor of the mouth or in the submental region.

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The present research analyzes some of the patterns of anatomical variations involving the human digastric muscle, and proposes an original morphological classification for the human digastric muscle. In addition, we report a case of bilateral mentohyoid muscle (Macalister's muscle). This is an anatomical variation of the digastric muscle. Such anomalies should be remembered during surgical procedures and also in CT or MR imaging examinations involving the submental region.

Materials and methods

The present investigation was undertaken according to the bioethical regulations of the Brazilian Society of Anatomy and of the Brazilian Academy of Medicine. All morphological terms are in agreement with international anatomical regulations (Terminologica Anatomica 1998).

This study comprises anatomical dissections performed on 74 human adult cadavers (20–86 years of age, males N = 37, females N = 37) from the Department of Anatomy at the Federal University of Rio de Janeiro (Brazil) and from the Department of Anatomy of Souza Marques School of Medicine (Rio de Janeiro, Brazil). Cadavers were injected into their vascular bed, with a 10% formaldehyde solution. In order to analyze the morphology of the digastric muscle, systematic dissections of the anterolateral region of the neck were performed. External morphometry of the digastric muscle and anthropometric reference points were traced according to a morphometric methodology (Mandarim-de-Lacerda 1995). All measurements were performed with a precision calliper (Mitutoyo 0.05 mm, Japan) and the dissected regions were documented photographically. Linear and angular measurements were processed with an image software package (Image Pro Plus v. 4.0, Media Cybernetics, USA). The resulting data were analyzed with a statistical program (SPSS 11.0 for Windows, USA). Statistical analysis consisted of bivariate analysis of variance followed by univariate analysis of variance. The Duncan multiple range test was used to compare groups ($p < 0.01$). Schematic drawings of the digastric muscles were made in order to clarify some of the morphological types of the digastric muscle.

The following muscle morphometric data were studied: a) Length of the posterior belly of the digastric muscle (measured from its superior insertion either on the mastoid notch or on the styloid process and down to the posterior tip of the intermediate tendon); b) Length of the intermediate tendon (measured as the total length between the posterior and anterior tips of the intermediate tendon); c) Length of the anterior belly of the digastric muscle (from the anterior tip of the intermediate tendon to the superior insertion of the digastric muscle onto the mandible). In addition, we analyzed the width and thickness of each muscular belly and intermediate tendon assessed at the middle point of each portion of the digastric muscle. In this investigation we have also measured the interdigastric angle (between the anterior bellies on both sides) and the intradigastric angle (between the anterior and posterior bellies of the digastric muscle on the same side).

The following anthropometric measurements were additionally performed with the skull oriented according to the orbito-meatal (Frankfurt) plane: a) Mento-manubrium: distance from the mental (mentonian) point (at the tip of the chin in the median plane) to the jugular (suprasternal) notch (*suprasternal incisura*) of the manubrium of the sternum; b) Vertex-manubrium distance from the vertex (superior point of neurocranium) to jugular (suprasternal) notch of the manubrium of the sternum; c) Mento-mastoid distance from the mentonian point to the tip of the mastoid process of the temporal bone; d) Mastoid-manubrium distance from the tip of the mastoid process of the temporal bone to the jugular (suprasternal) notch of the manubrium of the sternum; e) circumference of the neck measured at the middle point of the mento-manubrium distance.

Results

Anatomical variations of the digastric muscle were observed and analyzed in this study. Based on these morphological variants we have proposed the following classification for the digastric muscle anatomy (Fig. 1). The anterior belly of the digastric muscle may be either absent or present. Absence of the anterior belly was noticed unilaterally in one male cadaver. When the anterior belly of the digastric muscle was present, the following five types of anatomical variants were seen (Fig. 2, top box):

- Anterior Belly (AB) Type I – One belly with origin on the inferior border of the mandible near the symphysis.
- Anterior Belly (AB) Type II – Two bellies with extra slips connected either to the mandible or to the mylohyoid muscle ipsi- and/or contralaterally.
- Anterior Belly (AB) Type III – Three bellies with extra slips connected either to the mandible or to the mylohyoid muscle ipsi- and/or contralaterally.
- Anterior Belly (AB) Type IV – Four bellies with extra slips connected either to the mandible or to the mylohyoid muscle ipsi- and/or contralaterally.

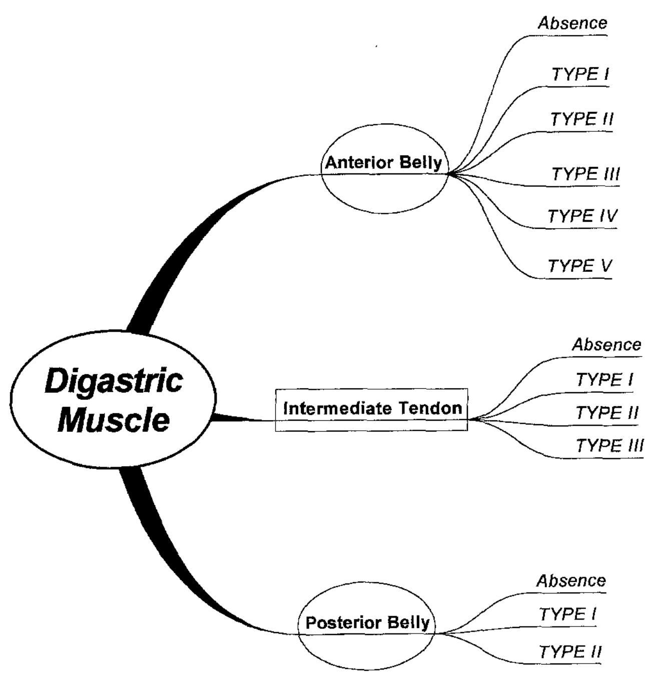

Fig 1. Schematic diagram of the morphological classification of the human digastric muscle.

- Anterior Belly (AB) Type V – Considering the extreme proximity between this variant type and the anterior belly of the digastric muscle, we have included in this classification a rare variation known as the mentohyoid muscle (Macalister's muscle), described frequently as an independent muscle (Macalister 1875). We have observed this variation bilaterally in one case, situated along the medial border of the anterior belly of the digastric, and extending between the body of the hyoid and the symphysis of the mandible (Fig 3).

The intermediate tendon of the digastric muscle may be either absent or present. Absence of the intermediate tendon was noticed in two cases. When the intermediate tendon of the digastric muscle was present, the following three types of anatomical variants were seen (Fig. 2 – middle box):

- Intermediate tendon (IT) Type I – The intermediate tendon seemed to pierce the stylohyoid muscle.
- Intermediate tendon (IT) Type II – The intermediate tendon was placed laterally (superficial) to the stylohyoid muscle.
- Intermediate tendon (IT) Type III – The intermediate tendon was placed medially (deep) to the stylohyoid muscle.

The posterior belly of the digastric muscle may also be either absent or present. Absence of the posterior belly was noticed unilaterally in one female cadaver. When the posterior belly of the digastric muscle was present, the

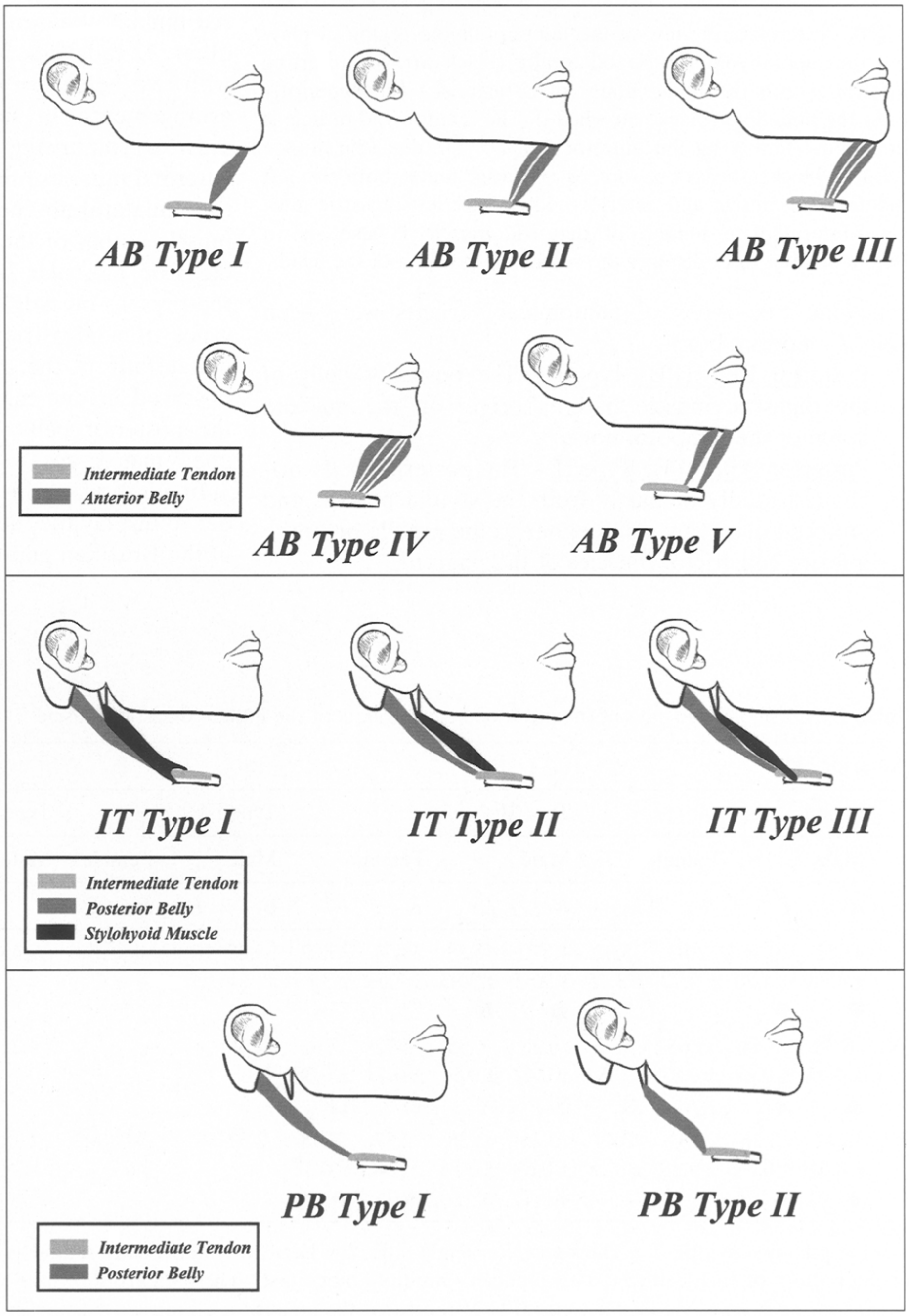

Fig. 2. Schematic representation of the observed variants of the human digastric muscle (bone landmarks displayed are: inferiorly, the hyoid bone; superiorly, the mandible and the styloid and mastoid processes). These two latter processes are only depicted in the middle and bottom boxes.
Top box: Anterior belly types from I to V. Intermediate tendon is represented in light gray and the anterior belly in dark gray.
Middle box: Intermediate tendon types from I to III represented in light gray; the posterior belly is shown in dark gray and the stylohyoid muscle in black.
Bottom box: Posterior belly types I and II shown in dark gray and the intermediate tendon is represented in light gray.

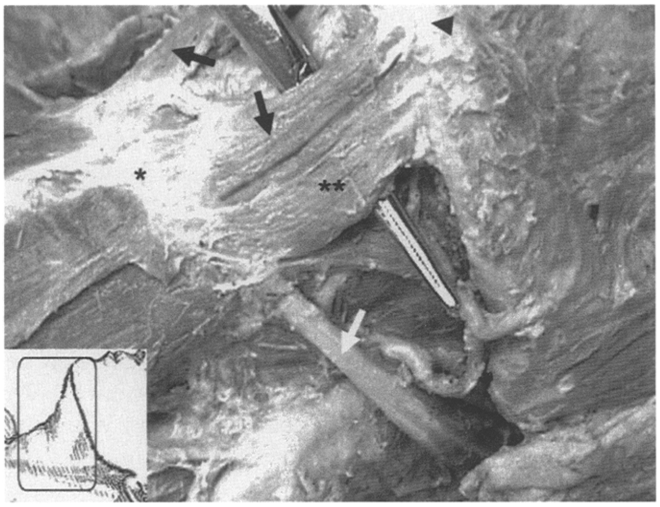

Fig. 3. Anterolateral view of the left suprahyoid region displaying the mentohyoid muscle bilaterally (black arrows) inserting inferiorly onto the hyoid bone (black asterisk) and superiorly onto the mandible (black arrowhead). The mentohyoid muscle is bounded laterally by the anterior belly of the digastric muscle (double black asterisks; a forceps is placed under both the left mentohyoid muscle and anterior belly of the left digastric muscle). Intermediate tendon of digastric muscle is also shown (white arrow). Inset displays the respective position of the head.

following two types of anatomical variants were seen (Fig. 2 – bottom box):

- Posterior Belly (PB) Type I – The posterior belly of the digastric muscle had its origin on the mastoid notch of the temporal bone.
- Posterior Belly (PB) Type II – The posterior belly originated totally or partly from the styloid process and attached or not by a slip either to the middle or to the inferior constrictor muscles of the pharynx.

In this investigation, morphometric data on the digastric muscle are presented according to an original morphological classification that encompasses anterior belly variant types (Table 1); intermediate tendon variant types (Table 2); and posterior belly variant types (Table 3).

Gross anatomy of the digastric muscle, analyzed in this study, revealed the existence of distinct digastric muscle arrangements, that were grouped in patterns A to J (Table 4), and the data were expressed based on their frequencies in groups of morphological patterns, according to the sexual and laterality distribution (unilateral or bilateral variation). In addition two other patterns were noticed: pattern **K** (in which the digastric muscle did not exhibit an anterior belly); and pattern **L** (in which there was an absence of the posterior belly). We analyzed 74 human cadavers of both sexes and, in only two occurred unilateral absences of one of the digastric bellies. All other 72 cadavers presented bilateral digastric muscles with two bellies on each side and diverse morphological arrangements. In sum, we have analyzed 146 digastric muscles comprising 144 muscles from 72 cadavers, and 2 normal muscles present in the individuals who exhibited the unilateral absence of a digastric belly. The remaining muscle bellies of the two variant types with absence of a digastric muscular belly were arbitrarily discarded from the present investigation. The two variant cases with absence of a digastric muscular belly included a) absence unilaterally of the anterior belly of the digastric muscle observed in one male corpse; b) absence unilaterally of the posterior belly of the digastric muscle observed in one female corpse.

In addition, anthropometric data were measured in order to display the morphological analysis of these samples of the Brazilian population (Table 5).

Table 1. Morphometric data of the anterior belly variants of the human digastric muscle

Anterior belly																				
	Type I				Type II				Type III				Type IV				Type V			
	Male		Female		Male		Female		Male		Female		Male		Female		Male		Female	
	R	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*
L	41.62 ± 4.78 ●	39.35 ± 4.26 ●	32.83 ± 2.77 ❍	33.32 ± 3.25 ❍	42.70 ± 2.65 ■	43.28 ± 3.83 ■	34.54 ± 3.53 □	33.82 ± 3.49 □	38.65	–	–	–	39.45	–	–	–	31.20 ⊙	30.42 ⊙	–	–
W	8.38 ± 0.45 ▲	8.44 ± 0.69 ▲	5.65 ± 0.87 △	5.73 ± 0.52 △	6.28 ± 0.42 ⊠	6.35 ± 0.51 ⊠	5.72 ± 0.47 ◘	5.61 ± 0.68 ◘	4.38	–	–	–	4.25	–	–	–	6.41 ✻	6.35 ✻	–	–
T	3.17 ± 0.57 ◆	3.26 ± 0.32 ◆	2.35 ± 0.35 ◇	2.44 ± 0.18 ◇	3.25 ± 0.61 ✻	3.38 ± 0.54 ✻	2.57 ± 0.48 ◈	2.48 ± 0.32 ◈	2.37	–	–	–	2.18	–	–	–	2.32 ◈	2.30 ◈	–	–

L = Length; W = Width; T = Thickness, *R* = Right side; *L* = Left side. Statistically similar groups are identified with the same symbol at the bottom of each cell ($p < 0.01$, Duncan's multiple range test). The data are shown as Mean (mm) ± SEM (Standard Error of the Mean) for each type. Values for types II to V represent the means for all muscle slips observed.

Discussion

This investigation proposes an original morphological classification for the human digastric muscle, based on the various arrangements of anatomic types observed in each portion of the digastric muscle. Distinct digastric muscle arrangements were grouped in patterns from **A** to **J** (Table 4), and the data were expressed based on their frequencies in groups of morphological patterns with distribution according to sex and laterality (unilateral or bilateral variation). In addition, two other exceptional patterns were noticed: pattern **K** (the digastric muscle with absence of the anterior belly); and pattern **L** (the digastric muscle with absence of the posterior belly).

Embryology of the human digastric muscle: A plausible explanation for morphological diversity. The human digastric muscle has two bellies, with distinct embryological origin, linked by an intermediate tendon (Radlanski et al. 2001). The striated muscles of the face and neck, sometimes described as branchiomeric because of their origin within the pharyngeal (branchial) arches, develop from a rostral continuation of the paraxial mesenchyme, which in the trunk, segments to form somites. The muscle mass of the first branchial arch forms the tensor tympani, tensor veli palatini and the masticatory muscles (temporalis, masseter, pterygoids), as well as the mylohyoid muscle and the anterior belly of the digastric muscle – all these muscles are supplied by the mandibular nerve, the largest

Table 2. Morphometric data of the intermediate tendon variants of the human digastric muscle.

Intermediate tendon												
	Type I				Type II				Type III			
	Male		Female		Male		Female		Male		Female	
	R	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*	*R*	*L*
L	40.2 ± 3.78 ●	41.50 ± 4.28 ●	27.42 ± 4.32 ❍	28.65 ± 3.92 ❍	38.53 ± 4.55 ■	39.26 ± 3.27 ■	27.83 ± 3.42 □	29.32 ± 3.53 □	42.78 ± 3.03 ⊙	43.93 ± 3.92 ⊙	32.72 ± 3.35 ⦸	31.90 ± 2.38 ⦸
W	5.55 ± 0.85 ▲	5.72 ± 0.93 ▲	3.85 ± 0.97 △	3.97 ± 0.83 △	5.80 ± 0.75 ⊠	5.76 ± 0.92 ⊠	3.55 ± 0.73 ▢	3.64 ± 0.83 ▢	5.63 ± 0.71 ✻	5.54 ± 0.79 ✻	3.51 ± 0.95 ▣	3.45 ± 0.87 ▣
T	2.88 ± 0.46 ◆	2.84 ± 0.35 ◆	2.14 ± 0.26 ◇	2.21 ± 0.32 ◇	2.49 ± 0.58 ❊	2.53 ± 0.44 ❊	2.31 ± 0.48 ◈	2.27 ± 0.34 ◈	2.52 ± 0.45 ⟐	2.63 ± 0.78 ⟐	2.32 ± 0.35 ⊡	2.48 ± 0.42 ⊡

L = Length; W = Width; T = Thickness, *R* = Right side; *L* = Left side. Statistically similar groups are identified with the same symbol at the bottom of each cell ($p < 0.01$, Duncan's multiple range test). The data are shown as Mean (mm) ± SEM (Standard Error of the Mean).

Table 3. Morphometric data of the posterior belly variants of the human digastric muscle

Posterior belly								
	Type I				Type II			
	Male		Female		Male		Female	
	R	*L*	*R*	*L*	*R*	*L*	*R*	*L*
L	52.73 ± 3.58 ●	53.13 ± 3.92 ●	42.53 ± 3.82 ❍	42.27 ± 3.78 ❍	55.92 ± 5.25 ■	56.48 ± 5.61 ■	46.42 ± 3.83 □	46.20 ± 3.23 □
W	10.42 ± 0.52 ▲	10.37 ± 0.41 ▲	8.62 ± 0.43 △	8.25 ± 0.37 △	10.83 ± 0.48 ⊠	10.27 ± 0.65 ⊠	8.86 ± 0.72 ▢	8.62 ± 0.54 ▢
T	4.35 ± 0.28 ◆	4.16 ± 0.22 ◆	3.65 ± 0.21 ◇	3.53 ± 0.38 ◇	4.32 ± 0.29 ❊	4.41 ± 0.45 ❊	3.53 ± 0.34 ◈	3.43 ± 0.25 ◈

L = Length; W = Width; T = Thickness, *R* = Right side; *L* = Left side. Statistically similar groups are identified with the same symbol at the bottom of each cell ($p < 0.01$, Duncan's multiple range test). The data are shown as Mean (mm) ± SEM (Standard Error of the Mean).

trigeminal nerve (cranial nerve) division (Moore and Dalley 1999).

The second branchial arch forms the following muscles: the occipitofrontalis, the stylohyoid, the stapedius, the auricular muscles, the platysma and the posterior belly of the digastric muscle – all these muscles are supplied by the facial nerve (VII cranial nerve) (Gray 1995).

Such distinct embryological origin offers a plausible explanation for the diversity of morphological arrangements of the digastric muscle, because the human digastric mus-

Table 4. Distinct human digastric muscle morphological patterns (A to J) with respective muscular arrangements. Data are expressed according to sex and laterality distribution (unilateral or bilateral variation). Two other patterns were also noticed (but are not shown since they are more appropriately classified as monogastric muscles): pattern K (the digastric muscle with anterior belly absence); and pattern L (the digastric muscle with posterior belly absence).

Digastric muscle		Number of digastric muscles	Percentage of total cases	Unilateral cases		Bilateral cases	
Pattern	Arrangement		(N = 146)	*M*	*F*	*M*	*F*
A	AB Type I IT Type I PB Type I	53 (M) 43 (F)	65.75	5	5	48	38
B	AB Type II IT Type I PB Type I	3 (M) 5 (F)	5.48	1	3	2	2
C	AB Type III IT Type I PB Type I	1 (M)	0.68	1	–	–	–
D	AB Type IV IT Type I PB Type I	1 (M)	0.68	1	–	–	–
E	AB Type V IT Type I PB Type I	2 (M)	1.37	–	–	2	–
F	AB Type I IT Type II PB Type I	6 (M) 8 (F)	9.59	2	4	4	4
G	AB Type I IT Type II PB Type II	2 (M) 4 (F)	4.11	–	2	2	2
H	AB Type I IT Type III PB Type I	4 (M) 8 (F)	8.22	2	4	2	4
I	AB Type II IT Type II PB Type II	1 (M) 3 (F)	2.74	1	1	–	2
J	AB Type II IT Type III PB Type III	2 (F)	1.37	–	–	–	2

Table 5. Complementary anthropometric data of the anatomic samples analysed in this study.

Mental manubrium (mm)		Vertex manubrium (mm)		Mental mastoid (mm)		Mastoid manubrium (mm)		Neck circumference (mm)		Interdigastric angle (degree)		Intradigastric angle (degree)	
M	*F*	*M*	*F*	*M*	*F*	*M*	*F*	*M*	*F*	*M*	*F*	*M*	*F*
143.72 ± 24.58	104.54 ± 32.74	315.63 ± 34.55	277.63 ± 43.52	184.45 ± 32.23	136.65 ± 37.92	183.32 ± 35.84	154.85 ± 28.81	421.24 ± 65.84	355.76 ± 54.82	27.26 ± 4.38	23.49 ± 2.73	122.84 ± 8.35	119.83 ± 6.82

M = Male; *F* = Female. The following anthropometric measurements were performed with the skull oriented according to the orbitomeatal (Frankfurt) plane. Data shown are Mean ± SEM (Standard Error of the Mean).

cle is in fact the result of the union of two embryologically distinct muscles that are linked by an intermediate tendon, thus forming anterior and posterior bellies.

Gross Anatomy: The variant digastric morphologies. The digastric muscles are relevant topographical elements in the anterolateral region of the neck. The anterior belly of the digastric muscle is located along the inferior aspect of the mylohyoid muscle and is covered by the superficial layer of the deep cervical fascia. The anterior belly is supplied by the mylohyoid nerve, a branch of the inferior alveolar nerve, and is vascularized by branches of the submental artery (Testut and Latarjet 1979). We did not observe the contribution of the facial nerve to the anterior belly reported recently by a Japanese study (Kawai et al. 2003).

In this study, absence of the anterior belly was noticed unilaterally in one female cadaver. When the anterior belly of the digastric muscle was present, the following five types of anatomical variants were seen; a) Anterior Belly (AB) Type I – One belly with origin on the inferior border of the mandible near the symphysis; b) Anterior Belly (AB) Type II – Two bellies with extra slips connected to the mandible or to the mylohyoid muscle ipsi- and/or contralaterally; c) Anterior Belly (AB) Type III – Three bellies with extra slips connected to the mandible or to the mylohyoid muscle ipsi- and/or contralaterally; d) Anterior Belly (AB) Type IV – Four bellies with extra slips connected to the mandible or to the mylohyoid muscle ipsi- and/or contralaterally; e) Anterior Belly (AB) Type IV – We have included in this classification the mentohyoid muscle (Macalister's muscle) (Macalister 1875), that we have observed bilaterally in one case. We did not find the Mori's "ape" type in which atypical anterior bellies of the digastric were described in a Japanese study (Mori 1964). We observed unilateral anterior belly morphological variants in types III and IV in male cadavers. The anterior bellies type V (the mentohyoid muscle) were seen bilaterally in a single male cadaver (Table 1).

The intermediate tendon of the digastric muscle is associated superficially with the submandibular gland. The facial artery runs deep to the posterior belly of the digastric muscle and exits along the superior border of the submandibular gland between the intermediate tendon and the lower margin of the mandible. A wide aponeurotic layer named the suprahyoid aponeurosis originates from the tendon and attaches to the body of the greater horn of the hyoid bone.

We noticed the absence of the intermediate tendon in two cases. When the intermediate tendon of the digastric muscle was present, the following three types of anatomical variants were seen: a) Intermediate tendon (IT) Type I – The intermediate tendon seemed to pierce the stylohyoid muscle; b) Intermediate tendon (IT) Type II – The intermediate tendon was located lateral (superficial) to the stylohyoid muscle; c) Intermediate tendon (IT) Type III – The intermediate tendon was located medial (deep) to the stylohyoid muscle. The intermediate tendon participates along with the posterior margin of the mylohyoid muscle and with the hypoglossal nerve (XII cranial nerve) in the formation of an important anatomical triangle – the triangle of the lingual artery (Pirogoff's triangle) – in which it is possible to incise the hyoglossus muscle in order to ligate a bleeding lingual artery (Homze et al. 1997). Another important surgical triangle is known as the Béclard's triangle in which it is possible to access deep structures in the neck. This triangle is limited superiorly by the posterior belly of the digastric muscle, inferiorly by the greater horn of the hyoid and posteriorly by the posterior border of the hyoglossus muscle (Paturet 1964).

The absence of the posterior belly of the digastric muscle was noticed unilaterally in one female cadaver. In this case the stylohyoid muscle exhibited a noticeable increase in volume, probably representing the stylomandibularis muscle that results from a fusion between the posterior belly and the stylohyoid muscle (Macalister 1871). When the posterior belly of the digastric muscle was present, the following two types of anatomical variants were seen: a) Posterior Belly (PB) Type I – The posterior belly of the digastric muscle had its origin on the mastoid notch of the temporal bone; b) Posterior Belly (PB) Type II – The posterior belly originated totally or partly from the styloid process and attached or not by a slip either to the middle or to the inferior constrictor muscles.

The length and width of the three portions of the digastric muscle were statistically different between male and female cadavers, with higher values observed in the male ones (Table 1, Table 2 and Table 3). In general, the length of the posterior belly of the digastric muscle was statistically different from that of the anterior belly. In addition, no differences were observed between left and right digastric muscle in each type. The most frequent form of the human digastric muscle, frequently named as "normal", is the morphological pattern A in our classification (AB type I, IT Type I, PB Type I), and it was in fact observed in the majority of the analyzed cases (65.75%). Series of complementary anthropometric measurements were additionally performed with the skull oriented according to the orbitomeatal (Frankfurt) plane and the data are presented in order to clarify the morphological interpretation of the findings observed in these anatomic samples of the Brazilian population (Table 5).

Clinical, surgical and radiological relevance of this study. Head and neck surgical procedures are strictly dependent on a solid human anatomical basis, mainly in cases of invasive tumors. The lymphatic system of the head and neck consists of numerous lymph nodes connected by afferent and efferent vessels. The lymphatic flow terminates in the thoracic duct on the left and the right lymphatic duct on the right (Bouchet and Cuilleret 1979). According to the American Head and Neck Society there are six levels and six sublevels of the lymph node groups in the neck (Robbins et al. 2002), and the digastric muscle is related to the levels I and II. Using radiologic landmarks, level I includes all of the lymph nodes that are located above the level of the lower body of the hyoid bone, inferior to the mylohyoid muscles, and also anterior to a transverse line drawn on through the posterior edge of the submandibular gland. We have observed lymph nodes that lie between the medial margins of the anterior bellies of the digastric muscles that correspond to the sublevel I A (submental nodes). In addition, we have found a characteristic distribution of lymph nodes corresponding to level I B (submandibular nodes) that lie below the mylohyoid muscle, above the level of the lower body of the hyoid bone, posterior and lateral to the medial edge of the anterior belly of the digastric muscle. An important radiologic correlation is that often the submandibular nodes are anterior to a transverse line drawn on neck axial images at a tangent to the posterior surface of the submandibular gland on each side of the neck. We have also noticed lymph nodes in close relation to the posterior belly of the digastric muscle, extending from the skull base, at the bony margin of the jugular fossa, to the lower body of the hyoid bone – those nodes are included in the level II group of lymph nodes, specifically sublevels II A and II B (comprising the superior jugular nodes). Level II nodes lie anterior to a transverse line drawn on neck axial images through the posterior edge of the sternocleidomastoid muscle and lie posterior to a transverse line drawn on neck axial scans through the posterior edge of the submandibular gland. The superior jugular group of lymph nodes is located on the undersurface of the posterior belly of the digastric muscle. This latter lymphatic group is a common site for metastases of carcinomas of the upper aerodigestive tract.

Surgical implications during either the ligation of the external carotid artery or in emergency interventions on patients with penetrating wounds in the neck (with venous air embolization due to internal jugular vein laceration) reinforce the relevance of the morphological variations of the digastric muscle in vascular surgeries (Mock et al. 1991).

Regional and free flaps and grafts for reconstruction of the head and neck are important elements either in buccomaxillofacial or in plastic surgery techniques. In those procedures, muscles are classified into five types on the basis of the number of vascular pedicles and their relative dominance within the muscle (Mathes and Nahai 1981). It is important to understand the anatomical basis for the application of innervated and vascularized muscle transfers involving the digastric and stylohyoid muscles in the treatment of velopharyngeal incompetence. In this investigation we observed for all digastric muscle variants that a neurovascular pedicle is located in the cranial third of the muscle bellies – this fact provides helpful hints during operative procedures (Tan 2002). The muscle transposition is combined with the classic Wardill-Kilner operation to lengthen the soft palate. The transferred muscles have to avoid scar contraction and shortening of the soft palate and to gain a muscular function role adequate to the proper functioning of the soft palate (Karcher et al. 1992).

Another important surgical correlation of this study is the Valentin's nerve injury. The mylohyoid nerve, a branch of the inferior alveolar nerve, gives rise to many motor and sensory branches. Motor branches innervate the anterior belly of the digastric muscle. Sensory branches innervate the submandibular gland and also the skin just under the chin. Valentin's nerve, the terminal cutaneous branch of the mylohyoid nerve (described by Valentin in 1843) can be damaged by horizontal mentoplasty (sliding-mentoplasty). Sensory disorders (hypoesthesia, anesthesia) can occur in case of Valentin's nerve injury without lesions to the mental nerve (Guyot et al. 1998).

Our results show the occurrence of anatomical variations concerning the adult human digastric muscle. We propose an original morphological classification for anatomical variations of the digastric muscle that may be a relevant issue when dealing with head and neck surgical dissections, as well as plastic surgery reconstructive procedures and medical imaging examinations.

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