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The Digastric Muscle: Its Anatomy and Functions Revisited

El Músculo Digástrico: Revisión de su Anatomía y Funciones

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SUMMARY: As one of the suprahyoid muscles, the digastric muscle is characterized by two separate bellies of different embryologic origins. The origin of the anterior belly is the digastric fossa, while the origin of the posterior belly is the mastoid notch. They share a common insertion: the intermediate tendon. When the digastric muscle contracts, the hyoid bone is raised. Opening of the jaw and swallowing of food boli are associated with digastric muscle activity. This review discusses the general anatomic features of the digastric muscle and its variation, primary functions, and clinical implications focused on surgical reconstruction and rejuvenation.

KEY WORDS: Digastric muscle; Anatomy; Suprahyoid muscles.

INTRODUCTION

The name “digastric” means “two bellies,” referring to a characteristic morphological feature of the digastric muscle. There are other muscles that have two separate bellies, including the omohyoid and the occipitofrontalis. The two bellies of the digastric muscle have different embryologic origins despite their common nomenclature; therefore, their innervation is different. The digastric muscle is one of four suprahyoid muscles and exists as a pair (Truong *et al*., 2022: Kim *et al*., 2023). The primary actions of this muscle are involved in chewing and deglutition. The muscle has been comprehensively studied regarding their function partly and probably because it is located quite superficially, and thus is easy to investigate. Clinically, the muscle has attracted attention mainly from the surgical perspective, with regard to maxillofacial reconstruction and neck rejuvenation. In the present article, the basic anatomic features and anomalies of the digastric muscle are summarized and the literature on its functions will be reviewed. Clinical implications will also be discussed.

General Anatomy (Figs. 1 and 2). The digastric muscle, as its name indicates, is composed of two separate bellies: the anterior and the posterior. The two bellies are united by an intermediate tendon. The posterior belly is longer than the anterior. The muscle exists as a pair; right and left, and is located below the mandibular body and above the hyoid bone. The main action of the muscle is to elevate the hyoid bone (Ahlgren & Lipke, 1977). If the hyoid bone is fixed by other muscles, such as the infrahyoid groups, it acts to open the mandible.

The number of muscle spindles in the digastric muscle is known to be small probably because of its limited proprioceptive importance compared to closing muscles (Lennartsson, 1979, 1980; Saverino *et al*., 2014). Type II muscle fibers are predominant, which is suitable for rapid acceleration in mandibular movements (Eriksson *et al*., 1982; Eriksson & Thornell, 1983). The digastric anterior belly is composed primarily of conventional myosin heavy-chain isoforms (Luo *et al*., 2014).

Interestingly, one morphometric study reported longer left-side muscle bellies compared to the contralateral side among men, which were longer compared to both sides in women (Zdilla *et al*., 2016). Although several studies sought to identify an association between facial morphology and

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activity in the head, neck and trunk muscles including the digastric muscle, no definitive conclusions could be drawn (Adachi *et al*., 1989; Tecco *et al*., 2010,2011).

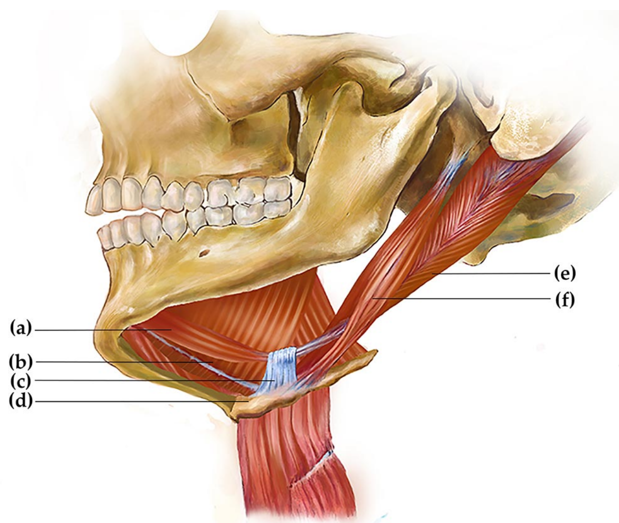

Fig. 1. Suprahyoid muscles (a). anterior belly of digastric muscle, (b). mylohyoid muscle, (c). intermediate tendon, (d). hyoid bone, (e). posterior belly of digastric muscle, (f). stylohyoid muscle.

Origin, insertion and direction. The origin of the anterior belly is the digastric fossa, which is a depression at the inner side of the mandible near the midline and the lower margin. The belly runs downward and backward and inserts into the intermediate tendon. The origin of the posterior belly is the mastoid notch of the temporal bone. The mastoid notch is a groove lying medial to the mastoid process and lateral to the styloid process that is located on the skull inferior surface. The belly slopes downward and forward and inserts into the intermediate tendon (Larsson & Lufkin, 1987). The intermediate tendon is a fibrous sling connected with the hyoid bone body and greater cornu as a common end point of the broad aponeurotic layer of the two bellies (Standring, 2016). The tendon generally perforates the stylohyoid muscle and occasionally is lined by a synovial sheath. It is related at the superior surface of the hyoglossus. Although the digastric muscle exists in many other mammals, the site of attachment is known to vary (Dean, 1984).

Embryologic development. The two bellies of the digastric muscle have different origins. The anterior originates from the first branchial arch, whereas the posterior originates from the second branchial arch (Ziolkowski *et al*., 1984). Their separate derivations from the embryogenic mesenchyme explain the different innervations of the two bellies, which will be described in the next section (Coquerelle *et al*., 2013).

Arterial supply and innervation. The anterior belly is supplied with arterial blood primarily via the submental branch of the facial artery; the posterior belly receives the arterial supply by the occipital artery and posterior auricular artery (Tang *et al*., 2011). The anterior belly is innervated by the mylohyoid branch of the inferior alveolar nerve and the posterior belly is supplied by the facial nerve (Standring, 2016).

Anatomic relations. The stylohyoid, sternocleidomastoid, platysma, splenius capitis and longissimus capitis muscles are all located superficial to the digastric. In addition, the parotid gland, submandibular gland, retromandibular vein and the mastoid process are also situated superficial to this muscle. Occurring medial to the digastric posterior are the hyoglossus, superior oblique and rectus capitis lateralis, whereas the mylohyoid is medial to the digastric anterior. There are also many important anatomic structures medial to the posterior belly; the transverse process of atlas, the internal carotid artery and internal jugular vein, the external

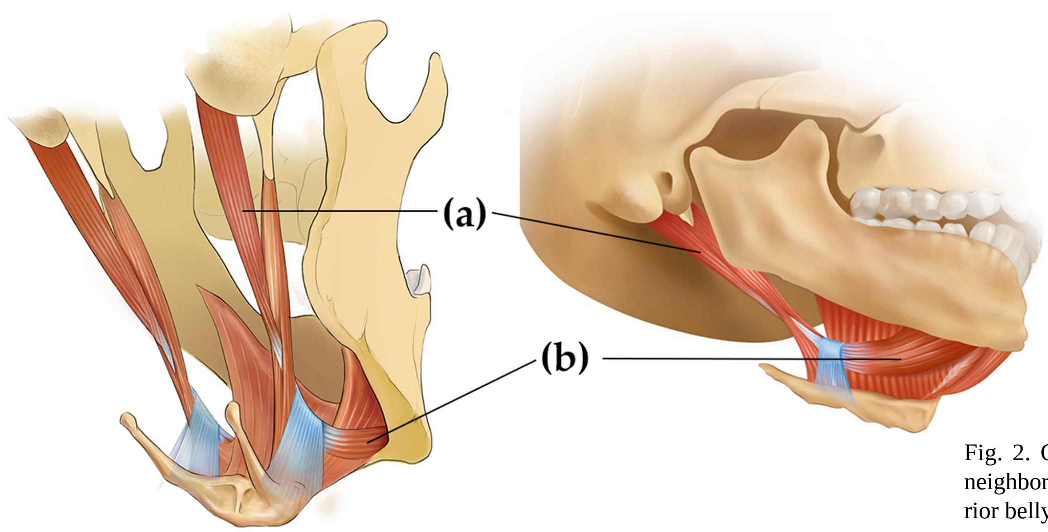

Fig. 2. Geniohyoid muscle and neighboring structures (a). posterior belly, (b). anterior belly.

carotid artery and its branches (occipital, facial and lingual arteries) and the 11th and 12th cranial nerves (Larsson & Lufkin, 1987). During anterograde parotidectomy, the posterior belly is occasionally used as a reference structure to locate the facial nerve trunk (Rea *et al*., 2010). Incidental compression of the internal jugular vein and external carotid artery by the digastric muscle has also been reported (McMurtry & Yahr, 1966; Jayaraman *et al*., 2012).

Relation to the anatomic triangle. The margin line between the anterior and posterior triangle of the neck is the anterior margin of the sternocleidomastod muscle. The anterior triangle of the neck contains two suprahyoid muscles (the digastric and stylohyoid) and all four of the infrahyoid muscles. The anterior triangle is further classified into suprahyoid and infrahyoid areas by the hyoid bone. The four subdivisions into digastric, submental, muscular and carotid triangle is made by the digastric and omohyoid passage, both of which have two muscle bellies. The digastric muscle contributes in dividing the anterior triangle into three smaller triangles. The digastric triangle is bounded by the two bellies of the digastric muscle and the line connecting the inferior margin of the mandible to the mastoid process (Vadgaonkar *et al*., 2012). The superficial part of the submandibular gland lies in this triangle. The submental triangle is bordered by both the anterior bellies of the left and right digastric muscle and the base is the hyoid bone body. The carotid triangle has superior margin of the digastric posterior with the stylohyoid. Several other anatomic triangles have been coined according to the descriptive needs of anatomy or surgery (Tubbs *et al*., 2011).

Relation to potential spaces. The submental space has lateral boundaries of left and right digastric muscles (Rani *et al*., 2013). The submandibular space is located between the two bellies of the digastric and it communicates with sublingual space over the posterior margin of the mylohyoid (Standring, 2016).

Anatomic variations. The digastric muscle exhibits considerable anatomic variation (Pradistassanee & Pariyakanok, 1975; Larsson & Lufkin, 1987; Yamazaki *et al*., 2011). Atypical fibers at the insertion site are not rare; aberrant bundles of this muscle are also common, such that subsequent submental asymmetry can be confused with pathological conditions (Ozgur *et al*., 2010, 2007a,b).

The anterior belly may fuse with the mylohyoid, (Reyes *et al*., 2007). and an accessory head of the anterior belly exists quite frequently (Traini, 1983; Reyes *et al*., 2007; Bang *et al*., 2015; Harvey *et al*., 2015). Even bilateral quadrification of the digastric anterior has been reported (Ozgur *et al*., 2007a). Unilateral hypoplasia of the digastric anterior was also observed (Ochoa-Escudero & Juliano, 2016). Furthermore, the agenesis incidence of the digastric anterior is high in patients with hemifacial macrosomia (MacQuillan *et al*., 2010).

The posterior belly of the digastric may insert into the styloid process or be connected to the pharyngeal constrictor muscle by a slip. A unique case of duplicated digastric posterior running into the infrahyoid muscles was once reported with absence of the omohyoid (Zhao *et al*., 2015). The intermediate tendon may lack. In addition, ectopic submandibular gland, a rare phenomenon, was reported in association with atrophy of the digastric and mylohyoid muscles, which was assumed to represent an abnormal migration of the gland due to the muscle maldevelopment (Hansmann & Lingam, 2011).

Functions. As the digastric contracts, the hyoid bone is pulled and elevated. When the infrahyoid muscles act to maintain the hyoid bone's position, contraction of the digastric muscle opens the mandible. Electromyography (EMG) is the most commonly used method of investigating the functions of the digastric and other suprahyoid muscles (Carlsoo, 1956; Ahlgren & Lipke, 1977; Ahlgren *et al*., 1978). Chewing and swallowing are the primary functions associated with the digastric muscle (Munro, 1972, 1974). Ultrasound is also frequently used to explore digastric function (Shawker *et al*., 1984). The digastric muscle has also been included in speech research (Painter, 1976; Sowman *et al*., 2009). An unusual high-frequency tremor of the digastric muscle occasionally occurs (Sowman *et al*., 2008). Postural reflex of this muscle is observed upon dorsal and ventral flexion of the head (Bratzlavsky & Eecken, 1977). A motion simulator capable of recreating mandibular movements incorporating various muscles including the digastric has been developed to create an intact temporomandibular joint and total joint prosthesis (Celebi *et al*., 2011).

Chewing. Chewing is a highly coordinated movement (Ishii *et al*., 2016). With regard to chewing movement, the digastric muscle has been studied using a wide variety of methodologies including EMG, ultrasound, magnetic resonance imaging (MRI), and physiological cross-sectional area measurement (Pearson Jr. *et al*., 2011; Macrae *et al*., 2013; Sierpinska *et al*., 2015; Hughes & Watts, 2016). Muscle activity changes according to the food consistency during the chewing.

The digastric anterior is highly activated when chewing triturated food and less activated when chewing liquid (Inokuchi *et al*., 2016). In patients with unilateral mastication, the average electrical peak and mandible displacement of the digastric muscle was lower compared to patients with bilateral mastication in a surface EMG study (Jia *et al*., 2016). Furthermore, patients with an anterior open bite exhibited higher activation of the digastric muscle on the balancing side during chewing and lower activation during clenching compared to normal subjects (Forrester *et al*., 2010; Yousefzadeh *et al*., 2010). In a study investigating the condylar position and EMG patterns in a deliberate forward head posture, the activity of the digastric muscles was increased (Ohmure *et al*., 2008).

In denture wearers, the activity is reduced compared to dentate subjects; the activity of the digastric muscle decreases especially in new denture wearers due to the increase in the vertical occlusal dimension (Dantas & Dodds, 1990; Sierpinska *et al*., 2009; Uram-Tuculescu *et al*., 2015).

Swallowing. Suprahyoid muscles and pharyngeal muscles take part in deglutition actively (Pearson Jr. *et al*., 2013). A critical point is hyolaryngeal complex elevation to open the upper esophageal sphincter (Pearson Jr. *et al*., 2012). The two bellies have similar patterns of activation with high amplitude of short duration in swallowing. However, they are not active synchronously (Widmalm *et al*., 1988). In drinking movement, the digastric anterior is activated simultaneously with the geniohyoid and masseter, while the masseter contracts earlier than the other two muscles when swallowing solid food (Inokuchi *et al*., 2014). During the process of swallowing, the increase in tongue-to-palate pressure coincides with the increase in digastric anterior activity (Palmer *et al*., 2008). The EMG burst of the digastric anterior lasts until tongue pressure offset (Ono *et al*., 2009). According to an MRI study, the digastric posterior initiates swallowing with the stylohyoid and mylohyoid (Pearson Jr. *et al*., 2012; Okada *et al*., 2013). Notably, women exhibited higher activity of the digastric in deglutition in an EMG study (Moreno *et al*., 2008).

Clinical implications

Surgical reconstruction. For the reconstruction of oro-maxillofacial defects especially those in the floor of mouth, the digastric muscles can be exploited (Suzuki *et al*., 2008). A pedicled submental flap including the digastric muscle is often indicated for closure of defects (Zwetyenga *et al*., 2007). Submental artery perforator island flap surgery is also frequently utilized (Cheng & Bui, 2014). Although it is advantageous to include the digastric muscle when protecting the vascular pedicle, this muscle is sometimes excluded to keep the flap thinner (Mutlu *et al*., 2016). The digastric muscle is occasionally used as a regional combined muscle flap with cross-facial nerve grafting during babysitter procedures in facial paralysis (Terzis & Tzafetta, 2009a,b). After resection of the anterior mandibular arch in patients with oral cancer, the tongue tends to fall behind. Thus, suspension of the tongue to the intermediate tendon can help eliminate the need for tracheostomy (Pandey, 2012).

Neck rejuvenation surgery. The digastric anterior muscle is considered important in many neck rejuvenation surgeries (Zdilla *et al*., 2016). A disproportionately large neck is a cosmetic problem caused by subplatysmal structures such as fat, submandibular glands and the digastric muscle, and it is difficult to address the problem of obtuse cervical angle (Langsdon *et al*., 2013). The digastric muscle is quite frequently removed for elimination of a prominent platysma band (Guyuron *et al*., 2010). Numerous surgical techniques have been developed and reported to enhance cosmetic results, and each has advantages and disadvantages (Citarella *et al*., 2010). In order to improve neck contours, structures are reshaped or repositioned sometimes under the name of subplatysmal necklift (Auersvald *et al*., 2017). The digastric muscle is sutured to the mylohyoid like a corset after lipectomy, which has been called the digastric corset technique (Labbe *et al*., 2013). However, some surgeons don't perform any procedures on the digastric (de Castro *et al*., 2012).

Subplatysmal fat is occasionally located very deep in the digastric anterior and submandibular gland (Larson *et al*., 2014). Identifying its location in relation to the platysma, digastric and mylohyoid is very important for successful surgical outcomes (Rohrich & Pessa, 2010). The usefulness of ultrasound was suggested during the diagnosis stage for this purpose (Mashkevich *et al*., 2009).

Miscellaneous. The majority of fibromyalgia patients reported pain of the digastric muscles as a symptom of temporomandibular disorder (TMD) (Fraga *et al*., 2012). Interestingly, the temperature of the digastric muscle increases substantially after occlusal splint therapy in patients with TMD (Barao *et al*., 2011). Fixed orthodontic treatment can improve myofascial pain in the digastric anterior (Tecco *et al*., 2012). The digastric muscle was investigated with regard to myogenous facial pain occurrence during the eye opening and closing (Monaco *et al*., 2010).

Patients with oromandibular dystonia present with involuntary jaw movements and dystonic activity of the digastric is reported frequently (Bakke *et al*., 2013). In the management of oromandibular dystonia, the botulinum toxin appeared to be effective (Sinclair *et al*., 2013). After mandibular advancement surgery, the digastric anterior exhibited unpredictable adaptations as an antagonist to the jaw-closing muscles, which was measured using maximum cross-sectional area (Dicker *et al*., 2008).

CONCLUSIONS

Literature on the digastric muscles was comprehensively reviewed from the perspective of basic anatomy, function and clinical implications. The digastric muscle is one of four suprahyoid muscles and contracts to elevate the hyoid bone, like other suprahyoid muscles. It has two bellies connected by an intermediate tendon on the hyoid. Movement of the digastric is closely associated with mastication and deglutition. These muscles are frequently involved with surgical procedures such as reconstruction and rejuvenation of the maxillofacial region. An in-depth understanding of the anatomic and functional features of this muscle will provide clinicians with a sound basis for decision making.

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RESUMEN: Como uno de los músculos suprahioideos, el músculo digástrico se caracteriza por dos vientres separados, de diferentes orígenes embriológicos. El origen del vientre anterior es la fosa digástrica, mientras que el origen del vientre posterior es la incisura mastoidea. Comparten una inserción común, El tendón intermedio. Cuando el músculo digástrico se contrae, el hueso hioides se eleva. La apertura de la mandíbula y la deglución del bolo alimenticio se asocian con la actividad del músculo digástrico. Esta revisión analiza las características anatómicas generales del músculo digástrico y su variación, funciones primarias e implicaciones clínicas centradas en la reconstrucción y el rejuvenecimiento quirúrgico.

PALABRAS CLAVE: Músculo digástrico; Anatomía; Músculos suprahioideos.

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