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Unreported anomalous musculature of first pharyngeal arch: Its embryogenesis and clinical anatomy

Kosuri Kalyan Chakravarthi
Department of Anatomy, Varun Arjun Medical College and Rohilkhand hospital, Banthra-Shahjahanpur, Uttar Pradesh, India
Corresponding author email: kalyankosuric@gmail.com

Venumadhav Nelluri
Department of Anatomy, Melaka Manipal Medical College (MMMC), Manipal University, Manipal, and Karnataka, India

Siddaraju Kaadukothanahalli Siddegowda
Department of Anatomy, KMCT Medical College, Manassery, Calicut, Kerala, India

Ankamma Sarvepalli
Department of Anatomy, Konaseema Institute of Medical Sciences and Research foundation, Amalapuram, Andhrapradesh, India.

***Abstract*---**Musculature of first pharyngeal arch play an important role in mastication, speech and swallowing thus a comprehensive knowledge of anatomical variations will be important for surgeons and Traumatologists which can increase the success of diagnostic evaluation and surgical approaches to the region. Accordingly, the purpose of this study was designed to evaluate the prevalence of anomalous musculature of first pharyngeal arch in the human cadavers. This study was carried out on 107 formalin embalmed human cadavers (male 62 and 45 female), and dissections were performed in accordance with the institutional ethical standards and Indian anatomy act. Out of 107 cadavers, in three cadavers the following rare unreported muscular variations of first pharyngeal arch were encountered in the present study: 1. Rare and unusual unilateral quadrilateral anomalous muscle in the submandibular region superficial to the submandibular gland with an accessory head of depressor labii inferioris muscle; 2. Anomalous unilateral facial muscle extending from the from the right lateral angle of mouth to coronoid process of mandible; and 3. An anomalous accessory head of temporalis muscle extending from the temporalis tendon to the posterior part of buccinator muscle. All accessory muscles noted in

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this study were supplied by the branches of mandibular nerve, nerve of first arch. Awareness of these rare muscular variations is necessary to avoid complications during various radiodiagnostic procedures or surgeries in the face, submandibular region and infratemporal fossa which can increase the success of diagnostic evaluation and surgical approaches to the region.

***Keywords*---**asymmetry, dermoid tumors, mandibular arch, mandibular neuralgia, hypertrophy, lipoma.

Introduction

The pharyngeal arches also called as brachial arches are seen in the embryonic development which contribute extensively to the formation of the face, nasal cavities, mouth, larynx, pharynx and neck. They began to develop early in the fourth week of intrauterine life as a series of surface elevations in the lateral wall of primitive pharynx caudal to the future mouth. At earlier stage of development pharyngeal arches are six pairs, but fifth arch pair disappears entirely before development is complete. Each pharyngeal arch in the center consists of a core of mesenchyme derived from lateral plate mesoderm, paraxial mesoderm and the neural crest. Externally each arch is covered by ectoderm and the internally with endoderm. The centre core of mesoderm is pluripotent in nature and differentiate into arterial arches, skeletal elements, and muscle masses. Muscles derived from each arch do not always attach to their own boney or cartilaginous components but sometimes they migrate into surrounding regions. In, addition each pharyngeal arch traversed by a cranial nerve derived from hind brain vesicle thus the muscular component of each arch has their own cranial nerve, and wherever the muscle cells migrate, they carry their nerve component. The first pharyngeal arch is also known as mandibular arch and the musculature derived from this arch includes muscles of mastication (temporalis, masseter, lateral pterygoid and medial pterygoid), anterior belly of the digastric, mylohyoid, tensor tympani, and tensor palatini; all first arch muscles are supplied by mandibular branch of fifth cranial nerve, the trigeminal nerve. Musculature of first pharyngeal arch play an important role in mastication, speech and swallowing thus a comprehensive knowledge of anatomical variations will be important for surgeons and Traumatologists can increase the success of diagnostic evaluation and surgical approaches to the region. Marked anatomical variations of the muscles of first pharyngeal arch are rarely seen, which may influence the biomechanics of joints, or they may simulate soft tissue tumors and can result in nerve or vascular compressions. Accordingly, the present study was designed to study the morphology of anomalous musculature of first pharyngeal arch and its clinical significance.

Material and Methods

Human Cadaveric specimens

This study was conducted on 107 formalin embalmed human cadavers (male 62 and 45 female) at Varun Arjun Medical College and Rohilkhand Hospital-Utter

Pradesh, Melaka Manipal Medical College- Manipal University-Karnataka, KMCT Medical College, Manassery, Calicut, Kerala and Konaseema Institute of Medical Sciences and Research foundation- Andhrapradesh. Dissections were performed on a body that had been donated for the purpose of medical education and research to the laboratory of anatomy in accordance with the institutional ethical standards and Indian anatomy act. This study was reviewed and approved by the Institutional Ethics Committee (reference number: VAMC-HAREC10 AN Aug 019).
Dissection

Dissection of face, neck and infratemporal fossa were done using standard anatomical procedures. Unusual gross anomalous musculature of first pharyngeal arch were observed their dimensions were measured and photographs were taken for proper documentation.

Results

Out of 107 human cadavers (male-62 and female-45), in 3 cadavers (2.8 %) the following unusual anomalous musculature of first pharyngeal arch were observed.

In the submandibular region

In a middle-aged female cadaver, a prominent swelling was observed externally over the left submandibular region. Upon reflecting the skin and platysma muscle, an unusual anomalous quadrilateral bulky muscle with four boarders (superior, inferior, anterior and posterior borders), and two surfaces (superficial and deep surfaces) was observed in the submandibular region (Figure-1). When traced above the bulky muscle (superior boarder) originated as fleshy fibers from the lower boarder of body of mandible, when traced below after covering superficial part of submandibular gland it is attached to the left half of hyoid bone and few fibers were merged with fascia covering submandibular gland, posterior belly of digastric muscle and stylohyoid muscle. Anterior boarder of anomalous muscle was noted free, which extended from the lower boarder of mandible close to the digastric fossa to the body of hyoid bone. Close to the anterior boarder it was supplied by branches from mylohyoid vessels and nerve. The dimensions of this anomalous muscle were 5.6 cm length, 5.7 cm width, and 0.9 cm thickness. Addition to this, an accessory head of depressor labii inferioris muscle was intermingled with the posterior boarder of anomalous quadrilateral bulky muscle (Figure-2).

In the facial region

In a middle-aged male cadaver, an anomalous facial muscle was noted on the right side of face (Figure-3). The muscle originated as fleshly fibers from the right lateral angle of mouth. When traced laterally, its thin long tendon is inserted to the coronoid process of mandible. Dimensions of this muscle were 4cm length, 0.3 cm width. The anomalous facial muscle was innervated by the mesenteric branch of mandibular nerve.

In the infratemporal fossa

In a middle-aged female cadaver, an accessory head of temporalis muscle was noted in the left infratemporal fossa (Figure-4). The accessory head originated from the anteromedial aspect of the temporalis tendon close to the coronoid process of the mandible was interdigitated with the posterior part of buccinator muscle. Close to its origin the anomalous muscle covering the lingual nerve, buccal nerve, nerve to lateral pterygoid and deep temporal branches of mandibular nerve (Figure-5). Dimensions of this anomalous were 2.1 cm length and 0.4 cm width. The anomalous accessory head was innervated by the deep temporal branch of mandibular nerve.

Discussion

The pharyngeal arches play an important role in the formation of the face, nasal cavities, mouth, larynx, pharynx and neck. Developmental anomalies of pharyngeal arches were not uncommon, Chakravarthi et al. 2020, in his study reported very rare anomalous triple (0.9 %) and double styloid process (1.8 %) of temporal bone in the Indian human dry skulls and described the anomalous reasons were may be due to errors of embryologic cleavage of Reichert cartilage of the second brachial arch during development. Whereas in the present study anomalous musculature of first pharyngeal arch (2.8%) were noted in the facial region, submandibular region and in the infratemporal fossa.

In the submandibular region

Anomalous or accessory muscles in the submandibular region are not uncommon. Anatomical variants of digastric, stylohyoid and very rare levator submandibuli (Banjo muscle) muscle have been reported in the literature (Buffoli B et al. 2016, Aktekin M et al. 2003, Norton MR et al. 1991, Peker T et al. 2000, Banjo AO et al. 2009). From the surgical point of view, muscles in the submandibular region were divided in to four muscular planes from superficial to deep. First muscular plane includes digastric, stylohyoid muscles; second muscular plane includes mylohyoid; third muscular plane includes geniohyoid, hyoglossus, and styloglossus muscles; and fourth muscular plane includes genioglossus and a part of superior constrictor of the pharynx. The submandibular region superficially includes submandibular triangle and submental triangle. The majority of submandibular triangle space is occupied by submandibular gland, facial artery and submandibular lymph nodes which are important structures present in the first muscular plane during the surgeries of submandibular region. Superficial to these important structures an unusual unilateral quadrilateral bulky additional muscle in the submandibular region noted in the present study was innervated from its deep surface by mylohyoid branch of inferior alveolar nerve. Such unusual and rare additional muscle and its nerve supply can be a challenging task for surgeons, during any surgeries related to the submandibular region damage to the nerve may leads to neurogenic muscular atrophy. Hypoglossal nerve, mylohyoid nerve and vessels are the important neurovascular structures present in the second muscular plane of submandibular region. Hypoglossal nerve is a solely motor in function which supply intrinsic and extrinsic muscle of tongue and control the movements of

tongue required for speech and swallowing. Trauma, infections, lipoma and dermoid tumors in the sublingual space are most common causes for compression or damage of hypoglossal nerve, and lead to unilateral atrophy of tongue muscles. Hypertrophy or spasmodic contraction of addition muscles in the submandibular triangle may compress the hypoglossal nerve which lead to unilateral weakness or wasting of tongue muscles, causing tongue deviation towards the week side. This constellation may lead to dysarthric speech. Such neuromuscular variations are clinically important because symptoms of hypoglossal nerve compression arising from similar variations are often confused with more common causes, such as trauma, infections, lipoma and dermoid tumors in the sublingual space.

Anatomical position and architecture of the skeletal muscle is an important factor in determining muscle function, any structural variations affect not only the overall shape and size of the muscle but also function range of motion or biomechanics of the joint. Anomalous quadrilateral fleshy muscles fibers were running parallel to the line of contraction, during contraction of this muscle (at the same time when the hyoid bone is kept fixed by the infrahyoid muscles) can helps in the depression of mandible during the opening of mouth. It can also help in elevation of the floor of the mouth and the tongue (due to elevation of hyoid bone), and thereby help in mechanical processes of deglutition and mastication. Based on the functional aspect this anomalous muscle can be named as depressor submandibuli or Kosuri muscle (after the author). In addition, anomalous additional muscle fibers of depressor labii inferioris were intermingled with the posterior boarder of depressor submandibuli made present study more unique. Anatomically depressor labii inferioris arises from the anterior oblique line of the mandible and inserted to the angle of mouth and draws the lower lip somewhat inferolaterally in the irony facial expression. Such unilateral additional heads may present greater clinical significance, since it may be responsible for asymmetry in the one side of the movement of the mouth. Even through additional muscles or additional heads gives additional strength or support the respective region, at the same time they may also simulate soft tissue tumors can result in nerve compression (Chakravarthi KK et al. 2013).

From an embryological point of view, depressor submandibuli or Kosuri muscle (after the author) noted in the present study may be due to duplication of mylohyoid muscle in the submandibular region, and its abnormal connection with depressor labii inferioris may be due to abnormal migration or mixing of some part of myogenic cells of second arch to the first arch.

In the facial region

Embryologically facial muscles were developed from the second pharyngeal arch, hence innervated by facial nerve, nerve of second arch. Facial muscles are located below the skin within the superficial fascia and they are arranged in groups around the orifices of eye, mouth and nose as sphincters and dilators of these orifices. They not only regulate the opening and closing of orifices, they play an important role in different type of facial expression. Any congenital absent or abnormalities of facial muscles may lead to unilateral or bilateral asymmetry in the facial expression of an individual. The facial muscles around the mouth play

an important role in movements of lips and checks. In the literature anomalous or absent or extra heads or bifid facial muscles around the mouth particularly at or above or below the lateral angle of mouth were reported (Pessa JE et al. 1998, Hu KS et al. 2008). In all reported cases embryologically they developed from the second pharyngeal arch, as they were supplied by facial nerve (nerve of second arch). But accessory facial muscle originated from the lateral angle of mouth noted in the present study was embryologically developed from the first pharyngeal arch, as it was supplied by the mesenteric branch of mandibular nerve (nerve of first arch). Its unusual insertion to the coronoid process of mandible may interfere biomechanics of temporomandibular joint or it may lead to unilateral asymmetry of angle of mouth. From an embryological point of view, a possible explanation for this anatomical variant could be the abnormal migration of muscle mass of the mandibular part of the first arch to the lateral angle of mouth. Based on the embryology, morphological anatomy and separate nerve supply from the mesenteric branch of mandibular nerve these muscles are not an accessory or anomaly of the facial muscles indicate is separate muscle present in the face. Such unusual new additional facial muscles close to the angle of mouth noted in this study were not cited in the medical literature till date.

In the infratemporal fossa

Infratemporal fossa contains vital neuro vascular structures such as mandibular nerve, chorda tympani nerve and maxillary artery. This fossa also contains lower part of temporalis, masseter medial and lateral pterygoids all are developed from the mandibular part of the first pharyngeal arch. Anomalous or accessory or aberrant musculature knowledge in the infratemporal fossa is great interest to the clinicians for any surgical procedure in the area, such as repair of the maxillary artery, as well as for greater understanding of the embryologic development of the first pharyngeal arch. An anomalous muscle pterygoideus proprius originating from the anterior infratemporal crest, running vertically down to insert on the lateral pterygoid plate, and another anomalous muscle termed as “temporalis minor” that originating from the anterior aspect of the temporalis muscle and inserted onto the mandibular notch instead of the coronoid process, was reported in the literature (Henle J et al. 1858). Akita et al. 2001, reported an aberrant fibro muscular band arising from the anteromedial aspect of the temporalis and interdigitating with fibers from the lateral pterygoid. In the present study, fleshy accessory head of temporalis muscle originating from its anteromedial aspect of the temporalis tendon close to the coronoid process of the mandible was interdigitated with the posterior part of buccinator muscle. Close to its origin accessory head of temporalis crossing the lingual nerve, deep temporal nerve, to lateral pterygoid and buccal branches of mandibular nerve. Accessory head of temporalis in the present study may interfere the action of buccinator or temporalis muscles during the deglutition and mastication. Muscular hypertrophy or irritation of such accessory heads can compress mandibular nerve branches. Such entrapment or compression neuropathy may lead to chewing disorders, pain during speech, numbness of the buccal region, loss of anaesthesia in the anterior two-thirds of the tongue and eventually cause mandibular neuralgia or this compression neuropathy could provoke trigeminal neuralgia (Chakravarthi KK et al. 2013). Anatomical knowledge of muscular anomalies and its relation to the mandibular nerve branches in the infratemporal fossa noted in the present study

is essential which facilitates determination of the exact cause of mandibular neuralgia or trigeminal neuralgia and allows a safe surgery or appropriate treatment for compressive neuropathies.

Conclusion

As per our knowledge anomalous musculature of first pharyngeal arch noted in the present study have not been presented in the modern medical literature. Comprehensive anatomical knowledge of these muscular variations is necessary to avoid complications during various radiodiagnostic procedures or surgeries in the face, submandibular region and infratemporal fossa which can increase the success of diagnostic evaluation and surgical approaches to the region.

Authors contributions

KKC: Designed the study, conducted research, collecting, analysis and interpretation of the data and writing the initial and final drafts of the article
VN: collecting data.
SKS: collecting data.
AS: collecting data.
All authors critically reviewed and approved the final draft.

Conflict of interest: None declared.

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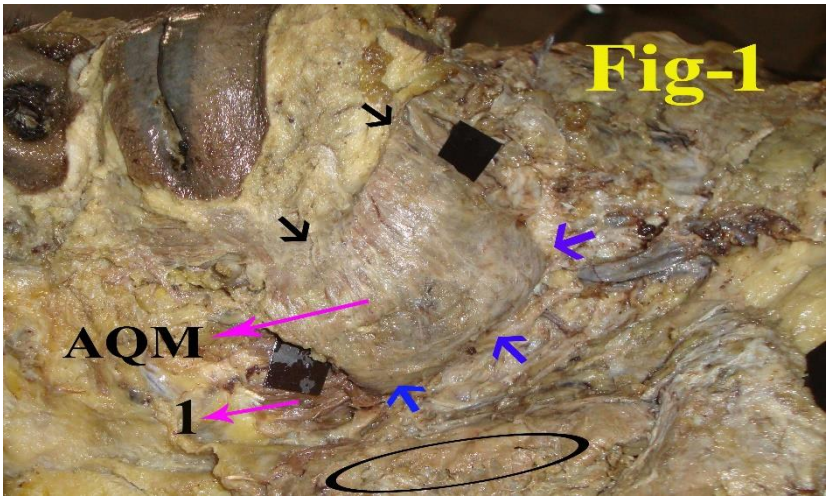
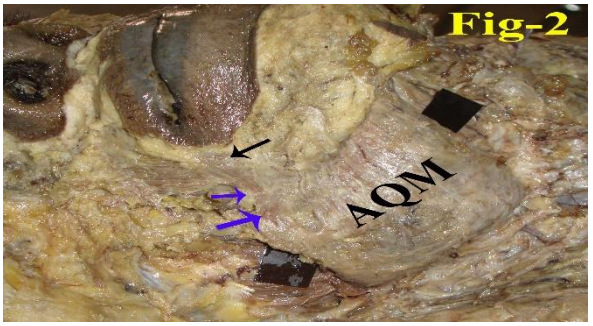
Legend for figure

Figure-1: Showing anomalous quadrilateral muscle / depressor submandibuli (Kosuri muscle) in the left side of submandibular region



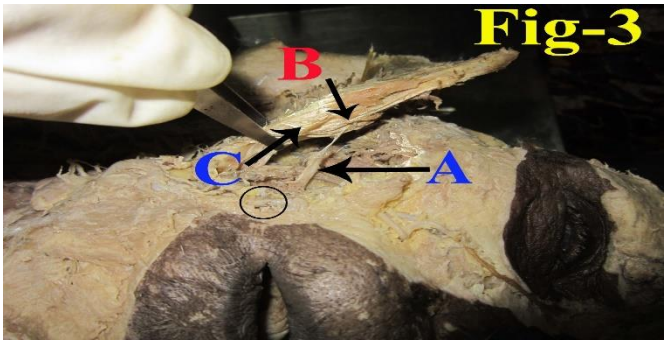
AQM- Anomalous quadrilateral muscle / depressor submandibuli (Kosuri muscle) in the submandibular region; Black arrows- anomalous originating from lower boarder of mandible; Blue arrows- anomalous muscle insertion to the left half of the hyoid bone and fascia covering the posterior belly of digastric muscle; 1- posterior belly of digastric muscle.

Figure-2: Showing additional head of depressor labii inferioris in the left side of submandibular region



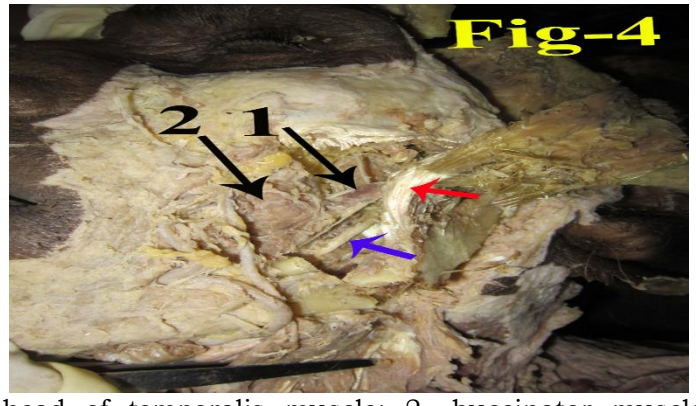
AQM- Anomalous quadrilateral muscle in the submandibular region; Black arrows- additional head of depressor labii inferioris; Blue arrows- additional head of depressor labii inferioris.

Figure-3: Showing an anomalous facial muscle on the right side of face.



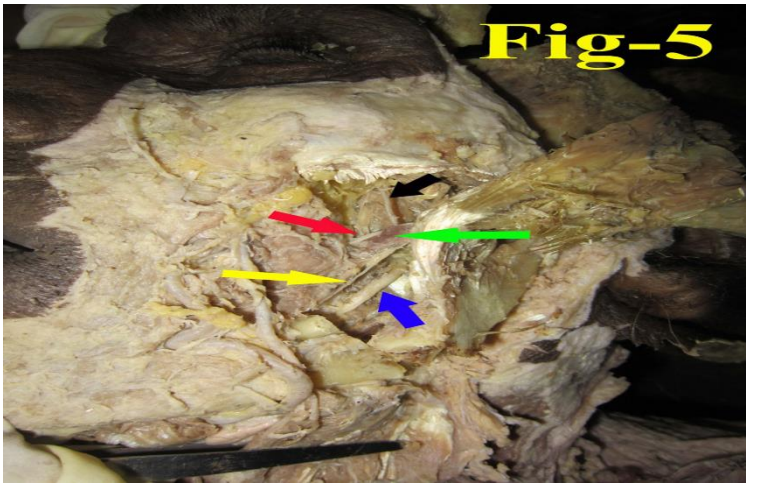
A- Anomalous muscle; B- coronoid process of mandible; C- temporalis muscle; Black circle- facial vessels.

Figure-4: Showing an accessory head of temporalis muscle in the left infratemporal fossa



1- accessory head of temporalis muscle; 2- buccinator muscle; Red arrow- temporalis muscle; Blue arrow- lingual nerve.

Figure-5: Showing relations of an accessory head of temporalis muscle in the left infratemporal fossa



Green arrow- accessory head of temporalis muscle; Blue arrow- lingual nerve; Yellow arrow- buccal nerve; Red arrow- nerve to lateral pterygoid muscle; Back arrow- deep temporal nerve.